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Master's Thesis – master Sustainable Development

Fostering Legume Cultivation in the Netherlands:

A Mission-Oriented Innovation System Analysis

By

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Summary
The Netherlands faces several critical sustainability challenges in its agricultural system, including excessive nitrogen emissions that harm ecosystems and a heavy reliance on imported legumes, particularly soy. These imports contribute significantly to deforestation and greenhouse gas emissions, especially in regions with a high biodiversity, like the Amazon. Despite the well-known environmental and agronomic benefits of legume cultivation, such as nitrogen fixation, improved soil health, and enhanced biodiversity, legume cultivation remains marginal, covering less than 1% of Dutch farmland. Therefore, this thesis investigates the systemic barriers and enables scaling legume cultivation in the Netherlands, aligning with national and European ambitions for a protein transition.

The study applies the mission-oriented innovation system (MIS) framework to analyse the adoption of legume cultivation. The analysis consists of three analytical steps: the problem-solution diagnosis, the structural analysis, and the functional analysis. By employing a qualitative methodology, including policy document analysis and semi-structured interviews with stakeholders such as farmers, policymakers, researchers, and agribusiness, the study uncovers critical systemic challenges and opportunities. The results reveal that significant progress has been made in aligning stakeholders around a shared goal. Moreover, networks and coalitions in the MIS facilitate effective knowledge diffusion. However, critical systemic barriers remain. Innovation development is hampered by the absence of key stakeholders and the lack of well-developed seed varieties. Furthermore, stakeholders struggle to effectively destabilise obstructive practices, thereby impeding regime transformation.

These findings contribute to the theoretical development of the MIS framework by demonstrating its applicability in agricultural transitions. This novel framework underlines the need for fostering innovation while also destabilising entrenched practices that hinder mission progress. Furthermore, this study offers policy recommendations, including the establishment of risk mitigation mechanisms for farmers and the empowerment of coordination frameworks to effectively steer the transition.

By examining the interplay of agricultural, economic, and institutional factors, this research contributed to a better understanding of the barriers and facilitators influencing the adoption of legume cultivation in the Netherlands. The insights of this research go beyond the Netherlands and offer insights that could support sustainable agriculture in other regions. Finally, this study validates the value of mission-oriented approaches in addressing complex societal challenges and contributes to the ongoing debate on sustainable food systems.

Key words
Agricultural Transitions, Barriers and Enablers, Legume Cultivation, Mission-Oriented Innovation Systems, Protein Transition

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List of abbreviations

Abbreviation	Definition
AIS	Agricultural Innovation System
CAP	Common Agricultural Plan
EC	European Commission
ESG	Environment, Social, Governance
ISA	Innovation System Analysis
GDEG	Green Deal Eiwitrijke Gewassen (i.e. Green Deal Protein-rich Crops)
GDPR	General Data Protection Regulation
MAIS	Mission-oriented Agricultural Innovation System
MIS	Mission-oriented Innovation System
MIP	Mission-oriented Innovation Policy
NES	Nationale Eiwitstrategie (i.e. National Protein Strategy)
SDG	Sustainable Development Goal

1. Introduction

This chapter provides the foundation for the research by discussing this study's key societal and scientific contexts. First, the chapter will outline the societal background, focusing on the challenges of sustainable agriculture in the Netherlands and the need to increase domestic legume cultivation. Next, the scientific background is discussed, introducing the mission-oriented innovation system (MIS) framework as a theoretical lens to study the barriers and drivers influencing agricultural innovation and adopting new practices. Then, the chapter presents the research gap resulting from the need for more empirical research on applying the novel MIS framework. Key research questions are presented after presenting the research gap, followed by a short introduction to the research framework. Finally, the chapter discusses the scientific and societal relevance of the study, demonstrating how this research contributes to advancing knowledge on innovation systems and supports ongoing efforts to transition towards sustainable agriculture in the Netherlands.

1.1 Societal background and problem

All over the world, environmental concerns are creating ambitions towards more sustainable food systems. Meanwhile, Europe relies heavily on imported legume crops such as beans, lentils, and peas for food and animal feed (van Loon et al., 2023). This dependency is particularly strong in the Netherlands, one of the world's largest soy importers (Escobar et al., 2020). Soy cultivation contributes to deforestation and significant greenhouse gas emissions in biodiversity-rich regions like the Amazon (Escobar et al., 2020), exposing a vital issue of importing legumes.

The Netherlands dedicates less than 1% of its agricultural land to the cultivation of legumes (CBS, 2022). If the Netherlands wants to transition towards a more sustainable agricultural system and reduce the emissions from legume imports, it needs to increase domestic legume cultivation. Legumes have the potential to contribute to a more resilient and sustainable agricultural system by offering multiple environmental benefits, such as nitrogen fixation, which reduces the need for synthetic fertilisers, and the enhancement of soil health, biodiversity, and crop yields through diversified cropping systems (Lüscher et al., 2014; Zander et al., 2016; Balázs et al., 2021a). Despite these advantages, legume cultivation remains marginal in the Netherlands.

To address these issues, both the European Union (EU) and the Dutch government have formulated ambitious strategies to promote domestic legume cultivation. Increasing legume cultivation forms one of the strategic plans of the EU's Common Agricultural Policy (CAP). The CAP prescribes that support for legumes should increase by 25% in 2027 compared to 2022 (European Union, 2022). Nationally, the Dutch government has initiated a protein transition by developing a National Protein Strategy (Nationale Eiwitstrategie, NES), which aims to increase self-sufficiency in protein production over the next decade. Plans to increase legume cultivation are further developed in the Green Deal Protein-Rich Crops (Green Deal Eiwitrijke Gewassen GDEG, also known as the Beandeal). These initiatives aim to reduce the environmental footprint of protein imports and enhance soil health and biodiversity by integrating nitrogen-fixing crops like legumes into the Dutch agricultural system.

Despite these efforts, progress has been slow. Legumes currently occupy only 1.5% of Europe's arable land, significantly below the global average of 14.5% (Watson et al., 2017). This figure remains even lower in the Netherlands, with no notable increase in recent years (CBS, 2022).

The slow adoption of legume cultivation in the Netherlands highlights significant challenges in realising the ambitions of the protein transition, which aims to shift from animal-based to more plant-based protein consumption. This lack of progress hinders efforts to reduce the Netherlands' environmental footprint and progress toward a more sustainable food system. Understanding the societal, economic, and institutional barriers that limit legume cultivation is crucial for advancing this transition. By overcoming these obstacles, legume cultivation can achieve its potential, playing a vital role in the transition to a more sustainable agricultural system.

1.2 Scientific background

The adoption of legume cultivation in the Netherlands has been slow because of the multifaceted nature of this wicked problem. Wicked problems are characterised by their complexity, resistance to straightforward solutions, and the interplay of technical, economic, and societal factors that complicate their resolution (Peters, 2017). Legume cultivation in the Netherlands can be considered a wicked problem because it involves complex interconnected factors. The following paragraph presents the barriers that make it challenging to find a straightforward solution.

Scientific literature has identified several barriers to adopting legume cultivation in Europe. Due to their relative novelty, knowledge of legume production in Europe is limited, which can result in low yields (Watson et al., 2017). To ensure the profitability of legume crops, knowledge about locally adapted varieties and production techniques is required to support development (Fogelberg and Recknagel, 2017). Another crucial factor affecting the adoption of legumes is the lack of stable market opportunities (Mawois et al., 2019; Watson et al., 2017; Zander et al., 2016), which deter farmers from cultivating legumes. Furthermore, markets often do not account for the external effects of legume cultivation, such as biodiversity enhancement, emission reductions, and soil improvements, thereby underestimating their true economic value (Zander et al., 2016). Finally, and critical to this study, policy interventions aimed at increasing legume cultivation have so far failed to make a difference (Watson et al., 2017). Therefore, this study will assess the impact of the Dutch mission-oriented policy on legume cultivation.

Missions

In an attempt to steer and accelerate the transition towards increased legume cultivation, the EU and national governments have initiated missions. Missions are initiatives that address grand social challenges through measurable, ambitious, and time-bound objectives that have the potential to help enable transformative change (Tõnurist, 2023). Well-known missions include the Apollo program that led to the moon landing, the eradication of smallpox initiated by the World Health Organisation, and the Sustainable Development Goal (SDG), which aims to end hunger. Missions are an increasingly popular means to address persistent societal challenges (Foray et al., 2012). They offer a clear and compelling narrative for policymakers, stakeholders and the public and can gather a diverse set of actors around a common goal. By promoting collective action across different sectors, missions have become a popular method for governments to address complex issues.

However, the effectiveness of missions in achieving their objectives and thereby bringing about societal change remains uncertain. Recent studies (e.g. Janssen et al., 2021; Kirchherr et al., 2023; Wanzenböck et al., 2020) have critically examined the mission concept and highlighted some underexposed issues, such as implementation complexity and the concept's inability to achieve transformation change. Despite implementing missions for decades, empirical examples of sustainability missions are very

limited (Kirchherr et al., 2023). Therefore, it is hard to say if missions are an effective means of governance for tackling complex societal problems.

Nevertheless, the Dutch government is betting heavily on the mission concept to guide the protein transition. Consequently, its effectiveness is crucial for the future of the Dutch agricultural sector and society in a broader sense. Therefore, this study will assess the effectiveness of the protein mission using a novel framework developed to assess missions-oriented innovation systems (i.e., Elzinga et al., 2023). In doing so, a comprehensive understanding of the underlying factors contributing to the slow transition will be examined. By identifying barriers, challenges, and opportunities regarding legume cultivation in the Netherlands, this work can enhance the mission. Additionally, policy recommendations will be formulated for interventions focussing on the acceleration of the protein transition. Addressing this research problem is essential for promoting sustainable agriculture and reducing the environmental impact of legume production globally.

Innovation systems

Innovation systems are networks of actors, institutions, and organisations that interact to create, develop, and diffuse new technologies and practices (Hekkert et al., 2007). These systems have been studied for decades, with various models and frameworks emerging, e.g., national (Godin, 2009) and agricultural (Klerkx et al., 2012). The core idea is that dynamic interactions between stakeholders such as researchers, policymakers, businesses, and societal actors drive innovation.

This study focuses on a specific type of innovation system known as a mission-oriented innovation system (MIS). MISs are innovation systems that form around a defined societal mission, such as the transition to sustainable agriculture or the reduction of greenhouse gas emissions. These missions aim to address grand challenges by aligning the efforts of different actors and sectors toward achieving a common goal (Hekkert et al., 2020).

According to Elzinga et al. (2023), understanding the effectiveness of missions requires an analysis of the innovation systems in which they occur. They propose a new framework for assessing these mission-specific innovation systems, highlighting how actors and institutions collaborate, the barriers and facilitators to innovation, and the potential they offer for transformative change. This framework plays a central role in this research. It will be further elaborated in the following chapters to assess how effectively the mission of promoting legume cultivation in the Netherlands is progressing.

1.3 Research gap

This section argues that addressing the slow transition towards increased adoption of legume cultivation in the Netherlands requires critically examining the MIS within which this transition occurs. Legume production in Europe has shown considerable potential for contributing to sustainable agriculture (Lüscher et al., 2014; Zander et al., 2016), and Dutch farmers have expressed a willingness to adopt these crops (Degieter et al., 2023). However, despite this potential, legume cultivation remains marginal, hampered by systemic barriers.

At the same time, mission-oriented innovation has emerged as a popular approach for addressing complex societal challenges and driving transformative change (Foray et al., 2012; Mazzucato, 2018). Despite its popularity, researchers and policymakers continue to face challenges in implementing and effectively monitoring Mission-oriented Innovation Policies (MIP) (Hekkert et al., 2020; Janssen et al.,

2021). Furthermore, while there has been increasing interest in missions, empirical studies that assess the dynamics and effectiveness of mission-oriented innovation systems, particularly in the context of agriculture, still need to be expanded (Klerkx and Begemann, 2020).

Specifically, in the agricultural sector, there is growing recognition of the need to map national (sub)missions aimed at transforming food systems, as Kok and Klerkx (2023) advocated. The concept of Mission-oriented Agricultural Innovation Systems (MAIS) proposed by Klerkx and Begemann (2020) offers a valuable framework, but empirical applications of this framework on actual agricultural transitions are limited. Therefore, a MIS analysis on the adoption of legume cultivation addresses this research gap by providing insights into how mission-oriented policies can effectively drive changes in agricultural practices and overcome persistent barriers to legume adoption. This study will contribute to a better understanding of missions and how they can be governed to achieve the desired goals.

1.4 Research aim, questions, and framework

The central aim of this thesis is to analyse the MAIS focused on promoting legume cultivation in the Netherlands. By applying the MIS framework, this research aims to evaluate how effectively this system is progressing towards its mission of increasing legume cultivation and thereby reducing the reliance on imported legume crops. The study will explore how different actors interact within this system, what challenges the system faces, and the solutions that are being proposed to address these challenges.

Research question
The following research questions have been formulated to structure and guide this study.

Main research question:

- To what extent is the mission-oriented agricultural innovation system (MAIS), which targets the adoption and increase of legume cultivation in the Netherlands, progressing toward achieving its mission goal?

Sub-questions:

1. What problem(s) does the mission aim to tackle, and what are the proposed solutions?
    - This sub-question will explore the critical societal and environmental issues the mission addresses, followed by an analysis of the solutions proposed to address these problems.
2. What is the number, type, and composition of actors in the innovation system, and what are their roles?
    - This question will identify the various actors involved in the innovation system, including government bodies, research institutions, agricultural cooperatives, farmers, and private sector companies. The number, type, and composition of actors will be analysed, as well as the roles of these actors and their contributions to the coordination and implementation of the mission.
3. How well is the innovation system performing based on the innovation system functions (as provided by Elzinga et al., 2023)?
    - This sub-question forms the main focus of this thesis, and it will assess the performance of the innovation system by examining the innovation system functions outlined in Elzinga et al. (2023). The analysis will focus on critical functions assessing coordination, novelty creation, and destabilisation within the innovation system. The

goal is to determine to what extent the innovation system supports these functions and thereby identify systemic barriers that hinder or drivers that accelerate mission progress.

Theoretical framework

The MIS framework will serve as the primary theoretical lens for this study. As defined by Hekkert et al. (2020), MIS focuses on the network of actors and institutions contributing to developing and diffusing innovative solutions to achieve a societal mission. This framework is particularly suitable for studying complex phenomena, like the transition toward more legume cultivation, which requires coordinated actions from multiple stakeholders.

The innovation system functions (knowledge development, market formation, entrepreneurial experimentation, etc.), as presented by Elzinga et al. (2023), will provide the basis for evaluating the performance of the MIS. These functions offer a structured method to analyse how well the system is progressing toward its mission goal and where policy interventions or systemic changes may be desired.

1.5 Scientific contributions

This study contributes to the scientific literature in three ways, building on recent research suggestions in the field of MIS. First, this research contributes to the limited empirical work on national missions by mapping the Dutch ambition of increasing legume cultivation. By focussing on the Netherlands' efforts to reduce reliance on imported protein sources, this study offers valuable insights into the dynamics of a national mission (Kok and Klerkx, 2023). This study will address the knowledge gap in this novel research area by examining a national mission. Second, this study contributes to testing and refining this theoretical lens by applying the MAIS framework, as developed by Klerkx and Begemann (2020). This research will test the applicability of MAIS in understanding the barriers and drivers for legume adoption within the Dutch protein transition, thereby contributing to the development of the framework. Lastly, this study utilises the novel analytical framework provided by Elzinga et al. (2023), which offers a method to assess the effectiveness of mission-oriented innovation systems in achieving transformative goals. By applying this framework to the Dutch agricultural context, this study will evaluate how effective the mission-oriented approach is in accelerating the shift towards increased legume cultivation. In summary, this research not only contributes to empirical evidence of studies on national missions but also contributes to the theoretical and methodological development of MIS and MAIS frameworks.

1.6 Societal relevance

This study offers significant societal relevance by contributing to critical aspects of environmental sustainability and food security. Legume crops can reduce the need for synthetic nitrogen fertilisers, thereby lowering nitrogen emissions and greenhouse gas outputs. This is especially crucial in the Netherlands, where addressing nitrogen-related environmental impacts is a key issue. Additionally, the cultivation of legumes supports biodiversity by enhancing soil health and diversifying crop rotations, supporting a more balanced and biodiverse agricultural system.

Beyond environmental benefits, increasing local legume production enhances food security by providing a sustainable, protein-rich food source that reduces reliance on imported proteins, such as soy, which often cause significant emissions due to land use change. Local production ensures a more

resilient food system, reducing risks associated with global supply chain disruptions. Furthermore, by reducing the need to transport protein crops from other continents, this transition can significantly decrease transportation-related emissions, aligning with broader climate goals.

Lastly, as the Netherlands uses MIPs to support this transition, this research contributes to a deeper understanding of how such policies can tackle critical (agricultural) challenges. The growing popularity of MIP is not limited to the Netherlands but reflects a global trend (OECD, 2021). Therefore, the results of this study are relevant to a broad audience, offering valuable insights into the transformative potential of MIPs, especially for promoting sustainable food systems.

To conclude, this study helps to address multiple societal challenges: reducing agricultural emissions, improving biodiversity, enhancing food security, offering a better understanding of MIP, and contributing to climate mitigation efforts by promoting local legume cultivation.

2. Theory

This chapter provides the theoretical foundation for understanding the adoption of legume cultivation in the Netherlands. It starts with outlining the fundamental theories that form the backbone of this research, with a critical role for the mission-oriented innovation system framework. Next, it explores the relevance of these theories and frameworks to the study, followed by a discussion and definition of its key concepts. The chapter concludes with an explanation of how these theories are applied and how they will guide the analysis throughout the research.

2.1 Mission-oriented innovation systems (MIS)

The concept of missions has evolved significantly over time, shifting from traditional technological applications like the Apollo moon mission to addressing more broad and complex societal challenges such as climate change and food security (Foray et al., 2012; Mazzucato, 2018). Missions are initiatives that aim to achieve specific, ambitious, and time-bound societal goals, bringing together a diverse group of stakeholders across sectors (Tõnurist, 2023). Unlike conventional missions that focused more specifically on technological issues, contemporary missions require a holistic approach, incorporating social, economic, and environmental aspects.

The MIS framework allows for such a holistic approach to missions by focussing on the alignment of all actors, institutions, and resources involved in a complex societal challenge. As defined by Hekkert et al. (2020), a MIS is 'the network of agents and set of institutions that contribute to the development and diffusion of innovative solutions with the aim to define, pursue, and complete a societal mission'. The MIS framework differs from traditional innovation systems, such as national or sectoral innovation systems, because it focuses specifically on the directionality of innovations, i.e., how innovation is guided towards achieving societal goals (Elzinga et al., 2023). For example, the EU's Farm to Fork strategy, which aims to reduce pesticide use and enhance organic farming among other things, illustrates how directionality shapes policy and steers innovations toward sustainable agricultural practices (Klerkx and Begemann, 2020). Similarly, the clear and ambitious targets set by the NES for increasing legume cultivation show how directionality helps steer efforts toward specific outcomes. This focus on coordinating innovation through setting clear goals makes the MIS framework well-suited for addressing the complex challenges involved with increasing legume cultivation in the Netherlands.

2.2 Mission-oriented agricultural innovation systems (MAIS)

Klerkx and Begemann (2020) further developed the MIS concept by focusing specifically on the role of the agricultural sector in achieving societal missions (e.g., the protein transition). This resulted in the concept of mission-oriented agricultural innovation systems (MAIS). MAIS emerge from the combination of agricultural innovation systems (AIS) and mission-oriented approaches. This framework can be used to understand how agricultural innovation can be steered towards societal goals (Klerkx and Begemann, 2020).

The MAIS concept is relevant for examining the adoption of legume cultivation in the Netherlands because it addresses the specific challenges within the agricultural sector. Furthermore, it focuses on aligning local farming practices with broader goals, such as promoting sustainable food production and reducing reliance on imported protein sources. Where the traditional AIS focuses on gradual improvements, MAIS is designed to contribute to transformative change. By focusing on systemic

changes that are required to achieve sustainability goals, the MAIS concept is particularly suited for analysing transitions like the one studied in this thesis (Elzinga et al., 2023; Kok and Klerkx, 2023).

The MAIS framework examines the dynamics between actors, such as farmers, researchers, policymakers, and industry players, to analyse how their interactions contribute towards the mission goals (Kok and Klerkx, 2023). This perspective is helpful because it gives insights into both the technical aspects of innovation and new practices, as well as the broader societal factors that influence agricultural transitions, such as market conditions and cultural acceptance (Elzinga et al., 2023).

2.3 Relevance of MIS for examining the adoption of legume cultivation

To ensure consistency and clarity throughout this thesis, the term 'MIS' (mission-oriented innovation system) will be used primarily. Although the research focuses on an agricultural system (which would typically be referred to as MAIS), using only 'MIS' aligns with the name of the analytical framework applied in this study (developed by Elzinga et al., 2023) and avoids potential confusion. While the system studied has the characteristics of a MAIS, referring to it as MIS throughout ensures clarity and consistency.

The MIS concept provides a useful analytical lens for understanding the efforts to increase legume cultivation in the Netherlands. It examines the interactions between stakeholders, policy, and the market. The mission to enhance legume cultivation aligns with broader policy objectives focusing on promoting sustainable agriculture and protein transitions, such as the Farm to Fork strategy of the EU (Klerkx and Begemann, 2020). By applying the MIS framework, we can examine the interactions between diverse stakeholders, including government bodies, research institutions, farmers, and processors, and focus on the coordination required to achieve systemic change (Kok and Klerkx, 2023).

A key element of MIS is the concept of directionality, which ensures that all innovation activities are aligned with the overarching mission goal. In this case, directionality can be illustrated by the European protein transition, which aims to reduce dependency on imported protein crops and promote local alternatives like legumes. Such policy direction affects the behaviour of all stakeholders, from incentivising farmers to grow new crops to accelerating research efforts. This clear focus on directionality ensures that all actors contribute towards the shared societal mission.

Lastly, applying a MIS view is helpful because, instead of focusing on incremental change (e.g., seed improvement) like an AIS would, MIS allows for a more transformative approach (Klerkx and Begemann, 2020). The adoption of legume cultivation would be part of a broader mission to fundamentally transform the Dutch agricultural sector in line with societal needs such as reducing agricultural emissions, improving soil health, and promoting biodiversity. This might involve systemic changes, like adjusting traditional crop rotations, encouraging plant-based diets, or restructuring supply chains. This holistic approach, which allows for an analysis of the entire system, from policies and markets to research and public awareness, makes the MIS framework particularly suitable for studying the adoption of legume cultivation in the Netherlands.

2.4 An analytical framework to assess MIS

To assess mission-oriented innovation systems (including sector-specific systems, such as MAIS), Elzinga et al. (2023) propose a new analytical framework. This framework builds on earlier work on technological innovation systems and is adapted to suit the mission-oriented approach. Elzinga et al. (2023) propose three analytical steps to achieve a comprehensive understanding of the MIS. These steps include a problem-solution diagnosis, a structural analysis, and a functional analysis. Since this framework serves as the backbone of this research, each step and its relevance for understanding the MIS will be briefly outlined.

2.4.1 The problem-solution diagnosis

The problem-solution diagnosis is the first step in MIS analysis. This step involves mapping the problem(s) that the mission aims to address and identifying the solutions that are considered viable to address these problems (Elzinga et al., 2023). In the context of this thesis, this step is crucial for understanding the barriers to adopting legume cultivation and exploring the various solutions that aim to overcome these barriers. Furthermore, this step helps to define the boundaries of the MIS by determining which actors, institutions, and resources are relevant to the mission (Elzinga et al., 2023). This study would include various actors, from farmers to agricultural cooperatives, processors, retailers, policymakers, and consumers. Additionally, a precise problem-solution diagnosis, required for a well-functioning MIS, is characterised by its ability to mobilise and align stakeholders around the mission goal (Janssen et al., 2021). This alignment is crucial for fostering collaboration and achieving impactful outcomes.

Moreover, this step should also address the multiple solution pathways that may contribute to the mission. For adopting legume cultivation, these pathways might include increasing yields, promoting consumer awareness, or creating better economic incentives for farmers. However, since innovation is uncertain, it is unclear which solutions will be most effective. This uncertainty could be managed using tentative governance, a form of governance that emphasises experimentation, learning, and the ability to adjust strategies over time (Kuhlmann et al., 2019).

Additionally, the problem-solution diagnosis should analyse the interactions between different solutions pathways, as these can be symbiotic, neutral, or competitive (Sandén and Hillman, 2011). For example, farmer networks can promote knowledge diffusion while also improving the economic positions of farmers in the value chain, illustrating a symbiotic relationship. By bringing individual farmers together, these networks can create a stronger, united voice instead of leaving farmers to act alone. Finally, the problem-solution diagnosis should consider the potential for contestation and conflicting values among stakeholders (Wanzenböck et al., 2020). Farmers and retailers may have different perspectives on which solutions are best suited to achieve the mission goal. Therefore, it is essential to align stakeholders to ensure mission success.

By determining the problems the MIS aims to address, identifying the solutions it deems viable to tackle these issues, and analysing the interaction of these solution paths, the problem-solution diagnosis provides a strong foundation for the structural and functional analyses.

2.4.2 The structural analysis

The second step is the structural analysis, which helps to understand the configuration and dynamics of the MIS. The structural analysis examines the network of actors, institutions, technologies, and interactions that address the societal challenge at hand. The analysis focuses on two key dimensions: the performance structure, which consists of the network of actors and institutions that drive solutions, and the programming structure (or mission arena), which governs and coordinates these efforts (Figure 1).

The performance and programming structure

First, the **performance structure** encompasses the network of actors, technologies, and institutions involved in the development and diffusion of innovations and new practices. In this study, stakeholders such as farmers, processors, researchers, government agencies, agricultural cooperatives, and market actors could make up the performance structure. For a well-functioning MIS, it is important to have a balanced representation of private and public stakeholders, as well as incumbents and newcomers (Elzinga et al., 2023). Incumbent actors, such as large agricultural cooperatives, can bring significant resources and influence, which can accelerate mission progress. Simultaneously, influential actors may prioritise solutions that align with their own interests rather than those that offer the most effective or transformative outcomes (Geels, 2021). On the other hand, newcomers can promote niche and innovative practices but might lack the resources needed for scaling (Kattel and Mazzucato, 2018)

Second, the **programming structure**, or mission arena (Wesseling and Meijerhof, 2021), is the part of the MIS responsible for governance and strategic decision-making. It decides priorities, coordinates solutions, and aligns stakeholders (Elzinga et al., 2023). In this study, the mission arena is essential for coordination and fostering collaboration among public and private actors. A key function of the mission arena is to provide clear directionality, ensuring stakeholders align on which solutions to prioritise (Mazzucato, 2018). This is crucial because a MIS becomes more effective in addressing societal challenges when there is less contestation over which solutions to support, allowing for collective and coordinated action (Parks, 2022). Absent or poor coordination might hamper mission progress.

Governance challenges and opportunities

The presence of multiple solution pathways highlights the importance of **actor alignment**. On the one hand, a diverse representation of stakeholders can create system linkages, which can enhance the integration of solutions across different sections of the supply chain. However, such a heterogeneous stakeholder group can complicate decision-making and slow mission progress (Elzinga et al., 2023). On the other hand, a more homogeneous stakeholder group will allow for quicker decision-making, but with fewer diverse perspectives (Elzinga et al., 2023).

Representation and balance of stakeholders in the MIS is another governance challenge the structural analysis must address. Underrepresented groups must be included in the decision-making process, to avoid overlooking practical, ground-level insights into legume cultivation (Elzinga et al., 2023). Literature suggests empowering a coalition of 'the willing' and being hesitant to include more powerful actors, which might dominate the mission arena (Christoff, 2006; Kattel and Mazzucato, 2018; Loorbach, 2010). Additionally, an overrepresentation of powerful incumbents may result in short-term gains rather than long-term sustainability (Wesseling & Meijerhof, 2021).

Moreover, coordination is important to align actors and prevent fragmentation. Intermediary organisations, such as agricultural cooperatives or farmer networks, can facilitate collaboration, which

can align competing solution pathways and thereby promote **synergies** (Elzinga et al., 2023; Kivimaa et al., 2019). Additionally, the mission arena must ensure that resources are strategically allocated, with financial, technological, and institutional resources directed toward solutions with the highest transformative potential.

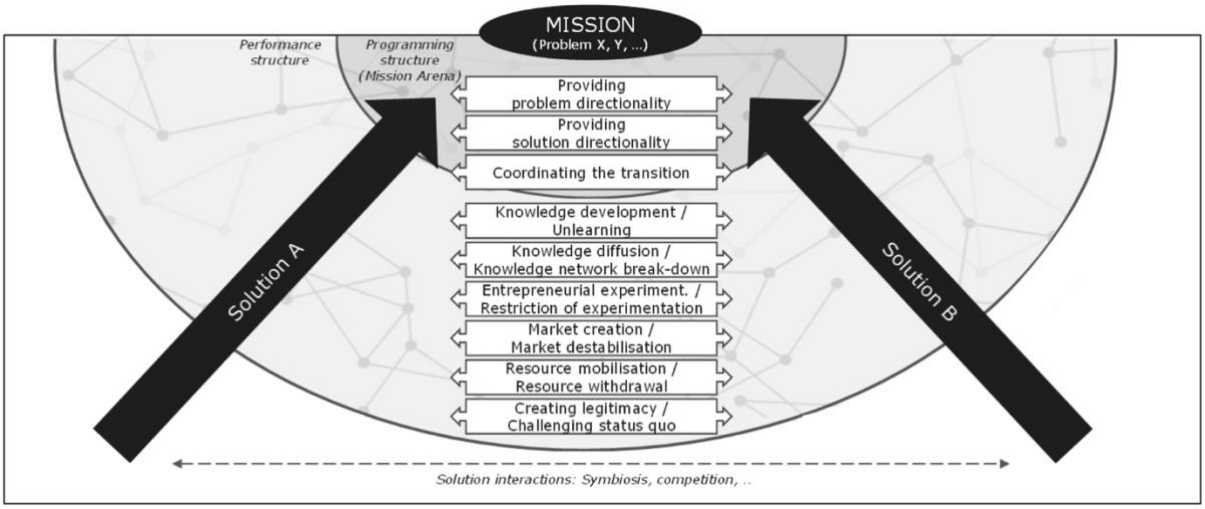

Figure 1 The MIS framework, containing a problem-solution diagnosis, a structural analysis, and functional analysis (adopted from Elzinga et al., 2023)

2.4.3 The functional analysis

Following the problem-solution diagnosis and structural analysis, the third and final step in the analytical framework is the functional analysis. This step enables a thorough examination of the systemic processes that drive or hinder mission progress. The framework builds on earlier work by Hekkert et al. (2007) and is adapted by Elzinga et al. (2023) to allow for an analysis of the dual nature of innovation systems that address societal missions. Unlike conventional approaches, this adaptation acknowledges that mission success often depends on destabilising existing systems as much as fostering innovation. The adaptation introduces a new set of innovation system functions, specifically tailored to examine the governance, innovation, and destabilisation side of the system (Table 1). Analysing each function allows for a comprehensive evaluation of the MIS's effectiveness in achieving its mission goals. This includes identifying the barriers that hinder and the facilitators that promote the adoption of legume cultivation in the Netherlands.

First, Elzinga et al. (2023) divide the functions into programming and performance functions, in line with the distinction made in the structural analysis (Janssen et al., 2020; Wesseling and Meijerhof, 2021). **Programming functions** focus on steering and aligning actors toward mission goals. **Performance functions** evaluate to what extent the system is achieving these goals. The following sections will first explore the programming functions problem directionality, solution directionality, and coordination, followed by a brief overview of the performance functions.

Problem and solution directionality

Directionality plays a critical role driving innovation and aligning efforts across sectors to achieve the mission goal (Weber and Rohracher, 2012). To incorporate directionality in the analysis, Elzinga et al. (2023) divided the original 'guidance of the search' function into two distinct functions: problem-directionality and solution directionality.

Missions are centred around societal challenges which require urgent and collective action. To address these challenges, the actors within the MIS must establish a shared understanding and prioritisation of the issue. This is often done through creating narratives that highlight the significance of the problem. Wanzenböck et al. (2020) referred to this process as providing **problem-directionality**. Narratives are important as they can play a crucial role in supporting societal transformation (Wittmayer et al., 2019).

Secondly, **solution-directionality** refers to the process of aligning and promoting specific solution pathways that are being proposed in the MIS (Wanzenböck et al., 2020). As discussed earlier, interactions between solutions can be either symbiotic, neutral, or competitive (Sandén and Hillman, 2011). To reduce complexity, actors in the programming structure should align and promote specific solution pathways that are deemed viable to address the challenges within the MIS. Solution directionality can, for example, be provided by publishing strategic reports and launching campaigns (Elzinga et al., 2023). Clear solution directionality enhances the effectiveness of the MIS in achieving societal goals by ensuring that the most feasible and suitable solution paths are prioritised.

Coordination

To complete the programming structure, Elzinga et al. (2023) introduce coordination as an independent function. **Coordination** is essential to manage directionality and resolve contestation among diverse solution paths. It helps to bring together and align actors across multiple sectors. Lack of coordination can lead to suboptimal decision-making and hamper mission progress.

This function can be assessed by examining roadmaps or coalitions created to coordinate the mission or promote specific solutions. Coordination can be facilitated by government agencies, sectoral organisations or other networks that aim to accelerate the transition. By orchestrating interactions, these intermediaries can contribute to alignment and momentum for system transformation (Kivimaa et al., 2019). Lastly, good coordination requires reflexivity because it helps actors assess whether the solutions are effective, ensuring they can adapt to changing circumstances and stay aligned with the mission's goals (Avelino and Grin, 2017; Voß et al., 2009).

Regime transformation

Traditional innovation systems have been criticised for insufficiently addressing processes of regime change (Fuenfschilling and Truffer, 2014). Regimes are the 'semi-coherent set of rules that orientate and coordinate the activities' of actors within a system (Geels, 2011). Regimes present the 'rules of the game' that determine which solutions can develop and diffuse within a system. The concept is particularly relevant for sustainability transitions since phasing out unsustainable or mission-hampering practices is crucial (Markard, 2020). Therefore, when missions conflict with the rules of the game of the existing regime, it is essential to destabilise this system.

To address regime transformation, the MIS framework creates a distinction between the **innovation side** (or novelty creation) and the **destabilisation side** (Table 1). Actors in the MIS can transform the regime by creating novelty and generalising results (Sengers et al., 2021) and by phasing out practices, knowledge, and networks that hamper mission progress (Elzinga et al., 2023). Thus, by adding a destabilisation side, the framework assures that all factors contributing to system transformation (innovation and dismantling) are being assessed in the functional analysis.

A complete overview of all the innovation system functions and their definition can be found in Table 1.

Table 1 Overview of the innovation system function proposed by Elzinga et al. (2023) to assess mission-oriented innovation systems

Programming functions	
Providing problem directionality: Actions aimed at creating consensus regarding the urgency of the adoption and diffusion of legume cultivation and the level of prioritisation over other societal problems.	
Providing solution directionality: Actions aimed at providing insight in viable solutions, aligning expectations regarding solutions or strategies to ultimately converge around solution directions.	
Coordinating the transition: Monitoring solution potential and progress to coordinate and structure solution directions, according to learned lessons. Creation or rise of coordinating actors or groups via platforms, intermediaries, or transition teams to provide validation, comparison, and structuring of transition routes.	
Performance function	
Innovation side	*Destabilisation side*
Knowledge development: Learning by searching and by 'doing', resulting in development and better understanding of new technical and social knowledge on innovative solutions, through R&D, social research, and behavioural science research.	**Unlearning**: Likewise, activities, but for knowledge development regarding societal problems caused by practices that hamper possible solutions; unlearning practices that obstruct mission completion.
Knowledge diffusion: Stakeholder meetings, conferences, governance structures, public consultations, mission progress reports and other forms of disseminating technical and social knowledge for innovative solutions.	**Knowledge network break-down**: Deconstructing knowledge-sharing networks on practices obstructing mission completion.
Entrepreneurial experimentation: Experiments with (clusters of) solutions to enable learning; entering markets for novel solutions; engaging in business model innovation to foster the diffusion of solutions.	**Restriction of experimentation**: Limit innovations reinforcing the regime; experiment with destabilising actors, institutions, and technologies that support mission-obstructing practices.
Market creation: The formation, protection and generalisation of (niche) markets and demands for practices, guidelines and standardised solutions.	**Market destabilisation**: Diminishing or removing regulatory or financial advantages for existing practices and technologies that obstruct the mission.
Resource mobilisation: Allocating financial, human, material, and infrastructural resources to support development and diffusion of solutions.	**Resource withdrawal**: Reallocating resources and supportive physical infrastructure away from practices that obstruct mission completion.
Creating legitimacy: Creation of a supportive socio-institutional environment for solutions that contribute to mission completion, through raising awareness for the mission and solutions and lobbying for resources and supportive policies in line with the mission.	**Challenging status quo**: Question the desirability of practices obstructing mission progress by raising awareness for the societal problems; lobbying against institutions supporting undesirable practices; mitigate power and access of incumbents' lobby.

2.5 Key concepts and their definitions

Several key concepts are critical for understanding the dynamics of the adoption of legume cultivation in the Netherlands. These concepts provide a theoretical basis for analysing the interaction between innovation, policy, and stakeholder activities within a MIS. Some key concepts, such as mission-oriented (agricultural) innovation systems, have been discussed in the previous sections. Other key concepts, such as mission-oriented innovation policy, directionality, and actor networks, require further explanation and will be explored in the following sections.

1. Mission-oriented innovation policy (MIP)

Mission-oriented innovation policy has become increasingly popular in recent years (Boon and Edler, 2018). It combines elements of innovation policy, which traditionally aims to create economic growth, and transition policy, which aims to stimulate societal change (Alkemade et al., 2011). MIP can be defined as 'a directional policy that addresses societal problems by formulating and implementing goal-oriented strategies, recognising the complexity of the challenges and the active role of policy in ensuring coordinated action and legitimacy of both problems and innovative solutions across multiple actors' (Wanzenböck et al., 2020). MIP is crucial for steering innovation activities toward societal needs, such as sustainability and food security (Pigford et al., 2018). Similar to the MIS concept, MIP focuses on system-wide change rather than incremental improvements. Finally, in MIP there is a strong emphasis on directionality (Pigford et al., 2018), which requires a more active and guiding role of the government (Mazzucato, 2016).

In the Netherlands, agricultural policies promoting legume cultivation (e.g., CAP, NES) exemplify how MIP drives such changes. While the NES and the GDEG can be classified as MIP, they can be best described as strategic frameworks or action plans. These strategic frameworks aim to reduce reliance on imported legumes and contribute to broader sustainability goals, such as soil health and biodiversity. In the mission discussed in this thesis, MIP plays a critical role by setting clear targets (e.g., expanding legume cultivation to 100.000 hectares by 2030) and aligning efforts of stakeholders, including policymakers, farmers, and research institutions, toward this shared goal.

2. Directionality

Directionality is a distinct feature of missions (Mazzucato, 2018) and, in the context of innovation systems, refers to the strategic steering of innovation processes and policies towards a specific societal goal or mission, ensuring that innovations contribute to a defined public objective (Wanzenböck et al., 2020). Ideally, a MIS is characterised by constant directionality through ambitious targets, continuous monitoring, and process evaluation (Hekkert et al., 2020). In MIP, directionality ensures that policies, investments, and innovations are strategically coordinated to reach the overarching goal of a societal mission. This coordination involves formulating clear, time-bound goals and ensuring that stakeholders collaborate and mobilise resources effectively to achieve these outcomes.

For the adoption of legume cultivation in the Netherlands, directionality is particularly useful as it helps to assess how government, research institutions, farmers, and private actors can align their efforts to support the mission. Therefore, by applying directionality, this study enhances its capacity to examine how policies, financial incentives, and innovation networks ensure that separate efforts are aligned and focused on achieving the mission goal.

3. Actor networks

Actor networks refer to the formal and informal relationships between various stakeholders within an innovation system (Freeman, 1987). These networks facilitate knowledge exchange, collaboration, and the diffusion of innovations and new practices. In an agricultural context, effective actor networks are essential for scaling new practices and technologies because they bring together different types of stakeholders and resources. In the case of legume cultivation, networks that include farmers, agricultural scientists, and policymakers can help drive the diffusion of knowledge about new farming practices.

For legume cultivation to be more widely adopted, the actor-network must include a diverse range of actors and be well-coordinated. Previous research has shown that farmers' involvement in innovation networks is a key factor in the successful adoption of new crops like legumes (Mawois et al., 2019). Additionally, networks enhance the scaling of innovations, helping to move beyond pilots and experiments to broader, systemic change (Hermans et al., 2017).

2.6 Theory building and testing

This thesis employs the MIS and MAIS framework to investigate the adoption of legume cultivation in the Netherlands. As both frameworks are relatively new and have not been extensively tested, this study contributes to theory building rather than theory testing.

By applying the frameworks in a new empirical context, this study aims to address gaps in the novel frameworks. Since both frameworks are in the early stage of development and have not been extensively tested, the application in this thesis might provide valuable insights into how these systems function in practice. This aligns with the call of Klerkx and Begemann (2020) for more empirical studies to explore the dynamics of a MAIS.

In addition to applying these frameworks, this thesis considers the future research directions outlined in the literature. Elzinga et al. (2023) emphasise the need to understand the structural elements of MIS better. Furthermore, Klerkx and Begemann (2020) highlight the importance of exploring the directionality and barriers within agricultural innovation systems. This thesis addresses these gaps by incorporating empirical evidence from the Dutch legume MAIS.

To conclude, this research tests theory by applying the MIS and MAIS frameworks to a new empirical context. In doing so, it contributes to the development of the conceptual frameworks.

2.7 Relationships between key concepts

Integrating key concepts such as MIS, MIP, directionality, actor networks, and innovation system functions creates a useful foundation for studying the adoption of legume cultivation in the Netherlands. Together, these concepts illustrate how transitions are coordinated and provide a framework for analysing how the adoption of legumes contributes to broader sustainability missions.

Central to this framework is the interaction between MIS and MIP, where MIS focuses on the networks of actors and institutions working towards societal goals. MIP provides the directionality needed to steer innovation towards these goals. Directionality ensures legume adoption aligns with broader sustainability targets, overcoming resistance from the incumbent (mission-obstructing) agricultural

practices (Elzinga et al., 2023). Setting clear directionality is essential to avoid fragmented efforts and ensure alignment with long-term goals (Mazzucato, 2016).

Actor networks play a vital role by facilitating collaboration across sectors and actors, linking farmers, policymakers, researchers, and businesses. These networks contribute to the mission's goals, enabling the development and diffusion of new knowledge and practices, such as new legume varieties and sustainable farming practices (Klerkx and Begemann, 2020; Mawois et al., 2019). The interaction between these networks and the direction provided by MIP ensures that innovations are not only technically feasible but also socially and economically viable (Hekkert et al., 2007).

Innovation system functions, such as coordination, knowledge development, and entrepreneurial experimentation, determine the performance of the MIS by assessing key system aspects. These functions ensure that innovations and new practices gradually get adopted into the innovation system (Hekkert et al., 2007). For example, knowledge from research institutions helps develop legume varieties suitable for the Dutch climate, while market formation creates niche markets where farmers can sell their products.

Integrating these concepts creates a useful framework to enhance the study of legume adoption in the Netherlands. It offers a systemic approach that identifies drivers and barriers to adoption (Hekkert et al., 2020), which can be used to scale up sustainable agricultural practices. Combining these concepts enables a comprehensive analysis of the adoption of legume cultivation as a part of the broader societal mission of sustainable agriculture.

This chapter has outlined the main theoretical concepts and frameworks used to study the adoption of legume cultivation in the Netherlands, focusing on applying the MIS perspective. It has discussed the background and relevance of these frameworks, defined the key concepts, and explained their relationships. Using a MIS framework, this study aims to provide new insights into how mission-oriented approaches can drive transformative change in agricultural systems, contributing to the broader field of sustainability transitions.

3. Methodology

This chapter presents the methodology used to analyse the adoption of legume cultivation in the Netherlands. This research is structured in line with the MIS framework as proposed by Elzinga et al. (2023), including a problem-solution diagnosis, a structural analysis and a functional analysis. The study combines qualitative methods, such as policy document analysis and semi-structured interviews, to explore the innovation system's structure and performance. Furthermore, these techniques facilitate the identification of both the barriers and enablers to increasing legume cultivation in the Netherlands. This chapter will discuss the research approach, data collection, measurement of concepts, data analysis, ethical considerations, and reliability and validity.

3.1 Research approach

This study employs qualitative methods, specifically policy document analysis and expert interviews, to examine the adoption of legume cultivation within the MIS framework. Qualitative methods are well-suited to this research because they can help understand the complex, context-specific interactions among key actors, including farmers, agribusinesses, policymakers, and researchers. These methods enable a comprehensive understanding of how various stakeholders perceive and influence the mission. This helps uncover systemic interactions and specific contextual factors critical for a thorough MIS analysis (Elzinga et al., 2023).

The MIS framework consists of three analytical steps: the problem-solution diagnosis, the structural analysis, and the functional analysis. Policy document analysis supports the problem-solution diagnosis step, providing essential information on regulatory frameworks, policy objectives, and institutional support for the mission. By examining these documents (i.e., NES, Beandeal), the study identifies core challenges, mission goals, and proposed solution pathways. This step builds a foundation for understanding the context of legume cultivation in the Netherlands. Additionally, the policy document analysis provides data for the structural analysis, such as the number, type, and composition of actors involved in the mission.

Following the policy document analysis, expert interviews will contribute to the structural and functional analyses. Interviews are a particularly suitable method for gathering data for a MIS analysis, as they provide in-depth insights into the perspectives, roles, and interactions of key actors. By engaging directly with stakeholders involved in legume cultivation, including farmers, agribusinesses, policymakers, and researchers, interviews reveal how these actors understand and influence the mission. Interviews also highlight practical challenges and collaborative dynamics within the system, clarifying how these stakeholders interact with each other or encounter obstacles in contributing to mission success. Together, these qualitative methods provide a comprehensive understanding of how the MIS functions, identifying barriers hindering mission progress and determining facilitators that could accelerate legume adoption in the Netherlands.

In addition to the document analyses and expert interviews, two stakeholder meetings were attended. These meetings were held on farms and attended by various stakeholders involved in legume cultivation in the Netherlands. These meetings not only facilitated access to interviewees but also offered a first-hand experience with legume farming practices, which provided valuable contextual insights into the structural and functional aspects of the innovation system.

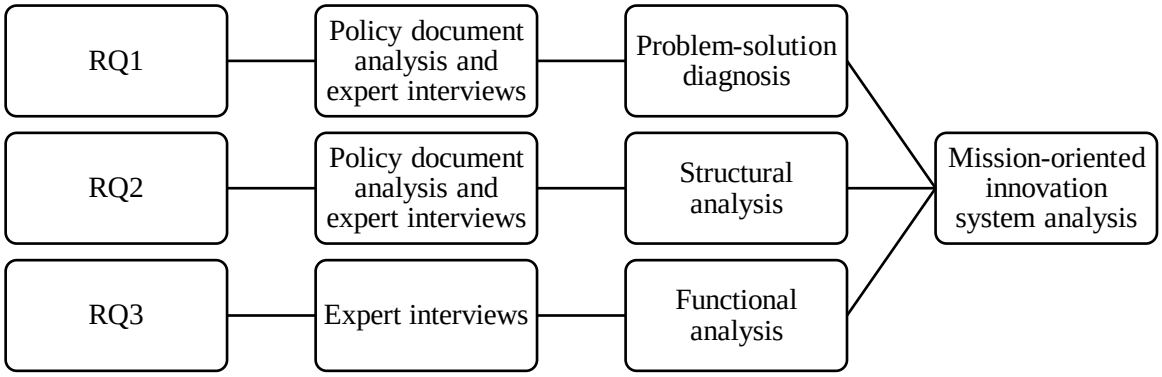

Figure 2 Research framework, linking research questions, methods, and analytical steps

3.2 Operationalisation and measurement of concepts

Chapter 2 presented the theoretical background of the MIS framework. This section will focus on the operationalisation of the framework, building on the innovation system functions presented in Table 1. A structured qualitative coding and scoring process was developed to critically assess the innovation system functions used to analyse the MIS in this thesis. This process uses open and axial coding with a three-point scoring system adapted from Vermunt et al. (2022). This framework allows for a systematic and comparable evaluation of each function's performance within the MIS and, thereby, its role as a facilitator or barrier to legume cultivation.

Each innovation system function was defined as an axial code, representing a key component in promoting legume cultivation. For each function, 1-4 open codes, or indicators, were created to further differentiate and measure specific aspects of the function (see Appendix A). These indicators, or open codes, are derived deductively from the innovation system functions and are complemented by inductive coding of the interviews. The indicators examined different aspects of each function, providing a detailed view of each function's performance. By breaking down each function into these measurable indicators, a comprehensive assessment of the function's impact on legume adoption is achieved.

Table 2 presents an overview of the operationalisation of the framework, using the innovation system function 'knowledge diffusion' as an example. It illustrates the indicators used to assess the function (i.e., frequency of knowledge dissemination activities, accessibility of knowledge, and diversity of knowledge dissemination) and presents the scale and meaning of the score. A complete overview of the operationalisation, including all indicators and functions, is available in Appendix A.

Table 2 Example of the operationalisation of the framework

Innovation system function	Indicators	Scale (where 1 = no or a slight barrier, and 3 = significant barrier)
Knowledge diffusion	(1) Frequency of knowledge dissemination activities (Number of stakeholder meetings, conferences, public consultations, and progress reports conducted within a given period.)	(3) Rare or no events (less than 1 event per quarter), (2) moderate frequency of events (1-2 events per quarter), (1) frequent and regular events (more than 2 events per quarter)
	(2) Accessibility of knowledge (The extent to which essential information is accessible to stakeholders.)	(3) Difficult to access (behind a paywall), (2) moderately accessible, (1) highly accessible (free and widely accessible)
	(3) Diversity of knowledge dissemination (The variety of methods used to share information with stakeholders (e.g., meetings, reports, digital media).)	(3) Limited channels for dissemination (e.g., only one type of meeting or report), (2) moderate range of channels (e.g., a mix of meetings, reports, and some digital media), (1) extensive range of channels (e.g., stakeholder meetings, conferences, social media, webinars, etc.).

3.3 Data collection

This study employs two primary data collection methods to support the MIS analysis. These methods aim to gather the data required for assessing the 15 innovation system functions. The data collection includes an analysis of strategic action plans (i.e., NES, GDEG) and a series of expert interviews, each providing unique insights into the challenges and potential of the MIS focused on adopting legume cultivation.

The first data collection method is an analysis of two key policy documents: the National Protein Strategy (NES) and the Green Deal for Protein-Rich Crops (GDEG). Both documents are strategic action plans, rather than traditional policy documents, that outline objectives, proposed actions, and collaborative efforts aimed at supporting the protein transition. The GDEG focuses specifically on legume cultivation. These documents provide a useful view of the institutional support and the set goals that drive legume cultivation. In this study, both documents are classified as MIP because they set ambitious societal goals to transform the agricultural sector, foster innovation and collaboration, encourage systemic change, and address complex challenges that require cross-sectoral solutions. The analysis of these documents aims to enhance the understanding of legume cultivation in the broader institutional and policy context. This approach might reveal key goals, support mechanisms, and potential barriers to legume cultivation in the Netherlands.

The second data collection method, which serves as the central component of the study, is expert interviews with key stakeholders involved in legume cultivation. A total of 18 semi-structured interviews were conducted with a diverse group of experts, each offering a different perspective on the innovation system. The interviewees included actors from agribusiness, agricultural cooperatives or networks, government officials, farmers, and a research institution. This diversity ensures a balanced and comprehensive view of the MIS. It captures a broad range of insights into the challenges and opportunities different stakeholders face in adopting legume cultivation.

This study's data collection involved attending two stakeholder meetings, where representatives from various sectors within the legume sector came together. These meetings helped connect with potential

interviewees, observe legume cultivation practices firsthand, and understand how stakeholders interact within the innovation system.

Table 3 Stakeholder categories and the number of interviewees

Category	Number of interviewees
(Agri)business	6
Agricultural cooperative or network	6
Government official	3
Farmer	2
Research institution	1

The semi-structured format of the interviews provided flexibility to explore various topics relevant to the MIS, enabling interviewees to delve deeper into areas of their specific expertise. Interviewees were, therefore, allowed to provide in-depth insights into topics within their expertise, such as policy, agricultural practices, and market dynamics. Interview questions were designed to gather insights on the 15 innovation system functions assessed in the study. Data gathered from the interviews provides an in-depth and diverse perspective into the MIS, complementing the more broad and superficial data from the policy document analysis. This combination offers a holistic examination of the potential of the MIS to achieve systemic change.

3.4 Data analysis

This study applied a structured data analysis method using open and axial coding, following the approach described by Williams and Moser (2019). NVivo was used to facilitate the coding and organisation of data. This method enabled a detailed assessment of data from policy documents and expert interviews, uncovering insights into the structural and functional aspects of the MIS.

Axial coding served as the backbone of the analysis, with the innovation system functions serving as predefined axial codes established deductively from the theoretical framework (Elzinga et al., 2023). In contrast, open coding was conducted inductively and iteratively to identify and determine well-suited open codes (indicators) for each axial code (innovation system function). Through this approach, each innovation system function was linked to 1-4 open codes or indicators that captured critical aspects of the function. For example, the function ‘knowledge diffusion’ was analysed through indicators such as ‘frequency of knowledge dissemination activities,’ ‘accessibility of knowledge,’ and ‘diversity of knowledge dissemination’ (Table 2). This coding process provided a robust framework for examining the innovation system's overall performance while capturing more nuanced details.

The (open) coding process was conducted in three subsequent rounds to ensure rigour and comprehensiveness. Initial open codes were created and refined in the first two rounds, focusing on identifying concepts that aligned with the axial codes. The final set of open codes was established for each axial code in the last round. This iterative process ensured that the indicators accurately reflected the innovation system functions and that all relevant information was derived from the data.

The analysis was conducted using NVivo, a qualitative analysis software program that facilitated and systemised the coding and organisation of data. NVivo allowed for a comparable and consistent analysis of multiple data sources, including policy documents and interview transcripts. The policy documents were analysed to gather preliminary insights into the problems and solutions of the MIS and the number,

type and composition of actors involved. Subsequently, expert interviews provided more nuanced qualitative data on stakeholder perspectives and interactions within the MIS.

The combination of axial and open coding, supported by NVivo, provided a systematic and robust analytical framework. This allowed for a detailed examination of each indicator of all innovation system functions. The final coding structure is presented in Table 5 in the results section. A version with illustrative references from the interviews can be found in Appendix B . This coding framework forms the foundation for understanding the barriers and facilitators influencing the adoption of legume cultivation in the Netherlands.

Scoring indicators and innovation system functions

Once the data was organised, each indicator was systemically assessed and rated using a three-point scoring system adapted from Vermunt et al. (2022). Each indicator was given a score of 1-3, indicating to what extent the function forms a barrier to adopting legume cultivation (Table 4). The comprehensive table used to score each indicator is available in Appendix A. A 3-point scale was used instead of the 5-point scale used by Vermunt et al. (2022) to maintain simplicity and clarity. The 3-point scale provides sufficient detail to assess whether a function forms a slight, moderate, or significant barrier.

Table 4 Scoring system used to rate indicators

Rating	Meaning
●○○	The function forms no or slight barrier
●●○	The function poses a moderate barrier
●●●	The function presents a considerable or extreme barrier

Each indicator within a function is scored individually on this scale. The scores of each function's indicators are then averaged to get an aggregate score, resulting in a complete evaluation of each function. For example, if the indicators of a specific function received scores of ●●○, ●○○, and ●●○, the aggregate score would be ●●○, calculated as the average of the score ((2+1+2)/3=1.67). This would mean this innovation system function poses a moderate barrier. This scoring system quantifies the impact of each function, enabling a clear identification of barriers and facilitators to the adoption of legume cultivation.

3.5 Ethical considerations

In conducting this research, ethical considerations are essential to ensure participants' rights, protect sensitive information, and comply with data management standards such as the General Data Protection Regulation (GDPR). This section outlines the ethical approaches adopted throughout the study, addressing informed consent, data handling, and storage practices in line with academic and regulatory guidelines.

Informed consent

Informed consent is a fundamental ethical requirement, particularly for studies conducting interviews. In this research, all participants were provided with an informed consent form that outlined the purpose of the study, the expected duration and structure of the interviews, and the ways their information would be used. The consent form, provided in the appendix, was designed to ensure participants were fully aware of their rights, including the right to withdraw from the study at any point without any consequences. Consent was obtained in writing before each interview, ensuring that all participants

voluntarily agreed to contribute to the research. Additionally, participants were provided with a project information sheet before the interviews, ensuring participants were informed about the purpose and objectives of the study.

Ethical issues in data collection
In addition to analysing policy documents, data was collected through semi-structured interviews with experts in legume cultivation, research, processing, and policy. The data collection process was designed with ethical considerations to protect participants, ensure confidentiality, and reduce potential bias. Additionally, participants were allowed to skip any questions they were uncomfortable answering, respecting their autonomy and ensuring the data collection process adhered to ethical standards.

Data handling and storage
In line with GDPR, specific measures were taken to ensure secure data handling, storage, and eventual deletion. All collected data were anonymised to protect the identities of participants and their organisations. Each participant received a unique code, known only to the researcher, that allowed them to remain anonymous. Throughout the thesis, identifiable information is replaced by generic labels, such as 'F2' or 'B5' (F=farmer, and B=business), which prevents linking responses to specific individuals and ensures confidentiality. This coding system protects participants' privacy by preventing any link between their responses and their identities, thus maintaining confidentiality.

Data was stored on password-protected devices, accessible only to the researcher. Following university guidelines, data will be kept until the end of the thesis period to meet GDPR and ethical requirements. After this period, all data will be permanently deleted according to data protection guidelines. By addressing these ethical issues, this research aims to maintain ethical standards, ensuring participant rights and data security.

3.6 Reliability and validity

Reliability and validity are essential to ensure the rigour and trustworthiness of this research. In qualitative research, reliability means the data and findings are consistent and dependable. This study ensures reliability by using a standardised approach to data collection. Each participant underwent the same interview structure, ensuring that the same topics were addressed in every interview while allowing the participant to elaborate on specific issues. This consistent approach helped to create comparable data across interviews, enhancing the reliability of the findings.

Additionally, reliability was ensured through data triangulation, meaning that data was gathered from multiple sources, including policy documents and interviews with a diverse set of stakeholders, such as agribusinesses, government officials, farmers, and researchers. By integrating these diverse perspectives, the study minimised potential bias. It enabled cross-validation of findings across different interviews, allowing insights from one participant to be compared and verified against those from others. This approach strengthened the credibility of the results by ensuring consistency and reliability across multiple visions. Clear documentation of each research step, including coding frameworks and scoring systems adapted from Vermunt et al. (2022), was maintained. This made the methodology transparent and replicable, allowing other researchers to understand and apply the same approach, strengthening the study's reliability. To reduce researcher bias, the researcher practised reflexivity by regularly reflecting on personal assumptions to remain objective throughout the study.

Validity, which assesses the accuracy and credibility of the findings, was addressed through a systematic and transparent approach. Data triangulation helped ensure that the findings accurately represent the study's focus by integrating insights from different sources, giving a more reliable representation of the MIS framework and its relevance to legume adoption in the Netherlands. Furthermore, the clear and systematic coding framework, created with guidelines from Williams and Moser (2019), enhanced validity by providing consistency in data interpretation and analysis.

In summary, the study's reliability and validity were ensured through consistent data collection, triangulation, systematic coding, and reflexivity. These strategies make the findings reliable and contribute to a deeper, valuable understanding of legume adoption in the Netherlands.

4. Results

This chapter will discuss the results structured according to the 15 innovation system functions proposed in the MIS framework (Elzinga et al., 2023). Each function is examined in detail to provide insights into the system's performance in addressing the mission of increased legume cultivation in the Netherlands. While the methodology chapter presented the problem-solution diagnosis, structural analysis, and functional analysis as separate analytical steps, this chapter will discuss the different analyses through the functions to avoid repetition. This structure provides a comprehensive view of how each system function contributes to the mission, integrating all three analytical dimensions.

Each analytical step is represented within various aspects of the functions. The problem-solution diagnosis, for example, is addressed by programming functions like problem directionality and solution directionality. These functions explore the MIS core challenges, assess proposed solutions, and examine alignment among actors. In other words, the programming functions capture the essence of the problem-solution diagnosis by clarifying the problems the mission aims to resolve and the solutions proposed to address them.

Furthermore, the structural analysis is addressed within each function by identifying the relevant actors, institutions, and networks involved. This helps to map the structural aspects of the MIS. Structuring this chapter around each function provides a complete view of how various structural elements support or hinder mission progress. For example, knowledge diffusion requires a closer look at the networks (e.g., the Protein Farmers) and institutions responsible for spreading knowledge. In this way, structural analysis is integrated into each function, providing a clear overview of the actors and networks that shape the MIS.

Finally, the functional analysis is addressed by examining each function's performance. Focusing on performance within each function allows for a thorough assessment of how effectively the MIS framework supports mission progress. For example, discussing market creation or resource mobilisation reveals how effectively these areas support the mission's goals, highlighting barriers and drivers within each function. By addressing each innovation system function separately, a comprehensive overview of the performance of different aspects (e.g., the level of coordination or market destabilisation) of the MIS is created.

Organising the analysis by discussing each innovation system function separately avoids repetition and provides a clear, structured view of the complex dynamics within the MIS. This approach comprehensively covers all analysis steps (i.e., problem-solution diagnosis, structural analysis, and performance analysis). This approach provides a detailed understanding of each function's role in the system and ensures that all three analytical steps are clearly discussed throughout the chapter.

Coding structure and presentation of the results

Before presenting the results, a brief overview of the structure and approach is provided here to ensure clarity. As outlined in the previous section, the results are organised according to the innovation system functions proposed by Elzinga et al. (2023). As discussed in the methodological chapter, each innovation system function has been labelled an axial code (deductive). Subsequently, each axial code has been given 1-4 open codes or indicators. These codes have been inductively derived from the data. An overview of the coding scheme, with the innovation system functions represented as axial codes and the indicators as open codes, is presented in Table 5.

Table 5 The coding scheme developed and applied in this study

Open codes (indicators)	Axial codes (functions)	Themes
(1A) Consensus on urgency	(1) Providing problem directionality	Programming functions
(1B) Clarity of problem definition		
(1C) Support from key actors		
(2A) Provision of roadmaps or frameworks	(2) Providing solution directionality	
(2B) Consensus on solution direction		
(2C) Alignment of stakeholders		
(3A) Stakeholder engagement and collaboration	(3) Coordinating the mission	
(3B) Effectiveness of coordination mechanisms		
(3C) Funding for coordination		
(4A) Level of research and development	(4) Knowledge development	Performance functions: innovation side
(4B) Collaboration across sectors (for knowledge development)		
(5A) Frequency of knowledge dissemination activities	(5) Knowledge diffusion	
(5B) Accessibility of knowledge		
(5C) Diversity of knowledge dissemination		
(6A) Experimentation activities	(6) Entrepreneurial experimentation	
(6B) Support for risk-taking and innovation		
(6C) Collaboration in entrepreneurial experimentation		
(7A) Emergence of niche markets	(7) Market creation	
(7B) Consumer awareness and demand creation		
(7C) Involvement of key market actors		
(7D) Formation of value chains		
(8A) Availability of financial resources	(8) Resource mobilisation	
(8B) Allocation of funding		
(8C) Material resources		
(9A) Public awareness and support for the mission	(9) Creating legitimacy	
(9B) Media attention and advocacy		
(9C) Alignment with policy agendas		
(10) Identification of obsolete practices	(10) Unlearning	Performance functions: destabilisation side
(11) Dismantling obstructive knowledge networks	(11) Knowledge network breakdown	
(12) Limiting regime supporting innovations	(12) Restriction of experimentation	
(13) Removing support for existing practices	(13) Market destabilisation	
(14) Redirecting resources from current practices	(14) Resource withdrawal	
(15) Lobbying against mission obstructing practices	(15) Challenging status quo	

To provide context and insights, Table 6 presents examples of references for the innovation system function 'knowledge diffusion'. A complete overview of examples for each indicator is provided in Appendix B.

Table 6 Example references for the indicators of the innovation system function knowledge diffusion

Innovation system function	**Indicator**	**Example reference**
Knowledge diffusion	(1) Frequency of knowledge dissemination activities	"Each quarter, the different parties of the Beandeal come together to discuss the progress."
	(2) Accessibility of knowledge	"They have a website with information on legumes ready behind the scenes, but it is not published yet. Because to maintain this, quite a bit of money is needed, and that has to be provided by the researcher."
	(3) Diversity of knowledge dissemination	"As a company we make promotions. We do this with our customers, the retailers and we support this through various channels such as television and social media. We do this for various legumes. Consumers can also find recipes on our website and via a QR code on the packaging." "There is a lot of interesting information in there, which I then bundle into the newsletter." "Trade media are important, magazines."

Table 7 displays the total number of references gathered for each innovation system function, combining references from all corresponding indicators (open codes) associated with each function, also referred to as axial codes. Three functions are shaded in orange to highlight areas with limited data (knowledge network breakdown, restriction of experimentation, and resource withdrawal), indicating that fewer than five references were coded for these functions in the interviews. Given the limited data for these areas, no conclusive findings are drawn for these functions, as the references are insufficient for meaningful analysis.

Table 7 The total number of references found for each innovation system function

Programming functions		Number of references	
Providing problem directionality		67	
Providing solution directionality		34	
Coordinating the mission		47	
Performance functions			
Innovation side	Number of references	Destabilisation side	Number of references
Knowledge development	55	Unlearning	26
Knowledge diffusion	19	Knowledge network break-down	0
Entrepreneurial experimentation	53	Restriction of experimentation	0
Market creation	84	Market destabilisation	13
Resource mobilisation	51	Resource withdrawal	3
Creating legitimacy	26	Challenging status quo	27

To enhance readability and context, stakeholder groups have been divided into five categories, each assigned a unique code, as shown in Table 8. This coding allows for easy identification of stakeholder perspectives throughout the chapter without revealing the identity of interviewees. For example, if a

representative from agribusiness provided input on, for example, the indicator 'involvement of key market actors,' an indicator from the 'market creation' function, the statement would appear as follows: "The big retailers did not get involved at the start of the Beandeal." (B3). This approach helps maintain transparency and provides more context to support the results.

Table 8 Stakeholder categorisation and codes

Category	Code in the text	Number of interviewees
(Agri)business	B	6
Agricultural cooperative or network	C	6
Government official	G	3
Farmer	F	2
Research institution	R	1

Lastly, the extent to which each indicator and each innovation system function as a whole presents a barrier to the adoption of legume cultivation in the Netherlands is illustrated using 1-3 dots, as described in the methodology chapter. This serves as a guide throughout this chapter, providing the reader with a clear understanding of the results.

4.1 Programming functions

This section discusses the results of the programming functions 'providing problem directional,' 'providing solution directionality,' and 'coordinating the transition.' Note that this section goes beyond the problem-solution-diagnosis. It assesses the performance of these functions, contributing to the functional analysis. Furthermore, in addition to assessing problem and solution directionality, the following sections also provide a brief overview of the various identified problems and proposed solutions to offer contextual understanding.

4.1.1 Providing problem directionality ●●○

In this study, three indicators determine the problem directionality level. First, the 'level of consensus on urgency' measures the extent to which actors agree on the urgency of adopting and diffusing legume cultivation. Secondly, 'clarity of problem definition' defines the extent to which the problems are recognised and agreed upon by actors. Lastly, 'support from key actors' determines the presence and activity of key actors driving the mission of adopting legume cultivation.

4.1.1.1 Level of consensus on urgency ●●○

The agreement on the urgency of adopting legume cultivation in the Netherlands reveals a complex and somewhat divided perspective. While the protein transition is recognised as a strategic priority by many stakeholders, the practical adoption of legume cultivation remains contentious due to economic concerns and the structure of the agricultural market.

Multiple stakeholders mention that the protein transition is a strategic priority for their organisation. For instance, one respondent (C2) highlighted that "legumes play a role within our broader strategic theme of the protein transition." Another interviewee (B3) similarly noted that their company views plant-based proteins as a core pillar of their long-term strategy, stating: "six years ago [the company] determined that plant proteins should become a fundamental pillar of our business strategy." This indicates that there is a growing acknowledgement of the urgency of integrating legumes into the Dutch agricultural system to support the protein transition.

However, at the same time, several stakeholders question the feasibility of the widespread adoption of legume cultivation in the Netherlands. While legumes are being recognised for their sustainable characteristics and environmental benefits, some critical obstacles might limit their widespread adoption. Actors mention the high cost of land, low profitability of legume crops, and highly profitable competitive crops like potatoes and beetroot as key barriers. One farmer (F2) illustrated this by stating: "I am enthusiastic about the cultivation [of legumes], but at the end of the day I, am an entrepreneur, and I need to make a living from it."

Overall, most actors recognise the adoption of legume cultivation as a critical step in the transition toward a sustainable agricultural system. However, this urgency is tempered by concerns about the economic feasibility of legume cultivation in the Netherlands.

4.1.1.2 Clarity of the problem definition ●●○

This indicator tries to map the problems that form a barrier to the success of the mission and tries to determine if different stakeholders unanimously recognise this. Actors have listed several issues that limit the widespread adoption of legume cultivation in the Netherlands. Rather than one or two key

barriers, the combination of problems all contribute to the limited adoption of legume cultivation. One actor (G2) described the problem as a "multi-headed monster". The following paragraphs outline the most frequently mentioned problems, structured according to four key themes that emerged from the interviews.

Economic barriers and market dynamics

One of the most frequently mentioned challenges is the economic infeasibility of cultivating legumes in the Netherlands compared to other crops. Respondents expressed scepticism about the profitability of large-scale legume production, citing both the costs of production and the lack of sufficient market demand as major barriers. One interviewee (C1) stated, "We do not believe that legume crops like field beans, soybeans, and peas will take off in the Netherlands. Economically, there is no return to be made from these crops. You can import them much cheaper from the Baltic states or other parts of the world." Other participants (B3, C2, F1, F2) shared similar perspectives, explaining that farmers favour high-yielding crops like potatoes and unions, which pose fewer risks and deliver higher profits.

The role of retailers and the supply chain

The influence of large retailers and globalised food supply chains also play a crucial role in creating possibilities for legume cultivation. Many interviewees highlighted the significant influence of retailers and the limited efforts they have made toward advancing the mission (the absence of supermarkets in the innovation system is a key barrier and will be discussed further in the next section). One interviewee (C5) noted, "The power lies at the end [of the supply chain], at the supermarket." highlighting their importance. Another (B3) criticised their efforts by stating: "I really think that supermarkets have been sitting back too long in this discussion. They point to the consumer but do not look at their own role and the impact they can have." This quote illustrates the frustration felt by actors in the MIS, who feel that retailers are not doing enough to support the transition.

Agronomic challenges and uncertainty

Interviewees also highlighted several agronomic (i.e. the practical and scientific aspects of growing crops) challenges and uncertainties for growing legumes in the Netherlands. A key barrier is the low yield of legumes compared to other crops, as well as issues with pests and diseases. "Another issue is the yield," one respondent (C1) noted. "For example, you can harvest 2,500 kg of beans, but you can harvest 100,000 kg of sugar beets. The yield for other crops is much higher." This illustrates one of the key issues that makes legume cultivation less attractive to Dutch farmers.

Another fundamental issue concerns the breeding of different varieties. Plant breeding is a costly and timely process that requires significant investments. Some legumes require breeding to make the crop suitable for the Dutch climate. However, due to the small scale of the (Dutch) legume market, seed companies are reluctant to invest. One interviewee noted, "You can't ask breeders to develop new varieties for a couple of acres. It doesn't make financial sense unless they can serve the world market." This highlights the "chicken-and-egg" problem that many actors mentioned. There is insufficient demand for legumes to warrant investment in breeding, and the lack of suitable varieties hampers the growth of the legume sector.

Government policy and support

Government policy and support is one of the most divisive issues. Broadly, opinions are divided into two camps: those advocating for government intervention (e.g., through subsidies) and those favouring a market-driven transition. Advocates of the first group feel that financial backing from the government

is insufficient. One interviewee (F1) remarked, “The Beandeal is great, the government is organising all kinds of things, but they say they do not have any money. Farmers can’t be convinced without financial support. It’s all about money and the market.” This underscores the need for stronger government intervention, which is being advocated for by a considerable part of the interviewees, to address the economic barriers that are currently hindering the adoption of legumes. Government interventions and policy will be further discussed in section 3.1.3.

Summary
While actors recognised economic barriers, the role of retail, agronomic challenges, and government policy as challenges, there was no consensus among actors on which problems were most critical. Additionally, no clear problem definition was provided by the two assessed policy frameworks.

4.1.1.3 Support from key actors ●●○

The analysis of interview data reveals diverse perspectives on the involvement and support of key actors, including government agencies, research institutions, and companies, in driving the mission. While certain actors are actively engaged, others are less actively involved, resulting in a varied and complex influence on the overall progress of legume adoption. This section discusses the private sector, with a special role for retail, the engagement of agricultural cooperatives, and the support of the government.

Private sector involvement
Several key companies have made legume cultivation a core component of their long-term strategies, positioning themselves as leaders in this transition. For example, one key player (C6) stated: “The protein transition is one of our strategic themes. In recent years, we have fully committed to this to prepare the company for the future.” Several other industry leaders (B3, B6, C1, C2) illustrated similar proactive attitudes.

Supermarkets and other retailers are seen as pivotal actors in the adoption of legume cultivation, yet their involvement is very limited. As previously stated, the Beandeal was signed by a wide range of stakeholders, but retailers were initially reluctant to participate. Supermarkets' market power places them in a crucial position, but their reluctance to fully engage has hindered progress. One participant (F2) highlighted that retailers often prioritise price competition over supporting domestic legume production: “For the transition of the supply chain, the supermarket is the most essential player. They [supermarkets] seek the flexibility to pressure us [farmers] or, at the very least, to compare us with other suppliers to minimise their costs as much as possible.”

Furthermore, another respondent (C3) criticised supermarkets for being slow to take responsibility, instead placing the focus on consumers while ignoring their own potential impact: “I believe supermarkets have leaned back in this discussion for far too long. They point to the consumer but don't consider their own role and the impact they could have.” These observations underscore the need for retailers to take a more proactive role in supporting the adoption of legume cultivation.

Beanwashing
Although many industry leaders are involved in the mission, some challenges persist. This is clearly illustrated by a key player which initially signed the Beandeal but later scaled back its engagement. One respondent (G1) explained: “[the organisation] signed the Beandeal at the beginning, but we never heard from them again.” To describe this action, the interviewee (G2) coined the term “beanwashing”. When

confronted with their absence, the organisation explained that they "would not adjust all their production lines for a small portion of Dutch beans."

Engagement of agricultural and industry organisations
In contrast to the inconsistent role of retailers, various agricultural organisations and industry associations are actively engaged in supporting legume cultivation. A diverse set of stakeholders is involved across the entire value chain, from breeding to cultivation and processing. To support individual farmers who are pioneering in legume cultivation, a producer organisation has been founded (the Protein Farmers). By creating a collaborative network of farmers focusing on legume cultivation, this organisation has taken on a leading role in the mission.

Government support
By drafting the NES and composing the Beandeal, the government has initiated the mission and brought a wide range of stakeholders together. The role of the government will be further discussed in the next sections.

Summary
The mission has a relatively high level of support from a wide range of actors from across the value chain. Many industry leaders take a leading role by integrating the cultivation of legumes into their business strategy. However, retailers have a critical role in the value chain, and their absence forms a key barrier to the widespread adoption of legume cultivation in the Netherlands.

4.1.1.4 Conclusion

Each indicator of the innovation system function 'providing problem directionality' formed an average barrier. Regarding the urgency of the mission, actors recognise legume cultivation as a critical step toward a sustainable agricultural system but are hesitant to commit due to concerns about economic feasibility. Considering the problem definition, many problems limiting the widespread adoption of legume cultivation are known, but unanimous agreement on key barriers remains absent, and it is unclear which problems should be prioritised. Finally, although the mission is supported by a variety of actors, the absence of retail is a significant problem.

4.1.2 Providing solution directionality ●○○

The level of solution directionality is determined by three indicators: 'provision of roadmaps or frameworks,' 'level of consensus on solution direction,' and 'strategic alignment of actors.'

4.1.2.1 Provision of roadmaps or frameworks ●●○

Two policy documents provide guidance to the mission. First, the National Protein Strategy (NES) is a policy framework developed by the government to reduce dependency on imported protein sources and promote sustainable, locally produced plant-based proteins. Launched in 2020, the strategy's overarching goal is to enhance food security, reduce environmental impact, and support the global protein transition towards more plant-based sources. The NES sets an ambitious target of increasing legume cultivation to 100.000-125.000 hectares in 2030, compared to fewer than 10.000 hectares in 2023. Besides the production of plant-based proteins, this strategy also supports innovation in new protein sources like algae and insects.

The Beandeal, officially known as the Green Deal Protein-Rich Crops (GDEG), is a concrete initiative that stems directly from the goals of the NES. It is a collaborative effort involving various stakeholders, including farmers, businesses, research institutions, and the government, with the aim of increasing the cultivation of protein-rich crops, such as legumes, in the Netherlands. The Beandeal supports this strategy by encouraging domestic production, fostering collaboration, and creating market opportunities.

Critique
The interviews have highlighted critiques on the Beandeal. While symbolically important, it has been criticised for its lack of formal structure, funding, and accountability. It remains a voluntary agreement without strong incentives, limiting its practical impact despite aligning with the goals of the NES. A government representative (G1) stated: "The Beandeal is essentially nothing. It is not an organisation; we have no money. It is just individuals connecting under a common goal." This illustrates the lack of formal structure and resources. Another interviewee (G2) critiqued the Beandeal for being too informal, as some parties have set goals but have not made active efforts to achieve them: "Some parties have written down goals, but no one has been able to contact them, so they're not working on their goals." This highlights a significant limitation: without accountability or resources, the initiative remains largely symbolic.

Despite its limitations, actors also mentioned positive aspects of the Beandeal. Besides bringing stakeholders together, the initiative provides confidence to businesses that align with sustainability goals: "If you, as an entrepreneur, strongly believe in a certain direction, and you see that the government is going in the same direction, it gives you confidence." (B5) This demonstrates the symbolic value of the Beandeal.

Summary
While the NES has set ambitious targets and actors support the collaborative initiatives resulting from the Beandeal, the critique highlights the lack of formal structure, funding, and accountability of the strategic frameworks.

4.1.2.2 Level of consensus on solution direction ●○○

The interviews reveal a diverse range of opinions regarding the direction of legume cultivation in the Netherlands. While there is broad agreement on the need to increase local legume production, stakeholders differ significantly in their views on how this should be achieved.

Divergent strategies among stakeholders
The adoption of large-scale cultivation of low-value bulk legume crops, such as fava beans, soy, and peas, is favoured by some stakeholders, particularly plant breeding companies. They see this model as creating a larger market and opening up business opportunities. This solution direction would focus on the production of legumes for animal feed. Advocates of the animal feed direction believe that once this market is established, the costs will decrease, and the transition to human consumption will follow naturally.

However, many other actors remain sceptical about the viability of bulk legume crops in the Netherlands. One stakeholder (C2) notes, "We do not believe in bulk protein crops in the Netherlands, such as fava beans, soy, and peas. There is no financial return to be gained from such bulk crops." Instead, there is a stronger belief among many stakeholders in the potential of higher-value, niche products. Certified seeds and legumes intended for direct human consumption are considered more

economically viable, although they still represent only a small segment of the market. These products offer greater economic returns compared to bulk crops, making them more attractive to certain actors.

Government vision and policy support
There is a strong critique of government strategies, particularly regarding the economic model underlying the proposed cultivation goals. Multiple respondents highlight the difficulty of achieving large-scale legume cultivation without significant financial incentives or regulatory support. One interviewee (C3) commented: "The government wants 100,000 hectares of protein crops in the Netherlands. If that is really your goal, you need to offer a big subsidy for that. It is strange to just write down such a goal without backing it up." However, there is no unified vision on the issue of financial support. Some argue that funding should come from the market rather than from government subsidies. "There is no consensus on where the transition money should come from; some say it should come from the government, and others believe it should come from the market," an interviewee (G2) noted.

Collaboration in the Beandeal
Despite the differences in visions, the Beandeal brings together many stakeholders in collaborative initiatives. Many interviewees view the Beandeal as a positive step towards aligning actors around the goal of increasing legume production. One interviewee (B1) notes, "There are many initiatives that reinforce each other, and the Beandeal brings these different parties together. It is about strengthening each other, even though that takes time and effort." While there is a broad consensus on the importance of increasing protein production from local sources, the diversity of strategic priorities among stakeholders remains significant. This diversity is seen as both a challenge and an opportunity. One respondent (B3) summarises this view by saying, "The diversity among the group is actually good. If everyone walks the same path, you will not get far. It is a transition, so you need to try different things."

Summary
To conclude, while there is a general agreement on the goal of increasing legume cultivation in the Netherlands, the interviews reveal a lack of consensus on which path to take to achieve this goal. Stakeholders differ significantly in their economic visions, crop preferences, and views on government intervention. The absence of a unified vision might hamper the transition's success, but the diversity of solution directions might also benefit the mission. Especially since the solution intersections are symbiotic in nature, they all focus on increasing the adoption of legume cultivation. Initiatives like the Beandeal can help by fostering collaboration and aligning different solution paths.

4.1.2.3 Strategic alignment of stakeholders ●○○

The last indicator that illustrates the level of solution directionality is the level of strategic alignment of stakeholders. This section explores the degree of alignment and collaboration among various stakeholders and aims to assess how these stakeholders work together to provide direction and solutions for increasing legume cultivation.

Collaboration and alignment within the mission
The mission involves a wide range of stakeholders, from farmers and agribusinesses to research institutions and policymakers. Collaboration in this network is multifaceted but often fragmented, with smaller groups of 2-4 actors working together within the broader network. Several initiatives highlight strong collaboration, particularly between farmers and agribusinesses. A notable example is provided by a collaboration of farmers, an agricultural cooperation, and a retailer, that focuses on the development

of kidney bean cultivation. Participants explained that clear agreements were made between the participants in advance of the cultivation process, ensuring farmers a market for their crops.

Another example of effective alignment between stakeholders is presented by the producer organisation, which plays a pivotal role in the coordination of legume cultivation. Farmers who grow legumes often work closely within this association, which acts as a bridge between individual farmers and larger industrial partners. This network facilitates knowledge-sharing and provides collective bargaining power for setting fair prices. One respondent (B2) explained: "We do not negotiate with each farmer individually but with the group. We ask: what is needed to make this a financially sustainable cultivation?" Such coordination helps to make legume cultivation more attractive to farmers. The interviewees highlight many more coordinated initiatives among stakeholders. However, there are concerns about the decentralisation of knowledge efforts, with different provinces conducting similar experiments without adequate coordination. As the same participant (B2) pointed out: "Experiments often happen at the provincial level, so you need to be careful not to repeat the same experiments in different regions."

Summary
The level of alignment of stakeholders in legume cultivation varies, with some strong coalitions but also fragmentation. Farmers, agribusinesses, and producer organisations work effectively together, particularly in projects where clear agreements ensure a market for crops and collective bargaining strengthens farmers' positions. However, challenges persist in aligning and coordinating efforts nationally.

4.1.3 Coordinating the transition ●●○

Going beyond the coordination of the different solution pathways, this function examines the overall coordination in the MIS. The level of coordination in the transition is determined by the following three indicators. The first indicator examines the presence and role of coordinating actors. Secondly, the effectiveness of coordinating mechanisms such as the Beandeal will be examined. Lastly, the level of funding and resource allocation for coordination will be assessed.

4.1.3.1 Stakeholder engagement and coordination ●●○

The presence and role of coordinating actors are key to understanding the level of support for the mission. Additionally, engagement of a wide variety of stakeholders is crucial for inclusive and effective coordination. The mission is characterised by the inclusion of a wide range of stakeholders, from farmers and agricultural cooperatives to research institutions and large processing companies.

Absence of retail
Despite the efforts of various actors, the role of retailers was highlighted as a significant barrier to effective coordination. Retailers are seen as critical players who have not fully committed to supporting the mission. The absence of major retailers in coordination of the mission might, therefore, limit large-scale adoption of legume cultivation (see section 4.2.4.3 for more information on the absence of retail).

Role of government in coordination
Interviewees expressed mixed perceptions of the government's role in coordinating the transition. Many actors were positive about government let initiatives like the NES and the Beandeal, but the general consensus was that governmental efforts lacked sufficient funding and concrete direction. Additionally,

attention mainly at the provincial level, national involvement and coordination seems insufficient: “There is attention to the protein transition at the municipal and provincial levels. Nationally, there is the National Protein Strategy, but I think it could be better.” (B1)The was frequently referenced as a significant coordinating platform, but it was also critiqued for its lack of structure and resources. The Beandeal connects various stakeholders, but it operates without formal organisational power or funding. The next section will discuss the effectiveness of this coordinating mechanism in more detail.

Central coordinating actors
In addition to the government, several central actors from the private sector and agricultural organisations are playing key roles in driving the transition. Interviewees identified at least four large companies and organisations as important coordinating actors. These coordinating actors include industry leaders, large agricultural cooperatives and the legume Protein Farmers. While not formally appointed leaders, these actors have taken up a natural leadership role in facilitating the cultivation and processing of legumes: “[these companies] are leading actors, more from a natural division of roles. They play a supportive role, along with the legume Protein Farmers.” (G2)

Summary
Various actors are involved in coordinating the adoption of legume cultivation in the Netherlands, including governmental platforms like the Beandeal, industry leaders, and agricultural organisations. However, the absence of large retailers appointed as key players within the transition might hamper the mission’s progress.

4.1.3.2 Effectiveness of coordination mechanisms ●●●

Interviewees frequently highlighted a lack of effective coordination mechanisms, particularly from the government. Many respondents expressed frustration with the limited support from the government. Although there are platforms like the Beandeal, these initiatives are criticised for their lack of practical impact and strong direction. One respondent (G1) stated: “There is no real leadership. Everyone does what they want, in a good way, but there is no clear steering.”

Effectiveness of the Beandeal as a coordination platform
The Beandeal functions as a central coordination mechanism for the mission. Overall, the Beandeal is seen as a well-intentioned initiative but criticised for its lack of outcomes. Many respondents viewed the platform as too informal and lacking resources: “The Beandeal is essentially nothing. It is not an organisation, it has no budget, just individuals connecting under a common goal.”[2] (B2) While the Beandeal created a network of stakeholders, including farmers, NGOs, and the government, its ability to generate concrete results was questioned. One respondent (G2) mentioned that they had little contact with several partners who had signed on to the initiative, indicating a lack of follow-up on commitments: “It is too voluntary, they are not working towards their goals.” This suggests that although the Beandeal facilitates collaboration, it lacks strong mechanisms for monitoring progress and ensuring accountability.

Role of the government and monitoring
While the NES sets ambitious long-term goals, the government’s approach to supporting these goals through platforms like the Beandeal was perceived as insufficient. Several respondents felt that the government could do more to support the transition, particularly by offering stronger financial support: “The NES has great goals for the next 5 to 10 years, and the government supports the Beandeal, but with limited money, hoping things will get rolling. It is like delivering a car without any fuel.” (G2)

Additionally, respondents emphasised the limitations in monitoring the progress of the legume transition within existing coordination frameworks. There was a perception that the Beandeal, despite its meetings, did not have effective mechanisms for tracking the implementation of goals. There is little follow-up on if the agreements are being implemented and if actors are achieving results.

Informal networks and the need for more structured coordination
One government actor involved in coordinating the transition explained that informal networks play a key role in coordinating the mission. The interviewee (G1) explained that LinkedIn is being used to foster collaboration: "I try to keep an eye on who is doing what, and from that position, I try to bring different parties together." Finally, several actors stressed the need for more comprehensive and structured coordination mechanisms to accelerate the mission. The Beandeal was not seen as sufficient to achieve large-scale transformation. One interviewee (C5) pointed out: "We need much bigger steps. Conduct a bigger analysis of what [plant] proteins are consumed in the Netherlands and where they come from and then try to replace those with locally produced crops."

Summary
The interviews reveal that the current coordination mechanisms, particularly the Beandeal, are viewed as well-intentioned but ineffective in supporting progress towards the adoption of legume cultivation. While the Beandeal facilitates dialogue, networking, and collaboration, it lacks sufficient structure, resources, and monitoring mechanisms to ensure that stakeholders follow through on their commitments.

4.1.3.3 Funding and resource allocation for coordination ●●●

This section specifically focuses on funding and resource allocation directed toward coordination of the mission. A more general discussion on funding and resource allocation is provided in section 3.2.5.

Lack of substantial government funding
A recurring theme in the interviews is the insufficient level of government funding allocated specifically for transition coordination activities. While the Beandeal is regarded as a positive initiative, there is consensus that the lack of financial resources limits its effectiveness. One participant (G1) stated: "There is one person that gets to spend 1.5 days per week to work on the Beandeal. That is not much. The Beandeal is not an organisation, and they cannot make payments, for example. So, there is very little financing." This limited funding for coordination has constrained the ability of the Beandeal to deliver concrete results, with many ambitious targets set and agreements made but few substantial outcomes. Another interviewee (G2) described the situation as: "The NES has great goals for the next 5 to 10 years, and the government supports the Beandeal, but with limited money, hoping things will get rolling. It's like delivering a car without any fuel."[2] This metaphor emphasises the gap between ambitious policy goals and the resources required to achieve them.

Disagreement on the source of funding
There is also no consensus among stakeholders on where the transition funding should come from. Some argue that the government should take the lead in financing, while others believe that the markets should play a more prominent role. One interviewee (G2) noted: "There is no consensus on where the transition money should come from. Some say it should come from the government, others believe it should come from the market"[2]

Summary
Symbolically, the government has supported the adoption of legume cultivation by setting out ambitious goals in initiatives such as the NES and the Beandeal. However, funding for the coordination of the transition remains very limited. Several actors emphasise the need for sufficient funding if the government wants to achieve the set targets.

4.2 Performance function – innovation side

The following sections discuss the performance functions of the innovation side of the MIS. These include functions that assess the level of knowledge development and diffusion, entrepreneurial experimentation, market creation, resource mobilisation and the creation of legitimacy. These performance functions and their corresponding indicators will be comprehensively discussed before continuing with the performance functions of the destabilisation side in section 3.3. Note that data availability has allowed for extensive coverage of the innovation-side functions, whereas data on the destabilisation side is more limited, resulting in a less comprehensive and detailed analysis (Table 7).

4.2.1 Knowledge development ●●○

The level of knowledge development is determined by two indicators: the level of research and development (R&D) (the number and quality of R&D projects) and the level of collaboration across sectors (e.g., farmers, research, industry).

4.2.1.1 Level of research and development ●●○

The interviews reveal that there are several ongoing R&D initiatives aimed at increasing and improving legume cultivation in the Netherlands. A key focus are cultivation experiments performed by farmers, often on small plots of their land. Farmers experiment with different legume crops to see if these crops are suitable for their specific crop rotation. Research institutions and agricultural cooperations are also involved in cultivation experiments, focusing on the development of new varieties and refining cultivation techniques. One actor (C1) explained: "We always start with trial fields. In the last few years, we have introduced new beans like kidney beans, white beans, and black beans. We do this on our own trial fields for two or three years." These experiments are vital for exploring suitable legume varieties in the Dutch climate.

Research initiatives and collaboration

Regional efforts, particularly in lupine and faba bean cultivation, are also prominent. Several groups have emerged to share knowledge and conduct experiments. However, such efforts are still in the pioneering phase, as one farmer (F1) explained: "It is really pioneering, and sometimes it costs a farmer a lot of money. Last year, one farmer dropped out because of financial considerations." Collaboration is not limited to local initiatives alone. Larger national organisations, especially agricultural cooperations and research institutions, have taken a leading role in research efforts. For example, one project focuses on adapting fava beans for human consumption, shifting their traditional use from animal feed.

Source of innovation

The sources of innovation relevant for the mission are mixed, but the majority of R&D is driven by the private sector. One notable exception is a large subsidy program focussing on the development of the fava bean, the most cultivated legume in the Netherlands. The project specifically focuses on increasing yields and limiting risks for farmers. However, most R&D initiatives are organised by the private sector and collaborative initiatives like the Protein Farmers. Many interviewees praise the latter for significant contributions to knowledge development, fostering collaboration and experimentation among farmers, and focusing on a wide range of legume crops. Agricultural cooperations have also been recognised as leading actors in innovation, investing trials and research. More examples of private R&D initiatives will be discussed in the next section.

Challenges in knowledge development

Despite the large number of research projects, some knowledge gaps persist. Some actors point to the government for the lack of sufficient funding, specifically funding directed at plant breeding, as this is recognised as a critical barrier to advancing legume cultivation. One actor (C2) stated: "If the government thinks it is important to help the cultivators of these crops, they need to invest. There is simply no other party that is going to do it." Other cultivation knowledge gaps persist, such as optimal harvesting times, storage, and drying techniques. An expert (B3) expressed the need for more structured research: "We have to learn a lot about cultivation: what is the right time to harvest, how do you store it best, how do you dry the beans? In all these aspects, I think there is still a lot of missing knowledge." Another issue concerns the fragmentation of knowledge development. As stated in an earlier section, research is oftentimes being carried out on a provincial level, leading to similar initiatives in different provinces. This lack of coordination hinders efficient knowledge development.

Quality of the research

Assessing the quality of research efforts can be challenging, but some stakeholders based it on the involvement of prominent research institutions, such as universities. While certain projects are comprehensive and involve collaboration among multiple stakeholders, the participation of universities remains limited. This lack of involvement is viewed as a significant barrier to the widespread adoption of legume cultivation. As one interviewee (B5) noted, "It is really unfortunate that the government is not pushing [universities] to get involved. We really need knowledge development."

Summary

There is a wide range of small-scale and local research projects, which are primarily led by private sector actors and farmer networks, with minimal support from the government. While numerous and promising R&D projects exist, such as the project focussing on the faba bean, significant challenges remain. One obstacle of significant importance to the widespread adoption of legume cultivation is the absence of research focusing on plant breeding. The lack of coordinated large-scale research efforts and funding constraints hinder the overall advancement of the mission.

4.2.1.2 Collaboration across sectors ●○○

The second important indicator for assessing the level of knowledge development is the amount of collaboration across sectors. The interviews revealed a high level of collaboration across different sectors, with a diverse range of partnerships and mechanisms of knowledge development.

The high level of collaboration is illustrated by the active engagement between various stakeholders, including farmers, research institutions, and industry representatives. A participant (B1) highlighted the importance of collaboration between different organisations to optimise legume cultivation: "We are also working with [another organisation] to explore which crops are better. We look at taste, protein content, and yield per hectare." The government-led research project on faba beans also illustrates collaboration across different sectors. This project reflects a strategic alignment between public funding and private interests, fostering innovation through collaboration.

Collaborative networks

The formation of networks is a recurring theme in the interviews. Besides the largest producers organisation of legume farmers, there are several other smaller networks, each focusing on a specific crop. Farmers use these networks to come together and share experiences and best practices. One

respondent (C4) explained: “There is a need among farmers to talk to each other about very simple things. By bringing together all the knowledge from different farmers, we now know a lot.” More information on networks will be discussed in the next section (4.2.2.).

Summary
The results show strong cross-sectoral collaboration in the Netherlands. Significant efforts are made to foster knowledge development through collaboration between farmers, industry, research institutions and governments.

4.2.2 Knowledge diffusion ●○○

The level of knowledge diffusion is assessed based on three indicators. First, the frequency of knowledge dissemination activities like stakeholder meetings is examined. Following that, the accessibility of knowledge to stakeholders is considered. Finally, the diversity of methods used to diffuse knowledge

4.2.2.1 Frequency of knowledge dissemination activities ●○○

Based on the interviews conducted, several key knowledge dissemination activities were identified, including stakeholder meetings, public events, online publications, and public campaigns.

Stakeholder meetings
One of the most notable activities is the quarterly meetings held as part of the Beandeal. As one interviewee (G1) stated: “Each quarter, the different parties of the Beandeal come together to discuss the progress.” During these meetings, various organisations, companies, and governments come together to discuss progress, share insights, and align their efforts.

Public campaigns and events
Once a year, the government, together with several stakeholders, organises the ‘week of the legume.’ Similar to the ‘week without meat,’ this public campaign strives to promote the consumption of legumes via various forms of media. This event serves to raise awareness among consumers, bringing them in contact with legumes. Furthermore, several public events have been organised to showcase advancements in legume cultivation and introduce farmers to ‘new’ crops. For example, last year, a ‘Bean Day’ was organised, providing a platform for farmers and stakeholders to exchange ideas and experiences. Additionally, actors mentioned specific events that were organised for soybeans and lupine. Such events can be important for spreading practical knowledge about legume cultivation methods, including lupin and soy cultivation, and serve as inspiration for other farmers interested in adopting these crops. One actor (B6) noted: “We give workshops at different events, showing what you can do with a lupine bean. This is how we really hope to spread that knowledge.”

Online publications and reporting
The dissemination of knowledge is also supported through online reporting on, for example, LinkedIn and via a newsletter. The newsletter is prepared by a governmental actor and compiles key insights and developments in legume cultivation, including new research and collaborations. One interviewee (G1) mentioned, “The government publishes a newsletter. For example, when there is a new report, which contains a lot of interesting information, that would be compiled into the newsletter.” Furthermore, weekly updates on LinkedIn are used to keep stakeholders informed about the latest developments in the sector, including research findings and new collaborations. Although a diverse range of information

is frequently shared on LinkedIn, the group of recipients is fairly limited, not exceeding 2.000 online members.

Summary
The frequency of knowledge dissemination activities within the network is high, with multiple mechanisms in place for regular interaction and information sharing. Quarterly stakeholder meetings, annual events such as the "Week of the Bean," regular reports and newsletters, and public events all contribute to a dynamic and well-connected innovation system.

4.2.2.2 Accessibility of knowledge ●○○

One of the most prominent findings from the interviews is the active sharing of knowledge among farmers. Stakeholders emphasised that farmers cultivating legumes often share information with others in relevant networks and organisations. One respondent (B2) noted: "The Protein Farmers shares information. So, if one farmer acquires new information, for example about chickpeas, they share it with everyone. That is very nice." This illustrates a cooperative dynamic within the farming community, which is easily accessible to interested newcomers.

Role of organised platforms
The Beandeal was frequently mentioned as an important source of information. One respondent (C1) explained: "Through the Beandeal, we mainly stay informed about what is happening." In addition to the Beandeal, other platforms such as CRKLS, which aims to collect scientific information for arable farmers, play a key role in spreading knowledge. However, the legume section on this platform is still in development, and users are required to pay for certain information, which limits accessibility. One interviewee (G1) described the situation: "They have a webpage ready for legumes behind the scenes, but it has not been published yet. Maintaining this requires quite a bit of money."

Informal knowledge dissemination
The informal exchange of knowledge extended beyond the farmer networks. During the interviews, it became clear that many stakeholders are familiar with each other, and some even communicate on a regular basis. One farmer (F1) exemplified this by stating: "I came into contact with [a lupine farmer] through [another stakeholder]. Through [that farmer], I found out that you could also eat lupine. We started exchanging knowledge, and I eventually started harvesting lupine myself."

Media and technology
Media and digital tools are also used for knowledge dissemination but with mixed results. A positive example is illustrated by a company that uses promotions, social media, and QR codes on packaging to educate consumers about legumes. On the other hand, agricultural magazines struggle to generate interest in articles about legumes compared to more established crops, such as potatoes. One respondent (C3) explained: "An article about potatoes gets read a lot because they are cultivated on such a large scale. But for something unfamiliar like legume crops, it is much harder." This indicates that while knowledge might be accessible, it may not always reach the intended audience.

Summary
The accessibility of knowledge on legume cultivation in the Netherlands is characterised by a combination of informal farmer networks, organised platforms, and media. However, financial barriers and challenges in media visibility might limit the widespread accessibility of essential knowledge.

4.2.2.3 Diversity of knowledge dissemination ●○○

The previous sections already discussed the various methods applied to disseminate knowledge within the mission. Therefore, this section will briefly summarise the range of approaches stakeholders use to share information. Interviews revealed that knowledge exchange occurs through both formal and informal channels. Informally, peer-to-peer sharing plays a crucial role, as farmers actively exchange relevant cultivation information through social networks. Meanwhile, the government and companies use media and technology to reach a wider audience. For example, companies have introduced innovative methods, such as using QR codes to share detailed information with consumers, while the government regularly posts updates on developments in legume cultivation on platforms like LinkedIn and promotes legume consumption through public media campaigns. Additionally, the quarterly meetings of the Beandeal remain an important opportunity for stakeholders to exchange knowledge directly. Public events also contribute by showcasing new possibilities with legume crops, fostering broader awareness and encouraging stakeholder engagement with these emerging options.

Summary

The diversity of knowledge dissemination is robust and multifaceted. It includes both formal and informal channels, as well as digital and traditional methods. Knowledge is shared through networks, research projects, digital platforms, and public events and campaigns.

4.2.3 Entrepreneurial experimentation ●●○

The level of entrepreneurial experimentation is based on the assessment of indicators. First, the number and diversity of experimentation initiatives within the innovation system will be examined. Thereafter, the support for risk-taking and innovation, for example, funding, will be assessed. Lastly, the level of collaboration in entrepreneurial experimentation will be examined.

4.2.3.1 Diversity and number of experimentation initiatives ●○○

This indicator encompasses the variety of experimental approaches and the number of initiatives undertaken in efforts to explore and develop legume crops like lupine, kidney beans, chickpeas, and fava beans. The interviews reveal a wide range of experimental initiatives across different sectors. Farmers, research institutes, and businesses are all involved in testing legume crops, each with distinct methods and goals. Farmers often begin with small-scale field trials to assess the viability of different crops on their land. One interviewee (C1) mentioned, “We start with trial fields. Over the past few years, we have introduced new beans like kidney beans, white beans, and black beans. We do this on our own trial fields for two or three years.”[2]

Similarly, many farmers are experimenting with adding legumes into their crop rotation to test their agronomic and economic potential. As one respondent (C1) noted, “A farmer, for example, makes his money from beets and tries beans as a trial instead of wheat”. This shows how experimentation is combined with existing practices, which can help destabilise the status quo. Although there is a significant amount of experimentation, the size of these initiatives remains relatively modest, with most experimentation taking place on a small scale. Farmers generally only use a few hectares for trials. One respondent (B2) explained: “Farmers take two, three, or four hectares to experiment, to see how it goes, whether they like it, and how it affects weed control.”

Scale and diversity
Beyond individual efforts, larger-scale initiatives are also being conducted by innovative businesses and research partnerships. For instance, some companies are working with legumes to develop new products. One interviewee (C6) noted, "[x] has a factory in the Netherlands, where they can separate protein from field beans and make products. We worked with them to develop these products, testing if the texture was right and looking at the best places to grow the crops." These larger initiatives indicate the involvement of incumbent stakeholders in legume cultivation. More collaborative initiatives will be explored in the next section.

Experimentation is also diverse in terms of sectors, with farmers and businesses targeting different markets. Some initiatives focus on legumes for animal feed, while others aim to develop legumes for human consumption. One interviewee (G2) noted that these differences in focus can affect the scale of experimentation: "Some parties have a stronger belief in legumes for animal feed, and others focus on human consumption. It is riskier to focus on the latter since that market is still very niche."

Challenges and limitations
Despite the diverse experimentation efforts, challenges remain, particularly regarding scaling up and the economic perspectives. One respondent (B3) highlighted that some farmers stopped cultivating legumes because of low market prices: "In Flevoland, they cultivated a lot of field beans in recent years, but many farmers have stopped because the price is now so low." This underscores the financial risks associated with legume cultivation. Moreover, several interviewees pointed to the need for better infrastructure and processing capabilities to support legume cultivation. The same respondent (B3) elaborated: "The development of a new crop is difficult, not just technically but also in terms of infrastructure and having the right harvesting machines."

Summary
There is a diverse range of experimentation initiatives in legume cultivation in the Netherlands, from small-scale field trials to larger collaborative projects involving supply chains and product development. However, most experimentation is still small-scale and faces challenges related to market conditions and infrastructure. As one respondent (F1) summarised fittingly, "There is a lot of experimentation, but it is all quite marginal."

4.2.3.2 Support for risk-taking and innovation ●●●

The data reveals both the presence of some support mechanisms and significant gaps that limit broader adoption of these crops. Several interviewees highlighted existing government subsidies, such as those from the EU's Common Agricultural Policy (CAP), which incentivise farmers to include legumes in their crop rotation. This subsidy system is seen as one of the few mechanisms encouraging farmers to cultivate legumes. As one farmer (F2) explained: "Legume crops are eligible for subsidies under the EU eco-scheme. That is positive for legumes." However, it must be noted that not all actors agree that subsidies have a positive impact.

While the subsidy does encourage legume production, it does not actively stimulate market demand, leaving farmers in a vulnerable position: "You are stimulating production without there being any demand." (C1). This remark shows the disconnect that is created by government intervention. Financial support encourages farmers to grow legumes, but without addressing market demand, it leaves them exposed to financial risks. Farmers have little incentive to innovate or scale up production due to the lack of a guaranteed market for their crops.

Lack of risk mitigation mechanisms

The absence of robust mechanisms for risk mitigation was repeatedly emphasised. Legume cultivation is considered highly risky, particularly because of unpredictable yields. One participant (F1) described a challenging experience with lupine cultivation: "Last year, eight of us cultivated lupin on 10 hectares, and in the end, we could only harvest two hectares." This highlights the potential for crop failure, which can lead to significant financial loss. Furthermore, there is no safety net in place for farmers who take these risks. The same farmer pointed out: "There is no risk fund for this. Farmers would like a pioneering premium or some sort of risk fund." Another farmer (F2) made a similar statement: "What is really needed is a fund to cover temporary losses. This would remove a major barrier for farmers to grow legume crops." These statements highlight the fact that the lack of crop insurance or risk funds discourages many farmers from adopting legume cultivation.

Structural issues in the system

Another issue is the existing agricultural system's risk structure, which places a disproportionate burden on farmers. In the current model, farmers must pay for inputs upfront, but they do not receive payment until after the harvest, leaving them vulnerable if the crop fails or yields disappoint. One interviewee (B2) noted: "The risk lies entirely with the farmer. They would like to reposition themselves in the chain." The model of the current supply chain increases the risk associated with adopting legume cultivation. Without a significant risk reduction, for example, through the implementation of a risk fund or a premium for pioneering, farmers are hesitant to experiment and invest in new legume crops: "What I think is really needed is a risk fund for farmers who dare to pioneer with the cultivation of legume crops." (C4)

Summary

While there are some support mechanisms in place, particularly in the form of subsidies, they do not sufficiently reduce the risks associated with legume cultivation. The lack of risk mitigation mechanisms, such as insurance or a pioneering fund, is a critical barrier to innovation.

4.2.3.3 Collaboration in entrepreneurial experimentation ●○○

The last indicator of the innovation system's entrepreneurial experimentation function is the degree of collaboration among stakeholders. This includes the extent to which different actors, such as farmers, businesses, and researchers, work together to conduct experiments and share results. The interview data revealed significant collaboration across various sectors.

Multi-stakeholder collaboration

The interviews show a lot of collaboration among stakeholders in the legume cultivation sector, particularly in conducting experimental pilots and sharing the results. One prominent example is illustrated by the collaboration of legume cultivators in the 'Protein Farmers,' an organisation that has the goal to stimulate the cultivation, production, and consumption of legumes in the Netherlands. By uniting in an organisation, they aim to strengthen the economic position of legume farmers within the supply chain. Furthermore, by promoting a comprehensive research agenda, they hope to enhance the cultivation of knowledge and yields.

An example is given by a collaboration between the Protein Farmers and a business focused on the production of humus: "We are collaborating with the Protein Farmers. There are now seven farmers growing chickpeas for us. Initially, we imported chickpeas, but now we source everything from the Netherlands. We went from 10% to 100% in one year." (B2) This example illustrates the entrepreneurial

experimentation that involved testing crop yields, pricing strategies, and the viability of scaling legume cultivation. Furthermore, it highlights the essential role of price negotiations and long-term agreements with farmers to encourage experimentation. The respondent continued: "We have agreed with the Protein Farmers on a fair price per kilo of chickpeas, which motivated farmers to experiment with this crop. They learn about yields, and if it works well, more farmers will join next year."

Several other partnerships between farmers and businesses have been highlighted in the interviews. These partnerships, focused on one specific crop, aim to shorten the supply chain by conducting local pilots, where legumes are cultivated, processed, and supplied to restaurants within the region. One interview (B1) highlighted a pilot with soybeans: "We are testing by cultivating soybeans with a farmer, processing them locally, and supplying them directly to restaurants. We also place the necessary machines at the restaurant to make tempeh."

Knowledge sharing and networks
A crucial element of collaborative experimentation is the sharing of knowledge and results across different regions and stakeholders, which often happens within platforms or networks. Platforms and networks, as well as collaborations with banks, agricultural cooperations, and industry leaders, have been instrumental in facilitating knowledge sharing and cooperation: "The [a bank] is a valuable partner; they are involved with farmers and innovative projects. Collaboration with [an agricultural cooperation] and [a leader in the processing industry] also plays a key role in experimentation." (C5) These networks create opportunities for peer learning, where farmers and businesses exchange information about their experiments, successes, and challenges. One interviewee (R1) noted that by participating in shared platforms and multi-stakeholder projects, they were able to test new crop variants with the support of other stakeholders: "We are part of networks and platforms like [two major projects], where we collaborate with companies leading the processing industry. These companies help test new bean variants and provide feedback."

Government support and subsidies
Institutional support, in the form of subsidies, has also played an important in facilitating entrepreneurial experimentation. For instance, the Fabafood project, which involves multiple stakeholders, was supported by a provincial government subsidy. This financial assistance allowed stakeholders to collectively experiment with new crops and share insights: "We have partnered with [several companies] to test new bean variants. We submitted a subsidy application to the province, which was approved, enabling us to experiment together." (R1)

Summary
The degree of collaboration among different stakeholders in conducting entrepreneurial experimentation is high, as shown by the multi-stakeholder partnerships, shared pilots, and networks. Farmers, businesses, and institutional partners collaborate extensively to test new crops, shorten supply chains, and share knowledge.

4.2.4 Market creation ●●○

Market creation, i.e., the formation, protection, and generalisation of (niche) markets, is assessed based on four indicators. First, the extent to which niche markets for legume products are being established is assessed. Subsequently, consumer awareness and demand creation are examined, followed by the

involvement of key market actors (e.g., supermarkets, wholesalers, etc.). Lastly, and a central issue of this study, is the examination of the formation of value chains.

4.2.4.1 Emergence of niche markets ●●○

The interviews reveal that while niche markets for legume products in the Netherlands are emerging, their establishment is still in its early stages. Several examples were provided, primarily focusing on four legume crops. Therefore, this section will be structured according to these different crops.

Chickpeas

Several interviewees point to the development of niche markets for chickpeas as a promising area. A collaboration with a processor and cultivators within the Protein Farmers has enabled the cultivation of chickpeas, as discussed in section 3.2.3.3. Because of the collaboration, the farmers are assured of a market for their chickpeas, enabling them to take the risk. The interviewee (B2)) emphasises that this initiative is still experimental, with farmers and companies learning from each other as they establish the supply chain: "We have a deal with the Protein Farmers. They produce just the right amount for us. For them, it is also an experiment to see how much yield they get." This suggests that although the niche market for Dutch chickpeas is still forming, this market is in the early stages, and scaling up will depend on continued collaboration between producers and buyers.

Field beans

Currently, field beans are the most prominent legume crop in the Netherlands, covering over 2.000 hectares. Most of these beans are cultivated for animal feed. However, new initiatives and markets are developing. One interviewee (C2) mentions the cultivation of field beans for protein powder production: "We are now in our third official production year. We buy a lot of field beans from Germany, but sourcing in in the Netherlands is increasing. Last year we sourced from 50 hectares, and this year it was 100 hectares." The actor noted that, while they would prefer to source the field beans in the Netherlands, German beans are significantly cheaper, making it a financially difficult choice.

Lupine

Lupine is a more novel crop, resulting in a very niche market. Producers position it as a premium product, as one retailer (B6) stated: "We pay a significant premium for lupine because it is a niche product, and consumers are willing to pay for it." This shows that niche markets can work for specific legume varieties, particularly when they are marketed as unique or high-value crops.

Edamame

The case of edamame serves as an example of a unique and well-established market. According to one interviewee (C5), edamame sales in the Netherlands have "quadrupled in the past 10 years." This growth is primarily driven by its use in composite products like poke bowls and salads rather than traditional canned beans. However, as the interviewee noted, these edamame beans are currently imported from Asia. This existing market offers farmers a unique opportunity. Instead of the need for demand creation, the market is already established. Furthermore, because retailers will soon be responsible for emissions of the products that they are selling (as a result of CSRD scope 3, which will be further discussed in section 3.3), they will be looking for products with lower emissions, one interviewer stated. This poses a unique opportunity for Dutch edamame farmers, since "the market does not need to be built from scratch", one interviewer explained (G3). Several interviewees suggest that focusing on crops with existing demand, like edamame and chickpeas, might be a more effective strategy than trying to develop entirely new markets for lesser-known legumes. The effectiveness of this strategy is demonstrated by a

recent partnership between a group of edamame farmers and a major retailer, which announced a switch to 100% Dutch-sourced edamame.

Institutional and market support
Besides the establishment of markets via the private sector, government initiatives also contribute to niche market creation. One interviewee (F1) notes the involvement of local governments in promoting legumes through catering policies: "The government is promoting the consumption of legumes by offering them in municipal and provincial government buildings." The interviewee admitted that these are limited efforts but stated that they "are important first steps." Additionally, several companies in the plant-based sector are collaborating on pilots to explore the potential of using Dutch-grown legumes in meat and dairy replacements. One interviewee (C6) explains that this represents a new category with significant opportunities: "It is a new category, and that means it is also a gap in the market. The entire supply chain is still under development."

Challenges and limitations
Despite these promising developments, the market for legumes in the Netherlands remains small. Several interviewees caution that these markets are still in their infancy, particularly for lesser-known legumes like lupine or crops used for animal feed. One interviewee (C5) notes that "new plus new is very difficult" suggesting that introducing both new products and new markets simultaneously poses significant challenges. Another challenge is the underdeveloped processing infrastructure, which limits the ability to scale up domestic legume production. As one interviewee (C1) mentions, "The supply chain is still not well organised, and processing is underdeveloped."

Summary
The emergence of niche markets for legume products in the Netherlands is progressing but still faces several challenges. Successful examples, such as edamame and chickpeas, highlight the opportunity to build on existing consumer demand. Collaborative partnerships between retail and Dutch farmers have proven to be key. At the same time, there are also options to create niche markets for more specialised and premium products, like those for lupine. However, broader adoption will require continued collaboration across the supply chain, improved processing infrastructure, and support from both the private sector and government initiatives. The market remains niche but offers significant opportunities for growth in the coming years.

4.2.4.2 Consumer awareness and demand creation ●●○

This indicator focuses on the consumer awareness and demand for legumes, particularly driven by sustainability, health, or public campaigns. Note that these results discuss the consumer awareness and demand creation for legumes as an individual product, this does not include the use in composite products.

Limited consumer demand
A clear theme across the interviews is the limited demand for legumes among Dutch consumers. Despite efforts to promote legumes, both in terms of their health benefits and their role in sustainability, the market for legumes remains small. Several reasons were given for this limited demand. First, price competition from imported legumes was identified as a key barrier. Retail prefers cheaper, imported options rather than domestically grown products, making it difficult for local legume production to grow. Additionally, some experts expressed concern that subsidies (both EU and national) may stimulate cultivation without addressing the underlying issue of consumer demand. One expert (C1) noted: "From

the EU, legume crops are eligible for subsidies, which is positive for legumes. But is that wise? You stimulate production without there being demand." This highlights the disconnect between supply and demand.

Despite the current low demand, there are signs that sustainability and health can be effective drivers for increasing consumer interest in legumes. Some campaigns and initiatives focus on promoting legumes as part of a sustainable diet. For instance, one interviewee (G1) mentioned the efforts of supermarkets to promote local and sustainable food: "[A supermarket] has focused a lot on local and sustainable food in their promotions, including beans, which ties into sustainability goals like reducing CO2 emissions." Supermarkets play a pivotal role in shaping consumer behaviour, as they can effectively nudge consumers through strategic product placement and promotions. Additionally, legumes are inherently linked to the protein transition. As part of this transition, companies and policymakers see legumes as a key component of more sustainable diets.

Public and private promotion campaigns

While demand creation is perceived to be difficult, there are efforts being made, particularly through public campaigns and corporate promotions. One stakeholder (B2) mentioned working with a caterer to promote chickpeas in various provinces: "I am working with a caterer in different provincial and municipal offices in October to raise awareness of chickpeas. We will bring tasty sandwiches and talk about what we do and where our products come from." Other companies, including industry leaders, have actively promoted legumes, launching new products and packaging to make legumes more appealing to consumers. For example, the introduction of legumes in more colourful and modern packaging has resulted in increased sales, as one interviewee (B4) revealed: "Yes, through the introduction of [new packaging and promotion], we are selling more legumes. And that is what you hope for, because we are raising awareness."

The most important public campaign focused on the promotion of legume consumption is the Beanmeal. The Beanmeal is an initiative from the Bean Deal and is organised and coordinated by several stakeholders. It is a public campaign, similar to the week without meat, that puts legumes in the spotlight. It is one of the few things the government is financially supporting, as one interviewee (G2) explained: "The ministry is making a fair contribution to the Beanmeal. They want to continue this for 3 to 5 years. That is aimed at increasing demand. Because growers can indeed do it, but the demand must increase." Several actors (B2, C5, F2, G2) acknowledge the importance of the Beanmeal for accelerating the increase of consumer demand: "I think the Beanmeal is a great example of what works well [to increase demand]. You are bringing market parties and government together. I do believe that this will have a stimulating effect." (F2)

Challenges in changing consumer behaviour

A recurring theme in the interviews is the difficulty of changing consumer behaviour. Stakeholders frequently pointed out that creating demand for legumes requires not only raising awareness but also shifting habits and routines. One interviewee (F1) explained the challenge of getting consumers to eat more legumes: "It is critical that consumer behaviour changes. But that is the hardest thing to do. It takes a generation to change." Several barriers to changing consumer behaviour were identified, including the idea that legumes are unfamiliar compared to other foods, such as meat. One interviewee (G3) explained: "If you want to replace meat with a legume-based meat substitute, you must change your routine. Legumes are placed in a different section of the supermarket. You need to make it easy for consumers, for example, by putting legumes next to meat along with recipe inspiration."

Summary
Consumer awareness and demand for legumes in the Netherlands remains limited. The market is still small, and changing consumer behaviour is a long-term challenge. Public and private initiatives, like the Beanmeal and other promotional efforts, are working to stimulate demand, but consumer awareness and demand is still minimal. However, the significant increase in sales of edamame and chickpeas in composite products raises the question of how essential consumer awareness is for driving the adoption of legume cultivation.

4.2.4.3 Involvement of key market actors ●●●

The involvement of key market actors in promoting and distributing legumes in the Netherlands remains minimal. Stakeholders repeatedly emphasise the critical role of supermarkets in driving the mission, noting that "Supermarkets are the most essential players for the supply chain transition." (G3). As a result, the limited engagement of these actors is identified as a significant barrier to the widespread adoption of legume cultivation.

Limited involvement of supermarkets and wholesalers
Most supermarkets have not yet taken significant steps to promote Dutch-grown legumes. As one respondent (C3) pointed out, supermarkets play a critical role in driving the sustainable transitions but have not taken responsibility for their role: "I think supermarkets are essential players in this transition, but they tend to hold back. They point to the consumer but do not acknowledge their own role and the impact they could have."

Despite the general lack of involvement, one organic supermarket chain has committed to the Beandeal. This supermarket reported having a slightly larger share of legumes in its product offering compared to conventional supermarkets, but it is not guaranteed they are sourced in the Netherlands. "Some of the legumes they sell do come from the Netherlands, but that is not guaranteed and depends on the type of bean." (B6) Furthermore, the supermarket has also been involved in promoting legumes: "They have also been very busy promoting Edamame. They are now also looking at Dutch chickpeas and field beans. I think they are doing the promotion quite actively, really trying to get the consumer excited. Both online and via magazines." (B6)

Additionally, there has been a recent pilot project involving one major Dutch supermarket collaborating with Edamame farmers. This collaboration shows promise in terms of establishing a new supply chain for locally grown legumes: "We are working toward a significant announcement about a partnership between a large Dutch supermarket and Edamame growers. This could help develop the chain." (C5) While these initiatives are positive steps, they are still isolated efforts rather than the widespread involvement necessary to significantly shift the market toward supporting domestic legume production.

Limited engagement from processing companies
Processing companies too, often prioritise cheaper imported legumes over domestically grown varieties. One respondent (G1) mentioned that large companies show some interest in domestic legume production but emphasised the challenges of scaling up while remaining competitive: "[The organisation] pays a fair price for field beans now, but I do not believe they will continue to do so once they scale up to industrial quantities. Then you will have to compete." Some food processors, however, have shown more involvement in the Dutch legume market. Companies in the plant-based food sector have begun to explore opportunities in the legume market. These companies are experimenting with

legumes as a key ingredient in plant-based meat and dairy substitutes: "[A large agricultural cooperation] started pilot projects with several companies interested in the Dutch market. These companies are involved in developing a new category of plant-based alternatives. The entire supply chain is still under development, but there is a market opportunity here." (C6)

The significance of limited retail involvement
The limited involvement of supermarkets and wholesalers is viewed by stakeholders as a major hurdle to scaling up the adoption of legume cultivation in the Netherlands. Several interviewees stressed that increasing the demand for locally grown legumes is crucial for farmers to commit to growing them. As one respondent put it: "Farmers can grow them, but demand needs to grow as well." For demand to increase, it is essential for supermarkets to take a more proactive role in promoting legumes. Some participants mentioned that supermarkets will feel more pressure to make changes as sustainability goals, become more critical: "The CSRD (Corporate Sustainability Reporting Directive) and scope 3 emissions are starting to make supermarkets move. They are now analysing their product offerings and looking at how much CO_2 they emit. Meat and dairy are suddenly under pressure, and legumes are one way to make a change." (C2)

Summary
The results show that the involvement of supermarkets and wholesalers in promoting and distributing locally grown legumes is still limited. While there are some positive developments, such as the organic supermarket and pilot collaborations, the overall lack of engagement is viewed as a major obstacle to accelerating and developing the legume market. Similarly, while food processors have shown more interest, they remain largely driven by cost considerations, often favouring cheaper imported legumes.

4.2.4.4 Formation of value chains ●●○

Another indictor that emerged as a central theme in the interviews, is this formation and presence of value chains, including actors from all across the sector. The development and establishment of value chains for legume cultivation in the Netherlands is progressing, but there are varying degrees of success depending on the crop, market demand, and the structure of the value chain.

Current structure of the supply chain
The existing legume value chains in the Netherlands are characterised by complexity and a lack of transparency. Multiple interviewees emphasised the need for simpler, shorter chains, where different stakeholders can collaborate in a more direct and transparent way, with fewer intermediaries. One interviewee (C4) highlighted the issues in current chains, noting, "At the moment, there are simply too many links in the chain, and no one really knows what they are doing or what they add, or how much it costs."

Efforts toward shorter value chains
Many stakeholders emphasise the need for shorter value chains, which aim to enhance transparency, fairness, and profitability for all participants. One actor (B1) mentioned the development of shorter chains as a strategic goal, stating: "We see a future in shorter chains. By making the chain smaller, and having farmers move up in the value chain, they gain more control, more flexibility in managing risks, and, ultimately, a better outcome." Shorter chains are considered more transparent and allow for fairer distribution of revenues, with each step adding extra value. The example of a local soybean pilot, given in a previous section (4.2.3.3), illustrates this clearly. In this pilot, the farmer added value by processing the soybeans. Additionally, the farmer had a direct link with a restaurant who turned the soybeans into

tempeh. This type of local, integrated chain reduces the need for intermediaries and allows farmers to take a larger share of the created value.

Another successful example of the development of shorter value chains is presented by the partnership between edamame farmers and a large retailer, also discussed in the previous section. In this case, the retailer expressed its ambition to replace the import of edamame for the use in composite products, by dutch sourced legumes. A last a positive development is presented by the partnership between chickpea farmers and a processor, which also has been mentioned earlier, creating a short and transparent value chain.

Challenges in value chain formation
Despite positive steps, the formation of mature value chains still faces several barriers. One significant challenge is the lack of alignment among all stakeholders. While some actors, particularly farmers and processors, are eager for more transparency and fairer distribution, others in the chain are less enthusiastic. One interviewee (B4) noted, "We are very enthusiastic about transparency in the chain, but not all parties share this enthusiasm" referring to supermarkets preferring cheaper imports. Moreover, the absence of large retailers in the innovation system is hindering the development of effective value chains. Because "retail was not really engaged for a long time," (C3) attempts focussed on the restructuring of value chains were hampered. However, this is slowly changing, with certain retail players now offering experimenting with collaborative initiatives of farmers.

To build economically sustainable value chains, many stakeholders are focusing on creating long-term contracts between farmers, processors, and retailers. These contracts provide price stability and ensure financial sustainability for everyone involved. One stakeholder (B4) stated: "We are investing heavily in long-term contracts [with farmers] based on actual cost levels. We want models that ensure everyone in the chain can make a living."

Summary
In conclusion, the formation of value chains for legume cultivation in the Netherlands is progressing, but challenges persist. As one interviewee (C6) put it aptly: "There is still much to improve in the chain, and you need a lot of patience." Efforts to shorten chains and increase transparency are promising, but destabilisation of existing chains and retail engagement is needed to create mature and sustainable value chains.

4.2.5 Resource mobilisation ●●●

Three indicators assess the level of resource mobilisation within the innovation system. First, the availability of financial resources examines the extent to which financial resources are available to support research, development, and implementation of solutions. Then, the allocation of funding will be explored to determine how efficiently resources are distributed within the innovation system. Finally, material resources will be taken into consideration, and the availability of farming equipment, seed technology, and storage space will be examined.

4.2.5.1 Availability of financial resources ●●○

This section discusses the extent to which financial resources, such as subsidies and private investments, are accessible to support legume cultivation efforts. One source of financial support frequently mentioned by the participants is the Common Agricultural Policy (CAP, known as GLB in Dutch). The

CAP is the European Union's framework for supporting farmers, for example, by providing financial aid through subsidies, grants, and programs. For legume farmers, the CAP offers direct payments tied to eco-schemes, rewarding sustainable practices. Many farmers have decided to include legumes in their crop rotation due to the financial incentives offered under the CAP's eco-schemes. One farmer (F1) noted: "As long as legumes are part of the GLB, you will continue to grow them. But you would not do it for the [selling] price." Another farmer (F2) stated: "If it had not been for the GLB, I might not have grown them at all." However, actors also note the negative side of subsidies. The same farmer (F2) mentioned how subsidies led to a price drop: "Legumes are subsidised through the GLB. So, everyone starts sowing beans. This resulted in [a legume processor] having too many beans, which led to a 21% price cut. There simply is not enough market demand." This highlights the unsustainable dependency on subsidies.

National support and public-private partnerships

On a national level, the government is investing in legume cultivation through the Fascinating program, a large-scale research and innovation initiative aimed at supporting the transition to more sustainable and plant-based protein sources, including legumes. The program is a collaborative initiative with three major agricultural cooperatives, which contribute resources, expertise and funding. The program supports the entire value chain for legumes, from research on new crop varieties for field beans, soybeans, and chickpeas to innovation in processing techniques. It is the largest government-funded initiative, and its collaborative approach helps to develop critical information on breeding and supports industry leaders in the development of processing technologies.

In addition to government subsidies, there are examples of private investments and public-private partnerships (PPP). One of these PPPs includes the collaboration with an impact fund that has committed to finance the investments needed to continue the Beanmeal, a project considered critical to increasing legume consumption according to stakeholders.

Challenges in long-term financial viability

Despite the availability of various subsidies and private funds, multiple interviewees expressed concerns about the long-term financial viability of legume cultivation. Interviewees advocated for more robust risk mitigation measures, like a pioneering premium or a risk fund, as a potential solution to encourage farmers to continue experimenting with legumes (as discussed in section 3.2.3.2).

Several experts emphasised the need for larger-scale, long-term government investment to truly support the legume sector, particularly in plant breeding research, as this forms a critical barrier. While the NES and Beandeal aim to increase legume cultivation, stakeholders expressed scepticism about the government's financial commitment to achieving this goal: "If the government really wants to achieve the 100.000 hectares of protein crops in the Netherlands, they will need to provide a substantial subsidy."[2] (C3) This highlights the gap interviewees perceive between the government's outspoken ambition and actual financial support.

Summary

Financial resources are available to support legume cultivation in the Netherlands, particularly through the EU's CAP, a national research project, and private funds. However, many interviewees question the viability of financially sustainable legume cultivation in the Netherlands. To support the legume sector, stakeholders advocate for a risk fund or pioneering premium to mitigate risk for farmers. Furthermore, stakeholders mention the need for more investment in plant breeding research.

4.2.5.2 Allocation of funding ●●●

The interviews indicate that substantial financial resources are currently allocated to alternative protein sources, such as cultured meat, insects, and algae. One actor (B1) stated: "I am not in favour of cultured meat. I see it as a step backwards and a foolish move. It is a very complicated and costly process that is difficult to implement on a large scale. I find it unfortunate that millions of euros are being invested in this when those funds could be better spent on legumes. The same goes for insects and algae." This quote reflects a broader concern among stakeholders that financial resources are not being allocated to more straightforward agricultural practices like legume cultivation.

Furthermore, as previously discussed, current funding mainly consists of cultivation subsidies directed to farmers. However, this system has proven to be ineffective as long as market demand is not sufficient. This is illustrated by the price reduction that occurred as a result of excess supply stemming from increased production driven by CAP subsidies, as discussed in the previous section (3.2.5.1). This illustrated that the reliance on subsidies can lead to an oversupply of legumes without a corresponding market demand, creating inefficiencies in the allocation of funding. Nevertheless, subsidies remain a contested topic among stakeholders.

Recommendations for allocation of funding

While some stakeholders demonstrated the disrupting effect subsidies can have on markets, several other stakeholders advocate for government subsidies, albeit in a different form. These stakeholders recommend directing away from general subsidies and direct support specifically at farmers who are willing to innovate and take risks in legume cultivation. Additionally, stakeholders recommend a more integrated approach to increase the effectiveness of research and funding initiatives across the agricultural sector, referring to the uncoordinated approach from provinces, resulting in similar research projects.

Summary

The current allocation of funding often favours alternative protein sources over legumes like cultured meat, insects, and algae. Additionally, the financial support directed toward legume cultivation is considered to be ineffective, creating market disruptions. Different government support and a focus on market demand are essential for fostering the adoption of legume cultivation in the Netherlands.

4.2.5.3 Material resources ●●●

The availability of material resources, such as farming equipment and seed technology, is a critical factor in the successful adoption of legume cultivation in the Netherlands. The results reveal that significant challenges persist regarding infrastructure, specialised machinery, and long-term investment in the required resources.

Access to specialised machinery and infrastructure

Several interviewees highlight the necessity for specialised farming equipment to successfully grow and harvest legumes. One respondent (B3) explained, "For kidney beans, you need a special harvesting machine, and there must be enough volume for it." This indicates that farmers require a certain scale of production to make such investments viable. Therefore, farmers may be reluctant to invest in the specialised machinery needed.

Another issue is the lack of infrastructure to support legume cultivation. One interviewee (F2) pointed out, "[In Zeeland] farmers have had brown beans in their crop rotation for years, and they are located

near a buyer. Therefore, it can thrive." This suggests that legume cultivation can be feasible when the infrastructure is present. The lack of transportation, storage, and processing facilities in the rest of the Netherlands might, therefore, form an obstacle to more widespread adoption.

Investments and long term-planning
One actor identified the role of subsidies in facilitating access to material resources by giving an example of a processing company that needed to acquire new material resources: "This subsidy can help processors who are transitioning from only processing sugar beets to also processing field beans. New machines are needed, and production lines must be rearranged." This emphasises the need for financial support to acquire the machinery and infrastructure needed for legume cultivation.

Long-term agreements between farmers and processors are considered essential for the development of a stable business model for legume cultivation. One respondent explained: "You do not tell a farmer to grow lupin for a year and then see what happens next year. A farmer may need different machines, extra investments, and knowledge." This illustrates the importance of long-term agreements. Farmers need stability to be able to invest in new equipment and technologies.

Summary
While some regions in the Netherlands have a well-developed infrastructure for the cultivation of legumes, other regions might lack the required machinery or proximity to processing factories. Financial support through subsidies and long-term business agreements are critical to overcoming these obstacles.

4.2.6 Creating legitimacy ●●○

The final system function on the innovation side is the level of legitimacy created within the MIS. This function evaluates the extent to which the socio-institutional environment supports solutions that contribute to the mission. To examine this function, the level of public awareness and support for the mission, media attention and advocacy, and the alignment with policy agendas will be assessed.

4.2.6.1 Public awareness and support for the mission ●●○

This indicator reveals a complex situation, with mixed levels of awareness and engagement among consumers. While there are ongoing efforts to promote legume consumption and its benefits, significant challenges remain in achieving widespread public support and awareness.

Limited public awareness
Several interviewees acknowledged the fact that legumes have been getting increasingly popular in the political and public discourse. Various policy plans and public campaigns were produced without significant results. One interviewee (C1) aptly said: "Beans are talked about more than eaten." This indicates that despite promotional efforts, legumes have not yet become a regular feature in Dutch diets. One participant (F1) explained that some legumes are still unfamiliar to many consumers, which poses a barrier to their adoption: "Lupine is an unknown product to the consumer."

Cultural and behavioural challenges
A major obstacle to increasing public support for legume cultivation are eating habits. One interviewee (B1) highlighted that the traditional Dutch meal consists of "potatoes, meat, and vegetables." Breaking this routine would be challenging: "The Dutch are used to potatoes, meat, and vegetables. If you remove

one of those three, something feels wrong. But I think it is just a matter of getting used to it." This suggests that changing consumer behaviour will require a shift in food routines. This is not an easy transition, as one stakeholder (F1) noted: "Changing consumer behaviour is the hardest thing there is. It takes a generation."[2]

Various initiatives try to raise public awareness of legumes, but their effectiveness is unknown. For example, the Beandeal and Beanmeal were mentioned as attempts to bring market players and the government together to promote legume consumption. However, besides various positive perceptions, there is also scepticism about their long-term impact: "I think the Beandeal brings some awareness, but it is questionable how much effect it will actually have." (C2)

On the other hand, some efforts were perceived as more successful. One stakeholder (B6) described the success of promoting lupine through collaboration with enthusiastic groups and promotional campaigns: "With lupine, there is a very enthusiastic group behind it, really pushing it forward." It concerned a collaboration between lupine cultivators and retail. Additionally, consumer research conducted by a stakeholder revealed that the Dutch public is increasingly interested in plant-based proteins, particularly when they are sourced in the Netherlands. Based on this insight, the farmer collective, the 'Protein Farmers, ' developed a label for their legume products to create public awareness about the origin of products (Appendix C).

The role of supermarkets in shaping consumer decisions

The role of supermarkets in influencing public awareness and product visibility was frequently mentioned (B3, B4, C2, C4, C5, G2, G3). Supermarkets are seen as key actors in promoting legume products to consumers. Several interviewees suggested that supermarkets have more power than the government in shaping consumer behaviour: "[A supermarket] is very good at influencing consumption behaviour. They are much better at it than the government." (B4)

Furthermore, interviewees discussed the placing of legumes in supermarkets. Stakeholders agree on the fact that they are currently placed in the wrong aisle, with the canned goods: "I want to introduce these products to a new target group. And that will not happen if they are in the canned goods section." (B3) Stakeholders did not unanimously agree on a solution to this issue. While some actors advocated for placing them in the vegetable section, others proposed placing them next to the meat section: "You should place legumes next to the meat, with recipe inspiration, and then you will get consumers to make the switch." (G3)

Summary

The results show that there is some public awareness and support for the mission of increasing legume cultivation, albeit limited. However, the adoption of legume consumption faces challenges due to cultural dietary habits and the unfamiliarity of some legume products. Despite that, initiatives like the Beandeal and collaborations between supermarkets and farmers show potential for increased consumer awareness.

4.2.6.2 Media attention and advocacy ●●○

The results show some advocacy and lobbying in favour of legume cultivation, primarily driven by specific organisations and coalitions. For instance, the farmer's collaboration with Protein Farmers is actively involved in promoting legumes. As one interviewee (C1) mentioned, "There is, for example, the producer organisation for protein farmers. They do some lobbying." The interviewee did not provide

details on the specific type of advocacy being conducted. Besides a general advocacy group for all legumes, there are crop-specific advocacy groups, such as the one focussing on lupine. Furthermore, lobbying takes place during high-level events, which brings together politicians and other stakeholders, as one actor (C3) explained: "They also organise [the event], where many politicians are present." Information about these efforts was limited, but it indicates that there is at least some lobbying.

Campaigns and promotional events
Several initiatives aimed to raise awareness and promote legumes in the Netherlands. Most prominently, of course, the Beandeal. As discussed previously, actors' opinions are divided on the effectiveness of these campaigns, as one stakeholder (C2) notes, "I think the Beandeal is bringing attention to it, but it's uncertain how much actual impact it has." Another key initiative is the Beanmeal, a weeklong campaign promoting legumes in several ways. The government and several other key stakeholders are involved, and interviewees believe it has the potential to grow significantly in the next few years if more large retailers join: "The Beanmeal has the potential to become something much bigger. We have high hopes that more retailers will join next year." (C3) The Beanmeal is seen as a promising project that could significantly accelerate the mission, as it brings together market players and the government. However, actors stipulate that "it could be a huge accelerator" (B4), indicating that its visibility is currently still limited.

Additionally, some stakeholders mentioned targeted campaigns for specific crops, such as Edamame, lupine, and chickpeas: "We have also been very busy with the promotion of Edamame. We are now also looking at Dutch chickpeas and field beans. I think we are doing the promotion quite actively, really trying to get the consumer excited. Both online and via magazines. For example, it works very well with lupine because there is a very enthusiastic group behind it, who really pull the cart." (B6) This suggests that campaigns can be effective if there is consistent promotion on multiple platforms and strong input from all actors involved.

Summary
There are several examples of media initiatives promoting legumes, but further development is required for more public awareness. While initiatives like the Beandeal and Beanmeal show potential, much of the promotional effort is still small-scale, and media visibility is relatively low. Interviewees stipulate the need for large-scale campaigns to shift food habits and increase public awareness of legumes. Again, the role of supermarkets in increasing public awareness and changing consumption patterns is underlined.

4.2.6.3 Alignment with policy agendas ●○○

The mission to promote the adoption of legume cultivation in the Netherlands shows a strong and inherent alignment with both national and European Union policy agendas. This alignment is apparent in key initiatives such as the national protein strategy, the Beandeal and the European CAP.

Nationally
At the national level, the Green Deal for Protein-Rich Crops (Beandeal) directly supports the mission. The Beandeal is the driving force behind the mission because it directly targets the increase of national legume cultivation by providing both political and practical support for this goal. It sets clear goals to reduce dependency on imported proteins, particularly by promoting the sustainable agricultural practice of legume cultivation. By doing so, this national policy framework offers a theoretical solid foundation for advancing legume cultivation across the Netherlands. Furthermore, the mission aligns with the

Netherlands National Protein Strategy (NES), which emphasises the need to increase the production of local legumes to enhance food security, reduce environmental pressures, and contribute to a sustainable protein transition. The document offers several alternative protein sources but explicitly mentions legumes as a critical crop for reducing nitrogen dependency and improving soil health.

European level

On the European level, the mission aligns with the broader agricultural and environmental objectives set by the European Green Deal and the CAP. Both policy frameworks emphasise the importance of transitioning to sustainable agricultural practices, with a specific focus on increasing the cultivation of legumes. Besides setting specific goals, the CAP (European Union, 2022) prescribes that "support for protein crops and legumes will increase by 25%," illustrating the alignment with the national mission. Additionally, the European Green Deal's Farm to Fork Strategy explicitly supports the diversification of crop production and stresses the importance of legumes in the EU to shift toward a more plant-based diet and sustainable agricultural practices.

Summary

The mission to increase legume cultivation in the Netherlands strongly aligns with both Dutch and European policy frameworks. It strives for the same goals as existing national initiatives, such as the Beandeal and the National Protein Strategy, and is strongly in line with the European Green Deal and the CAP.

4.3 Destabilisation side

To gain a comprehensive understanding of the development of the mission, the framework proposed by Elzinga et al. (2023) also incorporates an analysis of the degree of destabilisation of practices that obstruct the mission. Using the same structure as the corresponding innovation side functions, this section will examine the level of knowledge network breakdown, restriction of experimentation, market destabilisation, and resource withdrawal and assess if the innovation system is challenging the status quo.

As illustrated in Table 7, the destabilisation side functions were referenced considerably less often than the innovation functions. Three destabilisation functions were mentioned fewer than five times. Given the limited data available, these functions (i.e., knowledge network breakdown, restriction of experimentation, and resource withdrawal) are excluded from further discussion in this thesis due to insufficient evidence for robust analysis.

Given the limited data obtained from the interviews, the destabilisation-side functions will not be assessed through multiple indicators. Instead, each destabilisation function has been analysed using a single indicator to ensure meaningful evaluation. This method enables a more precise analysis while preserving the reliability of the results, even with limited data.

4.3.1 Unlearning ●●○

Unlearning involves getting rid of outdated practices and mindsets that obstruct progress toward the mission goal. By identifying such practices and mindsets, like the cultivation of conventional crops and livestock production, this function examines to what extent the innovation system is phasing out mission-obstructing knowledge.

Challenging dietary habits

One key barrier that needs to be unlearned, according to stakeholders, relates to consumer dietary preferences and cultural norms around food. As one interviewee (B1) noted: “Dutch people are used to potatoes, meat, and vegetables. If you remove one of those, it feels like something is missing. But I think it is just a matter of getting used to it.”[2] This quote underlines how deeply rooted eating habits, such as meat consumption, pose a challenge to introducing legumes as a mainstream dietary option. To achieve widespread adoption, consumers need to gradually shift away from these traditional meals. One participant (B4) suggested an ‘animal product tax,’ proposing that higher taxes on meat and dairy products could be effective. Another participant (B5) agreed on its potential effectiveness but argued that governments would not likely be willing to implement such a tax.

Economic and structural constraints

Another significant area where unlearning is required is in the existing agricultural supply chain. The agricultural system is currently structured around conventional ‘cash’ crops and livestock. Farmers are used to growing crops like potatoes, sugar beets, and onions. These crops are significantly more profitable than most legume crops. One farmer (F2) noted the issue of this system: “Farmers are used to a certain crop rotation, and as soon as there is demand for a particular product, they will grow it. But the current system, dominated by large seed suppliers and fixed price agreements, makes it difficult to introduce new crops like legumes.” This quote indicates that stakeholders identify the structural problems within the system.

Resistance from the livestock industry

Another challenge relates to the interests of the livestock industry, a sector that is very dominant in the Dutch agricultural system. The strong political and economic power of dairy and meat production creates significant resistance to change. As an interviewee (B1) pointed out: “We need to eat less meat, and the government is slowly starting to make that move. But this is happening very slowly because there are huge interests in dairy farming.” This shows that unlearning is also required at the policy level because incumbent interests in the livestock sector delay the mission goal.

Summary

Stakeholders have identified several practices that obstruct the mission's success. Among them are ingrained dietary habits, the cultivation of conventional crops, and resistance from the livestock sector. These well-established practices and mindsets will be extremely hard to unlearn and will require continued efforts from actors across the entire system.

4.3.2 Knowledge network breakdown ●●●

This innovation system function assesses the deconstruction of knowledge-sharing networks on practices obstructing mission completion. As presented in Table 7, no references to this function were identified in the data. This absence of data may suggest that actors within the system are not actively engaged in dismantling knowledge networks, which hinders progress toward the mission. Therefore, the lack of attention to this function is interpreted as a significant barrier, as obstructive knowledge networks could form a barrier to the adoption of legume cultivation.

4.3.3 Restriction of experimentation ●●●

Similarly, this innovation system function was not mentioned in the gathered data. Interviewees primarily focused on innovative entrepreneurial experimentation (the innovation side) rather than on restricting experimentation of regime-supporting practices. This lack of attention to restrictive experimentation is interpreted as a significant barrier to the mission, as it limits system transformation.

4.3.4 Market destabilisation ●●○

For the level of market destabilisation, the role of the Corporate Sustainability Reporting Directive (CSRD) emerged as a key theme. This section will introduce the CSRD and illustrate its implications for the cultivation of legumes in the Netherlands.

CSRD

The CSRD is a transformative regulatory framework introduced by the European Union to enhance transparency and accountability in corporate sustainability practices. The CSRD requires that companies report on their environmental, social, and governance (ESG) impacts, which also include carbon emissions throughout the value chain, known as Scope 3 emissions. These emissions encompass all indirect emissions that occur along a company’s entire value chain, which the company does not directly produce. This means that large companies, including supermarkets, must now account for the environmental impact of their supply chain, creating an incentive to adopt more sustainable practices. For example, in the case of legumes, if Dutch supermarkets choose to source locally grown legumes instead of importing them from other continents, the transportation emissions would be significantly

reduced. Additionally, compared to other (animal) products, like meat and dairy, legumes have a lower overall carbon footprint, making them more interesting for supermarkets.

The CSRD has significant implications for high-emission sectors such as meat and dairy production. As one interviewee (C2) noted, supermarkets are now starting to analyse their entire product offerings for emission levels: “Supermarkets are suddenly starting to move. They are analysing their entire offerings and looking at how much CO2 they emit.” This has direct implications for legume cultivation, which is recognised as a more sustainable alternative to traditional animal-based products. The destabilisation of the meat and dairy sectors creates a unique opportunity for legumes to gain market share as a lower-emission alternative in the food supply chain.

Destabilisation of traditional agricultural markets
As mentioned earlier, the Dutch agricultural sector is dominated by high-value crops such as potatoes and sugar beets (“potatoes might yield 10 times more than field beans”), as well as meat and dairy production, because of the strong financial returns. However, with the increasing focus on sustainability through the CSRD, the financial gap might narrow. This aligns with the preferences expressed by stakeholders, who strongly advocated that “meat and dairy should be taxed and priced according to their true costs.” (B5). The CSRD encourages companies to move away from high-emission agricultural practices by creating financial disincentives. One interviewer (G3) noted: “The CSRD ensures that the [big industry players] want sustainability and transparency in the chain, and legume farmers can anticipate this.” This indicates that the CSRD can destabilise the current market, creating a potential chance for legume cultivation.

Summary
The CSRD is playing a key role in destabilising traditional agricultural markets in the Netherlands by shifting financial and regulatory incentives towards more sustainable practices. The CSRD’s emphasis on Scope 3 emissions puts pressure on high-emission sectors such as meat and dairy, creating opportunities for low-emission alternatives like legumes. With regulatory frameworks like the CSRD in place, legume cultivation will become more appealing for both farmers and retailers. However, while the CSRD is contributing to market destabilisation, it is not yet driving a major transition. Although the traditional meat and dairy market shares may gradually diminish, the shift towards legumes and other sustainable alternatives remains in its early stages.

4.3.5 Resource withdrawal ●●●

This innovation system function was also not mentioned in the interviews, as participants primarily focused on discussing the mobilisation of resources to support the mission. This focus on resource mobilisation, rather than the active reallocation of resources or infrastructure away from obstructive practices, indicates that resource withdrawal remains an overlooked area. The absence of efforts to withdraw resources from mission-obstructing practices suggests this function forms a significant barrier to the mission.

4.3.6 Challenging status quo ●●●

This function evaluates whether the innovation system effectively challenges the desirability of practices that hinder mission progress by raising awareness of the associated societal issues. It also

examines the extent of lobbying efforts against these harmful practices and assesses whether the influence and power of incumbent stakeholders who support such practices are being mitigated.

Market and consumer shifts

The cultivation and promotion of legumes face challenges due to consumer preferences. Legumes are not yet mainstream in the Dutch diet, and cultural habits around food need to evolve. As one participant (B2) stated, "You can eat legumes directly, but something has to change. The Dutch are used to potato, meat, and vegetables. If you take one of those away, something feels wrong. But that is just a matter of getting used to it; I think."2 This illustrates the necessity of changing consumers' dietary preferences as part of challenging the status quo to achieve widespread legume cultivation.

Disrupting the supply chain and financial models

The existing agricultural system also presents challenges because of its traditional crop rotations and established supply chains. Farmers are stuck in a system where they depend on agricultural cooperatives and are bound by financially precarious contracts. One interviewee (B2) highlighted the financial pressures faced by farmers, noting, "What I notice with these farmers is that they really want to break free from the system they are currently in. This system is where large corporations supply seeds, pesticides, and advice, requiring farmers to pay upfront but only receive payment after the entire harvest. There are fixed price agreements, and if the harvest is poor, it is the farmer who suffers. The risk falls entirely on them, and they would prefer to reposition themselves differently within the value chain." Another stakeholder (C4) expressed a similar sentiment about breaking down existing supply chains: "The negative sides of this system are becoming more known, so we need to slowly move towards dismantling those supply chains." Among the stakeholders, there is a growing recognition that the status quo of the current system is unfavourable for farmers in general and legume cultivation in particular. However, steps to dismantle these chains are challenging and unsubstantial.

The role of CSRD

As with market destabilisation, the CSRD similarly plays a significant role in challenging the status quo. The transparency created by the CSRD disrupts existing business practices (i.e., the status quo) by forcing companies to account for emissions from their entire supply chain. For more information on the role of CSRD, see section 4.3.4.

Summary

Legume cultivation faces significant challenges, mainly due to the dominance of the meat and dairy industries, incumbent agricultural practices, and established consumer preferences. Promising developments, like the CSRD, make companies take responsibility for supply chain emissions. As stakeholders indicated, challenging the status quo within this MIS calls for more disruption of existing supply chains and increased political advocacy to drive systemic change.

4.4 Summary of the results

This section briefly presents the key results of each analytical step of the MIS analysis.

4.4.1 Problem-solution diagnosis

This sub-section presents the identified problems, solutions, and the interactions between different solutions.

The analysis of the policy documents and interviews revealed the following key problems contributing to the limited adoption of legume cultivation in the Netherlands (in random order):

- Economic viability for farmers
- Agronomic challenges (particularly regarding plant breeding)
- Market demand and consumer awareness
- Limited engagement of retail
- Infrastructure and supply chain issues

The solution paths that contribute to the overarching goal of scaling up domestic cultivation (in random order):

- Crop optimisation and knowledge development
- Creating shorter value chains (particularly to enhance the economic opportunities of farmers)
- Implementing supportive policies and financial incentives (to mitigate risk for farmers)
- Promoting consumer awareness and demand
- Enhancing processing infrastructure

Interaction between solution pathways is mostly symbiotic (e.g., the development of higher-yielding crops and the creation of better economic positions of farmers) or neutral (e.g., crop optimisation and promoting consumer awareness) in nature. One issue of contestation among stakeholders was found. While most actors favoured the production of high-quality legume crops for human consumption, plant breeding companies preferred the path of bulk production for animal feed due to the available larger market.

4.4.2 Structural analysis

In line with Elzinga et al. (2023), the number, type, and composition of actors have been examined. To delineate the MIS, this study exclusively focused on actors involved in the Beandeal. These actors represent all stakeholders actively involved in the mission. Additionally, interviewees (B3, G1) suggested limiting the focus on these actors, as they are the key players in the transition.

In total, 72 actors across the value chain are involved in the MIS. The MIS is characterised by a diverse set of actors, from farmers (represented by the Protein Farmers network) to food processing companies, non-governmental organisations, financial institutions, research institutions, and government bodies. Although retail was technically represented in the MIS, the active engagement of big retailers was lacking. The MIS includes several smaller coalitions, with actor groups of 3-7 that work together on various projects (e.g., creating knowledge platforms, crop-specific research, and public awareness campaigns). The MIS is characterised by a diverse composition, with no single actor having too much power, creating a balanced collaboration.

4.4.3 Functional analysis

The results of this study reveal mixed outcomes across the various innovation system functions evaluated for their role in promoting legume cultivation in the Netherlands. Lower scores show areas where the MIS functions as a facilitator with minimal barriers, while higher scores highlight challenges that should be addressed to achieve goals. A summary of each function score and justification for that score is presented in Table 9. The programming functions present low to medium barriers. This also applies to the innovation system functions, supported by sufficient data enabling critical and detailed analysis. In contrast, the destabilisation functions represent the most significant barriers to adopting legume cultivation in the Netherlands. Figure 3 graphically illustrates the contrast between the innovation and destabilisation sides. However, it is essential to note that data on destabilisation functions was scarcer, with three functions receiving insufficient references for a meaningful analysis.

Table 9 Overview of the results of the functional analysis, including the function, score and rational

Function	Score	Rationale
Programming		
Providing problem directionality	●●○	• There is a shared level of consensus among actors about the urgency of the mission • Several key problem areas are identified, but consensus on which problem to prioritise is lacking • Support from a wide range of stakeholders across the value chain, but the absence of retail remains an issue
Providing solution directionality	●○○	• Two strategic policy frameworks have initiated the mission, set ambitious targets, and brought a diverse range of stakeholders together • The solution pathways primarily interact in symbiotic or neutral ways, all contributing to the overarching mission goal • Stakeholders align themselves via various networks and coalitions
Coordinating the transition	●●○	• A broad diversity of stakeholders is engaged in coordination, except for supermarkets. No “real” leadership but fragmented coalitions • Coordination mechanisms such as the Beandeal lack formal structure and monitoring mechanisms to ensure commitment • Funding and resource allocation for coordinating the mission is very limited
Innovation		
Knowledge development	●●○	• The MIS is characterised by numerous and diverse R&D initiatives across the value chain. However, limited research on plant breeding remains a barrier • Cross-sectoral collaboration among farmers, industry, and governments to develop knowledge is widespread
Knowledge diffusion	●○○	• High frequency of knowledge dissemination via various mechanisms • Knowledge is accessible through networks, organised platforms, and media. However, visibility may be restricted, and certain information is accessible only through a paywall • High diversity of knowledge dissemination methods, including both formal and informal approaches, as well as digital and traditional channels
Entrepreneurial experimentation	●●○	• There is a wide range of diverse experimentation initiatives. However, these initiatives remain relatively marginal • Effective risk mitigation mechanisms are absent, and there is a lack of support for taking risks • High level of cross-sectoral collaboration in entrepreneurial experimentation

Market formation	●●○	• Niche markets are emerging, particularly for chickpeas, field beans, lupine, and edamame. However, challenges persist • Consumer awareness and demand remains a key issue • The absence of retail is a critical barrier to market formation • The formation of value chains is progressing, albeit gradually
Resource mobilisation	●●●	• Although subsidies are available for legume cultivation, actors highlight the ineffectiveness of these financial systems. Additionally, financial support for plant breeding is lacking • The allocation of funding within the protein transition is to be considered infective • Regarding infrastructure, some regions might lack the required machinery or proximity to processing factories
Creating legitimacy	●●○	• There is limited public awareness and support for the mission. Cultural and dietary habits pose challenges to the widespread adoption • Public and private campaigns aim to overcome this barrier, but the effectiveness of these strategies is unclear • The mission aligns with broader European and Dutch policy agendas
Destabilisation		
Unlearning	●●○	• Several mission-obstructing practices have been identified, including ingrained dietary habits, cultivation of conventional high-value crops, and resistance of the incumbent livestock sector • These are well-established practices, requiring continued destabilising efforts
Knowledge network breakdown	●●●	• The lack of data for the function suggests actors are not actively involved in dismantling mission-obstructing knowledge networks
Restriction of experimentation	●●●	• The lack of attention to the restriction of experimentation is interpreted as a significant barrier, as it hampers system transformation
Market destabilisation	●●○	• The level of market destabilisation is characterised by the new CRSD legislation • The CSRD makes legumes more appealing for Dutch farmers and retail, with the potential for transformative change • However, the CSRD is still in its early stages of implementation, and its effectiveness remains to be demonstrated
Resource withdrawal	●●●	• Resource withdrawal is an overlooked area, suggesting this function remains a significant barrier
Challenging status quo	●●●	• The dominance of meat and dairy industries, entrenched agricultural practices, and consumer preferences pose significant barriers to challenging the status quo • Initiatives like the CSRD show potential by holding companies accountable for supply chain emissions, but its impact is unclear • Stakeholders highlight the need for more substantial disruptions to existing supply chains and more political advocacy to challenge the status quo effectively

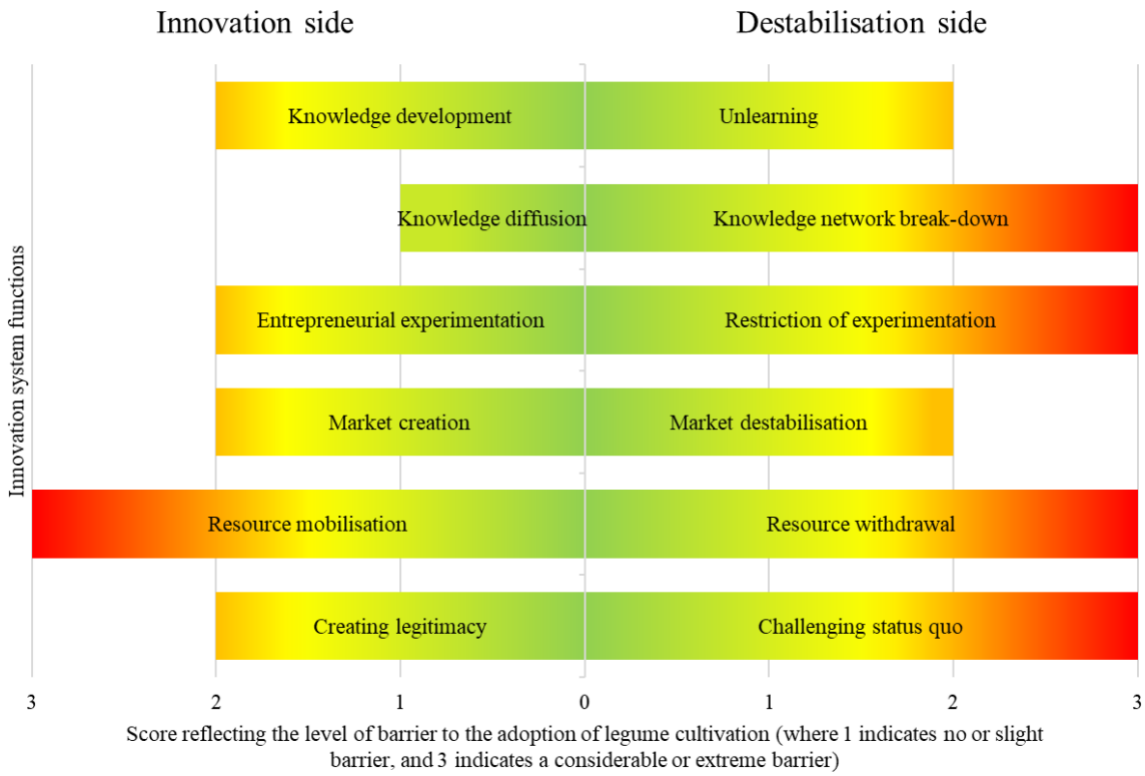

Figure 3 Stacked bar chart illustrating the performance of innovation and destabilisation system functions, indicating barriers and enables to the adoption of legume cultivation in the Netherlands

5. Discussion

This chapter will first interpret the results presented in the previous chapter, reflect on these results with the literature presented in the theoretical chapter, and discuss the theoretical contributions of this thesis. Then, policy implications will be discussed, followed by the limitations of this study.

5.1 Theoretical implications

This section reflects on the results by examining it with theoretical expectations and discusses the theoretical contributions to the MIS and MAIS framework.

5.1.1 Reflection on the results

The results will be discussed following the analytical steps outlined in the MIS framework, with each step critically compared to the literature reviewed in the theoretical chapter.

The problem-solution diagnosis

The solution paths identified in this study primarily illustrated symbiotic and neutral interactions (Sandén and Hillman, 2011), indicating a low level of contestation in the MIS (Hekkert et al., 2020; Wanzenböck et al., 2020). Since the ability of a MIS to address societal challenges is considered greater when contestation is minimal (Janssen et al., 2021; Parks, 2022). this finding suggests that the interactions between solution pathways in the MIS positively influence its capacity to drive societal change. Since consumer awareness and demand present significant challenges to the widespread adoption of legume cultivation and consumption, the low level of contestation is particularly helpful, as solution paths that require behavioural change often add extra complexity (Mazzucato, 2016). Furthermore, the clear and time-bound goal set out in the NES (cultivation legumes on 100,000 hectares in 2030) is in line with Janssen et al. (2021), who emphasise that such a target has a mobilising and aligning effect.

Contrary to the literature on MIP (Mazzucato, 2018) and transformative innovation policies (Weber and Rohracher, 2012), which emphasise the importance of strong directionality in aligning diverse stakeholders, this study found that low levels of contestation can still occur with relatively weak directionality. This may be explained by the high level of bottom-up experimentation within the MIS, which can mitigate contestation (Bergek et al., 2008). However, as strong coordination and leadership can foster the emergence of synergies between solutions (Elzinga et al., 2023), the absence of strong directionality may hinder or diminish these synergies, thereby slowing the adoption of legume cultivation.

The structural analysis

Mapping the number, type, and composition of actors involved in the mission revealed a broad diversity of actors, including public and private stakeholders, innovative newcomers, and more powerful incumbents. The results align with suggestions by Elzinga et al. (2023), who emphasise the importance of a balanced set of stakeholders to enhance system effectiveness. Additionally, the literature suggests empowering ‘the willing’ to limit potential domination by powerful incumbents (Christoff, 2006; Loorbach, 2010; Kattel and Mazzucato, 2018). The findings indicate that this approach has been successfully implemented, as many newcomers are actively participating in the mission, forming coalitions, and driving innovative projects. Furthermore, while powerful incumbents are involved, they

appear not to dominate the discourse. The involvement of these incumbents can be beneficial for providing resources for scaling and system transformation (Geels, 2021). However, the absence of incumbents can severely hamper mission progress (Elzinga et al., 2023). This is illustrated by the absence of powerful retail actors and plant breeding companies, which forms one of the critical barriers to the widespread adoption of legume cultivation in the Netherlands

Moreover, the findings showed that some actors have taken on leadership roles within the MIS, which results from the natural division of roles. This could make it easier to set directions than when a diverse group of actors with different visions and ideas must decide collectively (Pel et al., 2020). Finally, Elzinga et al. (2023) caution against governments setting overly ambitious goals, as this poses the risk of actors unwilling to engage in the mission. Several actors have expressed concerns, stating that the goal of achieving 100,000 hectares of legumes by 2030 is entirely unrealistic, questioning why the government would set such an unattainable target. The actual impact of this target on actor involvement is difficult to measure. However, it is essential to consider that such an ambitious target may have discouraged the engagement of key stakeholders.

The functional analysis

This section outlines the most significant findings of the functional analysis, structured according to the MIS framework. It begins with exploring the mission arena, continues with a discussion of the innovation side, and concludes with the destabilisation side.

Solution direction within the mission reflects the concept outlined by Elzinga et al. (2023), who describe campaigns as tools to promote specific solutions, and by Wanzenböck et al. (2020), who define this process as solution directionality. Initiatives such as the Beandeal, which focuses on increasing the cultivation, processing, and consumption of legumes, and the Beanmeal campaign, which markets legumes through supermarkets, caterers, and producers, serve as clear examples of efforts to align stakeholders around these targeted solutions. These initiatives target systemic change in the agricultural sector and shifts in consumer behaviour. By addressing supply and demand simultaneously, they ensure alignment among stakeholders and increase the mission's effectiveness. Moreover, the results indicated that monitoring mechanisms were absent, highlighting a lack of reflexivity that could impede mission progress, as reflexivity helps actors assess whether solutions are effective (Wanzenböck et al., 2020; Weber and Rohracher, 2012). Additionally, this lack of reflexivity may have contributed to limited commitment from actors, further hindering the mission's effectiveness.

Regarding the innovation side, the importance of the Protein Farmer organisation in bringing together actors and thereby enhancing mission progress should be underscored. This aligns with Kivimaa et al. (2019), who demonstrated that intermediaries, by facilitating collaboration and orchestrating interactions, play a critical role in strengthening alignment and generating the momentum needed for system transformation. Several coalitions play a significant role in shaping the MIS. Some of these coalitions have emerged through actor collaborations facilitated by the Beandeal, while others have developed independently. These coalitions are key in advancing specific solutions, fostering synergies across diverse trajectories and stakeholders, thereby accelerating the transition (Elzinga et al., 2023). The findings highlight the presence of several coalitions promoting different crops, including lupine, chickpeas, and soybeans, each contributing to the progress of the transition. Overall, the innovation side demonstrated relatively strong performance, with many actors engaging in experimentation and innovation (Sengers et al., 2021), with resource mobilisation being a notable exception. However,

several significant barriers persisted across most functions, hindering the effective adoption of legume cultivation.

To enable a comprehensive assessment of the MIS's ability to achieve system transformation, the analysis included an examination of the destabilisation side, as traditional innovation systems insufficiently addressed this aspect (Fuenfschilling and Truffer, 2014). The results indicated that actors, primarily farmers, are stuck in existing supply chains, illustrating the need for regime transformation. Currently, actors try to transform supply chains from inside the system, aligning with insights from Turnheim and Geels (2012). Additionally, the destabilisation side focused on social, organisational, and institutional dynamics, as suggested by Markard (2020), who observed that these aspects are often overlooked in classical innovation systems. This approach proved valuable, revealing that entrenched dietary habits represent a significant barrier to the widespread acceptance of legumes. Finally, it is crucial to acknowledge that participants have relatively overlooked the destabilisation side. This lack of attention poses a significant barrier to the adoption of legumes in the Netherlands, as destabilising the existing system is essential to create space for new practices.

Final reflections and insights

The application of the MIS framework has proven to be a valuable tool for examining the adoption of legume cultivation in the Netherlands. It effectively mapped diverse solution pathways, identified the actors involved in the mission, and analysed the coalitions they formed. Additionally, the framework provided a structured approach to assess the performance of the mission arena, which is responsible for coordinating the mission, as well as the innovation and destabilisation aspects of the system.

The overall structure of the MIS aligns well with the requirements outlined in the literature for an effective system. It features a diverse group of stakeholders, including both newcomers and incumbents, which enhances the potential for innovation and systemic change. The government has played a vital role by setting clear goals and providing two strategic frameworks that brought actors together and fostered the creation of coalitions, thereby enhancing the mission's effectiveness. However, these frameworks lacked sufficient structure and reflexivity, making them too non-committal to ensure actor engagement and mission progress.

Despite these strengths, significant barriers remain. The absence of suitable plant varieties and limited research on plant breeding are critical obstacles to the widespread adoption of legume cultivation. Additionally, the lack of retail actors within the MIS restricts progress, as their involvement is essential for bridging the gap between production and consumption.

Another critical issue is the limited attention to destabilising the existing agricultural regime. This aspect, crucial for creating space for new practices, has been largely overlooked by participants, highlighting a significant barrier to mission success.

In line with Mazzucato (2018), it can be concluded that this mission would benefit from stronger coordination and a more inclusive approach. Mechanisms to ensure reflexivity are essential, alongside the inclusion of retail stakeholders and increased investment in plant breeding research. Addressing these challenges would significantly enhance the progress and effectiveness of the mission to increase legume cultivation in the Netherlands.

5.1.2 Theoretical contribution

This study makes several theoretical contributions by enhancing the understanding of MAIS and applying the analytical MIS framework developed by Elzinga et al. (2023). It addresses theoretical gaps in the literature by following key suggestions by Klerkx and Begemann (2020) and Kok and Klerkx (2023).

First, the research focuses on analysing a MAIS, specifically, the Netherlands' mission to increase legume cultivation. Following Klerkx and Begemann's (2020) suggestion to study MAIS to better understand the dynamics of transformative food system changes, this study examined how systemic forces, actor interactions, and governance processes influence the progress of this mission. For example, the research examined the alignment of actors such as farmers, agribusinesses, and researchers, revealing how their strategies and networks interact to drive or hinder systemic change.

Second, this research operationalises the novel analytical MIS framework by Elzinga et al. (2023) to examine the structural and functional dynamics of the MAIS. The study conducted the three analytical steps proposed by Elzinga et al. (2023) to analyse the structure and performance of the MAIS. The analysis focused on both innovation and destabilisation within the system. For instance, the functional analysis highlighted how knowledge diffusion acted as a facilitator, while most destabilisation functions, such as restriction of experimentation and resource withdrawal, posed significant barriers to adopting legume cultivation. These findings illustrate the framework's capacity to capture both drivers and barriers of systemic change, illustrating its relevance for studying mission-oriented transitions in agriculture.

Third, by mapping the governance and power dynamics within the MAIS, this study addresses the research suggestions proposed by Kok and Klerkx (2023). The study examines what actors make up the structure of the MAIS and how these actors interact, and it assesses the contestation between different solution paths. Findings show that intermediary organisations play a crucial role in aligning stakeholders, contributing to a better understanding of how MAIS work in practice.

In summary, this research contributes to theory by analysing a MAIS using the analytical MIS framework. Applying theoretical concepts to a real-world issue provides valuable empirical insights that contribute to this emerging and developing research area.

5.1.3 Suggestions for future research

Several opportunities for future research directions on MAIS have emerged. First, comparative studies in other countries could explore how contextual differences influence the dynamics of MAIS, improving the generalisability of the framework. Second, research could focus on the destabilisation side of transitions, as this study gathered limited data on the destabilisation functions. More research on this aspect of MIS can shed light on the importance of destabilisation in achieving regime transformation. Third, the role of key actors in MIS could be investigated, as this study found that the absence of retail had major impact on MIS performance, i.e., the adoption of legume cultivation. Research on the role and influence of key actors could help to create more effective MIS. Finally, more research is needed on the long-term impact of missions. Longitudinal studies would be helpful for understanding how transitions develop over time and assess their long-term impact.

5.2 Policy recommendations

Following the results, the following policy recommendations have been developed to enhance the adoption of legume cultivation in the Netherlands:

- Empower and expand the role of the Beandeal
    - To enhance the effectiveness of the Beandeal, its role needs to be strengthened to ensure systemic progress. Providing the Beandeal with additional resources and authority would enhance its capacity to coordinate key actors, such as retailers, who may become more willing to engage in the mission. Improved coordination would facilitate collective action and align efforts across the supply chain. Additionally, monitoring of actions needs to be increased to ensure the reflectivity of solutions and allow for adaptive governance. This would include periodic evaluation of progress and gathering feedback from stakeholders. These insights would inform adjustments to strategies to ensure they stay aligned with mission goals while also addressing emerging challenges.
- Establish a risk mitigation strategy for farmers
    - To mitigate economic, technical, and market risks for farmers, a strategy could be a government-backed risk fund to cover potential income losses. This would offer subsided crop insurance for farmers to manage yield and price variations. By mitigating these risks, farmers can be encouraged to adopt legumes in their crop rotation.
- Support and finance research in plant breeding
    - The limited availability of legume varieties suited to the Dutch climate remains a significant barrier to achieving higher yields and profitability. Plant breeding companies are reluctant to invest due to the niche market for these varieties. Government investment in research is essential to develop legume varieties that are high-yielding, well-adapted to local climatic conditions, and resistant to prevalent diseases. Collaboration between research institutions, farmers, and processors is vital to ensure the development of varieties that align with practical farming needs and meet consumer preferences for taste and quality.
- Enhance public awareness of legumes
    - Increasing consumer awareness is key to driving demand for legumes. The Beanmeal provides an initiative that could be expanded and strengthened. Expanding the Beanmeal through partnerships with retailers, media campaigns, and food industry players can enhance its impact. This would help make legume consumption more common, boost consumer demand, and support mission progress.
- Fostering supply chain development
    - The CSRD already plays an important role by requiring businesses to analyse their supply chains, offering an opportunity for locally cultivated legumes. However, reflexive governance is necessary to monitor the CSRD and ensure effectiveness.

These recommendations are designed to address the systemic barriers identified in the study. By empowering institutions like the Beandeal, providing risk mitigation for farmers, and enhancing research and public awareness, these recommendations would enhance the adoption of legume cultivation in the Netherlands.

5.3 Limitations

The study acknowledges several limitations that could affect the reliability, validity, and comprehensiveness of the findings.

5.3.1 Reliability

One of the critical limitations affecting the reliability of this study is the potential bias in participant selection. Most interviewees were engaged in, or focused on, the innovation side of the MAIS, such as experimenting with new legume varieties or creating niche markets. As a result, the participants underrepresented the destabilisation side. This imbalance may limit understanding of the factors destabilising the system by overlooking challenges in dismantling mission-hampering practices. Additionally, while the 18 interviews were conducted with a diverse set of stakeholders, they may not encompass and represent all stakeholders involved in the mission. Notably, the absence of retail stakeholders, which was identified as a critical barrier to the widespread adoption and consumption of legumes, may have limited the study's ability to capture valuable insights from this key sector.

Second, the use of qualitative methods, such as policy document analysis and semi-structured interviews, comes with risks of subjectivity. While a systemic coding framework was employed to enhance consistency, the possibility of researcher bias must not be overlooked. However, the use of multiple data sources and enhance the reliability of the findings.

Lastly, it is important to acknowledge the temporal and contextual limitations of the research. As the analysis examines the MAIS at a particular point in time, it reflects the dynamics and performance of the system at that point. The approach does not capture changes over time, such as market dynamics, stakeholder involvement, or policy developments, which can influence the MAIS. Moreover, the study focuses specifically on the unique context of the Netherlands, which may limit the applicability of its findings to other regions with different socio-economic conditions or governance structures.

5.3.2 Validity

Regarding validity, the use of the novel MIS and MAIS frameworks presents a risk as there is limited empirical validation of these frameworks. While the study contributes to refining the frameworks, it is unclear whether they capture all relevant aspects of the transition. Moreover, while the use of a 3-point scoring system enhanced consistency and allowed for comparison, it may oversimplify the complex dynamics of the innovation system functions, reducing the nuance of the findings.

Second, while the two primary data sources, policy documents and stakeholder interviews, provide depth, they may not represent the system in a broad context. Specifically, the two strategic policy frameworks emphasise ambitious goals and strategies; this might lead to an overestimation of the alignment of actors and solution paths. Additionally, as noted in the previous section, the participants in the interviews may have been overly focused on the innovation side of the system. While this focus enables a comprehensive understating of the innovation efforts, it risks overlooking the destabilisation side, which is crucial for achieving system change. This might have resulted in an incomplete overview of the dual dynamics of the MIS.

Furthermore, the overrepresentation of actors involved in the destabilisation side might have led to a potential optimistic bias. A substantial number of interviews were conducted with actors who are highly enthusiastic about the potential of legume cultivation and intrinsically motivated to promote its adoption. While their insights provide valuable information about opportunities and innovations, this enthusiasm may have skewed the findings toward a more positive assessment of the system (particularly for assessment of problem-directionality).

Finally, as this study analysed a MAIS in the Dutch socio-economic, agricultural, and policy context, its external validity is limited. While the study provides valuable insights into the facilitators and barriers to legume adoption, these findings may not apply to other regions.

To conclude, the reliability and validity of this study are influenced by several critical limitations, including a focus on innovation over destabilisation and potential participant bias. However, these limitations also highlight opportunities for future research. Including a more diverse stakeholder group and testing the MIS framework in diverse contexts could enhance both reliability and validity. Despite these limitations, the research makes a valuable contribution to the understanding of the adoption of legume cultivation in the Netherlands.

6. Conclusion

This research aimed to answer the main research question: 'To what extent is the mission-oriented agricultural innovation system (MAIS), which targets the adoption and increase of legume cultivation in the Netherlands, progressing towards achieving its mission goal?' The study employed the analytical mission-oriented innovation system (MIS) framework proposed by Elzinga et al. (2023) and conducted the corresponding problem-solution, structural, and functional analyses. These analyses investigated diverse solution pathways within the mission, identified and mapped the key actors involved, and evaluated the system's performance through a systematic assessment of 15 innovation system functions. This comprehensive analysis identified key obstacles and facilitators, providing valuable insights into how the adoption of legume cultivation in the Netherlands can be advanced.

The results show that while significant progress has been made in aligning diverse stakeholders around a common goal, critical systemic barriers remain. Actors in the mission arena have a relatively clear overview of the challenges that limit widespread adoption, but consensus on which problem to prioritise is lacking. Several solution paths have been identified, all supported by different coalitions. Moreover, these solution paths interact in either a positive or neutral manner, collectively contributing to the mission's progress. Coordination efforts are promising, with strategic policy frameworks in place and active engagement of a variety of newcomers and incumbents. However, the effectiveness of coordination could be improved by additional funding and enhancement of monitoring mechanisms.

Innovation in the MIS is facilitated by effective knowledge diffusion through various networks and coalitions. Other aspects of innovation, such as entrepreneurial experimentation and market creation, demonstrate potential but still face certain challenges. The allocation of resources is identified as a significant barrier to innovation. The destabilisation side appears less promising for the adoption of legume cultivation, as the majority of functions are identified as significant barriers. This indicates that the mission is making limited progress in phasing out obstructive practices, which could restrain regime transformation and, thereby, mission progress.

To answer the research question, the MAIS is progressing towards its mission goal, albeit slowly. Progress is hampered by several systemic issues, such as the lack of strong coordination, insufficient allocation of resources, and the system's inability to destabilise the regime. To overcome these barriers, the MAIS could be strengthened by empowering coordinating actors and mechanisms, establishing risk mitigation strategies for farmers, supporting plant breeding research, and developing effective approaches to destabilise the obstructive regime.

In conclusion, this study contributes to the understanding of how mission-oriented approaches can support agricultural transitions. By identifying key challenges and offering strategies to address them, the study provides insights for policymakers and researchers to enhance the effectiveness of the MAIS. Addressing the barriers identified in this study can enable the Dutch government to refine and strengthen its MIP, promoting the adoption of legume cultivation in the Netherlands and thereby contributing to a more sustainable agricultural system.

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Appendix A. Operationalisation of the framework

Innovation system functions	Indicators	Scale (rating on a scale from 1 to 3, 1 = function forms no or a slight barrier, and 3 = function forms a significant barrier)
Programming functions		
Providing problem directionality	(1) Level of consensus on urgency (The extent to which actors agree on the urgency of adopting and diffusing legume cultivation in response to current societal or environmental challenges (e.g., climate change, soil health).)	(3) Little or no consensus; conflicting views on the importance or urgency of legume cultivation, (2) some level of consensus, but with notable disagreements or ambivalence, (1) strong consensus on the urgency of adopting and diffusing legume cultivation
	(2) Clarity of problem definition (The extent to which the problem (e.g., key boundaries to widespread adoption of legume cultivation) is unanimously recognised and agreed upon by actors.)	(3) The problem is poorly defined or ambiguous; multiple conflicting interpretations exist, (2) some agreement on the problem, but gaps in clarity or details, (1) the problem is clearly defined with wide understanding and agreement on its nature.
	(3) Support from key actors (The presence and activity of key actors (e.g., governments, research institutions, companies) driving the discussion around the adoption of legume cultivation.)	(3) Few or no key actors actively promoting legume cultivation, (2) some key actors involved, but inconsistent or not highly visible, (1) several key actors involved, which are highly visible and actively pushing for legume cultivation.
Providing solution directionality	(1) Provision of clear roadmaps or frameworks (Availability and clarity of roadmaps or strategic frameworks outlining the direction and milestones for innovation in legume cultivation.)	(3) No roadmaps or frameworks, (2) partial roadmaps or frameworks; some strategic goals and milestones are outlined but may lack detail or comprehensiveness, (1) comprehensive and clear roadmap or framework provided; detailed strategic goals, milestones, and timelines are well-defined and communicated
	(2) Level of consensus on solution direction (Extent to which interviewees express similar opinions or support for a solution or set of common solutions.)	(3) High level of disagreement or conflicting views on solutions, (2) moderate agreement on some solutions but still notable divergences, (1) strong consensus or alignment around a few key solutions.
	(3) Strategic coordination among stakeholders (Level of coordination and collaboration among different stakeholders (e.g., researchers, farmers, policymakers, industry) in providing a solution direction.	(3) Minimal coordination; stakeholders work in isolation with limited communication, (2) moderate coordination; some collaborative efforts and communication exist, but there are gaps in alignment, (1) high level of strategic coordination; stakeholders actively collaborate, share information, and align their efforts towards common goals.
Coordinating the transition	(1) Stakeholder engagement and coordination (The presence of coordinating actors (e.g., platforms, government) and the active involvement of key stakeholders (e.g., farmers, researchers, policymakers) in the transition process.).)	(3) No coordinating actors present, (2) some coordinating actors present, but limited in scope, (1) clear presence of coordinating actors actively structuring the transition
	(2) Effectiveness of coordination mechanisms (Quality and effectiveness of mechanisms used for coordination (e.g., regular meetings, workshops) and comprehensiveness of monitoring the transition process.)	(3) Little or no coordination, (2) moderate coordination and some monitoring, (1) highly effective coordination and well-established, formal systems for monitoring progress, facilitating meaningful collaboration

	(3) Funding and resource allocation for coordination (Level of funding allocated specifically for transition coordination activities (e.g., platforms, intermediaries, transition teams).)	(3) No dedicated resources, (2) some resources, but insufficient, (1) sufficient and well-allocated resources for coordination
Performance functions – Innovation side		
Knowledge development	(1) Level of research and development (Number and quality of ongoing R&D projects related to legume cultivation.)	(3) Limited or no R&D activities; few projects with minimal funding, (2) moderate R&D activities; several projects with reasonable funding and progress, (1) extensive R&D activities; numerous high-quality projects with substantial funding and clear results.
	(2) Collaboration across sectors (Level of collaboration between research institutions, industry stakeholders, and farmers.)	(3) Limited collaboration; few interactions between sectors, (2) moderate collaboration; some regular interactions and partnerships, (1) high level of collaboration; extensive and productive partnerships between research institutions, industry, and farmers.
Knowledge diffusion	(1) Frequency of knowledge dissemination activities (Number of stakeholder meetings, conferences, public consultations, and progress reports conducted within a given period.)	(3) Rare or no events (less than 1 event per quarter), (2) moderate frequency of events (1-2 events per quarter), (1) frequent and regular events (more than 2 events per quarter)
	(2) Accessibility of knowledge (The extent to which essential information is accessible to stakeholders.)	(3) Difficult to access (behind a paywall), (2) moderately accessible, (1) highly accessible (free and widely accessible)
	(3) Diversity of knowledge dissemination (The variety of methods used to share information with stakeholders (e.g., meetings, reports, digital media).)	(3) Limited channels for dissemination (e.g., only one type of meeting or report), (2) moderate range of channels (e.g., a mix of meetings, reports, and some digital media), (1) extensive range of channels (e.g., stakeholder meetings, conferences, social media, webinars, etc.).
Entrepreneurial experimentation	(1) Diversity and number of experimentation initiatives (Variety of experimental approaches and the number of distinct experimentation initiatives undertaken.)	(3) Few or no experiments, (2) some experimentation, but limited diversity, (1) diverse and numerous experimentation
	(2) Support for risk-taking and innovation (Availability and extent of support mechanisms (e.g., funding, mentorship) that encourage risk-taking and innovation.)	(3) Little to no support, (2) some support, (1) strong support for risk-taking and innovation
	(3) Collaboration in entrepreneurial experimentation (Degree of collaboration among different stakeholders (e.g., researchers, farmers, businesses) in conducting experiments and sharing results.)	(3) Minimal collaboration; experiments are mostly conducted in isolation, (2) moderate collaboration; some joint initiatives and sharing of results, (1) high level of collaboration; extensive joint experiments and robust sharing of results.
Market creation	(1) Emergence of niche markets (The extent to which niche markets for legume products are being established (e.g., local or organic legumes).)	(3) Little to no development of niche markets for legumes; market remains traditional and fragmented, (2) some niche market development, with a few actors entering; potential is recognised but not widespread, (1) significant niche market development; specialised markets and demand for legume products are growing.

	(2) Consumer awareness and demand creation (Recognition and demand for legumes driven by sustainability, health, or public campaigns.)	(3) Little to no consumer awareness or demand for legumes, (2) moderate consumer awareness with growing but niche demand, (1) widespread consumer demand and awareness across different demographics.
	(3) Involvement of key market actors (Involvement of supermarkets, wholesalers, and food processors in promoting and distributing legumes.)	(3) No involvement from major market actors, (2) some involvement (e.g., niche retailers), (1) strong involvement and support from key market players
	(4) Formation of value chains (Presence of well-established value chains from producers to consumers, including processing, distribution, and retail.)	(3) No or limited value chains established, (2) early-stage or fragmented value chains, (1) well-established, integrated value chains from production to market.
Resource mobilisation	(1) Availability of financial resources (The extent to which financial resources are available to support research, development, and implementation of solutions (e.g., subsidies, grants, private investment).)	(3) No or minimal funding, (2) limited funding, (1) ample funding with multiple sources available
	(2) Allocation of funding (How effectively are available financial resources allocated to priority areas (e.g., research, pilot projects, scaling solutions, market development)	(3) Poor allocation, with little strategic focus, (2) some allocation to important areas, but not fully aligned, (1) strategic and effective allocation of resources to key areas
	(3) Material resources (The extent to which material resources, such as modern farming equipment, seed technology, or irrigation systems, are accessible to support legume cultivation.)	(3) Limited or outdated material resources, (2) moderate availability of resources, (1) adequate and modern resources readily available
Creating legitimacy	(1) Public awareness and support for the mission (To what extent is there awareness and public support for the mission of increasing legume cultivation (e.g., understanding of environmental benefits, nutritional value))	(3) Little to no awareness or support, (2) moderate awareness but limited public engagement, (1) high public awareness and widespread support.
	(2) Media attention and advocacy (How much attention is the mission receiving in the media, and to what extent are advocacy groups (e.g., NGOs, interest groups) promoting legume cultivation?)	(3) No media coverage or advocacy, (2) some media attention and advocacy, (1) widespread media attention and strong advocacy efforts.
	(3) Alignment with policy agendas (How well does the mission align with existing national or European Union agricultural and environmental policies (e.g., CAP reforms, Green Deal)?)	(3) No alignment, (2) partial alignment, (1) strong alignment with supportive policies in place.
Performance functions - Destabilisation side		
Unlearning	(1) Identification of obsolete practices (The degree to which outdated or ineffective practices are identified and	(1) Obsolete practices are not clearly identified or acknowledged, (2) some obsolete practices are identified, but many remain unrecognised., (3) most or all obsolete practices are effectively identified and acknowledged.

	acknowledged as barriers to innovation in legume cultivation.)	
Knowledge network break-down	(1) Extent of knowledge fragmentation (The extent to which existing, mission obstructing, knowledge networks are being dismantled.)	(3) Minimal fragmentation, knowledge is largely shared and integrated, (2) moderate fragmentation, some gaps or disconnected areas are present, (1) severe fragmentation, significant gaps and disconnected areas impede effective knowledge sharing
Restriction of experimentation	(1) Regime reinforcement restriction (The extent to which the system limits or discourages innovations that reinforce the current dominant practices and structures within legume cultivation.)	(3) No restriction; the system actively supports innovations that reinforce the current regime, (2) moderate restriction; there are some measures to limit innovations reinforcing the regime, but they are not strongly enforced, (1) strong restriction; the system actively discourages and limits innovations that reinforce the current regime.
Market destabilisation	(1) Regulatory advantage removal (The extent to which existing regulations that favor traditional practices over innovative legume cultivation methods have been diminished or removed.)	(3) No significant changes to existing regulations that favour traditional practices, (2) some regulations have been adjusted or removed, but significant advantages for traditional practices still exist, (1) major regulatory changes have been made that significantly diminish or remove advantages for traditional practices.
Resource withdrawal	(1) Resource reallocation (Measures how effectively resources (financial, human, or physical) are being redirected from less effective practices to those that support legume cultivation.)	(3) Little to no effective reallocation; resources are still heavily invested in practices that hinder mission completion, (2) moderate reallocation; some resources have been redirected, but significant investments remain in obstructive practices, (1) high effectiveness; resources have been substantially reallocated away from obstructive practices towards those that enhance legume cultivation.
Challenging status quo	(1) Awareness raising (The extent to which interviewees believe that efforts are made to raise awareness about societal problems associated with current practices hindering legume cultivation.)	(3) Minimal or no awareness-raising; issues are largely ignored or downplayed, (2) moderate awareness; some efforts to highlight societal issues, but not widely recognised, (1) high awareness; concerted efforts to make societal problems well-known among stakeholders and the public.

Appendix B. Illustrative examples of indicators

Innovation system functions	Indicators	Example reference
Programming functions		
Providing problem directionality	(1) Level of consensus on urgency	"If we look at the legumes, the protein transition is one of our strategic themes. In recent years we have fully committed to that to be ready for the future as a company."
	(2) Clarity of problem definition	"The biggest problem is actually that supply and demand are not well matched. As a farmer you have no guarantee that your product will be purchased, while you are taking big risks."
	(3) Support from key actors	"The big retailers did not get involved at the start of the Beandeal."
Providing solution directionality	(1) Provision of clear roadmaps or frameworks	"I think the Beandeal and Beanmeal are great examples of how it does work. You are going to bring market parties and government together. I do believe that this will have a stimulating effect."
	(2) Level of consensus on solution direction	"The breeders for example, right at the beginning of the chain, believe much more in the track for the animal feed. They argue that if you get the animal feed going, the costs will go down, hey, and then human consumption will follow. So, everyone has their own motivations and their own vision." "I think there is one overarching vision: simply more proteins from Dutch soil."
	(3) Strategic coordination among stakeholders	"We do not negotiate with each farmer individually, but with the group. We ask: what is needed to make this a financially sustainable cultivation?"
Coordinating the transition	(1) Presence of coordinating actors	"There is no coordination. Everyone does what they want to do, but in a good way. I try to keep an eye on what is going on." "I think it is also too big to coordinate. The government cannot tell a large processor or retailer what to do."
	(2) Effectiveness of coordination mechanisms	"The complicated thing is that the Beandeal is actually nothing. We are not an organisation, we have no money. We have just connected stakeholders with each other under a common goal. Parties have written down goals, but I have never been able to contact some parties, then they are probably not working on their goals either. It is too non-committal."
	(3) Funding and resource allocation for coordination	"The beandeal is not an organisation or anything, it can't make payments for example. So, there is very little financing." "And that just shows: money is needed. Transition money. Then you can still discuss whether this should come from the government or not. This is another part where there is no consensus. One person thinks that this should come from the government, and the other thinks that it should come from the market."
Performance functions – Innovation side		
Knowledge development	(1) Level of research and development	"The cultivation has almost completely disappeared from the Netherlands in the past three decades. And with that, the knowledge has been lost. That is why there is a need among farmers to talk to each other about very simple things. By bringing together all that knowledge from all those different farmers, we now know relatively much." "With lupine you see bottom-up knowledge development." "Many experiments are being conducted; this is often done on experimental farms."

	(2) Collaboration across sectors	"Yes, many tests are done, this is often on test farms. This is often done with sounding boards. There are many different stakeholders in these, including growers." "That is the beauty of chain collaboration, to look together at how you can best improve and remove the bottlenecks. A kind of shared R&D. Doing research together."
Knowledge diffusion	(1) Frequency of knowledge dissemination activities	"Each quarter, the different parties of the Beandeal come together to discuss the progress."
	(2) Accessibility of knowledge	"They have a website with information on legumes ready behind the scenes, but it is not published yet. Because to maintain this, quite a bit of money is needed, and that has to be provided by the researcher."
	(3) Diversity of knowledge dissemination	"As a company we make promotions. We do this with our customers, the retailers and we support this through various channels such as television and social media. We do this for various legumes. Consumers can also find recipes on our website and via a QR code on the packaging." "There is a lot of interesting information in there, which I then bundle into the newsletter." "Trade media are important, magazines."
Entrepreneurial experimentation	(1) Diversity and number of experimentation initiatives	"There is a lot of experimentation going on, but it is all quite marginal." "We always start with trial fields. We have introduced a number of new beans in the last few years, such as kidney beans, white beans, black beans."
	(2) Support for risk-taking and innovation	"From the EU's CAP, legumes are eligible for subsidy via the eco-scheme. That is positive for the legume. I wonder if that is smart." "Cultivating lupine is very risky. Last year, for example, eight of us grew lupine on 10 ha, but in the end, we could only harvest 2 ha. There is no risk fund for this."
	(3) Collaboration in entrepreneurial experimentation	"An example is the partnership we have with a certain farmer. We have been growing various crops with him for 20 years. Lupine has recently been added to that. We do not need to find a new farmer for this, but based on our mutual trust, this farmer dares to take such a step." "We are working towards a very nice announcement of a collaboration between a large Dutch supermarket and Edamame growers."
Market creation	(1) Emergence of niche markets	"There are now seven farmers who grow chickpeas for us. We were already producing humus, but at first, we imported the chickpeas. Now we get all the products from the Netherlands. We went from 10% to 100% in one year." "Edamame sales have quadrupled in the Netherlands over the past 10 years. This is a valuable insight." "Look, you are building a market, and it has been quite successful over the years, but it is still very small, it's still a niche market."
	(2) Consumer awareness and demand creation	"What we see is that there is little demand for legumes." "Critical is that consumer behaviour will change. But that is the hardest thing there is. That takes a generation." "Ultimately, it is possible to grow legumes here, but you also have to look at consumer behaviour. You can want to grow many things, but you also have to have a market for them."
	(3) Involvement of key market actors.	"The big retailers did not get involved at the start of the Beandeal."

	(4) Formation of value chains	"You can try to shorten the chain. We are currently doing a test with that. We grow soybeans at a farmer and they are also processed there. And then it goes directly to a restaurant." "Secondly, you need strong chains. Focused on the processing of a Dutch product." "By shortening that chain and also allowing the farmer to move up in that value chain, they gain more control, more flexibility to play with risks and get better financial results"
Resource mobilisation	(1) Availability of financial resources	"[a agricultural cooperative] also has money and resources to invest in things." "On the other hand, you have the CAP. From this, farmers receive subsidies, for example for growing legumes."
	(2) Allocation of funding	"There is a huge amount of subsidy spent on meat substitutes, for example. Millions and millions of euros are invested, and I think that is a shame. Then you can better spend that money on legumes."
	(3) Material resources	"For the kidney beans you need a special harvesting machine, and there has to be enough volume for it." "In some regions, farmers have had brown beans in their crop plan for years. And they are located near a trader and a processor. In a certain region, it can thrive. In other regions, this infrastructure is lacking."
Creating legitimacy	(1) Public awareness and support for the mission	"I think the Beandeal does bring [legumes] to the attention, but the question is how much effect it actually has." "Lupine is an unknown product to consumers." "I do not believe that demand will increase significantly in the near future. You do not see it in the figures either. Beans are talked about more than they are eaten."
	(2) Media attention and advocacy	"We have also been very busy with the promotion of Edamame. We are now also looking at Dutch chickpeas and field beans. I think we are doing the promotion quite actively, really trying to get the consumer excited. Both online and via magazines. For example, it works very well with lupine because there is a very enthusiastic group behind it, who really pull the cart." "The Beanmeal has the potential to become something very big. Which will also become increasingly visible to consumers."
	(3) Alignment with policy agendas	"If the legumes were not in the CAP, they would not have been in my crop plan."
Performance functions - Destabilisation side		
Unlearning	(1) Identification of obsolete practices	"What I notice among growers is that they would like to get out of the system they are currently in." "Meat and dairy should be taxed and priced at a true value."
Knowledge network break-down	(1) Dismantling obstructing knowledge networks	N/A
Restriction of experimentation	(1) Limiting regime supporting innovations	N/A
Market destabilisation	(1) Removing support from existing practices	"What is helping now is the CSRD (scope 3) that focuses on CO2 footprint. Supermarkets are suddenly moving because of this. They analyse their entire supply and look at how much CO2 it emits. Then you see that meat and dairy suddenly come under pressure." "CSRD ensures that the large cooperation want sustainability and transparency in the supply chain, and growers of legume crops can anticipate on this."

		“The focus here should really be on phasing out those old supply chains.”
Resource withdrawal	(1) Redirecting resources from current practices	“No, there is not enough attention for [withdrawing resources from mission-obstructing practices]. I do not think that the stakeholders themselves are really working on that. We as a core group should be more aware of that. But of course, it is difficult to take concrete action on that.”
Challenging status quo	(1) Awareness raising	“We should at least eat less meat. The government is now slowly starting to take that step. This is happening so slowly because there are huge interests in dairy farming.”

Appendix C. Logo created for legumes cultivate in the Netherlands