

An approach for developing innovation policy for sustainability missions

Breaking away from path-dependencies in the Dutch
agri-food sector

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Abstract

To tackle complex societal challenges such as sustainability transitions policy makers put attention to mission approaches. Thereby, the typical focus on innovation policy does not suffice in tackling sustainability transitions. Exnovation policy is seen as an essential addition to accelerate transition processes and ensure sustainability missions are timely realized. Exnovation entails the deliberate exit from non-sustainable institutions, (infra)structures, technologies, products and practices (Heyen et al., 2017). However, there is a lack in a practical approach that can guide policy makers in developing exnovation policy for accomplishing sustainability missions.

This research aimed to address this gap by developing a practical stepwise approach for exnovation policy making to support sustainability missions and by empirically grounding it in policy for the mission of sustainable soil management in 2030 in the Dutch agricultural sector. In doing so, this research linked literature on path-dependency and literature on exnovation. To design exnovation policy effectively it is required to understand 1) how path-dependencies hamper transition processes and 2) what exnovation instruments could be used to break away from different types of path-dependencies and as such support sustainability missions. This research used qualitative data retrieved through desk research, interviews and exploratory workshops.

Results show that the different types of identified path-dependencies regarding soil management in Dutch agriculture were material, cognitive, financial, and regulative path-dependency. These could be targeted and broken away from using different types of exnovation instruments, namely, economic, regulatory, informational, and socioeconomic instruments. Overall, findings show that exnovation policy to support sustainability missions could be effectively designed following our stepwise approach consisting of five consecutive steps. This research contributed to the theoretical field of missions and sustainability transitions by demonstrating the value of taking path-dependencies as an analytical lens and starting point for developing exnovation policy. Further, the practical stepwise approach provided fruitful insights into policy design for transitions and sustainability missions.

Keywords: exnovation policy, exnovation policy instruments, path-dependencies, policy making approach, sustainability missions.

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Executive summary

Policy makers are increasingly concerned with tackling complex societal challenges such as sustainability transitions and therefore attention is put to new policy approaches such as mission approaches to stimulate sustainability transitions within a desirable timeframe (Janssen et al, 2020; Wanzenböck et al., 2020). Typically, the focus has been on innovation policy, however, the role of innovation policy in facilitating sustainability transitions has long been overemphasized (Kemp, Schot & Hoogma, 1998; Geels & Schot, 2007; Hekkert et al., 2007). Recently, more focus is put to exnovation policy. The concept of exnovation is an appealing concept for policy makers and is seen as a way to challenge dominant socio-technical regimes through deliberate exit from non-sustainable institutions, (infra)structures, technologies, products and practices (Heyen et al., 2017). However, there is a lack in a practical approach that can guide policy makers in developing exnovation policy for accomplishing sustainability missions.

To address aforementioned gap, this research developed a practical stepwise approach that could guide policy makers in developing exnovation policy for sustainability missions. This research linked literature on path-dependency and literature on exnovation. The insights gained through the combination of these theories provided the foundation of our approach for exnovation policy making for sustainability missions. Incumbent socio-technical regimes are often influenced and stabilized by so-called lock-in mechanisms that reinforce a certain pathway of economic, technological, industrial and institutional development (Klitkou et al., 2015). Such path-dependencies hamper transition processes and should therefore be overcome. In this research it is shown that exnovation policy holds the potential to open-up stable regimes by targeting the leverage points in path-dependencies and thereby directly challenge the stability of the regime and as such support transition processes.

To design exnovation policy effectively we must understand 1) how path-dependencies lead to a lock-in of socio-technical regimes and hamper transition processes and 2) what exnovation instruments could be used to break away from different types of path-dependencies and support sustainability missions. To accomplish these research aims, a step-by-step research approach was followed. This detailed step-by-step approach can guide policy

makers in developing exnovation policy for sustainability missions. It consists of five consecutive steps, i.e., first, choosing and defining the sustainability mission, second, defining and contacting actors carrying the sustainability mission, third, identifying path-dependencies and main factors leading to path-dependency, fourth, exploring exnovation policy instruments, and fifth, linking exnovation policy instruments and types of path-dependencies.

We explored our approach in the Dutch agricultural sector by focusing on the mission of sustainable soil management in 2030. This research used qualitative data retrieved through desk research, conducting sixteen semi-structured interviews and carrying out two exploratory workshops. Actors from governmental organizations (such as the Netherlands Enterprise Agency and the Dutch Ministry of Agriculture, Nature and Food Quality), actors from knowledge and research institutes, actors from the primary sector (such as branch organizations and Dutch farmers) and actors from civil society organizations were involved in the interviews and workshops.

The results show that four types of path-dependencies have been identified that hamper transition towards sustainable soil management practices in the Dutch agricultural sector. Firstly, regarding material path-dependency in soil management, high investments in material components and mutual dependence of actors lead to lock-in. It became clear that deeper economic structures prioritize the use of specific material components. Secondly, cognitive path-dependency is upheld by formal institutionalized knowledge that is shaped by the current dominant agricultural industry focused on high-efficient production for export as well as by informal knowledge and cultural causes that block alternative ideas on soil management. Thirdly, regarding financial path-dependency, high land prices and loans from banks lead to financial lock-in. Moreover, economic structures shape prices, business models, taxes and subsidies that are geared towards the dominant industrial agricultural model and repress alternative soil management practices. Fourthly, regulative path-dependency is upheld by formal policy, namely, existing laws and regulations that are shaped by incumbent actors such as chemical fertilizer or pesticide producers and powerful lobbying. Also, informal factors such as disintegrated organizational structures, i.e. organizational set-ups based on separate themes such as water, nitrogen and fertilizer, play a role.

Regarding exnovation policy to break away from these identified path-dependencies, our findings show that different types of exnovation instruments could be used to break away from different types of path-dependencies in the Dutch agricultural sector and as such support the mission of sustainable soil management in 2030. Material path-dependency could be overcome using regulatory and economic instruments, such as taxation, setting maximum weight of machinery, or bans on chemical substances. However, attention must be paid what alternatives are stimulated and made space for, as reproduction of structural causes of unsustainable soil management practices by core assumptions such as cost price reduction, scale enlargement, high-efficiency output should be avoided. Cognitive path-dependency could be targeted by socioeconomic and informational instruments, such as communication strategies for consumer awareness, adjusting education systems, labels on consumer products, or separating advice from sales of products to farmers. Financial path-dependency could be overcome by economic instruments such as withdrawal of subsidies per hectare and the abolishment of tax on labor in agricultural practices. Lastly, regulative path-dependency could be targeted by regulatory instruments such as removal of market forces in land policy or raising standards in zoning laws. However, most importantly, reorganization within institutions such as the Ministry of Agriculture, Nature and Food Quality, and removal of a sectoral approach in policy making is needed.

Overall, it became clear that exnovation policy could support sustainability missions by breaking away from different types of path-dependencies that lead to a lock-in of socio-technical regimes and hamper transition processes. To design exnovation policy effectively, policy makers could follow our approach consisting of five consecutive steps. The approach guides policy makers to think concretely about different possibilities of exnovation policy instruments for breaking away from different types of path-dependencies. Findings showed that a diverse mix of exnovation instruments will probably be most effective for breaking away from different types of path-dependencies and instigating a fundamental shift in soil management practices in Dutch agriculture, thereby leading to the realization of the mission of sustainable soil management practices in 2030. Thus to conclude, exnovation policy can fulfil its purpose as a convincing concept for policy makers when developed in a stepwise manner offering concrete ideas on exnovation instruments for breaking away from path-dependencies which will contribute to the much-needed realization of sustainability missions.

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1. Introduction

Policy makers are increasingly concerned with tackling complex societal challenges such as sustainability transitions and are searching for new instruments and approaches to address such challenges (Janssen et al., 2020). Currently, attention is put to mission approaches to target persistent societal problems and stimulate sustainability transitions within a desirable timeframe (Janssen et al., 2020; Wanzenböck et al., 2020). Sustainability missions, such as realizing a circular economy or carbon neutral neighborhoods, unite a diversity of actors and stakeholders in the development and the adoption of new ways of production, distribution and consumption (Janssen et al., 2020). Typically, the focus has been on innovation policy. Recently, mission approaches have been urged to include a mix of policy measures and instruments, since complex societal challenges such as sustainability transitions cannot be tackled by single innovative solutions and innovation policy alone (Janssen et al., 2020; Wanzenböck et al., 2020; Kivimaa & Kern, 2016). To accelerate transition and ensure sustainability missions are timely realized, exnovation policy is seen as an essential addition to innovation policy (Heyen, Hermwille & Wehnert, 2017).

The role of innovation in facilitating sustainability transitions has long been overemphasized in transition research and practice (Kemp, 1994; Kemp, Schot & Hoogma, 1998; Geels, 2002; Geels & Schot, 2007; Hekkert et al., 2007). Specifically, studies on socio-technical transitions are heavily influenced by the multi-level perspective (MLP), which describes how disruptive innovations are scaled up and adopted in mainstream markets, after destabilizing pressures in the landscape create windows of opportunities for the innovations to emerge (Geels & Schot, 2007; Loorbach, Frantzeskaki & Avelino, 2017). By assuming a key role for disruptive innovations in making space for novelties and seeing destabilization of dominant socio-technical regimes as a consequence of innovations, transition research and practice neglect processes of deliberate destabilization and intentional breakdown of such regimes (Loorbach et al., 2017; Turnheim & Sovacool, 2020).

Several scholars started to shift their focus towards the deliberate destabilization of dominant socio-technical regimes and what such a destabilization process entails (Johnstone & Hielscher, 2017; Rogge & Reichardt, 2013). Hereby, the concept of “exnovation” gained

traction as an appealing concept for policy makers and is seen as a way to challenge dominant socio-technical regimes through deliberate exit from non-sustainable institutions, (infra)structures, technologies, products and practices (Heyen et al., 2017). Contrary to innovation policy, exnovation policy departs from unsustainable pathways and questions what should be deliberately removed (David, 2017; David & Gross, 2019). Exnovation policy can comprise instruments such as technology bans, changes in market rules or performance standards (Rosenbloom & Rinscheid, 2020). This way, emphasis is put to breaking away from the dominant unsustainable and locked-in regimes that hamper transitions to more sustainable socio-technical configurations.

Incumbent socio-technical regimes are often influenced and stabilized by so-called lock-in mechanisms and as such present stable socio-technical configurations developing path-dependently (Holtz et al., 2008; Klitkou et al., 2015). These mechanisms reinforce a certain pathway of economic, technological, industrial and institutional development (Loorbach et al., 2017; van Mierlo & Beers, 2018). Such path-dependencies make sustainability transitions difficult as resources are mainly committed to upholding prevalent technologies, ideas and practices (Holtz et al., 2008). Thus, existing regimes, that set the preconditions for the development of new pathways, prevent and constrain patterns of change needed for transitions and the realization of sustainability missions (Klitkou et al., 2015, Turnheim & Sovacool, 2020). To design exnovation policy effectively it is required to understand how path-dependencies arise and dominant socio-technical regimes are locked-in and persist, and subsequently, what exnovation instruments could be used to specifically target path-dependencies and open-up such regimes to facilitate transition and support sustainability missions.

So far, research on exnovation policy has been rare, relatively abstract and lacks empirical grounding and no research looked at how to approach exnovation policy making for targeting specific path-dependencies that uphold existing socio-technical regimes (Stegmaier et al., 2014; Heyen et al., 2017; David, 2017). Specifically, there is a lack in a practical approach that can guide policy makers in developing exnovation policy for accomplishing sustainability missions. This research aims to address this gap by developing a stepwise approach for exnovation policy making in relation to a variety of path-dependencies and by empirically

grounding it in policy for the transition towards sustainable soil management in the Netherlands. We argue that exnovation policy holds the potential to open-up stable regimes as it can target the leverage points in path-dependencies and thereby directly challenge the stability of the regime.

We explore our approach in the Dutch agri-food sector which is specifically characterized by path-dependencies. The Netherlands, a global leader in agriculture, expressed the ambition to commit to and realize the mission of sustainable soil management in 2030. This sustainability mission entails realizing soil management practices that have a positive influence on soil quality without depleting it from natural resources and capturing 0.5 megatons carbon annually (Claus et al., 2017; Vrolijk et al., 2020; Ministry of Agriculture, Nature and Food Quality, 2019). At present, the Dutch agri-food sector is characterized by a dominant stable paradigm that is centered around increased production, economies of scale and price reduction (Termeer, 2019). As such, current soil management involves industrialized practices depending on large amounts of external inputs such as heavy machinery, artificial fertilizers, and pesticides, which lead to degradation of the soils (Claus et al., 2017).

Against this background, we aim to address previously mentioned research gap by focusing on the following main research question:

‘How could exnovation policy support sustainability missions?’

In order to address the main question, two consecutive sub-questions have to be answered:

SQ1) ‘In what way do path-dependencies hamper the transition towards sustainable soil management practices in the Dutch agricultural sector?’ and

SQ2) ‘What could exnovation policy look like in order to break away from path-dependencies in the Dutch agricultural sector and support the mission of sustainable soil management in 2030?’

To this end, factors influencing soil management practices in the Dutch agricultural sector will be studied. Different actors carrying the mission of sustainable soil management in 2030 will be involved in our stepwise approach. Answering these research questions will be

theoretically relevant as it contributes to the conceptual development of exnovation policy in relation to path-dependencies. Focusing on breaking away from path-dependencies through specific exnovation instruments will sharpen analytical clarity on how the direction and success of sustainability transitions can be governed and sustainability missions can be supported. Hence, it helps to overcome the innovation bias in the current literature and policy approaches for transitions and sustainability missions. The societal relevance lies in the acceleration of the transition towards sustainable soil management practices in the Netherlands through effective exnovation policy making for the mission of sustainable soil management in 2030. This way, societal challenges associated with the current path-dependent industrial agricultural model are timely averted and soil quality and functions are maintained and improved, which contributes to the ability of soils to supply services such as food provisioning, carbon sequestration and water purification (Claus et al., 2017).

This research is structured as follows: Chapter 2 presents the theoretical framework and conceptual model based on literature on path-dependencies and exnovation. Chapter 3 presents our stepwise approach for developing exnovation policy to support sustainability missions and addresses the methods used. Chapter 4 and chapter 5 illustrate the results of the research, corresponding the two consecutive sub-questions. Chapter 6 presents an analysis and interpretation of the results. Chapter 7 provides a reflection on our approach for developing exnovation policy and discussion of the research. Lastly, Chapter 8 presents the conclusions and recommendations for policy makers.

2. Theory

The theory section draws on transition literature, especially literature on path-dependency, and on exnovation literature, as these present the most relevant theories and approaches related to the research topic. The combination of these theories is vital for understanding how path-dependencies hamper the transition towards sustainable soil management practices in the Dutch agricultural sector (SQ1) and what exnovation policy instruments could look like to break away from such path-dependencies and realize the mission of sustainable soil management in 2030 (SQ2). The insights gained through the combination of these theories provide the foundation of our approach for exnovation policy making and help answering the main research question.

2.1. Path-dependencies and sustainability transitions

Researchers on sustainability transitions take a systemic perspective in order to analyze change in complex societal systems. Transition is understood as the process of fundamental change from one stable societal system state to another, resulting from the interplay of changes at different levels and in different domains (Loorbach et al., 2017). Within the field of sustainability transitions, studies are occupied with questions on how structural qualitative changes from persistent unsustainability to sustainable system states can be steered (Loorbach et al., 2017).

In researching transitions, the concept of the socio-technical regime is used to explain how dominant technologies, institutions, infrastructure, knowledge, routines and cultures emerge around social practices and out of historical decisions (Loorbach et al., 2017; van Mierlo & Beers, 2018). The notion of a socio-technical regime was introduced by Rip & Kemp to understand and illustrate path-dependency and lock-in of existing socio-technical systems around specific technologies (Loorbach et al., 2017). It was described as “the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artifacts and persons, ways of defining problems – all of them embedded in institutions and infrastructures” (Rip & Kemp, 1998, p. 338). A socio-technical regime is regarded as the dominant system that fulfills a societal function and is stabilized through various self-reinforcing mechanisms (van Mierlo

& Beers, 2018). Socio-technical regimes are *dynamically stable* configurations of actors and elements, meaning that they are constantly changing, yet in a smooth and incremental way (Holtz et al., 2008). This way, a trajectory is formed, along which the regimes change. Socio-technical regimes are thus inherently stable and path-dependent.

Several studies on the dynamics of path-dependencies provided insights into stabilization processes of existing regimes and trajectories (Dosi, 1982; David, 1985). Path-dependency is defined as “dynamical, stochastic systems in which local positive feedbacks provide self-reinforcing mechanisms directing the system towards particular outcomes, typically selected by the persisting consequences of transient conditions prevailing during the early history of the process” (Scott, 2006, p. 21).

Path-dependency stems from a variety of factors. The rules in the system, mutual dependence between actors, the long lifetimes of material components of a system as well as complementarities of material components add to its stability (van Mierlo & Beers, 2018). Specifically, literature suggests that cognitive routines, specific technical knowledge and capabilities, shared beliefs, widely accepted assumptions, industry mindsets, regulations and standards, shared norms, identities and missions, adaptation of lifestyles to technical systems, and sunk investments in machines, infrastructures and competencies are all factors leading to path-dependency (Nelson & Winter, 1982; Geels & Schot, 2007; Turnheim & Geels, 2012; van Mierlo & Beers, 2018). As such, literature presents a wide variety of factors leading to path-dependency that can be categorized and related to specific types of path-dependencies. Four main types of path-dependencies have been distinguished in existing literature on transitions namely: material, cognitive, financial and regulative path-dependencies (table 1) (Termeer, 2019).

2.1.1. Material path-dependency

Material path-dependency concerns previous investments in physical infrastructure, material components or technologies which makes investing in radically alternative material components or infrastructure less attractive (Seto et al., 2016; Termeer, 2019). Especially, the long life of physical infrastructure or material components leads to a lock-in that is difficult or costly to change (van Mierlo & Beers, 2018). Additionally, because of high investments and

long payoffs, substantial sunk costs are created (Seto et al., 2016). Small adaptations or additions to previous investments require smaller investments, thereby contributing to upholding the material path-dependency currently in place.

2.1.2. Cognitive path-dependency

Cognitive path-dependency refers to knowledge, experience and specialization in a certain method or area. Habits, norms, assumptions and beliefs about practices guide actions and perceptions and make alternative approaches less useful or interesting (Turnheim & Geels, 2012; Seto et al., 2016; van Mierlo & Beers, 2018). Additionally, these factors minimize the amount of cognitive effort to make a decision (Seto et al., 2016). Moreover, new ideas from outside are blocked as actors become locked into their relationships with network actors and no attention is given to other potentially fruitful collaborations (van Mierlo & Beers, 2018).

2.1.3. Financial path-dependency

Financial path-dependency concerns the financial architecture of socio-technical systems. Frequently, previously made investments that fit a specific business model rule out the probability that new loans are granted by banks if these are not in line with earlier investments (Termeer, 2019). Also, the formation of networks around a market results in actions of actors, such as suppliers, traders and buyers from a value chain, becoming intertwined and mutually dependent (van Mierlo & Beers, 2018). Therefore, the financial climate, a focus on economic efficiency and export are factors that lead to a financial lock-in.

2.1.4. Regulative path-dependency

Regulative path-dependency concerns the ease of new policy making based on existing rather than entirely new policy approaches (Termeer, 2019). Existing regulations are part of the deep structures on which actors draw in their actions and in that way provide the action context (van Mierlo & Beers, 2018). As rules are aligned within a system, changing one rule often requires altering others (van Mierlo & Beers, 2018). Notably, regulative path-dependency arises from conscious efforts by powerful economic, social and political actors which seek to reinforce a trajectory that favors their interests (Seto et al., 2016).

Table 1. Overview of path-dependencies based on van Seto et al., (2016), Mierlo & Beers (2018), Termeer (2019) and PBL (2018).

Path-dependencies	Main characteristics
Material dependencies	Previous investments in physical infrastructure, material components or technologies make investing in radical alternatives less attractive
Cognitive dependencies	Knowledge and specialization in a certain production method as well as habits, norms, assumptions and beliefs about practices make alternative approaches less useful or interesting
Financial dependencies	Alternative practices are less attractive if these are not in line with earlier investments that fit a specific business model; and network formation around markets makes alternatives less attractive
Regulative dependencies	Ease of making new policy based on existing policy rather than on entirely new policy approaches makes alternative policy approaches less favorable

To facilitate transitions and support sustainability missions, the stable and path-dependent incumbent socio-technical regimes need to be targeted. To this end, more attention is given to processes of deliberate destabilization, which could be governed through policy interventions (Turnheim & Geels, 2012; Loorbach et al., 2017; David, 2017; Heyen et al., 2017). Exnovation is seen as a way to challenge established socio-technical regimes through purposeful termination of technologies and practices (Heyen et al., 2017). Governing deliberate destabilization could therefore be done through developing exnovation policy that targets the leverage points in path-dependencies to open-up stable regimes and as such accelerates transitions and helps accomplishing sustainability missions.

2.2. Breaking away from path-dependencies through exnovation policy

The central idea is that exnovation policy could govern deliberate destabilization of stable regimes through targeting specific types of path-dependencies that uphold existing socio-technical configurations.

Typically, the focus has been on innovation policy in facilitating transitions and sustainability missions, whereby destabilization of existing regimes is assumed to automatically follow upon innovation processes (Geels, 2002; Turnheim & Geels, 2012). A different approach could be to take stability as a starting point and questioning what should be deliberately removed to destabilize existing regimes that develop path-dependently. Taking this approach, we argue that targeting path-dependencies through exnovation policy and as such directly challenging stability of the regime is a promising way to facilitate transitions and sustainability missions.

Research and practice regarding sustainability transitions have become aware of the bias for innovations (Turnheim & Geels, 2012; Klitkou et al., 2015; Turnheim & Sovacool, 2020). The heavy influence of the MLP on transition studies is criticized for overemphasizing bottom-up dynamics and privileging a niche-level focus which misrepresents processes of change as inevitably coming from below (Turnheim & Sovacool, 2020). The development of innovation policy for sustainability transitions is heavily inspired by MLP thinking. Essentially, it assumes that the fading out of existing unsustainable technologies and systemic reconfiguration is a side-effect or consequence of innovations (Geels, 2002; Turnheim & Geels, 2012).

In response to this criticism, the development of policy approaches and interventions that focus on deliberate destabilization has increasingly received attention (Rogge & Reichardt, 2013; Kivimaa & Kern, 2016; David, 2017; Davidson, 2019). It is proposed that the deliberate destabilization of dominant socio-technical regimes necessitates policy interventions that challenge the stability of socio-technical configurations. To shape such policy interventions, attention is put to exnovation. Exnovation is particularly a promising concept for policy makers as it serves as an intuitive term (Heyen et al., 2017). Exnovation policy is described as a sequence of linked events, actions, activities undertaken to remove or modify ideas, practices, or material artifacts for the purpose of making room for new innovations and facilitating transition and as such, breaking away from the path-dependencies previously discussed in section 2.1. (Holbek & Knudsen, 2020; Davidson, 2019).

Exnovation policy is of vital importance for the following reasons. Exnovation is said to drastically accelerate sustainability transitions (Heyen et al., 2017). The promotion of disruptive innovations alone may not facilitate the speed of transition that is necessary to avoid disastrous environmental problems (Johnstone & Hielscher, 2017). Stimulating exnovation helps to speed up the breakthrough and maturation of novel innovative solutions for sustainability (David, 2017). Exnovation thus facilitates urgent sustainability transitions by driving innovations and making space for them to emerge through active destabilization of the socio-technical regime (Heyen et al., 2017; Davidson, 2019).

Exnovation policy can include different types of instruments, differing according to the way in which unsustainability is targeted. Directly targeting unsustainable practices or technologies is done through instruments such as bans, immediately prohibiting the use or production of a technology or a practice (Heyen et al., 2017). Indirectly targeting unsustainability entails using instruments such as production standards, taxes or pollution limits (Heyen et al., 2017). Moreover, exnovation policy can include economic, regulatory, informational or socioeconomic instruments (figure 1). Economic instruments to target unsustainability introduce economic constraints, e.g., withdrawal of subsidies or taxation (Rogge & Reichardt, 2016; David, 2017). Moreover, economic instruments for exnovation policy can entail charges, specific tariffs, emission trading, and payments to the industry for the closure of non-sustainable (fossil fuel-based) activities (Stegmaier et al., 2014; David, 2017; Rogge & Reichardt, 2016). Such instruments are proposed as early and basic steps in exnovation policy (Heyen et al., 2017). Regulatory instruments introduce legal constraints, such as laws based on ambitious standards (Stegmaier et al., 2014; Heyen et al., 2017). Informational instruments target unsustainable ideas and concern rating and labelling programs, training on new technologies or public information campaigns (Rogge & Reichardt, 2016). Lastly, socioeconomic instruments are used to adjust socioeconomic aspects in a system and address effects of exnovation. Examples include campaigns to combat the dominant cultural framings of the system and re-education for managing structural skill mismatch (Heyen et al., 2017; Kanger, Sovacool & Noorköiv, 2020).

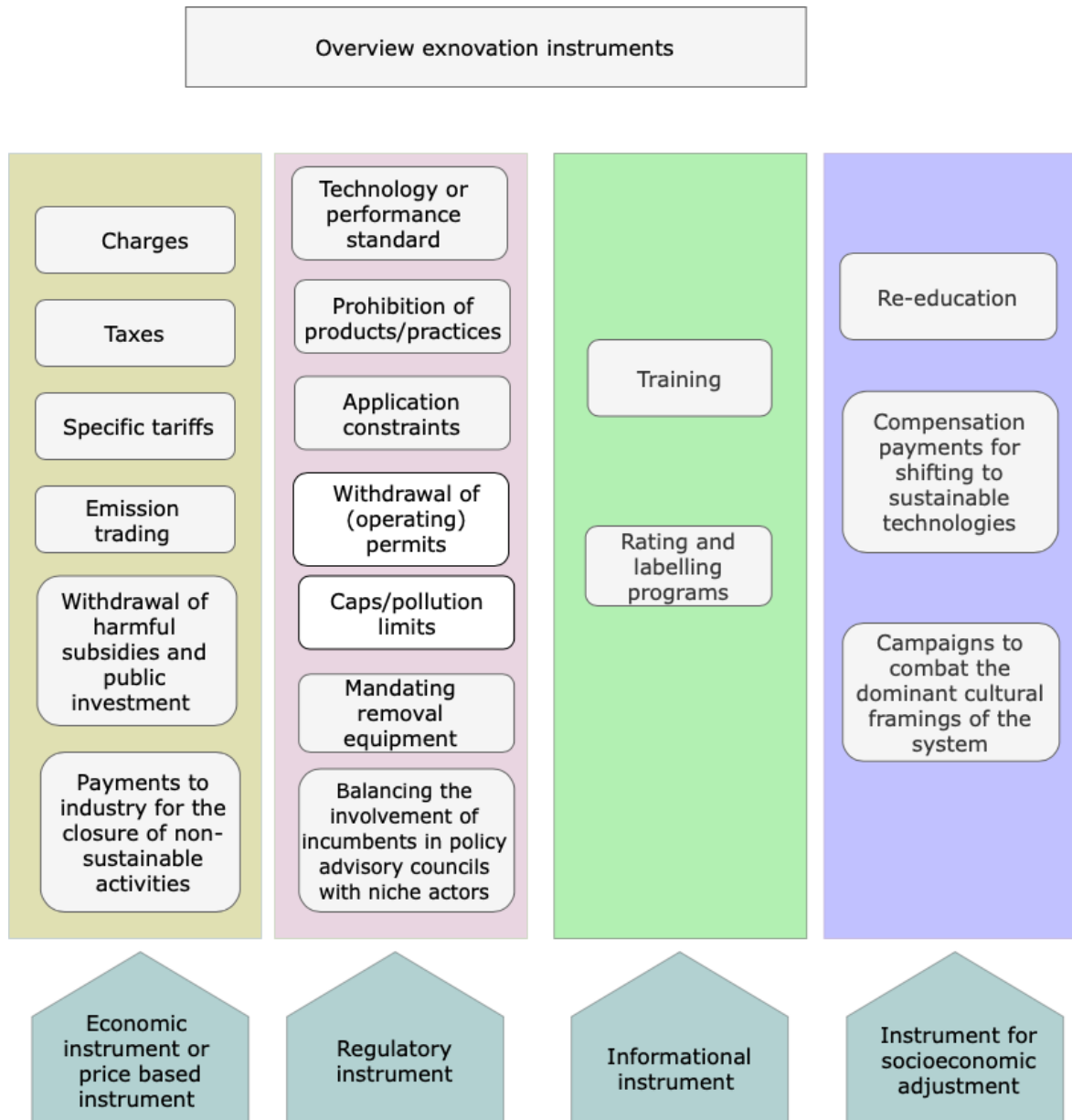


Figure 1. Examples of exnovation instruments mentioned in literature. Based on: Stegmaier et al., 2014; Rogge & Reichardt, 2016; David, 2017; Heyen et al., 2017; Kanger, Sovacool & Noorköiv, 2020.

2.3 Linking path-dependencies and exnovation policy instruments

It has become clear that stability of socio-technical regimes is created through path-dependencies and lock-ins. Deliberate destabilization of these regimes could be facilitated by exnovation policy that targets leverage points in specific types of path-dependencies (figure 2). No research has looked at how to practically approach exnovation policy making for targeting specific types of path-dependencies to support transitions and the realization of sustainability missions. Linking path-dependencies and exnovation policy can contribute additional value by offering insights into how path-dependencies hamper transition processes

and what specific types of exnovation policy instruments are needed to break away from specific types of path-dependencies. Particularly, developing a practical and stepwise approach to guide policy makers in the development of exnovation policy adds value to research and practice and directs attention to the possibilities of different types of exnovation policy instruments to break away from different types of path-dependencies. To further develop this argument, it will be empirically grounded in the case of the Dutch agri-food sector.

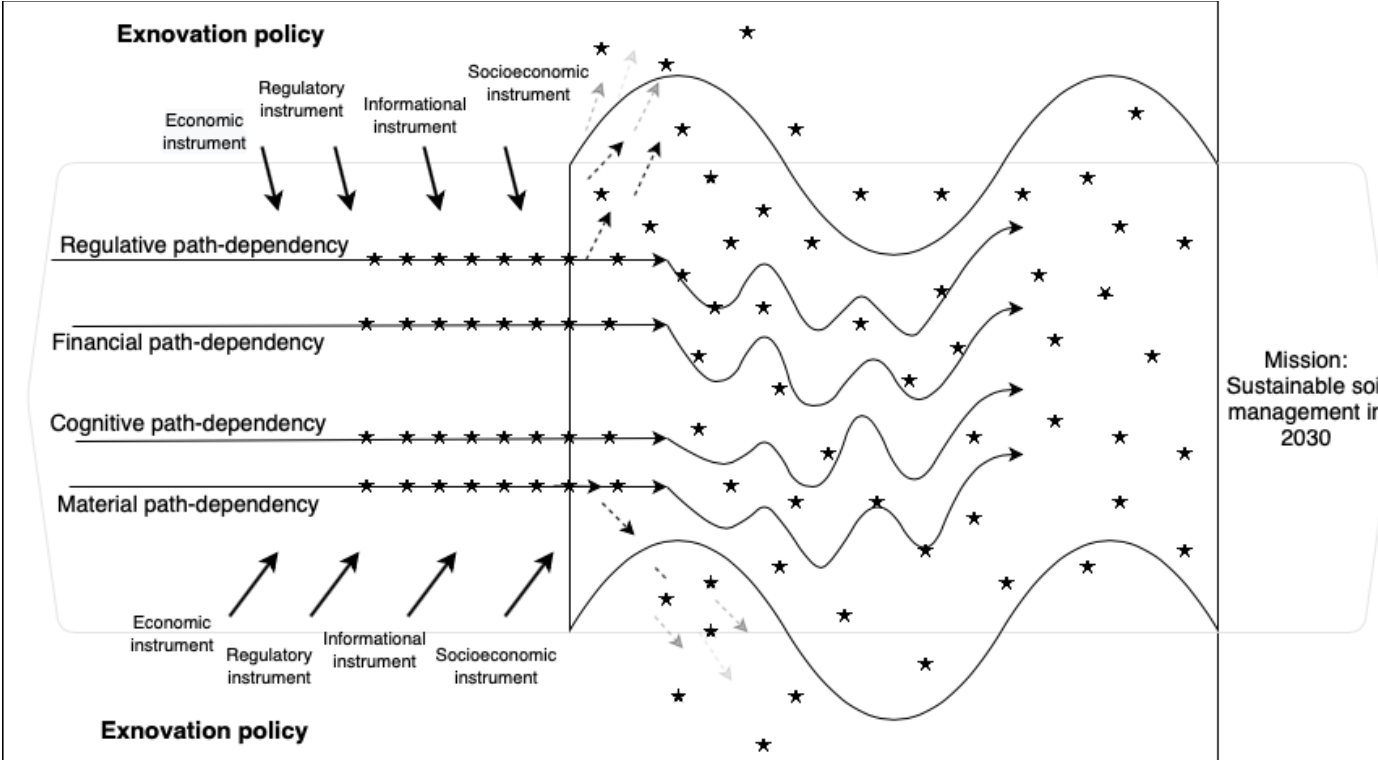


Figure 2. Exnovation policy targets leverage points in path-dependencies to destabilize regimes and facilitate transition.

3. Methodology

In this chapter we describe our approach for developing exnovation policy for the selected sustainability mission. The stepwise approach is structured according to the different analytical steps undertaken that form the basis of our research. First, the research design is explained (3.1). Hereafter, each step of the approach is discussed in separate sections (headings indicate step 1 to step 5). An in-depth explanation of each step is given in these sections and it is explained how the data collection methods are used to fulfill the main tasks of this research. Specifically, section 3.1.1. explains how data from desk research is collected and analyzed. Section 3.1.2. describes how interview data is collected and analyzed. Section 3.1.3. describes how data from workshops is collected and analyzed.

3.1. Research design

This research distinguishes two main research aims namely, (1) understanding how different types of path-dependencies and main factors leading to path-dependency hamper transition processes and (2) exploring what type of exnovation instruments could be used to break away from such different types of path-dependencies. Figure 3 presents an overview of the research design. This research is carried out step-by-step and the goal is to take the reader along each step. This detailed step-by-step approach can guide policy makers in developing exnovation policy and allows for replicability of the approach.

The approach entails five steps, which are explained separately in the following sections. Three main tasks needed to be fulfilled to answer the research questions and provided the rationale for the different data collection methods. In order to (1) understand how path-dependencies hamper the transition towards sustainable soil management practices in the Dutch agricultural sector, desk research and expert interviews were carried out. Subsequently, in order to (2) explore what exnovation policy instruments could look like to break away from path-dependencies and support the mission of sustainable soil management in 2030, exploratory workshops were carried out.

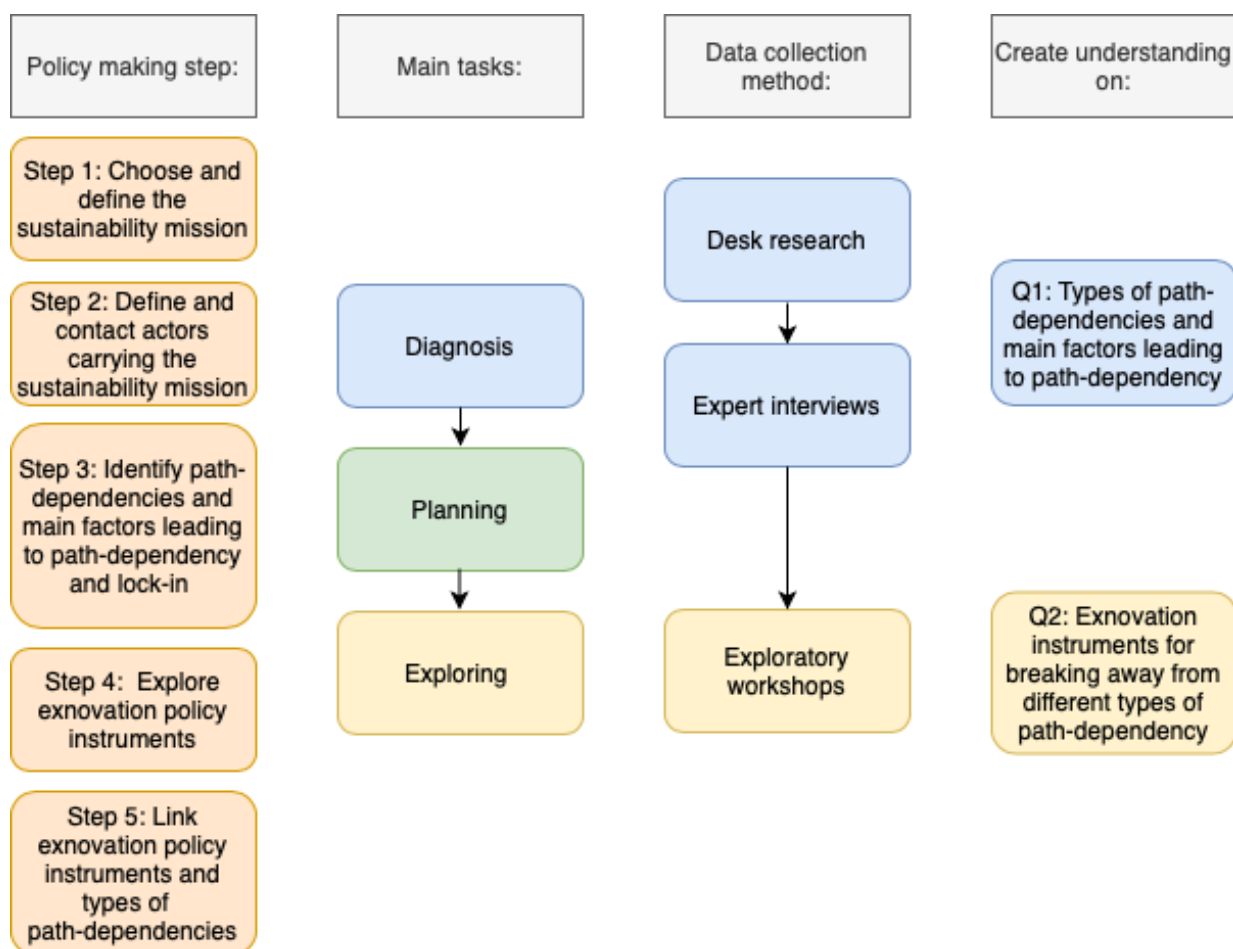


Figure 3. Research design and process: different steps and data collection methods for understanding path-dependencies and exploring how to break away from different types of path-dependency.

Diagnosis started with choosing and defining the sustainability mission that is focused on. The selected case for this research is described.

Step 1: Choose and define the sustainability mission: Sustainable soil management practices in 2030 in the Dutch agricultural sector

As policy has become more focused on sustainability missions rather than on transitions, policy makers are required to think about what urgent complex societal challenge needs to be tackled, what actors are involved and in what timeline this challenge should be tackled. Exnovation policy can aid in accelerating progress towards sustainability missions and as such, the first step in developing exnovation policy requires policy makers to specify a clear goal in a specific sector and in what timeframe it is desired to reach the goal.

The selected sustainability mission for this research is the mission of sustainable soil management in 2030 in the Dutch agricultural sector. This sustainability mission entails realizing soil management practices that have a positive influence on soil quality without depleting it from natural resources and capturing 0.5 megatons carbon annually (Claus et al., 2017; Vrolijk et al., 2020; Ministry of Agriculture, Nature and Food Quality, 2019). Focusing on this sustainability mission in the Dutch agricultural sector is specifically interesting for the following reasons. The Netherlands, the second largest exporter of agricultural goods worldwide and globally renowned for its farming practices, expressed the ambition to take the lead in contesting the industrial agricultural model by transitioning towards circular agriculture (de Boer & van Ittersum, 2018; Ministry of Agriculture, Nature and Food Quality, 2019; Rijksoverheid, 2021). As healthy soils lie at the basis of sustainable agricultural systems, the government published a Soil Strategy and launched the National Program Agricultural Soils to focus attention on improving soil quality and soil management practices (Ministry of Agriculture, Nature and Food Quality, 2019). However, presently, the Dutch agricultural sector is typified by a dominant paradigm centered around increased production, economies of scale and price reduction and is typically characterized by path-dependencies which complicate the realization of the sustainability mission (Termeer, 2019).

Currently, soil management practices in the Dutch agricultural sector involve industrialized practices and are characterized and influenced by three main aspects: crop rotation and cultivation plans, fertilization strategies, and cultivation and preparation of the soil (Ministry of Agriculture, Nature and Food Quality, 2019). *Crop rotation and cultivation plans* affect soil characteristics and soil functions. Specifically, the choice of crops and the frequency in which they return in crop rotation plans, affect the development of diseases, pests, and weeds (Grashof-Bokdam et al., 2018). Intensive crop rotation plans are characterizing for the current industrial agricultural model and decrease the resilience of soils. *Fertilization strategies* influence nutrient balance in soils. Particularly, chemical fertilizers decrease soil life and heavily influence the natural mineral cycle within soils (Zanen et al., 2011). Current industrial agricultural practices overly rely on inputs of chemical fertilizer. This way, vitality of soils is damaged, and soils become more vulnerable (Hijbeek et al., 2018; RLI, 2020). *Cultivation and preparation of the soil* is currently mainly done using heavy machinery as well as chemical inputs such as pesticides. Mechanization and the use of pesticides contributed to increased

productivity in the Dutch agricultural sector. However, problems such as deterioration of soil structure, soil compaction, decreased soil life and groundwater pollution are negative side effects and threaten future food production practices (Brussaard et al., 1988; Skevas & Lansink, 2014).

These three main aspects of soil management practices are heavily influenced by path-dependencies which hampers the transition towards sustainable soil management practices. Setting the goal of sustainable soil management in 2030 and contesting the industrial agricultural model compels the Netherlands to develop policy, and search for instruments, that tackle path-dependencies and facilitate transition. Consequently, the selection of this specific case allowed for an in-depth analysis on how path-dependencies hamper transition and provided invaluable information on the role of exnovation instruments in breaking away from path-dependencies to stimulate transition and realize the mission of sustainable soil management in 2030.

After the sustainability mission on which to focus was chosen and defined, diagnosis continued and served to gain an understanding on how different types of path-dependencies and main factors leading to path-dependency hamper transition processes and uphold existing trajectories. To this end, desk research was carried out.

3.1.1. Desk research

The suitable data collection method for this step is desk research. Desk research provided a reliable foundation of the research, since a comprehensive understanding on what is known about the research subject is created (Tranfield, Denyer & Smart, 2003).

Desk research was used in order to gain an understanding on how different types of path-dependencies uphold existing trajectories and hamper transition processes regarding soil management practices in the Dutch agricultural sector. In specific, desk research contributed to constructing an overview of the major themes within soil management and of the hampering factors for transitioning towards sustainable soil management practices. Data was collected through a review of scientific literature, public documents and policy documents. Databases used were Scopus, Google Scholar, Google Search and the database for official

publications from the Dutch government (Officiële Bekendmakingen). Search terms included key concepts, i.e., soil management Dutch arable farming. Furthermore, Dutch translations of key concepts were used, i.e., soil management arable farming (*bodembeheer akkerbouw*) and Dutch agriculture soil management (*Nederlandse landbouw bodembeheer*).

In order to construct an overview of the main themes and gain an understanding of how specific path-dependencies uphold existing trajectories and hamper transition concerning soil management practices, data was analyzed and coded according to preliminary dimensions and categories ('nodes') using coding software NVivo. Nodes are defined as 'a collection of references about a specific theme, place, person or other area of interest' (Bryman, 2012, p. 596). Preliminary dimensions and categories were based on and in accordance with the types of path-dependencies described in the theory section (2.1.). As such, the dimensions (parent nodes in NVivo) on which codes are developed concern material, cognitive, financial and regulative path-dependencies that were distinguished and specified in the theory section (Table 1). The different categories subsumed under each dimension (child nodes in NVivo) were based on the different factors related to each type of path-dependency as described in section 2.1.1 to 2.1.4 (Appendix A). The emergence of new dimensions and categories was accounted for during the coding process and are indicated in *italics* in the coding schemes in Appendix A. Desk research thus followed explicit procedures for data collection and analysis through coding software NVivo. Such an approach enhances transparency and contributes to the replicability of the research (Bryman, 2012).

Step 2: Define and contact actors carrying the sustainability mission

This second step entails defining and contacting actors carrying the sustainability mission. The goal is to involve and unite a diversity of actors that are needed for the realization of the sustainability mission. It is relevant to invite a diversity of actors as different commitments and actions by these actors guide and influence the transition process. Accordingly, different hampering factors will be experienced by different types of actors. These different perspectives are essential to gaining an in-depth understanding on how different types of path-dependencies and main factors leading to path-dependency hamper transition processes.

For this research, a variety of actors from the Dutch agricultural sector were selected for both expert interviews and workshops. Namely, different types of actors in the Dutch agricultural sector carry the mission of sustainable soil management in 2030. To ensure an in-depth understanding on how path-dependencies hamper transition towards sustainable soil management practices, expert interviews with the relevant stakeholders were carried out.

3.1.2. Expert interviews

The suitable data collection method for this step is expert interviews. Interview data provides more explanatory power than quantitative results and it allows for specific case insights on the effects of different types of path-dependencies and specific factors as well as on relations between them. Strengths of this method concern the generation of rich and detailed answers on new phenomena (Bryman, 2012). Interviewees were asked to give consent regarding their participation prior to the interviews. Additionally, interviewees were informed about recordings of the interviews prior to the start of the interviews.

In total, sixteen expert interviews were conducted with four different types of actors. Actors were selected following a purposive and snowball sampling strategy. Firstly, actors from governmental organizations such as the Netherlands Enterprise Agency and the Dutch Ministry of Agriculture, Nature and Food Quality were interviewed. Secondly, actors from knowledge and research institutes were interviewed. Thirdly, interviews with actors from the primary agricultural sector (such as branch organizations and Dutch farmers) were carried out. Fourthly, actors from civil society organizations were interviewed. An overview of the interviewees is provided below (Table 2).

Table 2. Interviewee overview.

Interviewee:	Organization type:	Organization:	Date of interview:
Interviewee 1	Governmental organization	Netherlands Enterprise Agency (RVO)	18/3/2021
Interviewee 2	Governmental organization	Netherlands Enterprise Agency (RVO)	19/3/2021
Interviewee 3	Governmental organization	Ministry of Agriculture, Nature & Food Quality	19/3/2021
Interviewee 4	Governmental organization	Ministry of Agriculture, Nature & Food Quality	22/3/2021

Interviewee 5	Primary sector	(Former) Stichting Veldleeuwerik	23/3/2021
Interviewee 6	Knowledge and research institute	Wageningen University and Research	24/3/2021
Interviewee 7	Primary sector	BO Akkerbouw	25/3/2021
Interviewee 8	Governmental organization	Ministry of Agriculture, Nature & Food Quality	26/3/2021
Interviewee 9	Civil society organization	Bodemisch Food	29/3/2021
Interviewee 10	Civil society organization	Wij.land	1/4/2021
Interviewee 11	Civil society organization	Voedsel Anders	6/4/2021
Interviewee 12	Primary sector	NAJK	8/4/2021
Interviewee 13	Knowledge and research institute	Louis Bolk Institute	12/4/2021
Interviewee 14	Primary sector	ZLTO	13/4/2021
Interviewee 15	Civil society organization	Bodemzicht	19/4/2021
Interviewee 16	Primary sector	Stichting Demeter	30/4/2021

Expert interviews were conducted following a semi-structured interview approach which allows for flexibility regarding the order and content of the interview. On average, each interview took 48 minutes. The interview guide was based on theoretical knowledge and information obtained during desk research (Appendix B). The use of semi-structured interviews enhances the replicability of the research, since the predetermined interview guide can be used to replicate the research (Bryman, 2012).

Next, the planning task needed to be fulfilled. Planning involved defining the path-dependencies and the main factors leading to path-dependency and lock-in, and subsequently preparing exploratory workshops.

Step 3: Identify path-dependencies and main factors leading to path-dependency and lock-in

Step 3 requires the researcher to identify the different types of path-dependencies and the main factors leading to path-dependency based on the data from desk research and expert interviews with actors carrying the sustainability mission. To this end, this step entails analyzing data and mapping out the main findings. The goal is to construct an overview of the different types of path-dependencies and the main factors leading to path-dependency, as

such it is meaningful to fill in the scheme depicted below in figure 4. A blank version of the fill-in scheme is provided in Appendix D.

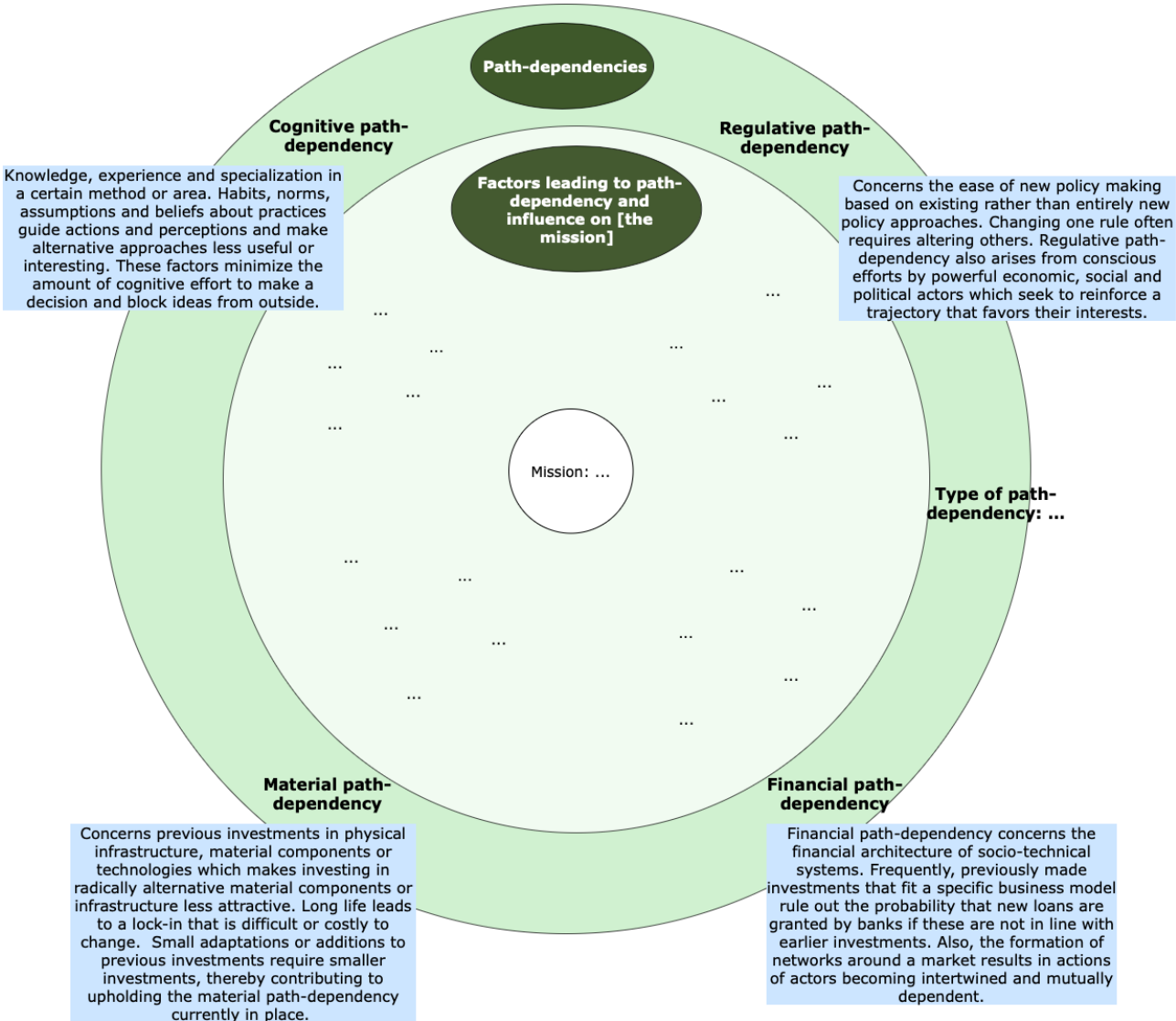


Figure 4. Fill-in scheme for path-dependencies and main factors leading to path-dependency used for step 3 of our approach.

During this research, interview data obtained through recordings was transcribed verbatim and analyzed using the coding software NVivo. The coding process shed light on the dominant topics and specific links and patterns that came forward during the interviews. The coding scheme used for analysis of the interviews built on the coding scheme used during desk research (Appendix A). As such, the dimensions (parent nodes in NVivo) on which codes are developed are material, cognitive, financial and regulative path-dependencies that were distinguished and specified in the theory section (Table 1) and found during desk research.

The different categories subsumed under each dimension (child nodes in NVivo) were based on the different factors related to each type of path-dependency as described in section 2.1.1 to 2.1.4 and on the factors that emerged during desk research. Similar to the desk research process, the emergence of additional dimensions and categories was accounted for during the coding process of the interviews and are indicated in *underlined italics* in the coding scheme in Appendix A. It is important to take this into account, since potential new path-dependencies and factors may arise when carrying out expert interviews.

During the coding process, an in-depth understanding of different types of path-dependencies and factors leading to path-dependency that hamper transition towards sustainable soil management practices was ensured by remaining as close to the data as possible. This conforms an interpretivist approach, which helps to grasp subjective meaning of social actions in a system (Bryman, 2012). Moreover, during the coding process in NVivo explicit coding procedures were followed, increasing transparency and contributing to replicability of the research (Tranfield et al., 2003; Bryman 2012).

After coding, all quotations that received the same code were listed and compared. This way, the main factors leading to and upholding specific types of path-dependencies and hampering transition to soil management were deduced. Next, the different types of path-dependencies and corresponding factors leading to a specific type of path-dependency were mapped out to create an overview of the path-dependencies and factors.

This overview based on data from the desk research and expert interviews was used to plan and prepare the exploratory workshops and formed the basis for the content of the exploratory workshops. Furthermore, planning entailed specifying the venue of the workshops and types of exercises to use during the workshop.

Step 4: Explore exnovation policy instruments

Step 4 entails carrying out workshops and gathering data on what exnovation policy instruments could look like to break away from path-dependencies so that transition is facilitated and the sustainability mission is supported. In specific, the goal of this step is to explore and identify what different types of exnovation policy instruments could be used to

break away from different types of path-dependencies. Workshops entail brainstorm sessions per type of path-dependency with the actors carrying the sustainability mission and as such provide in-depth insights regarding the use of different types of exnovation policy instruments.

For this research, all interviewees - a variety of actors from the Dutch agricultural sector selected in step 2 - were invited to the workshops.

3.1.3. Workshops

The suitable data collection method for this step is exploratory workshops. Workshops, which have a strong focus group character, provide rich qualitative data from several interacting participants at once (Ørngreen & Levinsen, 2017; Thoring, Mueller & Badke-Schaub, 2020). Especially for fuzzy challenges, such as sustainability missions, and exploratory studies in fields with little prior knowledge, such as exnovation policy, workshops are a useful approach (Ørngreen & Levinsen, 2017). Workshop participants were asked to give consent regarding their participation prior to the workshops. Additionally, workshop participants were informed about recordings of the workshops prior to the start of the workshops.

Two online workshops were prepared for groups of five to eight participants and had a strong focus group character. As all interviewees were invited, workshop participants included four different types of actors. Namely, actors from governmental organizations (such as the Netherlands Enterprise Agency and the Dutch Ministry of Agriculture, Nature and Food Quality), actors from knowledge and research institutes, actors from the primary sector (such as branch organizations and Dutch farmers) and actors from civil society organizations participated.

The workshops lasted 90 minutes and started with an introductory presentation on the subject matter and the workshop process. Then, a short recap on the research was given. Herewith, the overview of identified path-dependencies and the main factors contributing to upholding the path-dependencies was presented and verified. This way, the reliability of the main findings was checked. Next, theoretical information was provided on what exnovation policy entails. Hereby, the exnovation instrument overview was shown to workshop

participants (figure 1 from section 2.2) Hereafter, the workshops served to explore and identify what exnovation policy instruments could be used to break away from each of the four types of identified path-dependencies and as such support the mission sustainable soil management in 2030. The outline of the workshop programs can be found in Appendix C. The overview of different types of path-dependencies and factors created in step 3 was used and served as a canvas on which to brainstorm about instruments that could help in breaking away from each specific type of path-dependency. Per type of path-dependency workshop participants first brainstormed individually about possible exnovation instruments to break away from that specific type of path-dependency. After individually brainstorming, interaction between workshop participants was facilitated by time for discussion. During the brainstorm sessions per type of path-dependency tools were used such as an online whiteboard and memos, which helped workshop participants to express their ideas.

Workshop output comprised four canvasses – corresponding each type of path-dependency - on which ideas for exnovation instruments were mapped. Besides, the workshops, of which the outlines were written beforehand, accommodated the writing of workshop notes. This contributes towards the replicability and transferability of workshop procedures. Moreover, observations were made and data was obtained through recordings. As such, workshops allowed for the use of multiple data sources within the same workshop, assuring triangulation of sources within the workshops. Namely, the workshop notes and recordings served to check the data on the four canvasses, ensuring a high level of validity.

[Step 5: Link exnovation policy instruments and types of path-dependencies](#)

The final step of our approach entails linking the identified exnovation policy instruments of step 4 and the different types of path-dependencies. The goal of this step is to construct an overview of possible exnovation policy instruments that could be used to break away from different types of path-dependencies in order to support transition processes and sustainability missions.

During this research, to construct an overview of the possible exnovation policy instruments that could be used to break away from the different types of path-dependencies concerning soil management practices, each canvas was analyzed. In specific, the canvasses on which

memos with suggestions for instruments were put to target material, cognitive, financial and regulative path-dependency were studied according to types of instruments. Following the theoretical framework, the suggested instruments by workshop participants were categorized into economic, regulatory, informational, and socioeconomic instruments. This way, an overview was created of the suggested exnovation policy instruments per type of path-dependency, which served to create understanding on what exnovation policy instruments could look like to break away from different types of path-dependencies and support the mission of sustainable soil management in 2030.

4. Results: Path-dependencies and soil management

After choosing and defining the sustainability mission and defining and contacting the actors carrying the mission (step 1 and 2), the next step of our approach entails identifying the path-dependencies and the main factors leading to path-dependency (step 3). Findings from the desk research and interviews are used to construct an overview of the path-dependencies and main factors leading to path-dependency in the context of soil management practices in the Dutch agricultural sector. This chapter therefore provides insights in the path-dependencies that hamper the transition towards sustainable soil management practices. It contributes to answering sub-question 1: *'In what way do path-dependencies hamper the transition towards sustainable soil management practices in the Dutch agricultural sector?'*

As per theoretical framework this chapter discusses four types of path-dependencies namely material, cognitive, financial, and regulative path-dependency. Figure 5 presents an overview of the path-dependencies and main factors leading to path-dependency. Section 4.1. describes material path-dependency and main factors that lead to material path-dependency. Section 4.2. outlines cognitive path-dependency and corresponding main factors. Subsequently, section 4.3. provides insights into financial path-dependency and main factors contributing to this type of path-dependency. Lastly, section 4.4. describes regulative path-dependency and corresponding main factors.

4.1. Material path-dependency

Material path-dependency concerns previous investments in physical infrastructure, material components or technologies which makes investing in radically alternative material components or infrastructure less attractive. Several factors contribute to upholding the material path-dependency in soil management currently in place and hampering the transition towards sustainable soil management practices. Most frequently mentioned are *investments in material components* such as machinery. Furthermore, *high land prices*, *obligations to chain parties*, *vested interests* as well as *complementarities of machines* are shaping material path-dependency in soil management in Dutch agriculture.

4.1.1. Investments in material components

["But when you just bought a tractor of a few hundred thousand euros, then you can't just say I'll leave it in the barn next year, because you're dealing with long investments. You can't just make that switch in one year. An arable farmer often looks ten years ahead. It takes quite long to adapt something" (Interview 7)]

Historically, the Dutch agricultural sector focused on modernization, increased productivity, efficiency, and cost price reduction in order to rebuild the economy after the Second World War and ensure sufficient food production (Raad voor de Leefomgeving en Infrastructuur, 2020). Technological advances led to mechanization, intensification, the upscaling of farms and increased crop productivity (Mandryk et al., 2012). Agricultural machinery became bigger and heavier enabling farmers to cultivate land more efficiently. This industrial development was supported and financed by the government, agricultural value chain parties and banks (R1), causing financial lock-in (see section 4.3). All respondents pointed out that Dutch farmers heavily *invested in machinery and material components* in order to scale up and farm industrially, with the aim of staying in competition (Staps et al., 2015; R1; R2; R6; R7). As investments are made with a long-term perspective it appears difficult to break away from current soil management practices due to long payoffs of machinery. In addition to investments in machinery and long payoffs, one of the core barriers for transitioning as mentioned by respondents are *high land prices* (R1; R6; R7; R13; R16). Farmers experience pressure to be more productive and subsequently intensify in order to payoff high debts. In order to keep up with the current efficiency level enabled by mechanization many farmers see no other option than using big, heavy machinery (Staps et al., 2015).

4.1.2. Obligations to chain parties

According to the respondents, another important contributor to material path-dependency concerns *obligations to chain parties* (R3; R4; R6; R16). In specific, respondents indicate that current machinery and fixed delivery appointments are hampering sustainable soil management practices. Due to technological advances machines are able to enter the land any time, regardless weather circumstances which determine the capacity of the soil to manage the weight of the machinery. This way, machines affected flexibility of farmers to

work on the land. Big and heavy machinery decreases flexibility of the farmer and led to the possibility to work continuously, regardless weather circumstances (R6). Continuous work and supplies in turn influence relationships with agricultural value chain parties, such as processors, retailers and wholesalers.

["They know they actually shouldn't, but who will be the first one to say 'guys, I can enter the land but instead I'm going home, because I would ruin my soil. If necessary, I'll lose potatoes and won't be able to harvest them all, but I will not ruin my soil.' Who will be the first to do that? There is no one yet" (Interview 6)]

Due to continuous supply, chain parties are able to set fixed delivery dates to which farmers are obliged to keep themselves. As farmers' income is dependent on purchase by chain parties and competition among farmers is high due to much supply, farmers often feel like having no other option than using big and heavy machinery in order to deliver their agricultural products on time (R3). Therefore, agreements between and mutual dependence of these actors add to the stability of the agricultural system and hamper transition towards sustainable soil management practices.

4.1.3. Vested interests

Additionally, respondents indicated the role and influence of *interests of vested parties* in upholding material path-dependency regarding soil management in Dutch agriculture (R11; R12; R13). For example, investments in liquid manure stables and manure injection equipment hamper the transition towards solid manure, which would benefit the soil (Raad voor de Leefomgeving en Infrastructuur, 2020). Here, the role of banks in upholding material path-dependency is for example pointed out by one respondent, who argues that banks should stop financing such liquid manure stables if we are to transition to alternatives (R13). Another example given concerns the interests of the agricultural machinery manufacturers.

["The focus was on adapting the machines, so on the tires, better tires, broader tires and that kind of stuff, but that does not solve the actual problem, it is a solution in the sense that you won't make the existing problem much worse, but it doesn't fix any damage that has already been caused" (Interview 12)]

After increased awareness on damage to soil structure as a consequence of heavy agricultural machinery, an attempt was made to reduce the burden on the soil by focusing on adjustments of machines, such as wider tires to spread the weight, as discussed by one respondent (R12). However, respondents question the effect of adjustments and point to limited addressment of fundamental principles and causes of soil degradation in Dutch agriculture.

[“Yeah, and the machine-industry thinks yes, we will make light-weight machines. But if you have compacted soil, there is no use for light-weight machines. Those will not make the soil breathe again, only soil life can” (Interview 11)]

4.1.4. Complementarities of machines

Besides, respondents indicated that *complementarities of different machines* add to the stability of the current system and impede the transition towards sustainable soil management practices. The current agricultural system merely allows for small adaptations and incremental changes, which is characterizing for the dynamics of path-dependency.

[“All machines would have to be renewed. And that is quite an investment. For example, currently, there is much attention for strip cropping with fixed paths to drive on, but adapting a tractor so that the width is three meters and twenty centimeters, I believe that is an adaptation of thirty thousand euros per tractor. And then that tractor has been adapted, but then you still need to make sure that all other machines also have the exact same width” (Interview 12)]

Conclusion material path-dependency

In general, material path-dependency is upheld because of high investments in material components which often means there is no room for investing in sustainability measures regarding soil management in Dutch agriculture. Additionally, obligations to agricultural value chain parties and complementarities of machines lead to lock-in and parties with vested interests such as the agricultural machinery manufacturers uphold material path-dependency by focusing on small adaptations and incremental adjustments of material components. As

such, investing in radically different material components and equipment is not attractive or possible for farmers and a fundamental shift in soil management practices is hampered.

4.2. Cognitive path-dependency

Respondents put forward several factors that contribute to upholding the cognitive path-dependency currently in place and hampering the transition towards sustainable soil management. Overall, alternative knowledge and ideas on soil management in the Netherlands are excluded in two respects. On the one hand, *formal knowledge* regarding soil management plays a role in blocking ideas from outside. As indicated by respondents, specific types of knowledge are institutionalized, and other types of knowledge are systematically excluded. On the other hand, respondents point to various cultural causes that uphold cognitive path-dependency and exclude alternative ideas (i.e. informal knowledge).

4.2.1. Formal knowledge

Factors concerning formal knowledge that are indicated by respondents comprise *knowledge gaps, research and education, and advice*. These factors lead to cognitive path-dependency and hamper the transition to sustainable soil management in Dutch agriculture.

During the interviews, many respondents specifically stated that *knowledge* on sustainable soil management practices is insufficiently present. In specific, knowledge regarding soil quality and indicators for sustainable soil management practices are lacking (StuBo, 2006). Additionally, most respondents state that in general knowledge on physical and biological aspects is deficient.

["So actually, data on fungi and bacteria and quality of soil is still lacking. How do you measure quality of life, that is something we still do not know" (Interview 15)]

Since the introduction of chemical fertilizers and chemical pesticides, focus is solely put to chemical functionality of soils (R9; R10). Knowledge from before the 'chemical age', which focused on soil as a dynamic system, vanished (Zanen, 2013). As a result, the current generation of farmers has no other frame of reference and therefore is not aware of

alternative approaches and potentialities (R11). Modernization of the Dutch agricultural sector and the rise of industrial farming shaped the focus on specific assessment tools prioritizing chemical functionality and it paired with intergenerational knowledge loss.

["The way farmers are educated and the way the Dutch agricultural sector works, is that it is heavily focused on the chemical functionality of the soils. However, the other aspects, the physical and biological, are completely forgotten and neglected, and because of that, the farmers, the soils lost their capacity to function independently and to be resilient to external stressors" (Interview 10)]

Besides, the introduction of new knowledge and perspectives from outside the dominant agricultural system is limited. The dominant industrial agricultural system is said to shape *research and education*. Several respondents specifically state that educational institutes play a key role in upholding cognitive path-dependency, since farmers are educated to think within the current knowledge frames and are not introduced to alternative perspective and integral approaches to the food system (R9; R11; R16).

["You have got a vision based on the framework from which you can think, within which you were taught to think. Or, it is even worse, you are educated to think that way. So, the educational institutes are also controlled by specific stakeholders, they receive money for that and will be pushed to tell this story" (Interview 9)]

Furthermore, it is argued that research agendas regarding agriculture are directed by the current agricultural industry, which explains why alternative approaches and practices regarding soil management might be ignored.

["The research agendas have always been determined by the industry for the last X years. And that is clearly demonstrable, I believe, for research on organic agriculture, they will just use one percent of the total budget. So, it is not very surprising, that we do not know certain things there" (Interview 11)]

Furthermore, respondents point out that a lack of *independent advice* on soil management contributes to upholding cognitive path-dependency regarding soil management in Dutch agriculture. Currently, knowledge dissemination and advice are intertwined with and mainly limited to the sale of specific products or to the cultivation of a specific crop (Raad voor de Leefomgeving en Infrastructuur, 2020; (Grashof-Bokdam et al., 2018). According to respondents, independent advice is crucial for transitioning towards sustainable soil management practices (R1; R2; R8; R9; R11).

["You need independent experts, you need to be able to ventilate anything without having to worry about other opinions or potential damage to your own position. Too often I see that there are all kinds of other interests at play" (Interview 9)]

4.2.2. Informal knowledge

Factors concerning informal knowledge that are put forward by respondents that uphold cognitive path-dependency include *specialization* and *habits, concerns* and perceived *risk*, and *norms*. These factors are often cultural in nature, which are not captured in formal institutions as described above.

["I believe that one of the most important reasons that it is so difficult to break away from this is behaviour, and that people are used to and have the knowledge to work in that specific manner and that they don't know that there is another possible way" (Interview 10)]

First of all, respondents state that cognitive path-dependency is upheld by *specialization* as well as *habit*, since these factors contribute to the exclusion of alternative knowledge and ideas on soil management practices. More specifically, dispersion of the agricultural value chain and specialization in one aspect of the chain causes alternative ideas from outside to be less useful and interesting (Staps et al., 2015). This is due to the fact that such ideas are often not directly compatible with or relevant for such specific aspects of the chain (R10). Furthermore, respondents indicate the role of habit in conjunction with specialization. Particularly, once specialized in specific areas and having knowledge on certain practices such as maximizing production by using chemical inputs it is difficult to divert from them (R10; R16).

Namely, habits decrease cognitive effort to make decisions and therefore causes one to be blind for alternative ideas.

["Of course, many farmers do not want to use "poison", but at a certain moment you will get familiar with what you always do. And we are creatures of habit, at a certain moment you don't really see in what system you are trapped and how you can escape from it" (Interview 16)]

Furthermore, respondents indicate that alternative ideas on soil management practices are excluded because of *concerns* and *perceptions of risk and urgency* (R1; R6; R12). As pointed out by respondents, when farmers do not experience difficulties or declining yields, the urgency to transition to alternative soil management practices is very low (R6).

["Look, at the moment you notice that your profit is going down or that you have water on your land, if you can see that there is something going on, you will take action, but if you don't see that something is going on, if you don't notice, why would you go and take a risk" (Interview 12)]

Moreover, farmers seem reluctant to transition to alternative soil management practices when not experiencing difficulties, because transition involves risk (R12). Since many farmers lack financial space, the idea of switching to alternative practices and potentially risking lower yields poses a cognitive barrier for transition. Pointed out by one respondent is that many farmers live below the poverty line in the Netherlands (R1).

["For many agricultural businesses, and that is a high percentage of farmers, that lives under the poverty line. So that is certainly a big financial obstacle, regardless of whether sustainable soil management costs more money or not, but that is I think in the mind of farmers like 'oh no I have to do it differently' – They really have other concerns than investing in a new system" (Interview 1)]

Additionally, respondents mention *norms* to play a role in upholding cognitive path-dependency regarding soil management in Dutch agriculture (R7; R15; R16). These norms

underlie deeper systemic structures and determine dominant frames of mind. Such frames of mind shape actions and perceptions concerning dominant industrial soil management practices. Respondents point out that a general thought among farmers and policy makers is that making impact is only possible with many hectares of land. The norm among farmers seems to be ‘the bigger the better’ and scaling down is viewed as ‘losing’.

["I do think that what's going on, more concerning the norms and values within the sector, so to say, that you notice that when one sells a piece of land and scales down, that is still a taboo within the sector. So, it is still like, the bigger, the more you are a tough guy and when you scale down you are kind of a loser. So, there is that kind of thought like it should always be more and bigger, well clearly that's caused by a financial incentive" (Interview 7)]

Besides norms among farmers, norms among consumers and retailers are strongly emphasized by respondents in upholding cognitive path-dependency regarding soil management in Dutch agriculture (R6; R10; R12). Currently, the norm is cheap food and consumers lack awareness and knowledge on on-farm practices and external costs, such as soil degradation as a consequence of intensive cultivation plans (R10; R5).

["I think that we need a more societal change in the sense that people, society - so not just the farmers - need to realize that the cheap food that they buy in the stores also comes with a cost" (Interview 6)]

Sustainable soil management practices during production are separated from consumption of agricultural products. Lack of consumer awareness and knowledge on soil management as well as norms within the agricultural value chain hamper transition processes, because consumer demand and market forces are still leading in determining and motivating farmers' soil management practices (R12).

["Eventually I would rather have the market, I would have more faith if market demand would change and that there would be a demand for well managed soils" (Interview 12)]

Conclusion cognitive path-dependency

Overall, cognitive path-dependency in soil management is upheld by formal knowledge through dominant *research and education* institutes that are shaped and directed by the current agricultural industry. This explains why alternative approaches and practices regarding soil management might be ignored. Moreover, respondents emphasize that breaking away from cognitive path-dependency is hampered by informal types of knowledge and cultural causes such as *specialization, habits, concerns* and *norms* which cause one to be blind for alternative ideas on soil management. This way, a fundamental shift in soil management practices in Dutch agriculture is hampered.

4.3 Financial path-dependency

Financial path-dependency concerns the financial architecture of socio-technical systems. Previously made investments as well as network formation around a market and a focus on economic efficiency leads to financial lock-in. Within the Dutch agricultural sector, various factors contribute to upholding the financial path-dependency regarding soil management currently in place and hamper the transition towards sustainable soil management practices. Most frequently mentioned financial factors by respondents include *land prices, loans from banks, consumer prices and export, business models* and *subsidies and taxes*.

4.3.1. Previously made investments, land prices and loans from banks

["Land and land prices, if we are talking about one huge barrier in The Netherlands then it would be the high land prices. Such high prices, means you really need a high production level. So also, depreciation of land, is something that is thought about at LNV, but we also need political mandate to realize that" (Interview 8)]

As described in section 4.1, the modernization of the Dutch agricultural sector and technological advances after the Second World War led to development of machinery that enabled a higher level of productivity. The *investments* made by farmers to adapt to this mechanized, industrial agricultural model, caused financial lock-in (section 4.1.1.). Besides, the increased labor productivity - as a consequence of mechanization - translated into the need for more land per unit of labor, leading to higher *land prices* (RLI, 2020). Moreover, since

2007 liberalized lease of land led to higher lease prices and shorter leasing terms (Staps et al., 2015). According to respondents, the high land and lease prices and speculation in the land market are core problems financially (R1; R6; R7; R8).

["An arable farmer will then try to profit as much as possible from his hectare so he can pay his bills to the bank, so that is a motive, and that leads to a search for high-efficiency crops. And often those are crops that are intensive for the soils" (Interview 7)]

Specifically, transition towards alternative soil management practices is hampered by such high prices, since it causes intensification of land use. After all, farmers are forced to earn back their investments on a short term and pay off *loans from banks* or work on smaller areas (Staps et al., 2015; RLI, 2020; R8). Consequently, farmers look for crops with high yields, which are often the crops that are burdensome to soils (R7).

4.3.2. Consumer prices and export

["Prices force farmers to specialize in a few crops – if there would have been more sales possibilities then the picture would have been completely different" (Interview 13)]

Furthermore, respondents stress the pressure from the market and from agricultural value chain parties for upholding financial path-dependency regarding soil management in Dutch agriculture. Market forces and pressure from chain parties lead to a focus on profit maximization (R1). Thereby, *consumer prices* are leading in determining crop choices (Mandryk et al., 2012; Staps et al., 2015; Grashof-Bokdam et al., 2018). Such consumer prices do not take external social and ecological costs into account (R16).

["In the pricing of products, the the-polluter-pays principle, that's just not included" (Interview 16)]

Moreover, respondents indicate that export plays a big role in upholding financial path-dependency regarding soil management in Dutch agriculture, as competition and a level playing field on the international level affect national economic structures (R8; R14). The

short-term focus on cost price reduction resulting from current economic structures, barely leaves room for maintaining soil fertility on the long-term. The formation of market networks in which farmers, chain parties and consumers are intertwined and mutually dependent leads to a financial lock-in and hampers transition to sustainable soil management practices (R1; R13; R14; R16).

["The way we do it now is very logical seen the history, the focus up to now has always been on producing more and more efficiently against lower costs. Because yeah, the price of our products does not go up, but the costs are becoming higher, so somehow you will have to save costs" (Interview 12)]

4.3.3. Business models

["It's always, everything with us and with the ministry of Agriculture, Nature and Food Quality, once you speak about becoming sustainable, you always come back to the topic of business models (Interview 8)]

In addition, respondents point out that current *business models* are upholding financial path-dependency regarding soil management in Dutch agriculture, as their design is based on present-day value structures that do not take ecological and social externalities into account (R3; R8). Particularly, it is stated that the agricultural sector is an atypical economic sector which is characterized by many suppliers and only a few buyers, which leads to little opportunity to differentiate. Suppliers – the farmers – have little bargaining power in the agricultural value chain, so investing in sustainability practices does not pay (R3). Therefore, since taking sustainability measures is not valued according to the current financial architecture, farmers are not stimulated to do so and transition towards sustainable soil management is hampered.

4.3.4. Subsidies and taxes

Other factors maintaining financial path-dependency regarding soil management that are mentioned are *subsidies and taxes*.

["Concerning subsidies for example. You only receive financing for material things, while my investments concern compost or trees, those are not material, we barely have fixed assets and we try to keep that as minimal as possible – It is thought way too much that things need to be material things in order to receive subsidies" (Interview 15)]

As stated by respondents, currently, subsidies add to the stability of the financial architecture as mainly the dominant industrial agricultural system is subsidized (R15; R16). It is emphasized that only mainstream material components and fixed assets are subsidized, while alternative soil management practices may require investments in other (non-material) components, such as compost or trees (R15). Additionally, the subsidy thresholds and ceilings are very high. The respondent points to the norm and thought that impact can only be made with many hectares of land (section 4.2.2.). Then, labor taxes are stated to play a role in upholding financial path-dependency, since it perpetuates and favors large scale, automated soil management practices (R15). Furthermore, taxes and subsidies are stated to obscure the true cost of soil management practices and of agricultural practices in Dutch agriculture in general (R1). According to one respondent, it keeps the agricultural system untransparent and therefore hampers consumers to get insights and knowledge on actions they could undertake to contribute to sustainable soil management practices.

["This whole transition is not going to happen only by the use of subsidies. And that is also not what farmers want, in practice they want to be rewarded for what they are doing. They do not want to be kept on a subsidies-leash and I find that very nontransparent, like we are all going to eat cheap food and then all our tax money goes to the Common Agricultural Policy (CAP) and then through the CAP farmers receive money when they do not pollute water or something. Because of subsidies and the way our system currently is, it is very nontransparent for people to know what can I actually do about it" (Interview 1)]

Conclusion financial path-dependency

To conclude, financial path-dependency regarding soil management in Dutch agriculture is upheld by *high land prices* and *loans from banks* which leads to financial lock-in. Moreover, it became clear that *consumer prices*, *business models*, *taxes* and *subsidies* are geared towards the dominant industrial agricultural model and repress alternative soil management practices.

This way, financial lock-in and lack of financial resources blocks the possibility to invest in radically different soil management practices and as such, transitioning towards sustainable soil management practices is hampered.

4.4 Regulative path-dependency

Finally, regulative path-dependency concerns policy making processes. Respondents indicate that regulative path-dependency is upheld in two ways. First, factors that are mentioned are *existing policy*, *alignment of rules within a network*, and *vested interests*. These factors heavily influence formal policy making, i.e., laws and regulations. Second, respondents stress the influence of informal factors, which concern organizational aspects. Most often mentioned is *disintegration* and a *disintegrated* organizational structure. Additionally, respondents point to the lack of *vision*. These factors contribute to upholding the regulative path-dependency currently in place and hampering the transition towards sustainable soil management practices.

4.4.1. Formal regulations

Concerning policy making processes, it is stated that new policy making is typically based on *existing policy* regarding Dutch agriculture (R4). This is characterizing for path-dependency and excludes alternative regulations that are not compatible with current regulatory frameworks regarding the agricultural sector.

["Existing policy, you always take that into account, preferably there is no diversion, when you try to improve something" (Interview 4)]

Respondents also highlight that *alignment of rules* within a network poses a difficulty for breaking away from regulative path-dependency (R2; R3). An example given concerns manure and fertilizer policy, which is based on the EU Nitrates Directive. The goal of the Nitrates Directive is good water quality, therefore the main focus of manure and fertilizer policy is the use of manure and fertilizer in relation to water quality. Only recently, the importance of good soil quality in this issue gained attention. However, respondents state that soil management remains underexposed in policy making as strict international policy guidelines do not allow much flexibility and therefore constrain national policy (R2; R3).

["The main focus of the policy board is on the Nitrates Directive and well execution of this Nitrates Directive, and attention for soil is not really there" (Interview 2)]

Moreover, several respondents pointed to the influence of dominant actors from the agricultural industry such as chemical fertilizer producers and *vested interests* on policy making processes (R1; R8; R13; R16). Such structures that are created over the past years are difficult to break away from (R1). Especially, lobby from chemical fertilizer producers and other dominant parties is stated to be still too powerful (R1; R16). A frequently mentioned example concerning vested interests relates to the Common Agricultural Policy (CAP). A recent study points out that the goals of the CAP are focused on perpetuating stable, varied and safe food supply as well as improving competitiveness of the agricultural sector (Buitenhuis, 2020). This way, it is geared towards upholding the status quo. Several respondents express that it reinforces the dominant trajectory regarding soil management and hampers transition regarding soil management in Dutch agriculture (R8; R15; R16).

["We as the government should also ask ourselves the question 'who are we going to support?' Are we going to run after the big money or do we say 'we are really going to support the sustainable farmers. And we are going to formulate an exit strategy'. But we haven't really made a decision in that area as a government" (Interview 8)]

4.4.2. Informal factors: 'rules of the game'

Respondents strongly emphasize that *disintegration* currently hampers transition towards sustainable soil management practices and impedes breaking away from regulative path-dependency. It is stated that instead of acknowledging systems' complexity, we approach complex systems as if they are complicated, i.e., making it linear and sectoral (R15). By taking a sectoral and linear approach in policy making regarding the agricultural sector, root causes of the problems are not addressed (R9; R15).

["We approach complex systems as if they are complicated. That is the mistake that is continuously made. Complex is as the world is. And we people find it very difficult to manage that complexity. And instead, we pretend as if it is a complicated system, then we make it

sectoral and linear. But that is not how the system works. So, I think that is the great paradigm change, the transition that we must make.” (Interview 15)]

In specific, it is stated that *disintegrated* organizational structures in governmental organizations, especially at the Ministry of Agriculture, Nature and Food Quality, exclude ideas on integral policy approaches (R5; R8; R9; R11; R13; R15; R16). A disintegrated organizational structure, i.e., organizational set-ups based on separate agricultural themes such as manure, pesticides, water or nitrogen, leads to separate approaches in which chances on synergy are missed (Staps et al., 2015). As pointed out by respondents, to realize such chances, sustainability of soils should be internalized in all agricultural policy files as a prerequisite (R5; R8; R9; R11). Moreover, one respondent points to the strict divide and tension fields between finance departments and sustainability departments in governmental organizations (R8).

[“If you want to benefit in terms of both water management and soil and biodiversity, then you work fundamentally integrated. But the difficulty is thus that regulations currently are very sectoral and based on industrial monocultures” (Interview 15)]

Furthermore, respondents indicate that a lack of *vision* and long-term perspectives in policy regarding Dutch agriculture hampers transition towards sustainable soil management practices (R5; R6; R13). It is stated that continuous change in visions, e.g., due to election cycles, severely constrains development – especially, since farmers are required to make long-term plans because they are bound by natural processes.

[“Then, there is a whole category of farmers, they are, and that is really what is happening right now, overwhelmed by continuous switches in visions or regulations and they really do not know where to start. So, they encounter strongly varying visions. While, if you have a rotation plan of six years, then you are six years later before you can do something new” (Interview 5)]

Conclusion regulative path-dependency

To conclude, regulative path-dependency is upheld by the influence of *existing policy*, *alignment of rules* and by *vested interests*. It became clear that alternative regulative ideas

regarding soil management may be excluded when they are not compatible with current regulatory frameworks concerning agriculture or do not favor interests of dominant actors such as chemical fertilizer producers. Furthermore, several informal factors shape regulative path-dependency. Most importantly, *disintegrated organizational structures* at the ministry of agriculture hinder integral policy approaches in policy regarding Dutch agriculture, hampering transition to sustainable soil management practices. Moreover, a *lack of vision* in policy regarding agriculture are informal factors characterizing the current regulative path-dependency in soil management in Dutch agriculture.

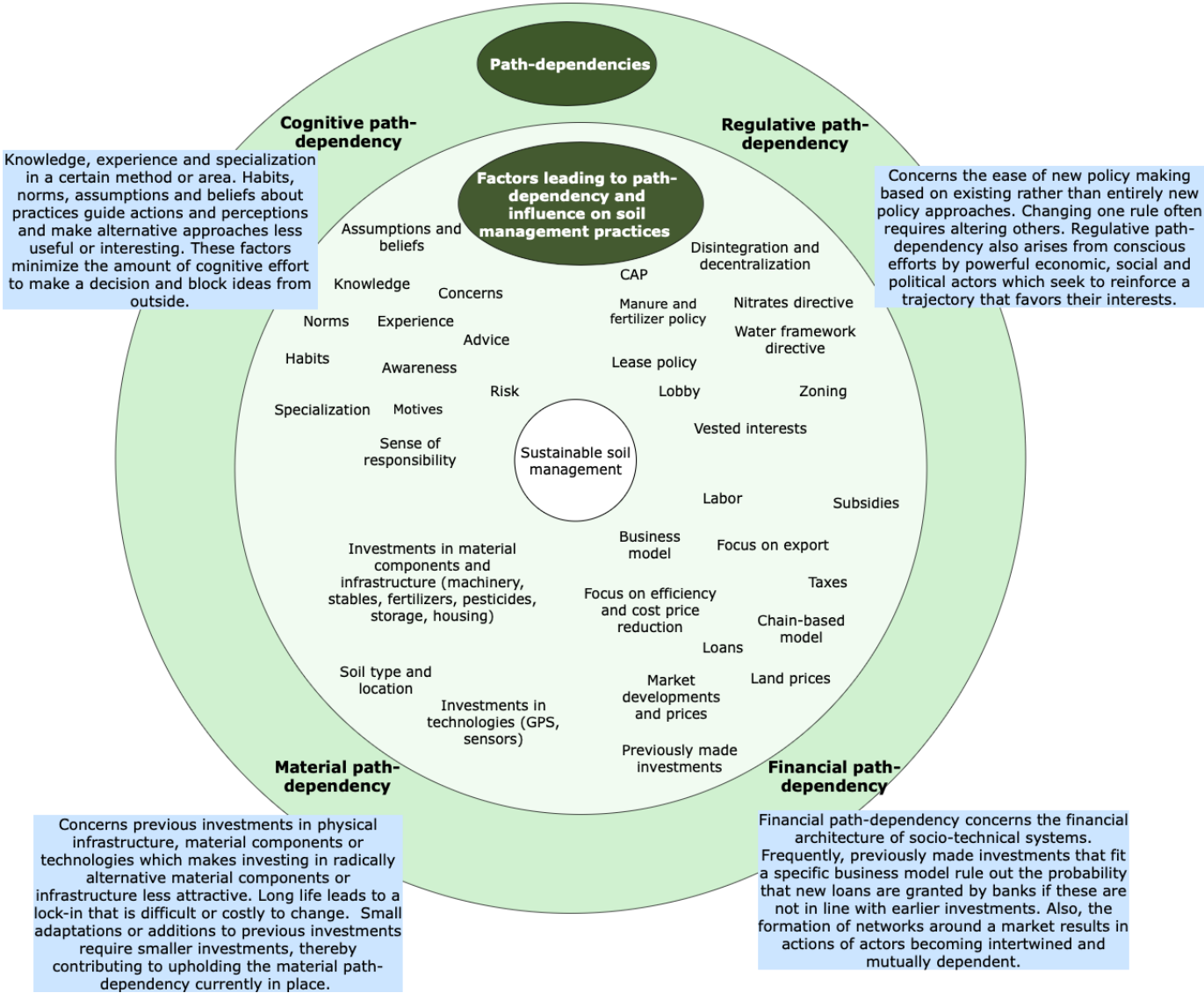


Figure 5. Overview of the path-dependencies and factors leading to path-dependency and influence soil management practices.

5. Results: suggestions for exnovation policy

The next steps of our approach entail exploring what exnovation policy instruments could be used to break away from different types of path-dependencies and subsequently linking these instruments and types of path-dependencies (step 4 and step 5). Findings from the workshops contributed to exploring what exnovation policy and instruments could look like in the context of soil management practices in the Dutch agricultural sector. This chapter therefore provides explorative insights on how previously described path-dependencies (chapter 4) could be targeted through exnovation policy to accomplish the mission of sustainable soil management in 2030. This contributes to answering sub-question 2: *‘What could exnovation policy look like in order to break away from path-dependencies in the Dutch agricultural sector and support the mission of sustainable soil management in 2030?’*

As outlined in section 2.2., exnovation policy can include different types of instruments, namely: economic, regulatory, informational, or socioeconomic instruments. The following sections discuss which specific types of instruments may be applicable to break away from specific types of path-dependency and what these could look like in the context of soil management practices in the Dutch agricultural sector. Firstly, section 5.1. outlines exnovation instruments for breaking away from material path-dependency. Then, section 5.2. discusses exnovation instruments for breaking away from cognitive path-dependency. Next, section 5.3. describes exnovation instruments for breaking away from financial path-dependency. Lastly, 5.4. illustrates exnovation instruments for breaking away from regulative path-dependency.

5.1. Exnovation instruments for material path-dependency

To break away from material path-dependency, exnovation policy could entail several different types of instruments. Suggested instruments concerned mostly *economic* and *regulatory* ones. In table 3 an overview of the suggested exnovation instruments is shown.

Workshop participants used the exnovation instrument overview (figure 1, section 2.2.) for inspiration during the brainstorm session, which is based on existing exnovation literature. As suggested by the workshop participants, in the light of sustainable soil management **economic**

instruments would entail taxing pollution, introducing a carbon dioxide tax and taxing unsustainable chemical inputs to make the use and production of harmful soil management practices and products among farmers less attractive and as such break away from the existing material path-dependency. Hereby, the workshop participants pointed out that providing subsidies to farmers for alternative pesticides such as natural pest control is then a necessary accompanying instrument to support the transition towards such alternatives. Moreover, the workshop participants provided suggestions such as a trade-in subsidy for large and heavy machinery, subsidies enabling the purchase of light-weight machinery, or providing financial compensation during transition processes. Such interventions are said to aid in targeting *investments in material components and complementarities of machines*, which lead to path-dependency (as discussed in section 4.1).

Concerning **regulatory instruments** for the exnovation of material components to support the mission of sustainable soil management in 2030, the workshop participants provided several suggestions. They put forward that limitedly granting permits for large-scale infrastructure and setting a maximum weight of machinery on land could be possible regulatory instruments for exnovation policy focused on sustainable soil management practices. Some workshop participants suggested actual bans and phase-outs, such as a ban on (deep) ploughing, a ban on tight rotations and a ban on the use of pesticides. Also, phasing out chemical fertilizers was mentioned as an intervention to break away from material path-dependency. Moreover, workshop participants suggested a ban on cheap food. Workshop participants state that this would enable farmers to profit more from their products and as such enable them to invest in sustainable soil management practices and break away from material path-dependency in current soil management.

Table 3. Suggestions for exnovation policy instruments for breaking away from material path-dependency.

	Economic instrument	Regulatory instrument	Informational instrument	Socio-economic instrument
Material path-dependency	Taxing chemical fertilizer, pollution tax, tax on products produced with pesticides, carbon dioxide tax	Limitedly granting permits and giving compensation for the breakdown/closure of large-		

	<p>Trade-in subsidy for large and heavy machinery</p> <p>Providing subsidies for alternative pesticides such as natural pest control and enabling the purchase of light-weight machinery by subsidies</p>	<p>scale infrastructure</p> <p>Setting a maximum weight of machinery on land</p> <p>Ban on (deep) ploughing</p> <p>Ban on pesticides</p> <p>Phasing out chemical fertilizers</p> <p>Ban on tight rotations</p> <p>Ban cheap food</p>		
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5.2. Exnovation instruments for cognitive path-dependency

In order to break away from cognitive path-dependency, exnovation policy could entail several different types of instruments. Suggested instruments concerned mostly *socioeconomic* instruments, but *informational* and *economic* instruments are suggested as well. Table 4 shows an overview of the suggested exnovation instruments for breaking away from cognitive path-dependency.

Regarding soil management practices, workshop participants suggested a **socioeconomic** instrument, namely, a communication strategy to raise awareness among consumers about the true cost of their food. The workshop participants proposed this instrument to target current ideas that uphold consumer norms. In addition to this, it was suggested to use an **informational** instrument, such as putting labels or information about sustainable soil management practices on consumer products. As indicated by respondents, such *socioeconomic* and *informational* instruments would aid in challenging dominant ideas and breaking down myths about feeding the world or Dutch extraordinary efficiency. Breaking down such myths was emphasized to be of crucial importance, as it would support in contesting consumer norms and challenging assumptions in Dutch agriculture such cost price

reduction. One respondent pointed out that such myths currently legitimize the continuation of industrial soil management practices, thus directly targeting these myths is crucial for breaking away from cognitive path-dependency and supporting the transition towards sustainable soil management practices. However, specific ideas on how to break down such myths were not proposed.

Furthermore, a frequently suggested idea for a *socioeconomic* instrument was adjusting education systems. As discussed in section 4.2., workshop participants state that this is an important issue to address, since currently ideas and knowledge on alternative soil management practices are systematically excluded and suppressed by the dominant agricultural industry. Challenging ideas that are shaped by the industrial agricultural model and removing courses on soil management practices based on industrial farming is said to be an important intervention for new generation of farmers and their education. As such, it would aid in breaking away from cognitive path-dependency. Additionally, workshop participants suggested an *informational* instrument to target cognitive path-dependency, namely, to separate advice to farmers and sales of products to farmers. Such an instrument is believed to contribute to breaking away from current unsustainable soil management practices, as it targets ideas emanating from the dominant agricultural industry. Specifically, space would be made for alternative forms of advice and knowledge that are currently blocked by dominant industrial parties and it would be possible to break away from dominant knowledge that is limited to the sale of specific products or to the cultivation of a specific crop. As such, it would help breaking away from the current cognitive path-dependency.

Besides *informational* and *socioeconomic* instruments, the use of **economic instruments** in innovation policy could help breaking away from cognitive path-dependency as well. In light of soil management, workshop participants indicated that an *economic* instrument at the consumer level could help targeting cognitive path-dependency. The workshop participants suggested to put a climate tax on products that contribute to soil degradation and are produced with the use of environmentally harmful production practices. This way, as said by the workshop participants, awareness on unsustainable soil management practices among consumers could be raised and consumers who buy unsustainable agricultural products are held responsible for external ecological and social costs.

Table 4. Suggestions for exnovation policy instruments for breaking away from cognitive path-dependency.

	Economic instrument	Regulatory instrument	Informational instrument	Socio-economic instrument
Cognitive path-dependency	Climate tax on products		Labels/information about sustainable soil management on consumer products Separate advice and sales of products to farmers	Breaking down myths about feeding the world/ extraordinary efficiency (through series or TV shows) Communication strategy to raise awareness among consumers about the true cost of their food Adjust education systems

5.3. Exnovation instruments for financial path-dependency

A variety of instruments could be used to challenge financial path-dependency. Suggested instruments concerned mostly *economic instruments*. Table 5 gives an overview of the suggested exnovation instruments.

Regarding soil management practices, workshop participants most often suggested **economic instruments**. Specifically, workshop participants suggested to provide transition subsidies for farmers to steer away from unsustainable soil management practices. Additionally, it was suggested to provide subsidies from the Common Agricultural Policy only for farmers that invest in green services focused on landscape, nature, and accessibility of the area. This way, industrial soil management practices that do not include such services are made less attractive as farmers no longer receive subsidies for such practices. As such, workshop participants state that the subsidy structures shaped by the dominant industrial agricultural system are targeted and it would be possible to break away from the current financial path-dependency. Furthermore, workshop participants suggested withdrawal of subsidies per hectare as well as abolishment of tax on labor. The rationale behind this was that such subsidies and taxes favor

large scale, automated soil management practices and thereby repress small-scale and sustainable soil management practices, which hampers the realization of the mission of sustainable soil management in 2030.

Lastly, the workshop participants suggested *economic* instruments that target high land prices. Namely, it was suggested to set performance standards and reduce lease prices once specific requirements on sustainable soil management are met by farmers. Additionally, the workshop participants pointed to the role of banks. It was stated that the way of thinking at banks should shift from quantity to quality. According to respondents this means that banks should stop focusing on the number of hectares a farmer produces on and start assessing how they produce and how soil is managed. Currently, production capacity is measured by number of hectares, which is problematic according to the workshop participants. Though, as stated by one participant this also implies a new system is required for covering risk. No specific exnovation instruments were suggested to target this issue.

Table 5. Suggestions for exnovation policy instruments for breaking away from financial path-dependency.

	Economic instrument	Regulatory instrument	Informational instrument	Socio-economic instrument
Financial path-dependency	Transition fund, transition subsidies Subsidies for management and quality, withdrawal subsidies per hectare CAP only for green services Lower lease prices for land provided that land is sustainably managed/performance standard Abolish tax on labor			

5.4. Exnovation instruments for regulative path-dependency

Lastly, to break away from regulative path-dependency in the Dutch agricultural sector, the workshop participants mostly suggested exnovation instruments that concerned *regulatory* instruments. Furthermore, *socioeconomic* instruments are suggested. Table 6 gives an overview of the suggested exnovation instruments.

Concerning **regulatory instruments**, the workshop participants suggested to remove market forces in land policy, as regulated land policy is preferred. Namely, market forces and speculation in the land market drive up land and lease prices which lead to severe financial problems for farmers, as stated by the workshop participants. High land and lease prices induce farmers to intensify their production using industrial soil management practices to produce as efficiently as possible and yield most profit. As such, soil is degraded and depleted and the mission of sustainable soil management is hampered. Moreover, an idea was to remove manure and fertilizer policy and start soil policy, meaning that soil management was taken as a starting point for policy making. As stated by the workshop participants this would lead to a more integral policy approach. Also, adjusting and raising standards in zoning laws was proposed, as currently a strict divide between nature and agriculture in zoning laws is stated to be problematic for sustainable soil management practices.

The overarching idea for targeting and breaking away from regulative path-dependency that was suggested multiple times during the workshops concerned a **socioeconomic instrument**, namely reorganization within the ministry and the removal of a sectoral approach to addressing unsustainabilities. As discussed in chapter 4, the workshop participants stated that the current sectoral approach in policy making is a consequence of organizational set-ups based on separate themes, such as manure, pesticides, water or nitrogen, especially at the Dutch Ministry of Agriculture, Nature and Food Quality. This was the main conclusion during the brainstorm session on regulative path-dependency during the workshop, however, it appeared challenging to suggest specific ideas on instruments or measures that could be used to tackle the sectoral approach and organizational set-ups.

Table 6. Suggestions for exnovation policy instruments for breaking away from regulative path-dependency.

	Economic instrument	Regulatory instrument	Informational instrument	Socio-economic instrument
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<p>Regulative path-dependency</p>		<p>Remove manure and fertilizer policy, start soil policy</p> <p>Remove market forces in land policy, regulated land policy is preferred; abolish free market forces in land policy</p> <p>Adjust and raise standards in zoning laws</p>		<p>Reorganization</p> <p>Remove sectoral approach (in policymaking)</p>
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6. Analysis of results

This chapter presents an analysis of previously described results in chapter 4 and 5. First, section 6.1. analyzes the results from chapter 4: path-dependencies and soil management. All four types of path-dependency (material, cognitive, financial, and regulative) are discussed subsequently. Moreover, in section 6.2. the results from chapter 5: suggestions for exnovation policy to break away from these path-dependencies are analyzed.

6.1. Analysis of chapter 4: path-dependencies and soil management

Firstly, from chapter 4 it becomes clear that **material path-dependency** is about deeper, fundamental principles of structural unsustainability in the Dutch agricultural sector. More specifically, the analysis of material path-dependency foregrounds specific core assumptions on how our economy should work and highlights deeper economic structures that prioritize the use of specific material components, such as big, heavy machinery and chemical inputs. In particular, fundamental assumptions in Dutch agriculture - such as cost price reduction, scale enlargement, high-efficiency output, and export orientation – legitimize the use of big, heavy machinery. Namely, the use of such material components appears a necessity for keeping up with the current efficiency level of Dutch agriculture, for example to comply with obligations to chain parties to deliver their agricultural products on time. Such core assumptions on how our economy should work hamper breaking away from material path-dependency. Furthermore, it demonstrates the interlinkage of material and financial path-dependency in Dutch agriculture, as the use of specific material components by farmers is required to meet financial goals and stay in competition in the agricultural sector.

Furthermore, it becomes clear that breaking away from material path-dependency implies reconsidering the role of dominant industrial parties in Dutch agriculture, such as agricultural machinery manufacturers and producers of pesticides or chemical fertilizer, as those dictate specific material and economic structures such as high-efficient production for export by using heavy machines and large amounts of chemical inputs. Moreover, banks that finance material components, such as large, heavy machines, contribute to upholding the financial architecture that is built around such material components. Successfully breaking away from material path-dependency thus requires an approach that tackles these deeper, fundamental principles and

structures. Therefore, developing exnovation policy entails critically reflecting on what type of instruments may be suited for addressing fundamental principles and causes of soil degradation and for instigating a fundamental transition in the Dutch agricultural sector.

Next, concerning **cognitive path-dependency**, chapter 4 makes visible what ideas, assumptions, norms and values are foregrounded in the agricultural sector and in society. The fundamental assumptions that underlie Dutch agriculture - cost price reduction, scale enlargement, high-efficiency output, and export orientation – took shape with the modernization of the agricultural sector and the rise of industrial farming. It came to the fore that these developments shaped the financial architecture as well as the dominant industrial farming mindset, education system, and consumer norms, which are still prevailing today. For example, as indicated by respondents, knowledge dissemination is intertwined with the sale of specific products, such as crop protection products, and research agendas are largely directed by the current agricultural industry. This way, dominant industrial types of knowledge regarding soil management are institutionalized and other types of knowledge are systematically excluded. Moreover, it became clear that cost price reduction, norms in the agricultural value chain and consumer demand for cheap agricultural products predominantly determine and motivate farmers' soil management practices and necessitate farmers to specialize in specific practices. Consequently, alternative practices regarding soil management might be ignored, as those are not financially profitable enough and many farmers live below the poverty line, therefore lack financial space to transition to alternative practices. This underlines the position of the farmer in the Netherlands. Such deeper societal structures influence and shape cognitive barriers for transition processes. So, we learned that cognitive path-dependency is about deeper power structures as well as economic structures.

Accordingly, breaking away from cognitive path-dependency and developing exnovation policy requires critically reflecting on the design of our research and education system, as well as on societal structures and the influence of market forces in the agricultural sector. Questions arise about who benefits and who carries the burden in current systemic structures and transition processes. Moreover, it implies questioning who should be held responsible and take accountability for e.g., external ecological and social costs.

Then, concerning **financial path-dependency**, chapter 4 demonstrates that financial path-dependency in soil management in Dutch agriculture is about economic structures that shape the current financial architecture of the agricultural sector. In specific, it exposed core assumptions on how the economy should work, namely by focusing on productivity, efficiency and the scaling up of agricultural practices. Besides shaping the current financial architecture – e.g. subsidy and tax systems - and prioritizing specific material components such as heavy machinery and chemical inputs, such core assumptions also demonstrate current value structures. It shows that ecological and social costs are systematically disregarded and not valued in present economic structures. Such structures affect prices and agricultural business models, which in turn guide soil management practices. It thus becomes clear how specific soil management practices are favored and alternative practices are repressed by the current foundations of the economy. As described in chapter 4, related to this is the lack of consumer awareness and knowledge on external costs of unsustainable soil management practices, which is an important cognitive factor contributing to financial lock-in. This points to the interlinkage of financial and cognitive path-dependency.

Similar to material path-dependency, breaking away from financial path-dependency therefore requires challenging such deeper structures and reconsidering the relationship between economic growth and sustainability in the agricultural context. Taking a fundamental holistic sustainability approach necessitates rethinking the role of farmers, agricultural value chain parties and consumers in the economy.

Lastly, from the analysis of **regulative path-dependency** in chapter 4 it becomes clear that alternative regulative ideas on soil management practices may be excluded when they are not compatible with current regulatory frameworks concerning the Dutch agricultural sector. Alignment of rules within the current agricultural policy system hampers transition processes, as changing one rule will require altering others. Moreover, breaking away from regulative path-dependency is complicated by the current intertwined and aligned rules as those are geared towards upholding the status quo in Dutch agriculture. Namely, the dominant regulative trajectory is shaped by vested interests and powerful economic actors, such as producers of pesticides or chemical fertilizer, and powerful lobbying. This demonstrates that regulative path-dependency is interlinked with financial path-dependency.

Moreover, we learned that regulative path-dependency regarding soil management in Dutch agriculture is upheld by core assumptions on our economy, such as increased productivity and high efficiency, and by organizational disintegrated set-ups based on separate themes within agriculture, i.e. water, fertilizer, or nitrogen, and a strict divide between financial departments and sustainability departments for example at the Ministry of Agriculture, Nature and Food Quality, provinces, and municipalities. Specifically, it became clear that those core assumptions and organizational set-ups make that sustainability measures in soil management and economic benefits are systematically viewed as trade-offs. Namely, such organizational set-ups lead to separate approaches in policy making in which chances on synergy between sustainability and soil management are missed. Challenging deeper economic structures and reconsidering the relationship between economic growth and sustainability in the agricultural context thus also requires rethinking such theme-based and divided organizational structures that affect policy making. Here, the interlinkage between financial and regulative path-dependency is demonstrated.

Breaking away from regulative path-dependency therefore necessitates addressing questions about what is favored, who is supported and what is obscured. It also requires reshaping organizational structures and rethinking policy design processes for agricultural policies concerning the achievement of sustainability missions such as the mission of sustainable soil management in 2030.

6.2. Analysis of chapter 5: suggestions for exnovation policy

Regarding **material path-dependency**, the suggested exnovation instruments for breaking away from this type of path-dependency in the Dutch agricultural sector to realize sustainable soil management practices, mostly concerned *economic* and *regulatory* instruments. Notably, it became clear that most suggestions for breaking away from material path-dependency concerned instruments that intervene at the farm-level and target the scope of usage of unsustainable products or the performance of unsustainable soil management practices. However, we learned that material path-dependency regarding soil management is also about reconsidering the role of dominant industrial parties and deeper economic structures that prioritize the use of specific material components, such as heavy machinery. Therefore,

questions arise about whether the suggested exnovation instruments are sufficient for realizing a fundamental transition towards sustainable soil management practices in the Dutch agricultural sector.

Specifically, suggested *economic* instruments such as taxing pollution and unsustainable chemical inputs or a trade-in subsidy for large and heavy machinery are important first steps to undertake, however, they might not suffice for targeting deeper economic structures or reconsidering the role of dominant industrial parties. Further, suggested *regulatory* instruments such as limitedly granting permits for large-scale infrastructure and setting a maximum weight of machinery on land are important possible first steps in exnovation policy and could function as precursors of bans and phase-outs, for example by gradually setting stricter requirements discouraging the use of such material components. Suggested bans on (deep) ploughing and on the use of pesticides and chemical fertilizers will stimulate the transition towards sustainable soil management practices, however, attention must be paid what alternatives are stimulated and made space for. Namely, reproduction of structural causes of unsustainable soil management practices by core assumptions as cost price reduction, scale enlargement, high-efficiency output should be avoided. If deeper economic structures and core assumptions are not addressed, there is a risk of fixing one issue and leaving the rest unchanged, resulting in failure of realizing transition in soil management practices in the Dutch agricultural sector. Therefore, when developing exnovation policy for a fundamental transition towards sustainable soil management practices, more policy instruments besides the mentioned economic and regulatory ones might be needed to target such deeper structures and assumptions. From chapter 5 it becomes clear that workshop participants find it difficult to suggest instruments that target such structural causes of material path-dependency.

Regarding **cognitive path-dependency**, suggestions for exnovation policy in chapter 5 concerned mostly *socioeconomic* instruments, but *informational* and *economic* instruments were suggested as well. From the workshops it became clear that most suggestions for breaking away from cognitive path-dependency concerned instruments that target the current education system concerning agriculture and soil management and the consumer

side. Interestingly, this suggests the responsibility of consumers in the transition towards sustainable soil management practices.

As cognitive path-dependency is about deeper power structures, e.g. between powerful educational institutes or agricultural value chain parties and farmers, as well as about economic structures, it should be critically assessed which type of instruments are used to target what type of practice or actor. The suggested *socioeconomic* instruments - such as a communication strategy to raise consumer awareness on unsustainable soil management practices and the true cost of food or adjusting education systems - appear to target and challenge the fundamental assumptions underlying the Dutch agricultural model and soil management practices. Suggestions concerning *informational* instruments such as labels or information about sustainable soil management practices on consumer products and separating advice to farmers from sales of products to farmers, are potential additional instruments to use. Notably, *socioeconomic* instruments that are discussed in literature are suggested as 'aftercare', i.e., when governments have pushed for exnovation such instruments could be used to lessen social and economic hardships (Heyen et al., 2017). This research demonstrates that *informational* and *socioeconomic* instruments could be used directly to target cognitive path-dependency in soil management practices in Dutch agriculture.

However, such exnovation instruments will most likely be more effective in conjunction with *economic* instruments and *regulatory* instruments, as those instruments present clear economic or legal constraints offering more planning certainty (Heyen et al., 2017). Suggestions concerning an *economic* instrument, namely, putting a climate tax on products that contribute to soil degradation could support aforementioned *socioeconomic* and *informational* instruments. This way, consumers who buy unsustainable agricultural products are held responsible for external ecological and social costs. Strikingly, no ideas for exnovation policy instruments were suggested to target dominant agricultural industry mindsets - focused on cost price reduction and export - of industry actors such as wholesalers or processors. Therefore, questions arise on the role of such industry actors and how to target these, since these actors will also have to shift towards other practices focused on sustainable soil management practices. Using *socioeconomic* instruments that help alter dominant industry

mindsets as well as using additional *regulatory* instruments that address the role of industry actors could be crucial for increasing effectiveness of exnovation policy instruments mentioned above, that are mostly targeted at consumers and farmers.

Regarding **financial path-dependency**, suggestions for exnovation policy in chapter 5 mostly concerned *economic* instruments. It became clear that thinking about instruments that target deeper structures such as the focus on high-efficient production for export was difficult. Moreover, thinking about instruments targeting the roles of value chain parties such as processors or wholesalers or roles of dominant industrial actors such as agricultural machinery manufacturers, appeared difficult during the workshops.

At first workshop participants mainly proposed *economic* instruments that are focused on the micro-level, namely, at the farm-level, such as providing transition subsidies or setting lower lease prices for land provided that farmers manage the land sustainably. However, the suggestion of workshop participants to abolish the of tax on labor in agricultural practices, does seem to be targeted at deeper economic structures, as it aids in challenging large scale, automated soil management practices. Importantly, targeting deeper economic structures by such *economic* interventions may require more time and therefore extended transition periods are necessary (Heyen et al., 2017).

Interestingly, during the brainstorm on exnovation policy instruments for breaking away from financial path-dependency, questions among the workshop participants arose on how to challenge the dominant set of beliefs and ideas of powerful incumbent actors such as processors, wholesalers or retailers and they pointed to the need to tackle cognitive path-dependency and financial path-dependency simultaneously. One participant indicated that financial myths about Dutch extraordinary efficiency or feeding the world must be broken down. It was stated, that only then financial as well as cognitive path-dependency will be overcome. Namely, it is those ideas that currently distribute power and resources in the agricultural sector and legitimize and dictate the perpetuation of routinized industrial agricultural practices. Yet, no specific suggestions were provided on how to break down financial myths and what potential instruments for this could look like, but a possible

socioeconomic instrument proposed in literature could be a public information campaign to reshape dominant ideas (Rogge & Reichardt, 2016; Kanger, Sovacool & Noorköiv, 2020).

Furthermore, *regulatory* instruments could be used to push incumbent actors to alter practices. Withdrawal of operating permits, pollution limits and production standards are typical examples in literature. Notably, as pointed out by Heyen et al. (2017), *regulatory* instruments seem to offer more legal and planning certainty for business, workers, infrastructure planning, consumers, and the educational system. Strikingly, no *regulatory* instruments were suggested for breaking away from financial path-dependency in current soil management practices. Since incumbent actors, such as processors and wholesalers hold a lot of power and dictate current economic structures, breaking away from financial path-dependency might be more effectively done through additional *regulatory* instruments such as pollution limits or production standards. Notably, this may be challenging as it requires broad political support.

Lastly, with regard to **regulative path-dependency**, suggested instruments mostly concerned *regulatory* instruments. Furthermore, *socioeconomic* instruments are suggested to break away from this type of path-dependency. Some proposed instruments target existing laws and regulations such as the current manure and fertilizer policy and zoning laws, while other proposed ideas are targeted at general aspects related to policy making such as the sectoral approach in current policy making or organizational set-ups based on separate themes.

Suggested *regulatory* instruments such as removing market forces in land policy or raising standards in zoning laws are regarded as important steps by respondents. However, it became clear that such instruments do not address the root cause in regulative path-dependency. Namely, it was stressed by the workshop participants that breaking away from regulative path-dependency is mostly about reorganization and the removal of a sectoral approach to addressing unsustainabilities within policy making. Strikingly, it appeared difficult to come up with suggestions on how to do this. Questions about what agricultural practices are favored, who is supported and what is obscured should first be answered in order to be able to have a clear focus in policy making processes. As stressed in current exnovation literature, it is thus crucial that policy making for exnovation processes entails reconsidering organizational

resources, that support alternatives as opposed to incumbent ideas and practices (Kivimaa & Kern, 2016; Davidson, 2019). Instruments supporting reorganization processes within for example the ministry so that integral policy making approaches concerning soil management become the norm must therefore be discovered and developed.

Overall, a diversity of exnovation policy instruments for the achievement of the mission of sustainable soil management in 2030 is suggested. In general, the variety of the instruments matches the variety of the types of the identified path-dependencies in soil management practices in the Dutch agricultural sector. Results show that material path-dependency could mainly be targeted and as such broken away from using regulatory and economic instruments. Cognitive path-dependency could mostly be targeted by socioeconomic and informational instruments. Financial path-dependency could mostly be targeted by economic instruments. Lastly, regulative path-dependency could be targeted by regulatory instruments. A diverse mix of exnovation instruments is crucial for effective exnovation policy. As shown figure 1 in section 2.2., informational and socioeconomic instruments for exnovation policy currently seem to be underdeveloped compared to economic and regulatory instruments.

7. Discussion

The discussion chapter starts with a reflection on our approach for developing exnovation policy and on the validity and quality of the findings and it elaborates on the theoretical contribution in section 7.1. Next, we discuss the methods that are used and limitations of this research in section 7.2. Lastly, we reflect on the theories used and provide avenues and questions for future research in section 7.3.

7.1. Reflection on approach and theoretical implications

This research was a first attempt to develop an approach for designing exnovation policy to support sustainability missions and the approach was empirically grounded in the Dutch agricultural sector by focusing on the mission of sustainable soil management in 2030. This section reflects on the strengths of the approach, on the validity and quality of the results, on the difficulties that were encountered using the approach and, lastly, discusses the theoretical implications of the research.

The strength of the approach for developing exnovation policy to support sustainability missions lies in the stepwise manner of guiding policy makers in the exnovation policy making process. At each step policy makers are stimulated to think concretely about different possibilities to break away from different types of path-dependencies. Moreover, such a stepwise approach - with specific descriptions and instructions for each step of the approach (chapter 3) - allows for replicability of the research as well as for the application of it to other sustainability missions and other sectors.

Regarding validity of our approach, construct validity is maximized in the following ways. Firstly, it is enhanced by the use of multiple data sources, assuring triangulation (Yin, 2009; Bryman, 2012). Moreover, it is enhanced by interviewing multiple types of actors until theoretical saturation has been maximized within the possible time and with the possible resources. A strength of the approach is thus the inclusion of multiple types of actors carrying the mission of sustainable soil management in 2030 in Dutch agriculture. The different types of actors were able to provide input for exnovation policy, first individually during interviews and then collectively during workshops. Additionally, during data analysis we remained as

close to the data as possible which further ensures validity. Moreover, validity of the results is enhanced as the data obtained in different steps is checked and verified during subsequent steps. For example, data from the interviews was verified at the beginning of the workshops. Then, regarding external validity, the generalizability of the outcomes in other contexts, this research had a specific case i.e. the mission of sustainable soil management in the Dutch agricultural sector. As other sectors and missions may have different dynamics, conclusions should not be generalized. Nevertheless, because of the detailed description of the steps performed and methods used, this stepwise research approach can be repeated in other sectors and with other missions.

Furthermore, a few difficulties and striking findings were encountered during the research. First of all, factors leading to path-dependency discussed during interviews and ideas suggested for exnovation policy during the workshops seem to be scattered. Overall, it appeared difficult for the workshop participants to specify detailed ideas on exnovation instruments and participants find it difficult to clearly distinguish between innovation and exnovation ideas. It became clear that the workshop participants are mostly used to think in solutions and are naturally inclined to 'innovation thinking' as opposed to 'exnovation thinking'. For example, a suggestion provided during the brainstorm on breaking away from financial path-dependency was developing a Key Performance Indicators (KPI) system that could be coupled to agricultural business models, so it would be possible to express ecological and social benefits in monetary values. This would typically be classified as innovation. Therefore, extra workshops might be beneficial in order to provide participants with enough time to grasp 'exnovation thinking'. Further, some factors mentioned during interviews and suggestions given in workshops concerned the micro level - in this case the level of the Dutch farmer - and other factors and suggestions concerned institutionalized aspects - such as subsidy flows. This highlights the complexity and multi-scalar nature of transition processes and sustainability missions. It might be necessary to further categorize such factors and suggestions into different levels in order to get a more organized overview of factors leading to path-dependency and suggestions for exnovation policy.

Another striking finding is that thinking about exnovation instruments differed per path-dependency. During the brainstorm about exnovation instruments for breaking away from

material and financial path-dependency more concrete ideas arose, than during brainstorming about exnovation instruments for breaking away from cognitive or regulative path-dependency. This might be because there are various cultural and informal factors at play, such as norms and values, lack of vision, short-term thinking or assumptions and beliefs, that may be more difficult to grasp and are less concrete as these are not 'material things'. A recommendation for improving the approach is to separate such cultural and informal factors from formal factors in cognitive and regulative path-dependency, for example by categorizing such factors under cultural path-dependency and institutional or organizational path-dependency. This could help in reflecting on deeper knowledge structures, power structures, economic structures, and societal structures that drive unsustainability and understanding how such structures are created. As such, it could aid policy makers in thinking about how to target such deeper structures for the achievement of sustainability missions. This way, sustainability missions could be pursued in more fundamental ways, which is increasingly being stressed to be crucial for transition processes by several scholars (Koretskaya & Feola, 2020; Arora & Stirling, 2020). In specific, these scholars underline the importance of laying bare deeper structures, recognizing diversity and pluralizing knowledge, in order to challenge incumbent, dominant ideas and practices that drive unsustainability. Ultimately, this could also stimulate the further development of exnovation instruments for targeting the deeper cultural and informal factors in cognitive and regulative path-dependency, which are currently underexposed in exnovation literature. Particularly, further insights are to be gained in thinking about such nonmaterial contributors to path-dependencies and how to target those.

Lastly, a difficulty in our approach that was encountered concerned thinking about the time span of exnovation policy interventions. However, to develop exnovation policy effectively, it is crucial to think about what exnovation instruments are implemented when and in what order. Namely, exnovation can either be carried out suddenly or gradually (Krüger & Pellicer-Sifres, 2020). The time span of exnovation processes is important for the social and economic acceptance of it (Heyen et al., 2017; Davidson, 2019). Extended transition periods are likely to increase the acceptance of the exnovation proposal among the affected individuals, companies and organizations (Heyen et al., 2017). This way, companies and organizations can take the transition into account in planning and investment cycles (Heyen et al., 2017). Therefore, it is recommended to organize separate workshops for the different types of path-

dependencies, as this would allow a more in-depth brainstorm session about exnovation instruments and the time span per type of path-dependency.

By analyzing the relationship between path-dependency and exnovation, this research contributes to the theoretical field of missions and sustainability transitions in several respects. First, our approach for developing exnovation policy for sustainability missions highlights the need to first analyze and understand stability of existing regimes before being able to think about exnovation policy interventions for opening up stable regimes and instigating transition. Building on this, we showed that it is crucial to understand in what way different types of path-dependencies uphold such unsustainable pathways that hamper transition processes and the achievement of sustainability missions. Therefore, we demonstrated the value of taking stability and specifically path-dependencies as an analytical lens and starting point for developing exnovation policy. Second, our research shows the multidimensional and interlinked nature of stability and demonstrates that sustainability transitions and the achievement of sustainability missions requires a varied set of instruments that exert pressure on different types of path-dependencies. Namely, different types of path-dependencies require the use of different types of exnovation instruments to break away from them. Moreover, the different types of path-dependencies are interlinked and therefore the combined use of economic, regulatory, informational, and socioeconomic instruments will be most effective to target factors that continuously legitimate existing practices, ideas, assumptions, rules and structures in existing socio-technical systems. Thirdly, this research empirically grounded the approach in the Dutch agricultural sector. The approach has proven to be useful for developing exnovation policy for sustainability missions. The structured and stepwise manner of the approach provided fruitful insights into the interplay between exnovation instruments and policy design for realizing sustainability transitions and accomplishing sustainability missions. Especially, the delineation of different types of path-dependencies helped to think about developing exnovation policy that addresses unsustainability in an exhaustive and holistic manner.

7.2. Limitations of the research

This research has several limitations. First of all, the qualitative data obtained in this research is done through semi-structured interviews and only one researcher collected and analyzed

the data. Investor triangulation could not take place. This could involve subjective interpretation of the data. Nevertheless, this has been minimized by staying as close to the data as possible during the data analysis. Secondly, interviews and workshops – with a strong focus group character – as research methods are susceptible to social desirability bias, which means that respondents could provide socially acceptable answers or refrain from speaking their mind. However, this has been minimized by anonymizing the data as well as by using desk research and verifying data obtained in each step in subsequent steps to achieve data triangulation. Second, we specifically looked at the Dutch agricultural sector and the mission of sustainable soil management in 2030. This comes with its contextual specificities and therefore the findings are not generalizable to other missions or other sectors. However, the approach we developed can be generalized and applied to other missions or other sectors. Thirdly, in this research we only looked at exnovation policy. However, for the achievement of sustainability missions and the realization of sustainability transitions both innovation policy and exnovation policy will be needed. Not only a diverse mix of types of exnovation instruments is needed, also a variety of innovation policy instruments will be needed. Thus, a large density of instruments with diversity in instrument types is required for the design of effective policy for sustainability missions. Fourthly, we only looked at exnovation in formal policy making. However, exnovation might require actions beyond formal policy making. This has been pointed out by workshop participants on exnovation policy, namely, it was stated that the government has an important role in exnovation processes, but that actions from consumers and branch organization are required as well.

7.3. Further questions for future research

To answer the research questions, this research used literature on path-dependency and on exnovation as these presented the most relevant theories and approaches related to the research topic. It became clear that the combination of these literatures was vital for understanding how exnovation policy instruments could target path-dependencies and as such break away from these path-dependencies and open-up stable regimes. To first gain an in-depth understanding on stability of the existing agricultural regime and the way transition towards sustainable soil management is hampered, path-dependency literature has proven to be useful. Subsequently, the use of exnovation literature has proven to be useful in exploring what types of exnovation policy instruments could be used to break away from

different types of path-dependencies, however, more research is needed on the time span concerning exnovation policy and on the way in which exnovation policy could address cultural factors which are less concrete as these are nonmaterial contributors to path-dependency, such as norms and values, short-term thinking, and assumptions. Therefore, we propose several avenues for further research on exnovation policy in relation to path-dependencies.

Firstly, to further develop our practical stepwise approach for designing exnovation policy and examine the time span of implementing exnovation instruments, the research could be replicated. In particular, focus could be put to what exnovation instruments are to be implemented when and in what order. Replication of the research could also increase the external validity of the research.

Secondly, future research could further examine cultural and informal factors, which mostly play a role in cognitive and regulative path-dependency, and how exnovation policy instruments could address such nonmaterial contributors to path-dependency. Namely, current literature on exnovation discusses only a few instruments that seem underdeveloped. Specifically, it describes a few informational and socioeconomic instruments for policy, such as re-education, rating and labelling programs, and public information campaigns that could aid in reshaping knowledge on unsustainabilities and providing new knowledge on alternative practices (Rogge & Reichardt, 2016; Heyen et al., 2017; Kanger, Sovacool & Noorköiv, 2020). To effectively target cultural and informal factors, i.e. nonmaterial contributors to path-dependencies, it is required to understand how instruments could not only target knowledge, but also shared ideas, meanings, and routines. Namely, in this research it came forward that it is for example those ideas about Dutch extraordinary efficiency or feeding the world that currently distribute power and resources in the agricultural sector and legitimize and dictate the perpetuation of routinized industrial agricultural practices. To further examine, explore and develop exnovation instruments targeting such factors, a social practice theory perspective could be applied which specifically zooms in on shared, routinized, ordinary ways of doing (Shove, Pantzar & Watson, 2012; Spaargaren, Lamers & Weenink, 2016).

Furthermore, future research could focus on the combination of innovation and exnovation policy instruments for the achievement of sustainability missions, here, literature on policy mixes could be a valuable reference (Kivimaa & Kern, 2016). In specific, it should be researched what types of innovation and exnovation instruments should be used together to target path-dependencies effectively and on what time span this should take place in order to timely achieve sustainability missions.

Potential questions for such future research could therefore be: When and in what order could exnovation policy instruments effectively be implemented to timely achieve sustainability missions? How should exnovation policy be developed in order to target cultural and informal, i.e. nonmaterial factors upholding path-dependencies? How could exnovation and innovation policy instruments be combined effectively in order to break away from path-dependencies and help the accomplishment of sustainability missions?

8. Conclusions

Policy makers are increasingly concerned with tackling complex societal challenges such as sustainability transitions and therefore attention is put to new policy approaches such as mission approaches to stimulate sustainability transitions within a desirable timeframe (Janssen et al, 2020; Wanzenböck et al., 2020). Typically, the focus has been on innovation policy, however, the role of innovation policy in facilitating sustainability transitions has long been overemphasized (Kemp, Schot & Hoogma, 1998; Geels & Schot, 2007; Hekkert et al., 2007). Recently, more focus is put to exnovation policy. The concept of exnovation is an appealing concept for policy makers and is seen as a way to challenge dominant socio-technical regimes through deliberate exit from non-sustainable institutions, (infra)structures, technologies, products and practices (Heyen et al., 2017). However, there is a lack in a practical approach that can guide policy makers in developing exnovation policy for accomplishing sustainability missions. Accordingly, the following main research question was posed:

‘How could exnovation policy support sustainability missions?’

To answer the main research question and address aforementioned gap, this research developed a practical stepwise approach that could guide policy makers in developing exnovation policy for sustainability missions. We explored our approach in the Dutch agricultural sector by focusing on the mission of sustainable soil management in 2030. To design exnovation policy effectively we must understand 1) how path-dependencies lead to a lock-in of socio-technical regimes and hamper transition processes and 2) what exnovation instruments could be used to break away from different types of path-dependencies and support sustainability missions.

The results show that four types of path-dependencies have been identified that hamper transition towards sustainable soil management practices in the Dutch agricultural sector. Firstly, regarding material path-dependency in soil management, high investments in material components and mutual dependence of actors lead to lock-in. Material path-dependency is heavily intertwined with financial path-dependency. It became clear that deeper economic

structures prioritize the use of specific material components. Secondly, cognitive path-dependency is upheld by formal institutionalized knowledge that is shaped by the current dominant agricultural industry focused on high-efficient production for export as well as by informal knowledge and cultural causes that block alternative ideas on soil management. Cognitive path-dependency is also heavily related to financial path-dependency and is about deeper economic, societal, and power structures. Thirdly, regarding financial path-dependency, high land prices and loans from banks lead to financial lock-in. Moreover, economic structures shape prices, business models, taxes and subsidies that are geared towards the dominant industrial agricultural model and repress alternative soil management practices. Financial path-dependency is heavily intertwined with material path-dependency and with cognitive path-dependency. Fourthly, regulative path-dependency is upheld by formal policy, namely, existing laws and regulations that are shaped by incumbent actors such as chemical fertilizer or pesticide producers and powerful lobbying. Also, informal factors such as disintegrated organizational structures, i.e. organizational set-ups based on separate themes such as water, nitrogen and fertilizer, play a role. Regulative path-dependency is interlinked with cognitive path-dependency and with financial path-dependency.

Regarding exnovation policy to break away from path-dependencies, results demonstrate that different types of exnovation instruments could be used to break away from different types of path-dependencies in the Dutch agricultural sector and as such support the mission of sustainable soil management in 2030. Generally, the variety and nature of the types of exnovation instruments match the variety and nature of the types of path-dependencies. In specific, material path-dependency could be overcome using regulatory and economic instruments, such as taxation, setting maximum weight of machinery, or bans on chemical substances. However, attention must be paid what alternatives are stimulated and made space for, as reproduction of structural causes of unsustainable soil management practices by core assumptions such as cost price reduction, scale enlargement, high-efficiency output should be avoided. Addressing deeper structures and assumptions is crucial to avoid reproduction of structural causes of unsustainable soil management practices and may require additional policy instruments. Cognitive path-dependency could be targeted by socioeconomic and informational instruments, such as communication strategies for consumer awareness, adjusting education systems, labels on consumer products, or

separating advice from sales of products to farmers. However, such instruments are most likely more effective in conjunction with economic and regulatory instruments targeting dominant agricultural industry actors. Financial path-dependency could be overcome by economic instruments such as withdrawal of subsidies per hectare and the abolishment of tax on labor in agricultural practices. To target deeper economic structures and the financial architecture of the agricultural sector, additional regulatory socioeconomic and informational instruments might be crucial. Lastly, regulative path-dependency could be targeted by regulatory instruments such as removal of market forces in land policy or raising standards in zoning laws. However, most importantly, reorganization within institutions such as the Ministry of Agriculture, Nature and Food Quality, and removal of a sectoral approach in policy making is needed. Exnovation instruments that address such organizational resources and set ups must be developed.

Finally, the main research question can be answered: *'How could exnovation policy support sustainability missions?'*

Overall, our findings show that exnovation policy could support sustainability missions by breaking away from different types of path-dependencies that lead to a lock-in of socio-technical regimes and hamper transition processes. To design exnovation policy effectively, policy makers could follow our approach consisting of five consecutive steps, i.e. first, choosing and defining the sustainability mission, second, defining and contacting actors carrying the sustainability mission, third, identifying path-dependencies and main factors leading to path-dependency, fourth, exploring exnovation policy instruments, and fifth, linking exnovation policy instruments and types of path-dependencies. Exploring our approach in the Dutch agricultural sector by focusing on the mission of sustainable soil management in 2030, it became clear that the approach guides policy makers to think concretely about different possibilities of exnovation policy instruments for breaking away from different types of path-dependencies. Different types of exnovation instruments, such as economic, regulatory, informational, and socioeconomic instruments could be used to target and break away from different types of path-dependencies such as material, cognitive, financial, and regulative path-dependency. It became clear that a diverse mix of exnovation instruments will probably be most effective for breaking away from different types of path-dependencies and instigating

a fundamental shift in soil management practices in the Dutch agricultural sector, thereby leading to the realization of the mission of sustainable soil management practices in 2030. Thus to conclude, exnovation policy can fulfil its purpose as a convincing concept for policy makers when developed in a stepwise manner offering concrete ideas on exnovation instruments for breaking away from path-dependencies which will contribute to the much-needed realization of sustainability missions.

Recommendations for policy makers

Based on this research, which aimed to develop an approach for designing exnovation policy to support sustainability missions and empirically grounded it in the Dutch agricultural sector by focusing on the mission of sustainable soil management in 2030, the following recommendations are provided for policy makers.

- To design exnovation policy to support sustainability missions effectively, it is recommended to follow the five consecutive steps of our approach. These provide specific descriptions and instructions on what actions to undertake, i.e. first, choosing and defining the sustainability mission, second, defining and contacting actors carrying the sustainability mission, third, identifying path-dependencies and main factors leading to path-dependency, fourth, exploring exnovation policy instruments, and fifth, linking exnovation policy instruments and types of path-dependencies.
- Secondly, it is suggested to organize a separate workshop on the topic of exnovation policy in order to provide policy makers with enough time to grasp ‘exnovation thinking’ and gain a clear understanding on the relevance of exnovation policy in addition to innovation policy in mission approaches.
- Thirdly, it is recommended to organize separate workshops for each of the different types of path-dependencies at the fourth step of our approach. This would allow in-depth brainstorm sessions about exnovation instruments per type of path-dependency and about the time span of the exnovation process, i.e. when to implement the exnovation policy instruments and in what order.

Regarding the mission of sustainable soil management in 2030 specifically, the following recommendations can be given. These recommendations are based on explorative findings from workshops in which a diversity of actors carrying the mission participated, as such it needs to be stressed that these provide *starting points* for exnovation policy for the mission of sustainable soil management in 2030:

- To break away from material path-dependency and facilitate the transition towards sustainable soil management practices, regulatory instruments could be implemented such as setting a maximum weight of machinery on land or bans on chemical substances. Further, economic instruments that could be used entail taxing pollution,

taxing chemical fertilizer, implementing a carbon dioxide tax, or a trade-in subsidy for large and heavy machinery.

- To break away from cognitive path-dependency and facilitate the transition towards sustainable soil management practices, socioeconomic instruments could be used such as adjusting education systems or starting a communication strategy to raise consumer awareness on unsustainable soil management practices. Moreover, informational instruments could be used labels about sustainable soil management practices on consumer products and separating advice to farmers from sales of products to farmers.
- To break away from financial path-dependency and facilitate the transition towards sustainable soil management practices, economic instruments could be used such as abolishment of tax on labor, withdrawal of subsidies per hectare, and lowering lease prices for land provided that land is sustainably managed.
- To break away from regulative path-dependency and facilitate the transition towards sustainable soil management practices, it is recommended to use regulatory instruments such as raising standards on soil management in zoning laws, or removal of market forces in land policy. Further, it is recommended to reconsider the organizational set-up of the Ministry of Agriculture, Nature and Food Quality which is currently based on separate themes such as water, nitrogen, biodiversity, which leads to a sectoral approach in policy making.
- Further, it is advised to pay attention to what alternatives are stimulated and made space for, as reproduction of structural causes of unsustainable soil management practices by core assumptions such as cost price reduction, scale enlargement, high-efficiency output should be avoided.
- Lastly, it is recommended to use a diverse mix of exnovation instruments as this will probably be most effective for breaking away from different types of path-dependencies and instigating a fundamental shift in soil management practices in the Dutch agricultural sector and as such realizing the mission of sustainable soil management in 2030.

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Appendices

Appendix A. Coding schemes

Preliminary coding scheme based in theoretical framework:

Dimensions (parent nodes)	Categories (child nodes)
Material path-dependency	Investments in physical infrastructure
	Investments in material components
	Investments in technologies
	Long life of physical infrastructure
	Sunk costs
	Other
Cognitive path-dependency	Knowledge
	Experience
	Specialization
	Habits
	Norms
	Assumptions and beliefs
	Other
Financial path-dependency	Previously made investments
	Loans from bank
	Market forces
	Focus on efficiency and export
	Other
Regulative path-dependency	Existing policy
	Alignment of rules
	Conscious efforts by powerful actors
	Other

Coding scheme desk research:

Dimensions (parent nodes)	Categories (child nodes)
Material path-dependency	Investments in physical infrastructure
	Investments in material components

	Investments in technologies	
	Soil type and location dependence	
Cognitive path-dependency	Knowledge	
	<i>Advice</i>	
	<i>Awareness</i>	
	Experience	
	Specialization	
	Habits	
	Norms	
	Assumptions and beliefs	
	<i>Concerns</i>	
	<i>Motives</i>	
	<i>Risk</i>	
	<i>Sense of responsibility</i>	
	Financial path-dependency	Previously made investments
Loans from bank		
Market developments and prices		
Focus on efficiency and cost price reduction		
Focus on export		
<i>Subsidies</i>		
<i>Taxes</i>		
<i>Business model</i>		
<i>Land prices</i>		
Regulative path-dependency		Existing policy
	<i>EU nitrates directive</i>	
	<i>EU water framework directive</i>	
	<i>Fiscal policy</i>	
	<i>Lease policy</i>	
	<i>Manure and fertilizer policy</i>	
	Alignment of rules	
	Vested interests	
	<i>Focus on measures</i>	
	<i>Vision</i>	
Soil management practices	Cultivation plan	Intensive cultivation plan
		Monocultures

	Fertilization	Chemical fertilizer
		Manure
	Tillage	Lowering water levels
		Mechanization
		Pesticides

Coding scheme interviews:

Dimensions (parent nodes)	Categories (child nodes)
Material path-dependency	Investments in physical infrastructure
	Investments in material components
	Investments in technologies
	Soil type and location dependence
Cognitive path-dependency	Knowledge
	<i>Advice</i>
	Experience
	Specialization
	Habits
	Norms
	Assumptions and beliefs
	<i>Concerns</i>
	<i>Motives</i>
	<i>Risk</i>
	<i>Sense of responsibility</i>
	<i>Awareness</i>
	<u><i>Capabilities</i></u>
Financial path-dependency	Previously made investments
	Loans from bank
	Market developments and prices
	Focus on efficiency and cost price reduction
	Focus on export
	<i>Subsidies</i>
	<i>Taxes</i>
	<i>Business model</i>
	<u><i>Labor</i></u>
	<u><i>Chain-based model</i></u>

	<i>Land prices</i>	
Regulative path-dependency	Existing policy	<i>CAP</i>
		<i>EU nitrates directive</i>
		<i>EU water framework directive</i>
		<i>Fiscal policy</i>
		<i>Lease policy</i>
		<i>Manure and fertilizer policy</i>
		<u><i>Zoning</i></u>
		<u><i>Transparency</i></u>
	Alignment of rules	
	<u><i>Contradiction</i></u>	
	<u><i>Lobby</i></u>	
	Vested interests	
	<i>Focus on measures</i>	
<u><i>Vision</i></u>		
<u><i>Disintegration and decentralization</i></u>		
<u><i>Exnovation ideas</i></u>		

Appendix B. Interview guides

Interview Guide Dutch

Type of question	Topic	Question	Possible follow up question
General questions	Sustainability transition within soil management	Wat doe je binnen je werk en waar houd je je dagelijks mee bezig?	
		Is er binnen jouw werk aandacht voor duurzaam bodembeheer binnen landbouwgronden?	Op welke manier?
	Lock in of the existing regime	Wat karakteriseert het huidige systeem rondom bodembeheer?	
		Wat staat de transitie naar duurzaam bodembeheer in de weg, waarom is het zo lastig om weg te komen van het huidige systeem en de huidige praktijken?	Wat zijn de grootste probleempunten binnen bodembeheer en -gebruik?
Main questions	Regulative path-dependency	Is er genoeg aandacht voor duurzaam bodembeheer binnen wet- en regelgeving?	
		Beperken bepaalde wetten of regelingen het omschakelen naar duurzaam bodembeheer?	
		Welke wet of regeling vormt de grootste belemmering?	Op welke manier?
	Material path-dependency	Vormen bepaalde materiële componenten belemmeringen tijdens het omschakelen naar duurzaam bodembeheer? (Zoals investeringen in technologieën, machines, loonwerkers etc.).	Op welke manier?
	Cognitive path-dependency	Hoe beïnvloeden cognitieve aspecten keuzes voor het omschakelen naar duurzaam bodembeheer?	
		Zijn er bepaalde overtuigingen die duurzaam bodembeheer in de weg staan?	
		Is er volgens jou een gebrek aan kennis of ervaring over duurzaam bodembeheer?	
		Wordt kennis over duurzaam bodembeheer voldoende verspreid?	Op welke manier?

	Financial path-dependency	Welke financiële belemmeringen worden er ervaren in het omschakelen naar duurzaam bodembeheer?	
Exploratory question	Exnovation	We hebben het nu over een heleboel dingen gehad. Als je nu 2 of 3 dingen zou mogen noemen waar de overheid echt afscheid van moet nemen, wat zou dat dan zijn?	
Ending questions		Is er nog iets wat we niet besproken hebben en dat je nog toe zou willen voegen?	
		Zou ik contact met je mogen opnemen als er verduidelijking vereist is over bepaalde onderwerpen?	
		Om de belemmeringen en punten waarop het landbouwsysteem nu vastloopt te overkomen, zal ik in het tweede deel van het onderzoek gaan kijken naar hoe we dit met beleid kunnen sturen. Hierbij staat de vormgeving van exnovatiebeleid rondom bodembeheer centraal. Om te onderzoeken hoe exnovatiebeleid eruit zou kunnen zien organiseer ik workshops met diversie actoren. Gedurende de workshops zal gebrainstormd worden over hoe exnovatiebeleid eruit zou kunnen zien, welke instrumenten gebruikt kunnen worden en hoe deze zullen uitwerken. Zou je het leuk vinden om deel te nemen aan de workshop? [Data voorstellen en inventariseren]	

Interview Guide English

Type of question	Topic	Question	Possible follow up question
General questions	Sustainability transition within soil management	Could you tell me something about your daily work?	
		Is there attention for sustainable soil management in agriculture within your work?	How? In which way?
	Lock in of the existing regime	What characterizes the existing regime around soil management?	
		Why is it so difficult to break away from the current regime and practices,	What are the biggest problems

		what is hampering the transition towards sustainable soil management?	within soil management?
Main questions	Regulative path-dependency	Do you think there is enough attention for sustainable soil management within laws and regulations?	
		Are there any laws or regulations that hamper the transition towards sustainable soil management?	
		Which laws or regulations are the biggest obstacles?	In which way?
	Material path-dependency	Are there any material components that hinder or hamper the transition towards sustainable soil management? (e.g., investments in technologies, machines, contractors, etc.).	How? In which way?
	Cognitive path-dependency	In what way do cognitive aspects influence decisions for transitioning to sustainable soil management practices?	
		Are there any beliefs or assumptions that hamper the transition towards sustainable soil management?	
		Is there a lack of knowledge or experience concerning sustainable soil management?	
		Is knowledge about sustainable soil management spread sufficiently?	How? Why (not)?
	Financial path-dependency	What financial barriers are experienced when transitioning towards sustainable soil management?	
	Exploratory question	Exnovation	So far, we discussed a wide variety of factors that are important for the transition towards sustainable soil management. What 2 or 3 factors should the Dutch government deliberately remove or destabilize in order to realize the transition?
Ending questions		Is there anything we have not covered, and you would like to mention?	
		Could I contact you in case I need any clarification about certain topics?	
		In order to overcome the barriers and path-dependencies, I will explore the way in which exnovation policy could	

		be designed, what instruments could be used and how it could look like in order to realize the transition towards sustainable soil management. This will be done through workshops. Would you like to participate in the workshops?	
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Appendix C. Workshop program

Number of participants: 4 - 8

Topic: Path-dependencies in Dutch agriculture and exploring exnovation instruments for destabilization.

Time	Activity	Individual/group work
5 minutes	Welcome	Group
5 minutes	Short introduction round	Group
15 minutes	Presentation <ul style="list-style-type: none"> ○ Recap of research ○ Path-dependencies: how are we currently locked-in in the system? ○ Exnovation: what is it and how can it contribute to breaking away from the current system? ○ Goal of the workshop and practicalities 	Group
60 minutes (15 minutes per path-dependency)	Brainstorm per path-dependency:	Group and individual
	Material path-dependency: How should we exnovate in order to realize healthy soils and sustainable soil management practices?	<ul style="list-style-type: none"> - 2-5 min. Individual thinking - Group: discussion
	Cognitive path-dependency: How should we exnovate in order to realize healthy soils and sustainable soil management practices?	<ul style="list-style-type: none"> - 2-5 min. Individual thinking - Group: discussion
	Regulative/organizational path-dependency: How should we exnovate in order to realize healthy soils and sustainable soil management practices?	<ul style="list-style-type: none"> - 2-5 min. Individual thinking - Group: discussion
	Financial path-dependency: How should we exnovate in order to realize healthy soils and sustainable soil management practices?	<ul style="list-style-type: none"> - 2-5 min. Individual thinking - Group: discussion
5 minutes	Closing	Group

Appendix D. Fill-in scheme for path-dependencies and factors leading to path-dependency

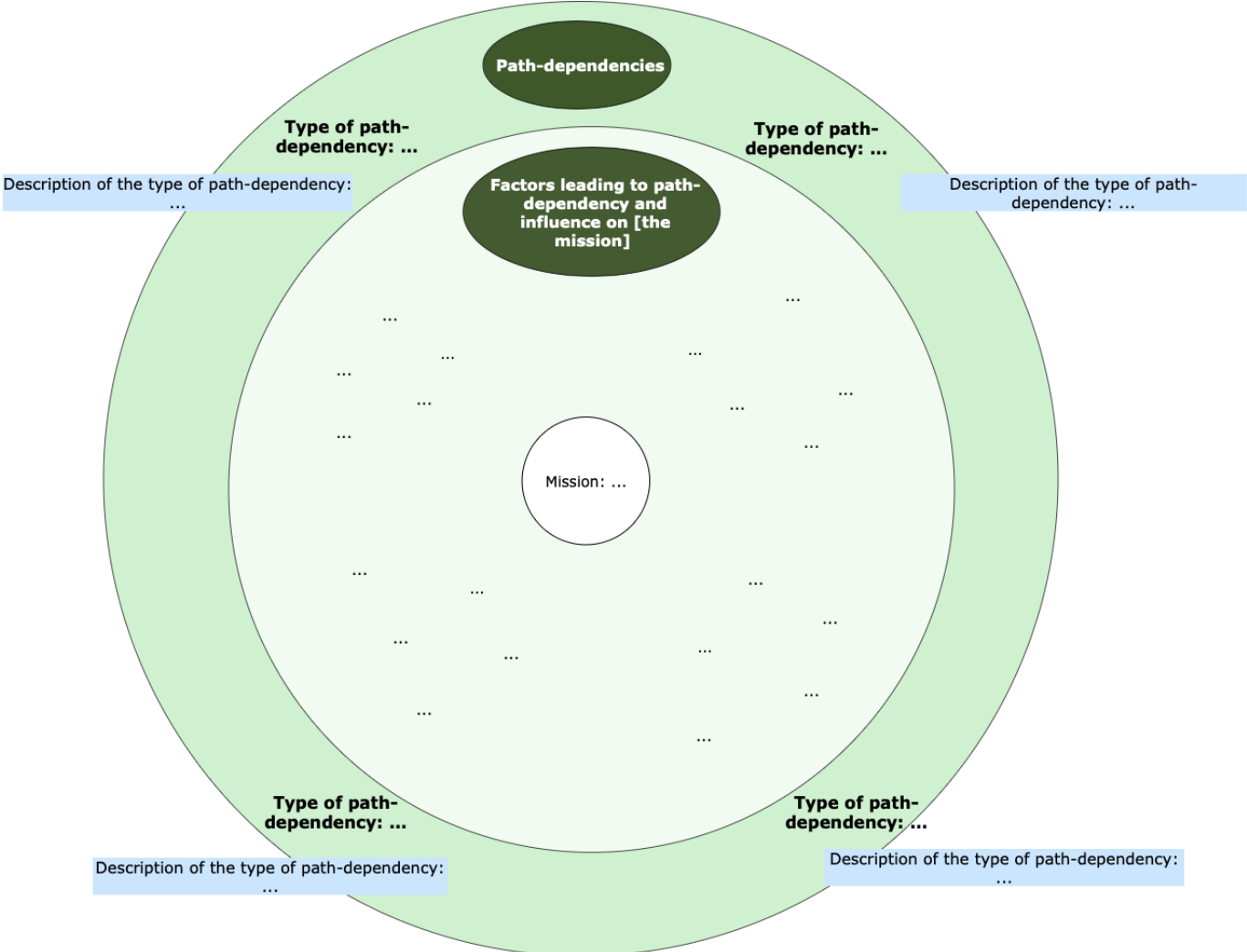


Figure 6. Fill-in scheme for path-dependencies and main factors leading to path-dependency.