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Institutional and behavioural drivers of sustainable farming uptake

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Abstract

If managed sustainably, agriculture has the potential to mitigate climate change and biodiversity loss associated with intensive production. Farmers are essential to sustainable agriculture, but their efforts are often constrained by market failures within the food system and by ineffective policy incentives to address environmental externalities. This doctoral thesis investigates the institutional and behavioural drivers that shape farmers' adoption of environmentally sustainable production practices, using a mixed research methods approach. Examined institutional drivers include both monetary and knowledge-based support, while examined behavioural drivers focus on farmers' decision-making processes and psychological factors. The thesis consists of four papers. Paper I investigates both monetary and non-monetary benefits of participation in climate-related measures by examining Swedish farmers' trade-offs between three co-benefits of cover cropping (i.e. biodiversity, soil health, and carbon sequestration). Paper II elicits cattle producers' willingness to adopt silvopastoral systems, the level of compensation they require, and how behavioural factors influence these decisions. Paper III explores how livestock farmers in Sweden perceive the role of advisory services in promoting the adoption of carbon farming practices. Finally, Paper IV investigates how Swedish farmers perceive the conditions of participation in the contractual measures for the management of semi-natural pastures. The contributions of this thesis improve the understanding of farmers' uptake of sustainable production practices and thereby support the formulation of both new and more effective policies to encourage adoption.

Keywords: Agriculture, sustainable production practices, agricultural policy, farmer decision-making, Sweden.

Institutionella och beteendemässiga faktorer för ett ökat upptag av hållbara produktionsmetoder i jordbruket

Sammanfattning

Om det bedrivs hållbart har jordbruket potential att bidra till att minska klimatpåverkan och bevara biologisk mångfald, i kontrast till de negativa effekter som ofta följer av intensiv produktion. Lantbrukare är avgörande för ett hållbart jordbruk, men deras insatser begränsas ofta av marknadsmisslyckanden inom livsmedelssystemet och av ineffektiva politiska incitament för att hantera miljömässiga externaliteter. I denna avhandling undersöker jag institutionella och beteendemässiga faktorer som påverkar lantbrukares beslut att tillämpa miljömässigt hållbara metoder. De institutionella faktorerna omfattar både ekonomiskt och kunskapsbaserat stöd, medan de beteendemässiga faktorerna rör beslutsprocesser och psykologiska drivkrafter hos lantbrukare. Avhandlingen består av fyra delstudier och bygger på en kombination av kvalitativa och kvantitativa metoder. I den första artikeln undersöker jag både ekonomiska och icke-ekonomiska nyttor av att delta i klimatrelaterade åtgärder, genom att analysera hur svenska lantbrukare gör avvägningar mellan tre samnyttor med mellangrödor – biologisk mångfald, jordhälsa och kolinlagring. I den andra artikeln kartlägger jag nötköttsproducenters vilja att införa silvopastorala system, vilken ersättning de anser nödvändig, samt hur olika beteendemässiga faktorer påverkar deras beslut. I den tredje artikeln studerar jag hur svenska djurhållare uppfattar rådgivningens roll i att främja införandet av kolbindande jordbruksmetoder. I den fjärde artikeln fokuserar jag på hur svenska lantbrukare upplever villkoren för att delta i de avtalade åtgärderna för skötsel av naturbetesmarker. Avhandlingens resultat bidrar till en ökad förståelse för lantbrukares införande av hållbara produktionsmetoder och kan därmed utgöra ett underlag för att utforma nya och mer verkningsfulla styrmedel som främjar omställningen.

Nyckelord: Jordbruk, hållbara produktionsmetoder, jordbrukspolitik, lantbrukares beslutsfattande, Sverige.

Preface

The Thought-Fox
by Ted Hughes

I imagine this midnight moment's forest:
Something else is alive
Beside the clock's loneliness
And this blank page where my fingers move.

Through the window I see no star:
Something more near
Though deeper within darkness
Is entering the loneliness:

Cold, delicately as the dark snow
A fox's nose touches twig, leaf;
Two eyes serve a movement, that now
And again now, and now, and now

Sets neat prints into the snow
Between trees, and warily a lame
Shadow lags by stump and in hollow
Of a body that is bold to come

Across clearings, an eye,
A widening deepening greenness,
Brilliantly, concentratedly,
Coming about its own business

Till, with a sudden sharp hot stink of fox
It enters the dark hole of the head.
The window is starless still; the clock ticks,
The page is printed.

Dedication

To my niece, and the memorable timing of her arrival.

Contents

List of publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I. Opdenbosch, H., Mattsson, E., Oyinbo, O., Rommel, J., Hansson, H., & Manevska-Tasevska, G. Farmers' trade-offs between co-benefits of climate change mitigation measures (manuscript).

II. Opdenbosch, H., & Hansson, H. (2023). Farmers' willingness to adopt silvopastoral systems: Investigating cattle producers' compensation claims and attitudes using a contingent valuation approach. *Agroforestry Systems*, *97*(1), 133-149. https://doi.org/10.1007/s10457-022-00793-0

III. Opdenbosch, H., Hansson, H., Källström, H. N., & Manevska-Tasevska, G. (2025). Upscaling carbon farming practices: perceived advisor leverage in farmer decision-making using Q-methodology. *The Journal of Agricultural Education and Extension*, 1–22. https://doi.org/10.1080/1389224X.2025.2533173

IV. Opdenbosch, H., Brady, M. V., Bimbilovski, I., Swärd, R., & Manevska-Tasevska, G. (2024). Farm-level acceptability of contract attributes in agri-environment-climate measures for biodiversity conservation. *Journal of Rural Studies*, 112, 103448. https://doi.org/10.1016/j.jrurstud.2024.103448

All published papers are published open access.

List of tables

List of figures

1. Introduction

1.1 Background

Agriculture is the leading driver of biodiversity loss, with increasingly negative trends due to shifting consumption patterns, a growing global population, the conversion of natural habitats into intensively managed farmland, and the release of various pollutants, including synthetic fertilizers and pesticides (Dudley & Alexander, 2017; Kleijn et al., 2009; Stoate et al., 2009). Biodiversity loss is further accrued by climate change, which alters ecosystems and intensifies extreme weather events, with agriculture and food production accounting for roughly one-third of global anthropogenic GHG emissions (Crippa et al., 2021). In Sweden, the empirical focus area in this doctoral thesis, agriculture contributes to over 14 percent of the country's territorial emissions (Naturvårdsverket, 2023). While Sweden represents a relatively small share of global food production, its high environmental regulations and well-developed agricultural sector make it a valuable case for exploring sustainable agricultural transitions in high-income contexts. Importantly, agriculture in Sweden and elsewhere is not only a driver of biodiversity loss and climate change but is also increasingly vulnerable to it. Climate change and biodiversity loss threaten agricultural yields and their resilience, posing risks to food security and rural livelihoods, especially in times of crises.

If managed sustainably, agriculture has the potential to contribute to climate change mitigation and to the provision of both public goods and ecosystem services that might otherwise be neglected (Martin & Hine, 2017). While farmers are central to implementing sustainable practices on their farms (Gaymard et al., 2020; Sollenberger et al., 2019), they operate within a wider food system shaped by market failures and negative externalities. For example, supply chain actors such as processing industries and retailers influence production decisions by prioritizing low-cost outputs, often at the expense of environmental sustainability. Similarly, consumer preferences and consumption patterns can reinforce intensive food production, while policy makers have frequently failed to establish effective incentives to internalize the environmental costs across the food system (e.g. European Court of Auditors, 2021; Pe'er et al., 2022). Although some farmers may independently adopt unincentivized sustainable practices, enabling conditions, such as through supportive institutional frameworks examined in this thesis, are essential to facilitate a broader transition toward sustainable agriculture (Buitenhuis et al., 2022; Mathijs et al., 2022).

In the European Union (EU), the Common Agricultural Policy (CAP) is among the most well-known target incentives offering Member States various contractual (incentivized) measures such as eco-schemes under Pillar 1 and agri-environment-climate measures under Pillar 2 (McDonald et al., 2021). These contractual measures, as part of the broader category of payment for ecosystem services, involve transactions between service users (e.g. consumers or taxpayers) and providers (e.g. farmers or land managers) contingent upon stipulated management practices aimed at generating public benefits (Canessa et al., 2024; D'Alberto et al., 2024; Wunder, 2015). They encourage farmers, through voluntary participation, to exceed the requirements of mandatory environmental regulations, which typically address issues like environmental pollution, animal welfare, and food safety violations (Martin & Hine, 2017). Depending on their objectives, these measures can support the extensification or intensification of environmentally sustainable management practices or encourage changes or maintenance of existing practices (Hasler et al., 2022). Enforcing controls on practices deemed "normal" by the public, such as feed-intensive cattle production, can be politically or socially challenging. Therefore, payments are often necessary to incentivize farmers to adopt environmentally sustainable production practices beyond conventional farming (Bazzan et al., 2023; Martin & Hine, 2017). These payments should cover both the direct and opportunity costs of implementation (Canessa et al., 2024).

The CAP also offers funding for investments, knowledge-building, innovation and co-operation aimed at promoting the modernisation of agriculture. Member States are required to include actions in their strategic plans to strengthen Agricultural Knowledge and Innovation Systems (AKIS) by better integrating digitalisation, research, and advisory services (EU SCAR AKIS, 2019). Advisory services are heavily relied upon within AKIS to underpin national strategic plans (Andrés et al., 2022; Ingram & Mills, 2019; Labarthe & Beck, 2022; Schomers et al., 2015; L. Sutherland et al., 2022), by offering impartial, well-qualified guidance to support farmers' practical decision-making and facilitate the uptake of innovation.

Despite substantive funding allocated to both a greener (through contractual measures) and innovation-friendly CAP (through AKIS), evidence suggest limited effectiveness in preserving biodiversity or ecosystem services (Ait Sidhoum et al., 2023; Batáry et al., 2015; Díaz & Concepción, 2016; Gaymard et al., 2020; Pe'er et al., 2022), along with criticism for the lack of significant progress in reducing agricultural emissions (European Court of Auditors, 2021). The voluntary nature of the contractual measures means that effective participation, encompassing the number and types of farmers engaged, is a crucial indicator of both their success and overall effectiveness (Canessa et al., 2024; Martin Persson & Alpízar, 2013).

There has been a strong interest over recent decades among researchers and policymakers in understanding the factors that influence farmers' adoption of both contractual and non-contractual environmentally sustainable production practices (Borges et al., 2019; Canessa et al., 2024; Pannell et al., 2006; Prokopy et al., 2019; Thompson et al., 2024). These studies have examined a wide range of drivers, including socio-demographic, economic, farm structural and social factors that shape farmers' decision-making processes. Especially, psychological and behavioural factors should also be considered to leverage intrinsic drivers of decision-making and to design more effective measures that can better support farmers' transition towards sustainable agriculture (Dessart et al., 2019; Howley, 2015; Leduc & Hansson, 2024; Schaub et al., 2023; Schlüter et al., 2017). However, institutional drivers have been under-researched and the use of theoretical frameworks based on behavioural theories, or models, remains limited in the literature (Thompson et al., 2024).

1.2 Aim and research questions

This doctoral thesis aims to investigate farmers' adoption of environmentally sustainable production practices by examining institutional and behavioural drivers that shape participation in voluntary and both contractual and non-contractual measures. The contributions of this thesis improve the understanding of farmers' uptake of sustainable production practices and thereby support the formulation of both new and more effective policies to encourage adoption.

To better understand the components of the thesis's aim, key terminologies are defined in this paragraph. *Environmentally sustainable production practices* (henceforth 'sustainable production practices') refer to farming practices whose main expected benefit, compared to conventional practices, is the provision of positive externalities, with a particular focus in this thesis on biodiversity and climate change (Dessart et al., 2019). This thesis investigates examples of such practices, including cover cropping, silvopasture, carbon farming, and semi-natural pasture. *Institutional* drivers include not only aspects of policy measures themselves but also the broader support network, such as advisory services and knowledge systems (Daugbjerg, 1999; Thompson et al., 2024). *Behavioural* drivers refer to the social and psychological factors that intrinsically influence farmers' decision-making (Leduc & Hansson, 2024). It is worth noting that each paper does not focus exclusively on either institutional or behavioural drivers; rather, behavioural factors are integrated alongside institutional aspects to deepen the understanding of decision-making. Finally, *contractual* and *non-contractual* measures refer to incentivised (i.e. through CAP measures) and not incentivised (i.e. independent of CAP measures) adoption of sustainable production practices, respectively (Schaub et al., 2023; Thompson et al., 2024).

Table 1 outlines the aim and research questions of each paper included in the thesis. Section 2 provides a more detailed account of the institutional and behavioural drivers examined in the thesis, along with the frameworks applied to link the papers and identify key behavioural factors. Methodologies used to investigate the aims are detailed in Section 3. Summaries and key findings of each paper are provided in Section 4, while the overall contributions, policy implications, and recommendations in relation to the results are discussed in Section 5.

Table 1. Aim and research questions of each paper composing the thesis

Paper	Aim	Research questions
I	To investigate farmers' preferences for the co-benefits of mitigation measures.	- Do non-climate co-benefits increase the likelihood of farmer participation in the cover cropping eco-scheme? - Do all farmers think the same?
II	To elicit farmers' willingness to adopt silvopastoral systems.	- What is the minimum level of compensation required by farmers to adopt silvopastoral systems? - Are farmers motivated by profit maximisation alone?

III	To examine the role of advisors in supporting the upscaling of carbon farming practices.	- Does the role of advisors in supporting climate change mitigation align with policy expectations? - At which stage of the farmer decision-making process can improvements in advisory services have the greatest impact?
IV	To assess farm-level acceptability of contract attributes within the agri-environment-climate measure for semi-natural pastures management.	- Are contracts adapted to local conditions and farming operations? - Does the current CAP reform for the period 2023-2027 offer an opportunity for improvements?

2. Conceptual framework

2.1 Institutional drivers within the participation framework

In this thesis, I follow the participation framework proposed by Canessa et al. (2024) (Fig. 1) to structure the overall content and connect the papers, thereby placing the examined institutional aspects within existing literature. Canessa et al. (2024) adapted the framework proposed by Whitten et al. (2013) to the context of voluntary CAP measures, by identifying eight major determinants and grouping them into four categories: *alignment, opportunity, engagement,* and *contracting*. The main idea is that the farmer's choice depends upon different considerations such as the relevance (*alignment*), the relative advantage of participation (*opportunity*), as well as on their degree of knowledge (*engagement*) and the offered contractual conditions (*contracting*) (Canessa et al., 2024).

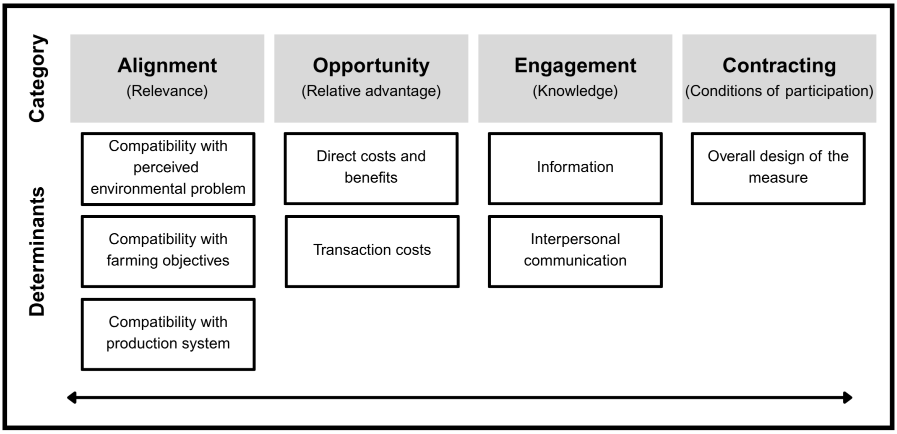

Figure 1. Participation framework adapted from Canessa et al. (2024)

Alignment is the first aspect farmers consider when deciding whether to participate in CAP measures, referring to how relevant and compatible the measure is with their perceived environmental problems, farming objectives, and production systems (Pannell et al., 2006; Rogers et al., 2008; Whitten et al., 2013). Farmers are more likely to participate when a measure addresses an environmental issue they recognise as important and when they hold strong pro-environmental attitudes (Baumgart-Getz et al., 2012; Dessart et al., 2019; Vanslembrouck et al., 2002). Compatibility with farming objectives also plays a role, as decisions are shaped by both economic and personal considerations, including household income, investment strategies, succession planning, and environmental priorities (Lastra-Bravo et al., 2015; Pannell et al., 2006; Prokopy et al., 2019). Finally, compatibility with the production system influences adoption, as farmers are more likely to join if the measure fits their existing management practices and minimises disruption (Pannell et al., 2006; Schaub et al., 2023).

Opportunity refers to farmers' evaluations of the relative advantage of participating in CAP measures, defined as the extent to which the new practice is perceived as better than their current management (Pannell et al., 2006; Rogers et al., 2008; Whitten et al., 2013). This perception depends largely on the direct, opportunity, and transaction costs associated with participation. Direct costs may include the need for new equipment, additional labour, or technical knowledge, while opportunity costs refer to any foregone productivity or reduced management flexibility (Canessa et al., 2024). Opportunity costs vary among farmers and are often difficult for policymakers to observe due to information asymmetries. Transaction costs further shape opportunity by reducing the net benefit of participation. These can arise both before adoption (e.g. searching for information, comparing options) and during implementation (e.g. monitoring and compliance burdens) (Mettepenningen et al., 2013). Payments should therefore cover such costs to be perceived as beneficial to the farmers (Canessa et al., 2024). In contrast, non-monetary benefits, such as environmental impact, are less commonly addressed in empirical studies, despite their potential to increase perceived advantage (Dessart et al., 2019).

Engagement refers to the processes of information dissemination, exchange, and communication that enable farmers to understand the existence, function, and implications of participating in CAP measures. Prior to making changes to their farming systems, farmers typically require a substantial amount of information to assess the relevance and feasibility of new practices (Pannell et al., 2006; Taylor & Van Grieken, 2015; Unay Gailhard et al., 2012). Interpersonal communication, such as access to agricultural organisations and advisory services, further facilitate the exchange of experience-based knowledge and build trust in the measure and its promoters. These forms of social and institutional capital have been shown to lower information-related transaction costs and enhance understanding of policy instruments (Unay Gailhard et al., 2015), thereby making participation more likely.

Contracting refers to how the design and administrative characteristics of voluntary environmental policy measures influence farmers' participation decisions. The contractual framework plays a central role in shaping both the perceived alignment and opportunity of a measure, thereby affecting its overall attractiveness (Schaub et al., 2023). Contract features such as payment levels, flexibility in implementation, and options for early withdrawal can encourage participation, while burdensome monitoring requirements, rigid rules, and excessive bureaucracy may act as deterrents (Dessart et al., 2019; Raina et al., 2021). Farmers generally favour contracts that are simple, clear, and adaptable to their circumstances (Mack et al., 2024). Crucially, economic compensation must reflect the true opportunity costs of participation.

Table 2. Determinants and categories of the participation framework addressed in each paper

	Alignment	**Opportunity**	**Engagement**	**Contracting**
Paper I	Compatibility with perceived environmental problem Compatibility with farming objectives	Direct costs and benefits	N/A	Overall design of the measure
Paper II	N/A	Direct costs and benefits	N/A	Overall design of the measure
Paper III	N/A	Transaction costs	Information Interpersonal communication	N/A
Paper IV	Compatibility with production system	Direct costs and benefits	Interpersonal communication	Overall design of the measure

Farmer participation in voluntary contractual measures is a dynamic and context-dependent process (as illustrated by the arrow in Fig. 1), with no single category fully accounting for decision-making (Canessa et al., 2024). Rather, participation results from the interaction of multiple determinants within and across categories. This is reflected in Table 2, where each paper addresses two or more components of the participation framework.

Paper I examines how the compatibility between a measure and farmers' objectives and environmental concerns (*alignment*), expressed through preferences and identity, influences the perceived benefits of participation (*opportunity*), including non-monetary co-benefits, and how this is shaped by the framing of policy goals within the contractual design (*contracting*). Paper II investigates participation through a focus on direct costs and benefits (*opportunity*), eliciting hypothetical compensation claims to inform policy design (*contracting*). Paper III highlights the importance of information and interpersonal communication (*engagement*), particularly the role of advisory services in supporting participation and reducing information-related transaction costs (*opportunity*). Finally, Paper IV investigates specific contract attributes that have direct implications on how the overall design of the measure is perceived (*contracting*): the supported activity influences compatibility with production systems (*alignment*); the payment and sanction affect the direct costs and benefits (*opportunity*); and the inspection process shapes interpersonal communication with inspectors (*engagement*).

2.2 Behavioural drivers and frameworks applied

Qualitative research methods are primarily employed to explore context-specific motivations and perspectives of farmers and stakeholders (Canessa et al., 2024; Schulze & Matzdorf, 2023), though they often lack generalizability (Brown et al., 2021). In contrast, quantitative methods focus on identifying correlations between observable characteristics of the broader farming population and participation. While such approaches offer generalizable insights, they often provide limited understanding of how farmer beliefs or archetypes influence decision-making, particularly given that the adoption of sustainable production practices is driven not only by economic considerations but also by intrinsic motivations, including social and environmental concerns (Dessart et al., 2019; Howley, 2015; Le Coent et al., 2021; Leduc & Hansson, 2024; Leonhardt et al., 2022; Schaub et al., 2023). To address these limitations, the (mixed) quantitative research papers in this thesis draw on insights from psychology and sociology to identify and analyse the underlying factors that influence decision-making in agricultural contexts. Table 3 presents an overview of the behavioural drivers addressed in each paper, based on a combination of behavioural concepts and theoretical frameworks detailed in Subsections 2.2.1 to 2.2.3.

Table 3. Behavioural drivers and frameworks applied in each paper

Paper	Research approach	Behavioural driver(s)	Framework
I	Quantitative	Environmental, social, and economic identity and attitude	Identity Economics Theory (Akerlof and Kranton, 2000)
II	Quantitative	Attitude, subjective norm and perceived behavioural control	Theory of Planned behaviour (Ajzen, 1991)
III	Mixed	Farmers' decision-making process	Triggering Change Model (Sutherland et al., 2012)
IV	Qualitative	N/A	N/A

2.2.1 Identity Economics Theory

Paper I is framed within the Identity Economics Theory of Akerlof and Kranton (2000) which is based on Stryker's identity theory (Stryker, 1968), where identity represents an individual's sense of self, self-concept, or self-image (Howley & Ocean, 2021). In this theory, identity is integrated into the standard utility framework to explain human choices, especially in settings where choices involve costs and benefits to the decision maker. The theory assumes that people gain (or lose) utility by undertaking actions that align with (or deviate from) norms and ideals related to their identity. Furthermore, it assumes that different clusters of people exist, with each cluster having unique norms and ideals. This means that utilities from actions differ across clusters, and these differences can be explained by identity differences. Following Oyinbo and Hansson (2024), individuals possess multiple, non-mutually exclusive identities, explained by identity distinctions along environmental, social, and economic sustainability. For instance, environmental identity clusters are formed based on farmers' attachment to the environmental concerns, allowing farmers to be grouped according to their level of pro-environmental disposition (Oyinbo & Hansson, 2024). While empirical applications of Stryker's identity theory in agriculture, such as in conservation, are still emerging and gaining attention (Spörri et al., 2025; Van Dijk et al., 2016; Zemo & Termansen, 2022), the use of identity economics theory remains limited, with only a few studies addressing trade-offs in dairy farming feeding systems (Oyinbo & Hansson, 2024), occupational crafts and trades (Binder & Blankenberg, 2022), and engagement in conservation practices (Howley & Ocean, 2021).

2.2.2 Theory of Planned Behaviour

Paper II applies the Theory of Planned behaviour (TPB) (Fig. 2). TPB establishes that adoption behaviour emanates from the farmer's intention to adopt, which is consecutively determined by three psychological constructs: attitude, subjective norm, and perceived behavioural control (Ajzen, 1991). Capturing both the level of understanding and appreciation of a behaviour, 'attitude' refers to an individual's positive or negative evaluation of the behaviour; the 'subjective norm' is the individual's perception of the social pressure put upon them to perform the behaviour; and finally, 'perceived behavioural control' relates to the individual's perception of their own ability to successfully perform the behaviour (Ajzen, 1991). TPB has been effectively applied in agriculture to explain diverse farmer behaviours, including farm diversification (Hansson et al., 2012; Senger et al., 2017), organic farming (Läpple & Kelley, 2013), environmental accounting practices (Tashakor et al., 2019) or on-farm food safety (Rezaei et al., 2019).

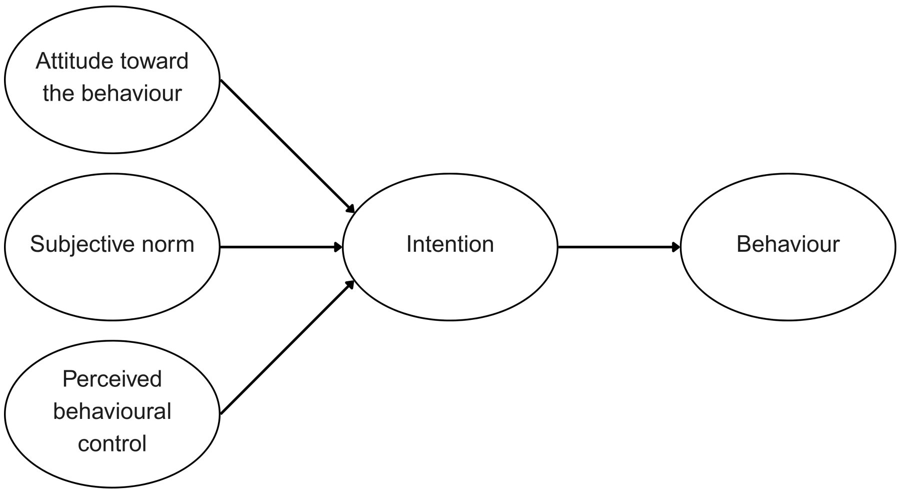

Figure 2. The Theory of Planned Behaviour from Ajzen (1991)

2.2.3 Triggering Change Model

Paper III uses the Triggering Change Model (TCM) by Sutherland et al. (2012) to illustrate farmers' decision-making process based on social-psychological theory (Fig. 3). TCM involves five stages: path dependency, trigger event, active assessment, implementation, and consolidation. According to the model, farmers adhere to their established farm management practices (path dependency stage) until a significant event prompts a need for change (trigger event stage), after which they actively seek and evaluate new options (active assessment stage). Following this, farmers implement a new course of action (implementation stage) before consolidating successful practices into their farm operations (consolidation stage). If not, farmers return to the active assessment stage in search of other options. Previous applications of TCM include reducing antimicrobial use (Enticott et al., 2024), exploring the role of farmers' personal networks in adopting digital technologies (Kvam et al., 2022), and examining the uptake of digital innovations (Mrnuštík Konečná & Sutherland, 2022).

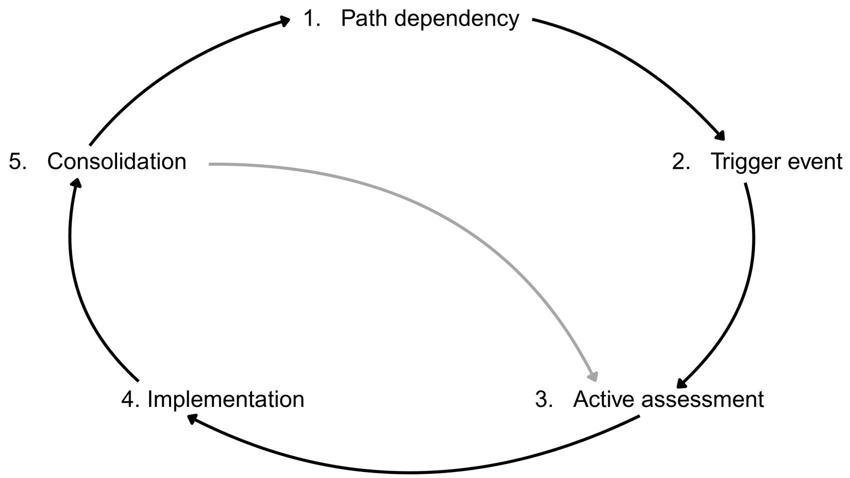

Figure 3. The Triggering Change Model from Sutherland et al. (2012)

3. Methodology

3.1 Methods

Each paper applies a different method, whether qualitative or quantitative, selected to best address its respective research questions. Mixed methods offer a powerful approach in agricultural economics, particularly when the research concerns human behaviour and decision-making processes, such as those of farmers. Since such behaviours are embedded in social and psychological contexts, they cannot be fully understood through quantitative methods alone (Goerres & Prinzen, 2012; Tashakkori & Teddlie, 2010). The use of multiple methods therefore enables a more comprehensive exploration of the topic by balancing diverse perspectives, supporting a deeper understanding of complex viewpoints, and allowing for statistical representativeness where appropriate. Table 4 provides an overview of the data and methodological and analytical approaches used in each paper, which are further elaborated in Subsections 3.2 - 3.4.

Table 4. Overview of methods, data, and analytical approaches

	Paper I	**Paper II**	**Paper III**	**Paper IV**
Research approach	Quantitative	Quantitative	Both	Qualitative
Method	Discrete choice experiment	Contingent valuation approach	Q-methodology	Exploratory qualitative approach
Data collection	Survey	Survey	Survey & workshop	In-depth interviews, nation specific scientific articles, & policy documents
Sample	179 Swedish farmers	84 Swedish cattle producers	32 Swedish livestock farmers, 16 Swedish stakeholders	8 Swedish farmers, 3 advisors, 11 scientific articles, 9 policy documents
Analytical approach	Multiple-indicators and multiple-causes model & latent class model	Exploratory factor analysis & Heckman two-step estimation method	Factor analysis	Qualitative thematic and content analysis

Paper I employs a Discrete Choice Experiment (DCE), a survey-based method to investigate preferences for goods, services, and policies (Louviere, 2001). In the questionnaire, respondents are given a description of the choice task and are then asked to repeatedly select their preferred option from a set of alternatives (choice sets). Each alternative is defined by a set of attributes that represent the good, service, or policy being studied, with each attribute having at least two levels to differentiate the options. The experimental design was created using Ngene, producing 18 paired choice sets, which were randomly assigned in groups of six to respondents. Each choice set included two unlabelled hypothetical alternatives, each featuring four attributes with three varying levels of improvements, along with an opt-out option. Once the data were collected, respondents' choices were regressed on the attribute levels to estimate their influence on choice behaviour. The DCE method is grounded in microeconomic theory, enabling the calculation of welfare measures such as willingness-to-accept values for individual attributes.

Paper II employs an open-ended contingent valuation method (CVM; Ciriacy-Wantrup, 1947), widely used to estimate non-use values, especially for the ecosystems and environmental services which have no market values (Carson et al., 2001; Lindhjem & Mitani, 2012; Mäntymaa et al., 2018). The open-ended questions format consists of directly asking the respondents to state freely the value they would require for a hypothetical good or service, therefore minimizing the risk of potential vehicle biases (Walker & Mondello, 2007).

Paper III uses Q-methodology (Stephenson, 1993), which offers an intuitive yet structured approach for assessing stakeholder perceptions of complex phenomena (Herrington & Coogan, 2011; Lien et al., 2018). It explores how stakeholders perceive relationships among various elements within complex issues (McKeown & Thomas, 2013; Watts & Stenner, 2012) and identifies both differences and similarities in their viewpoints (Durning, 2006; Zabala et al., 2018). By integrating qualitative methods, such as textual analysis and interviews, with quantitative factor analysis (Sneegas et al., 2021), Q-methodology provides robust statistical support for qualitative insights (Watts & Stenner, 2012). The approach is especially suited for studying human subjectivity, as it requires participants to critically engage with predefined opinion statements, thereby indirectly uncovering their subjective values.

Paper IV applies an exploratory, qualitative approach (Laurett et al., 2021), which is particularly suitable for understudied subjects and involves fieldwork to understand the perceptions, attitudes, and opinions of individuals involved (Creswell & Creswell, 2017).

3.2 Sampling and data

The empirical material for this thesis was collected independently for each paper and consists of both quantitative and qualitative data, reflecting the overall mixed-methods approach.

In Paper I and Paper II, primary data was collected through online survey. The use of online surveys among Swedish farmers is common and considered an efficient mode of data collection, given that 100% of Sweden's 16–64 years old has internet access (Internetstiftelsen, 2024). This also reduces the potential social desirability bias associated with face-to-face interviews (Lindhjem & Navrud, 2011). In both cases, farmers were invited to participate in the survey through emails (and reminders) stating the aims of the survey, that their answers would be kept anonymously, and providing a link to the questionnaire. Contact information was retrieved from Statistics Sweden. The adjusted response rates of 7.6% and 12% for Paper I and Paper II, respectively, is relatively low compared to recent surveys conducted in Sweden (e.g. Ha et al., 2024). Submissions via e-mail rather than from a marketing research company might have impacted the response rate. Additionally, the declining number of Swedish farms, coupled with a rise in the number of surveys can cause survey fatigue, manifested in decreasing response rates and increasing attrition.

Paper III included both a survey and a workshop. Following Q-methodology, a survey was conducted to obtain data for analysis. It is crucial to acknowledge that Q-methodology does not require a large sample size (Wijaya & Offermans, 2019). Instead, the method is particularly suitable for exploratory research with the sample typically ranging from 10 to 40 respondents (Dieteren et al., 2023). In Q-methodology studies, the primary objective is not to achieve statistical generalization to the broader population. Instead, the focus is on capturing a diverse range of perspectives and fostering a comprehensive understanding of various viewpoints, rather than striving for statistical representativeness (Wijaya & Offermans, 2019; Zabala, 2014). In this study, livestock producers collaborating with advisory services were chosen as the target participants, and a random sampling approach was employed (Dieteren et al., 2023). In total, 32 farmers participated in the survey. Then, 16 actors from the Swedish food system participated in a workshop to discuss the results, providing qualitative insights to the analysis. Stakeholder engagement in environmental and agricultural research is gaining attraction (Höglind et al., 2021) and is perceived as bringing significant benefits to the process of knowledge generation (Phillipson et al., 2012). Actively engaging with a range of stakeholders with multiple perspectives is crucial during research to facilitate knowledge exchange, joint learning, and the generation of integrated solutions (Šūmane et al., 2018). It also supports the effective implementation of measures for the sustainable use of ecosystem services (Geertsema et al., 2016).

Paper IV includes in-depth interviews to gather qualitative data on individuals' perspectives regarding specific ideas, phenomena, or situations (Legard et al., 2003). In this study, eight farmers and three advisors, contributed to the interviews. The selection process consisted of two parts. In the first part, sampling was of the purposive variety, with the Swedish Farmers' Association recommending advisors that have experience working with farmers who manage semi-natural pastures (SNPs) (Etikan & Bala, 2017). Advisors had different focus areas but both animal health and production were of interest for this study. In the second part, sampling was of the snowball variety, with advisors who participated in the study recommending farmers that actively manage SNPs to be interviewed (Etikan & Bala, 2017). A regional stratification based on the distribution of SNPs in Sweden was implemented to ensure proportional representation among the participants. In-depth interviews were initially structured and further complemented using a review of scientific literature. Eleven studies (reports and articles) containing evidence, gathered via interviews, surveys, literature review, on farmers' experience with management of SNPs after 1013 were selected. The obtained findings were then compared with policy documents for further analysis. Nine documents were selected based on the following criteria: i) CAP payment schemes supporting the management of SNPs, and ii) relevant Swedish laws, legal cases, and documents outlining the application of these schemes in Sweden. The documents were sourced from the European Commission (ec.europa.eu), the Swedish law platform (lagen.nu), and the Swedish Board of Agriculture (jordbruksverket.se).

3.3 Analytical approaches

Paper I applies a latent-choice approach to avoid inherent bias from the direct inclusion of behavioural latent variables, i.e., identity and attitude, in the utility function (Hess, 2012). The model consists of a latent variable component with measurement and structural functions estimated using a multiple-indicators and multiple-causes (MIMIC) model, and a choice component with utility and latent class membership functions estimated using latent class model (LCM). The MIMIC model produces scores for the latent identity and attitude variables included in the LCM as explanatory variables and follows a typical structural equation modelling framework (Diamantopoulos et al., 2008), where the measurement and structural models are estimated simultaneously. The measurement model (confirmatory factor analysis) tests the relationships between the latent behavioural variables and their indicators. The structural model then tests the effects of farm and farmer characteristics on latent behavioural constructs. LCM, relax the Independence of Irrelevant Alternatives assumption from the multinomial logit model (McFadden, 1972) and account for unobserved sources of heterogeneity in the deterministic component of utility (Hess, 2012). It assumes that a heterogeneous population of farmers is implicitly sorted into a discrete number of latent classes, and preferences are assumed to be homogeneous within each latent class but heterogeneous across classes (Hensher et al., 2015).

Paper II applies an exploratory factor analysis to reduce TPB statements to underlying constructs, and the Heckman two-step estimation method (Heckman, 1979) to elicit WTA estimates. Because only the outcomes of treated observations were observable, the method controls for selection bias in the first step by estimating a correction term, i.e., the inverse Mills ratio, with a probit model on independent variables. In the second step, the inverse Mills ratio is used as an additional explanatory variable in ordinary least squares (Heckman, 1979).

Paper III follows the traditional process in Q-methodology (Dieteren et al., 2023) with, first, the identification of a concourse, i.e. a broad collection of statements drawn from literature, expert conversations, and other sources, which was structured around the five stages of the Triggering Change Model. Next, participants completed a Q-sorting task, ranking the statements on a nine-point scale based on their personal agreement, following a normal distribution pattern with each level having a designated number of spaces to place the statements. This forced normal distribution forced participants to discriminate between statements. Finally, the data were analysed using principal component analysis and Varimax rotation to identify clusters of similar viewpoints, generating factor arrays that represent distinct perspectives.

Paper IV employs a combined Qualitative Document Analysis (QDA) to ensure a comprehensive and systematic examination of the gathered materials from various sources and individuals. This approach facilitates the extraction of relevant information, identification of patterns and themes, and the meaningful interpretation of the data (Wach & Ward, 2013). Qualitative thematic analysis (QTA) was first undertaken on the transcripts from the interviews for identifying, analysing, and reporting patterns (themes) within the data (Braun & Clarke, 2006), using NVivo 12.7 software (Jackson & Bazeley, 2019). The coding involved aggregating text fragments according to axial (deductive) and thematic (inductive) codes (Coopmans et al., 2021). Deductive coding involves applying pre-existing concepts or theories to the data, while inductive coding involves developing new concepts or theories based on the data (Skjott Linneberg & Korsgaard, 2019). Combining deductive and inductive coding approaches can result in a more comprehensive and nuanced understanding of the data by validating pre-existing concepts, while also allowing for the emergence of new ones. To minimize researcher bias, three researchers collaboratively coded and interpreted each transcript. The results obtained inductively from the interviews were triangulated with previous literature and policy documents to ensure that the discussed attributes were aligned (Manevska-Tasevska et al., 2023). QTA on the nation-specific studies consisted of two steps, data extraction and coding following the procedure outlined above. Coding and categorizing textual data to explore significant trends and Qualitative content analysis (QCA) was undertaken on policy documents patterns, without interfering with the information (Mayring, 2021; Pope et al., 2006). Contrary to QTA, the purpose of QCA is to depict the attributes of the document's content by examining "who says what, to whom, and with what effect" (Bloor & Wood, 2006).

4. Summaries and key findings of appended papers

4.1 Paper I – Farmers' trade-offs between co-benefits of climate change mitigation measures

The mitigation of greenhouse gas emissions in agriculture has become a central objective in the CAP. However, the voluntary nature of mitigation measures, such as the eco-scheme for cover cropping, raises the question about their practical relevance and whether they align with farmers' values, experiences, and on-the-ground needs (Canessa et al., 2024; Pannell et al., 2006; Whitten et al., 2013). This study addresses the drivers of participation in climate-related measures by examining Swedish farmers' preferences for three co-benefits of cover cropping: biodiversity, soil health, and carbon sequestration, through a DCE and LCM. Specifically, it elicits the trade-offs farmers make between the co-benefits by assessing the extent to which they are willing to forgo part of their subsidy payment in exchange for specific improvements in outcomes and how these preferences are shaped not just by monetary incentives, but by farmers' underlying environmental and economic identities and attitudes.

The analysis reveals two distinct groups of farmers with significantly different motivations. The majority (Class 1, approximately 75%) expressed strong preferences and a willingness to accept lower payments in exchange for the co-benefits of cover cropping. In contrast, Class 2 (25%) farmers showed little interest in participating unless offered high compensation, indicating that monetary incentives were their dominant driver. Heterogeneity in preferences was best explained by behavioural constructs rather than observable characteristics. Specifically, farmers' environmental identity and their attitude toward cover cropping were significant predictors of class membership while variables like gender, education, and farm type had limited explanatory power. Notably, the influence of environmental identity was found to be partly reflected through attitude, reinforcing the interconnected nature of these constructs in shaping behaviour.

Among the evaluated co-benefits, soil health was most valued across the sample. Farmers in class 1 were willing to trade-off approximately 1,255 SEK/ha/year (11 SEK ≈ 1 Euro) in subsidies for high improvements in soil health, more than they were willing to give up for high biodiversity (842 SEK) or a 20% increase in carbon sequestration (587 SEK).

While the CAP reform emphasizes climate mitigation, results underscore that farmers are primarily motivated by more tangible operational co-benefits such as improved productivity and soil fertility, than by public benefits. This reinforces previous findings suggesting that climate outcomes are often viewed as secondary benefits to actions taken for more immediate farm-level improvements (Davidson et al., 2019; Farstad et al., 2022).

Finally, although most farmers derived non-monetary value from co-benefits, economic incentives remain crucial. On average, farmers required around 1,720 SEK/ha/year to participate in the eco-scheme, which exceeds the current offer of 1,500 SEK. This suggests that under-compensating farmers risks undermining participation, particularly among those more financially motivated.

Overall, integrating behavioural insights and emphasizing co-benefits in policy design could increase uptake and alignment between mitigation objectives and farmer motivations.

4.2 Paper II – Farmers' willingness to adopt silvopastoral systems: investigating cattle producers' compensation claims and attitudes using a contingent valuation approach

The expansion of intensive cattle production is a major driver of GHG emissions and biodiversity loss in Sweden (IPBES, 2019; Swedish board of agriculture, 2018). As a response, silvopastoral systems, i.e., reforested treeless pastures, have been promoted for their potential to sequester carbon and improve farmland biodiversity (Bussoni et al., 2021; Raj et al., 2020). However, the implementation costs and continuous maintenance are borne entirely by farmers, while environmental benefits are often public goods, highlighting a lack of public incentives (Shrestha & Alavalapati, 2003). This paper explores cattle producers' willingness to adopt silvopastoral systems, the level of compensation they require, and how behavioural factors influence these decisions.

Using a CVM alongside exploratory factor analysis to incorporate behavioural constructs from the TPB, the findings show that 52% of respondents expressed willingness to adopt silvopastoral systems.

Compensation claims averaged 3,107 SEK/ha/year. The Heckman two-step model revealed that compensation demands, and adoption decisions were jointly shaped by demographic factors (education, gender, income) and maintenance costs. Adoption decisions correlated significantly with farmers' attitudes toward silvopasture, signalling that intrinsic values and perceptions matter beyond pure profit maximization. Interestingly, other TPB constructs like subjective norms and perceived behavioural control did not significantly influence adoption. This suggests that farmers act based on their own appraisal of silvopastoral systems rather than peer influence or perceived ability of implementation. Educated farmers tended towards both adoption and more compensation, implying awareness of the system's benefits but also higher cost valuation.

While economic considerations remain essential, the findings highlight that attitudes play a key role in decision-making. Further scaling-up will require not only compensations, but also educational outreach to facilitate social learning and build positive attitudes towards agroforestry practices.

4.3 Paper III – Upscaling carbon farming practices: Perceived advisor leverage in farmer decision-making using Q-methodology

Carbon farming (CF) is gaining attention as a key strategy in climate change mitigation, leveraging agricultural land to act as a carbon sink through practices like agroforestry, cover cropping, reduced tillage, biochar application, and peatland restoration (McDonald et al., 2021). Financial incentives for CF adoption are facilitated through carbon markets, where carbon credits allow businesses to offset emissions (Raina et al., 2024). In the EU, the 2023–2027 CAP reform further integrates CF by requesting Member States to prioritise climate objectives in their SP. This not only includes offering financial but also technical support through the AKIS for the implementation of CF practices (Andrés et al., 2022). AKIS fosters collaboration among advisors, researchers, and stakeholders to provide timely and relevant information, knowledge, and innovation support to farmers (Andrés et al., 2022). Agricultural advisors are positioned as central actors within AKIS, expected to bridge the gap between public climate goals and farmers' private decision-making (Ingram & Mills, 2019; Labarthe & Beck, 2022; Schomers et al., 2015; Sutherland et al., 2022). This raises potential tensions regarding advisors' roles in balancing environmental and economic concerns at the farm level (Farstad et al., 2025).

This study investigates how livestock farmers in Sweden perceive the role of advisors in promoting the adoption of CF practices, using Q-methodology and the TCM to frame the stages of farm-level decision-making. The analysis yielded three distinct perspectives.

The first, “Insufficient Information,” reflects a timing concern in which climate mitigation is still a relatively new policy objective for many farmers. Hence, advisors are perceived as providing insufficient information across the early stages of the TCM, especially in raising awareness and providing credible information related to CF, despite being recognized as crucial for possible future implementation.

In the second perspective, “Implementation Challenges,” farmers experience a sharp decline in perceived support from advisors during the implementation stage. They perceive that advisors lack the capacity, tools, or up-to-date information to help realize it practically on their farms, especially given the variability in farm types, soils, and systems. This highlights the need for advisors to have better access to evidence and tools for credible, tailored support (Ingram & Mills, 2019). This is especially challenging given the complexities of managing soil organic carbon including the monitoring, reporting, and verification of carbon sequestration (McDonald et al., 2021).

The third perspective, “Competing Priorities,” focuses on the dominance of economic considerations in advice, stemming from farmers’ demand. Farmers acknowledge the quality of the advisor-farmer relationship which leads to advisors being highly responsive to farmers’ operational needs but not particularly focused on CF or climate objectives.

These perspectives underscore structural tensions in the advisory landscape. While climate goals are being set at the national and EU levels, many farmers prioritize short-term viability and income stability, particularly amid rising production costs. Hence, despite the increasing policy attention on CF, most advisory services remain productivity-oriented, working on a ‘fee for service’ basis or providing advice linked to product sales, and are not yet fully equipped or incentivized to promote it effectively. This decentralizes advisory systems into a multi-pluralism of advisory services with varying objectives, priorities, and delivery approaches (Ingram & Mills, 2019). To overcome such issues, targeted investment in advisor training, development of robust monitoring, reporting, and verification systems, clearer communication of CF's non-climate and monetary benefits, and stronger policy incentives are needed.

4.4 Paper IV – Farm-level acceptability of contract attributes in agri-environment-climate measures for biodiversity conservation

Farmers managing SNPs in Sweden play a critical role in conserving biodiversity and maintaining the ecological and cultural values of traditional agricultural landscapes (Gaymard et al., 2020; Sollenberger et al., 2019). One AECM is specifically designed to support their efforts. However, the uptake and effectiveness of the measure has fallen short of expectations (Eksvärd & Marquardt, 2018; Jamieson & Hessle, 2021). This paper explores how farmers perceive key contract attributes of AECM, namely supported activity, payment, inspection, and sanction, and how these perceptions influence their willingness to participate.

Through QDA, including interviews with farmers and reviews of policy and scientific literature, the study reveals that farmers often experience a mismatch between supported activities and the practical realities of their farming operations. Supported activities determine the conditionality of the payment, meaning that farmers in the AECM receive the payment only if they implement the requirements specified in their contract (Guerrero, 2021). Many farmers reported that such requirements are ambiguous or insufficiently tailored to specific environmental conditions. This lack of clarity creates confusion and increases the risk of non-compliance, as they often conflict with animal welfare regulations, which can reduce farmers' willingness to participate in the AECM.

Payment, the financial aspect of the contract, was perceived essential by farmers to compensate for both direct and opportunity costs associated with SNP management. Respondents expressed concerns that over the years, they have become increasingly dependent on financial support, raising the risk that payments may not keep pace with rising costs and thus affect profitability (D'Alberto et al., 2024), especially given the reduction in direct support in the SP 2023–27 (Government of Sweden, 2023). Lack of sufficient economic incentives for farmers' environmental efforts increases the risk that they may choose to opt out of the support system and that society subsequently will lose SNPs.

Inspection procedures were a further source of concerns. Farmers expressed unease about encountering inspectors who are overly strict or unfair. Respondents fear the excessive power held by inspectors, which creates an imbalance in their relationship. While farmers recognize the need for rules, they seek flexibility that would allow for reaching compromises when inspections are carried out. Farmers also desire improved collaboration and communication with inspectors to allow for advice in a supportive, not punitive way.

Most respondents expressed satisfaction with sanctions, which include the repayment of support with interest, emphasizing the importance of taking good care of the land to qualify for AECM. However, some are concerned about potential consequences in cases where they have fulfilled their responsibilities but still fail inspections due to circumstances outside of their control. To minimize these risks, some farmers that are further exacerbated by administrative load and requirements uncertainty, apply for only a portion of their available grazing area, resulting in the potential abandonment of SNPs.

Overall, findings suggest that policies that incorporate clear guidelines, adequate compensation, procedural flexibility, supportive inspections, and fair sanctions are more likely to attract and retain participants. These insights offer valuable guidance for future reforms.

5. Conclusion

5.1 Contributions

Farmers' adoption of sustainable production practices is crucial, as sustainably managed agriculture can help mitigate climate change and biodiversity loss. However, adoption is often constrained by market failures within the food system and by ineffective policy incentives to address environmental externalities. This thesis contributes to the literature on farmers' adoption of sustainable production practices in various ways.

First, while relatively rich and often insignificant evidence has been found in the adoption literature for farm structural and socio-demographic factors (Borges et al., 2019; Burton, 2014), institutional drivers have been under-researched in agricultural economics (Thompson et al., 2024). Given their potential role in encouraging adoption, this thesis builds on the participation conceptual framework (fig. 1) by Canessa et al. (2024) to investigate how uptake can be supported through drivers such as policy objectives compatibility (*alignment*) in Paper I, monetary compensation (o*pportunity*) in Paper II, advisory services (*engagement*) in Paper III, and contract attributes (*contracting*) in paper IV. Results contribute to ongoing debates in agricultural economics concerning the design and effectiveness of agri-environmental policies (D'Alberto et al., 2024), particularly in evaluating the appropriateness of CAP measures as financial instruments and the capacity of governmental agencies and advisory services to implement them effectively (Bali & Ramesh, 2018).

Second, given the limited use of theoretical frameworks based on behavioural theories, or models, in the adoption literature (Thompson et al., 2024), a key contribution of this thesis lies in its interdisciplinary approach to understanding farmers' adoption of sustainable production practices by integrating behavioural and psychological perspectives into the fields of agricultural and behavioural economics. By doing so, it contributes to the growing body of literature that seeks to move beyond purely profit maximization (and financial incentives) in explaining farmer behaviour (Dessart et al., 2019; Howley, 2015; Leduc & Hansson, 2024; Schaub et al., 2023; Schlüter et al., 2017). Paper I builds on integrated choice modelling to elicit trade-offs involved in decision making by combining choice with latent variable models, thereby complementing neoclassical economic frameworks with behavioural insights (Howley & Ocean, 2021; Owusu-Sekyere et al., 2022, 2024; Oyinbo & Hansson, 2024; Wuepper et al., 2023). Paper II confirms that attitudes, using TPB, alongside economic considerations, are essential for understanding uptake of sustainable production practices. Paper III applies and extends TCM to explore the role of farm advisors across different stages of behavioural change, offering novel insights into the social and psychological mechanisms that influence the adoption and implementation of agricultural innovations.

Beyond the main contributions cited above, each paper also contributes to a specific strand of the adoption literature. Paper I addresses a gap by focusing on the potential of agri-environmental and climate benefits to increase uptake, as non-monetary benefits of participation have generally been underexplored in primary studies (Canessa et al., 2024; Dessart et al., 2019). Paper I also fills the need for economic valuation of trade-offs between the effects on different ecosystem services (Bartkowski et al., 2020). Paper II contributes to the limited and developing literature on agroforestry systems in European context and their economic implications (Leduc & Hansson, 2024). Paper III contributes to scarce literature on the role of advisory services in supporting climate mitigation efforts (Farstad et al., 2025; Stål & Bonnedahl, 2015). Finally, Paper IV enriches the existing literature on agri-environmental governance (Bazzan et al., 2023; D'Alberto et al., 2024; Gutiérrez-Briceño et al., 2024) by providing a comprehensive analysis of key contract attributes through a multi-source and structured approach.

Finally, understanding the factors that drive farmers' adoption of sustainable production practices is essential for reaching broader European and global sustainability goals. At the European level, this includes objectives outlined in the CAP (European Union, 2021), such as ensuring fair income for farmers, increasing competitiveness, promoting climate action and environmental care, preserving landscapes and biodiversity, protecting food and health quality, and fostering knowledge and innovation. These efforts are also aligned with the European Green Deal (European Commission, 2019), including its targets for climate neutrality by 2050, the Farm to Fork Strategy (European Commission, 2020a), and the EU Biodiversity Strategy (European Commission, 2020b). On a global scale, promoting sustainable agriculture contributes directly to several of the United Nations Sustainable Development Goals (SDGs) (United Nations, 2015), such as No Poverty (SDG 1), Zero Hunger (SDG 2), Good Health and Wellbeing (SDG 3), Clean Water and Sanitation (SDG 6), Responsible Consumption and Production (SDG 12), Climate Action (SDG 13), and Life on Land (SDG 15).

5.2 Policy implications and recommendations

The thesis addresses specific sustainable production practices that are increasingly gaining attention but differ in terms of their current policy support. On one hand, it examines non-contractual practices such as silvopasture, which currently lack dedicated policy frameworks, thereby offering information that can support the design and implementation of effective measures for their promotion. On the other hand, the thesis also investigates contractual practices that are already supported by existing policies, such as SNPs and cover crops. By analysing how farmers respond to these measures in practice, the research can inform future reforms of the measures and the capacity of governmental agencies and advisory services to implement them effectively. Overall, results from this thesis converge on simple but powerful insights for policy effectiveness: measures should align with farmers' values, objectives and operations, offer adequate compensation, and foster knowledge and communication.

Firstly, while public legitimacy from taxpayers and consumers is essential, especially as agriculture receives substantial governmental support across Europe (El Benni et al., 2024), results from Papers I, III, and IV suggest that the success of such measures ultimately hinges on how well they align with farmers' own goals and operational realities. Findings from Papers I and III reflect diverging priorities: while farmers may prioritize private benefits tied farm productivity and economic viability, frequently requiring advisory support to achieve these, the public tends to emphasize public goods with more tangible climate and environmental features (Kragt et al., 2016). For example, motivation for mitigation measures does not necessarily originate in climate consciousness nor a sense of responsibility (Davidson et al., 2019). Rather, as Paper I shows, farmers are primarily driven by the co-benefits these measures offer for farm operations, where climate action is perceived as a by-product of investments in farm management and performance (Farstad et al., 2022). Paper IV further emphasizes that policy measures are often perceived as incompatible with farmers' management practices and local circumstances. Results point to contract misunderstandings, insufficient recognition of regional variation, and conflicts with other regulations as key obstacles. These findings confirm that policy framing matters in how decisions are made on farms (Fleming et al., 2019). Achieving co-benefits as a direct consequence of sustainable farming uptake could therefore help farmers recognise that participation can align with (rather than take away from) their personal values and the objectives of their farm (Fleming et al., 2019). This highlights the need to integrate co-benefits in both policy design and advisory services, as complementary, not competing, strategies, so that uptake of sustainable production practices delivers the broader benefits that both the public and farmers value (Bain et al., 2016).

Secondly, due to the non-market nature of many environmental and climate benefits associated with the sustainable production practices examined, there is a clear need to compensate farmers for both the up-front implementation and opportunity costs involved in delivering these public goods. Results from Papers I, II, and IV therefore clearly underscore the critical role of payments in ensuring the successful management of sustainable production practices and demonstrate farmers' strong reliance on financial incentives (Le Coent et al., 2017). However, findings also reveal growing concerns: over time, farmers have become increasingly dependent on such support, raising the risk that payment levels may not keep pace with rising costs, thereby threatening long-term profitability and participation (D'Alberto et al., 2024).

Thirdly, the results on non-monetary and behavioural drivers from Papers I and II may imply that the potential of examined practices to mitigate emissions and biodiversity loss is consistent with the reasons they own and manage agricultural land. Uptake of sustainable production practices among farmers can therefore be achieved through advice and relatively low-cost training programs to increase farmers' environmental awareness and attitudes (García De Jalón et al., 2018). Results from Paper IV also emphasize farmers' potential to be a vital resource, whose intrinsic pro-environmental motivations can be strengthened through the thoughtful design of contractual features. This involves their participation such as co-design (Canessa et al., 2024; Gutiérrez-Briceño et al., 2024), in fostering a supportive culture with clear, consistent, sensible, and easily understandable rules (Kingston et al., 2021). Increased advisors' leverage in supporting the uptake of sustainable production practices is also necessary, as investigated in Paper III. Building technical capacity in advisory services through training and specialized tools will enable advisors to provide effective and tailored advice on issues such as climate change mitigation (Farstad et al., 2025; Sutherland et al., 2012). Paper IV further highlights the importance of increased communication during inspections to foster a more collaborative and transparent process bringing learning opportunities for both parties, resulting in improved land management (Mack et al., 2024).

5.3 Future research

This doctoral research examined the adoption of sustainable farming practices, with a particular emphasis on the role of public incentives, most notably those embedded in the CAP, in shaping farmers' decision-making. While grounded in institutional dimension, the thesis also engaged with behavioural drivers to provide a more nuanced understanding of decisions. Building on this foundation, future research is further needed in the field in various ways.

Firstly, while the papers in this thesis primarily rely on either qualitative or quantitative methods, future research should consider adopting a concurrent mixed methods strategy, as demonstrated in Paper III. By integrating both qualitative and quantitative data within a single study, this approach can improve the understanding of the research topic through the inclusion of multiple perspectives and a more comprehensive analysis.

Secondly, as demonstrated in this thesis, future research should make greater use of behavioural models and theories to better understand the complex motivations, cognitive biases, and social influences that shape farmers' decision-making. Integrating insights from psychology can enrich current economic and policy analyses by revealing the non-monetary factors that often drive or hinder the adoption of sustainable practices.

Thirdly, behavioural differences suggest that farmers do not respond uniformly to agri-environmental policies. In Paper I, we find that compensation claims vary with pro-environmental identity, while Finger & Pedersen (2025) show that prior experience can also influence engagement. Future research could explore how behavioural interventions might increase participation across different farmer segments, while also addressing potential equity concerns, particularly within the financial mechanisms of the CAP.

Fourthly, future research could move beyond the public policy focus of this thesis to investigate the role of private incentives in agricultural sustainability transitions. This includes examining how market-based mechanisms and other value chain actors, such as processors and retailers, can support public policies and contribute to shaping farmers' adoption of sustainable practices (Harmanny et al., 2025). Understanding how the private sector can share the cost is essential for fostering more integrated and effective sustainability transitions.

Finally, the empirical contributions of this thesis are based on the Swedish context, offering insights that may be relevant to similar Nordic settings. However, further research is needed to assess the extent to which these findings can be transferred to other countries or agricultural systems.

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Popular science summary

Intensive farming is not great for the environment, contributing to biodiversity loss and climate change. While some farmers may choose to adopt more environmentally friendly practices because they care about the environment or want to preserve the cultural value of agricultural landscapes, they often face barriers that make these choices challenging. Current food systems are driven by market pressures and consumer habits that prioritizes the intensive production of more food at lower cost, leaving little space for sustainability. This puts farmers in a tough situation when they want to do better for the planet but also need to stay financially afloat. That is where support systems come in. To make sustainable choices more viable, farmers need financial incentives, not just to cover the costs of switching to greener practices, but also to make up for any drop in productivity. In the EU, for example, the European Commission offers financial incentives that farmers can choose to receive, and in return, they commit to specific environmentally friendly practices.

This thesis explores various aspects of such support systems, including both monetary and knowledge-based support, as well as behavioural factors that influence farmers' decisions to adopt environmentally friendly practices. The research employs a mixed-methods approach, incorporating surveys, interviews, and experiments conducted with Swedish farmers. The thesis consists of four individual papers. Paper I examines how farmers value different environmental benefits of the climate-friendly practice of cover crops, which are plants grown (and promoted) to store carbon in the soil instead of being harvested. The result show that while many farmers are driven by their environmental identity and attitudes, they valued soil health, largely due to its link with farm productivity, more than biodiversity or carbon storage and were willing to accept lower payments in return for healthier soil. Paper II explores farmers willingness to plant trees on grazing land, a method called "silvopasture" that can benefit the environment but isn't currently funded by the government. Over half of the farmers were open to the idea, and on average, they would want about 3,100 SEK per hectare per year in compensation. But beyond money, farmers' attitudes also played a big role in whether they were willing to adopt the practice. Paper III explores how farmers perceive the role of agricultural advisors in promoting practices for climate change mitigation. Results found a gap between what climate policies aim to achieve and what advisors can offer. To close this gap, results suggest better training for advisors and stronger policy tools that connect national climate goals with the realities of everyday farming. Finally, Paper IV examines farmers' perceptions of the support system that compensates farmers to maintain natural pastures, which are grazing land important for biodiversity. It found that many farmers felt the rules did not match the realities they face in the field. They called for clear guidelines, fair compensation, cooperative inspections, and fair sanctions to ensure continued engagement. This thesis helps shed light on what motivates farmers to adopt environmentally friendly practices, offering valuable insights that can guide the design of both new and more effective support systems, making sustainable farming better aligned with real-life conditions at the farm.

Populärvetenskaplig sammanfattning

Intensivt jordbruk är inte särskilt bra för miljön. Det bidrar till förlust av biologisk mångfald och klimatförändringar. Även om vissa lantbrukare väljer att införa mer miljövänliga metoder för att de bryr sig om naturen eller vill bevara det kulturarv som jordbrukslandskapet representerar, möter de ofta hinder som gör dessa val svåra. Dagens livsmedelssystem formas av marknadskrafter och konsumentbeteenden som prioriterar ökad produktion till lägre pris, vilket ger begränsat utrymme för hållbarhet. Det här sätter lantbrukare i en svår situation där de vill göra gott för miljön men samtidigt måste få ekonomin att gå ihop. Det är här stödsystemen blir viktiga. För att hållbara val ska vara möjliga behöver lantbrukare ekonomiska incitament. Det handlar inte bara om att täcka kostnaderna för att ställa om till mer miljövänliga metoder, utan även om att kompensera för eventuella produktionsminskningar. Inom EU erbjuder till exempel Europeiska kommissionen ekonomiskt stöd som lantbrukare frivilligt kan ansöka om. I gengäld förbinder de sig att följa särskilda miljövänliga metoder.

I denna avhandling undersöker jag olika aspekter av sådana stödsystem. Jag fokuserar på både ekonomiskt och kunskapsbaserat stöd, samt beteendemässiga faktorer som påverkar lantbrukares beslut att införa miljövänliga metoder. Arbetet bygger på en blandad metodansats med enkäter, intervjuer och experiment som genomförts med svenska lantbrukare. Avhandlingen består av fyra fristående artiklar. I den första artikeln undersöker jag hur lantbrukare värderar olika miljöfördelar med att använda mellangrödor. Dessa växter odlas för att lagra kol i jorden och skördas inte. Resultaten visar att många lantbrukare drivs av sin miljöidentitet och sina värderingar, men att de värderar jordhälsa högre än biologisk mångfald eller kolinlagring. Det beror i stor utsträckning på att jordhälsa hänger nära samman med produktivitet. Många var därför villiga att ta emot lägre ersättning i utbyte mot friskare jord. I den andra artikeln fokuserar jag på lantbrukares vilja att plantera träd på betesmarker. Det handlar om en metod som kallas silvopastoralism och som kan gynna miljön men som i nuläget inte finansieras av staten. Över hälften av lantbrukarna var öppna för att testa metoden och i genomsnitt önskade de ungefär 3,100 kronor per hektar och år i ersättning. Men det var inte bara ersättningen som spelade roll. Även attityder hade stor betydelse för om lantbrukarna var villiga att anpassa sin verksamhet. I den tredje artikeln undersöker jag hur lantbrukare uppfattar jordbruksrådgivares roll när det gäller att främja klimatanpassade metoder. Resultaten visar att det finns ett tydligt avstånd mellan klimatpolitikens mål och vad rådgivarna faktiskt har möjlighet att stödja i praktiken. För att minska detta avstånd föreslår vi bättre utbildning för rådgivare och starkare policyverktyg som knyter samman nationella klimatmål med verkligheten på gårdsnivå. I den fjärde artikeln undersöker jag hur lantbrukare ser på stödsystemet som ger ersättning för att bevara naturbetesmarker. Dessa marker är viktiga för biologisk mångfald men många lantbrukare upplevde att reglerna inte stämmer med hur arbetet ser ut i verkligheten. De efterfrågade tydliga riktlinjer, rimlig ersättning, samarbetsinriktad tillsyn och rättvisa sanktioner som bättre speglar deras vardag. Denna avhandling bidrar med viktig kunskap om vad som motiverar lantbrukare att välja miljövänliga metoder. Resultaten kan användas som vägledning för att utforma mer effektiva stödsystem som är bättre anpassade till jordbrukets praktiska förutsättningar.

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Farmers' willingness to adopt silvopastoral systems: investigating cattle producers' compensation claims and attitudes using a contingent valuation approach

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Abstract Intensive cattle production systems are currently a major contributor to CO_2 emissions and biodiversity loss. Silvopastoral systems that combine foraging pastures and trees into an integrated system for raising livestock have been suggested a promising avenue to store carbon and preserve farmland biodiversity. However, investments and maintenance costs for these improvements are paid by producers, who reap few of the environmental benefits. The objective of the present study was to assess farmers' willingness to adopt silvopastoral systems by reforesting treeless pastures, their compensation claims related to adoption, and how both are affected by their attitudes towards silvopastoral systems. This study was based on a contingent valuation approach coupled with exploratory factor analysis to obtain measures of attitudinal constructs derived from the Theory of Planned Behavior. Results indicate that 52% of respondents were willing to adopt silvopastoral systems and the mean compensation claim per year per hectare is estimated at SEK 3107.17 (308€). Adoption decision is positively correlated with attitudes towards silvopastoral systems, suggesting that decision-making is not solely driven by profit maximization through concerns related to pecuniary factors.

Keywords Cattle production · Silvopastoral systems · Willingness to adopt · Compensation claims · Contingent valuation method · Theory of planned behavior

Introduction

The numerous environmental damages caused by livestock production, and notably, by intensive cattle production systems, are now well known (Steinfeld et al. 2006; Bilotta et al. 2007; Gill et al. 2010). In Sweden (the empirical focus area in this study), negative impacts of intensive cattle production on the environment are mainly characterized by carbon emissions and biodiversity loss. Today, around 13% of Sweden's total greenhouse gas (GHG) emissions emanate from livestock production, reflecting a release of more than 6.5 million tons of carbon dioxide each year (Swedish Board of Agriculture 2018). Simultaneously, the many plant and animal species linked to pastural landscapes which can traditionally be found in pastures and meadows have been crowded out in recent years, due to increasingly specialized and intensive livestock production systems (IPBES 2020). However, not all pasture systems contribute to the negative environmental impacts caused by livestock production. If managed sustainably, pastures have the potential to reduce such environmental degradations, and in some cases, even contribute positively to the mitigation

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of GHG emissions from livestock and to the preservation of farmland species and habitats (Raj et al. 2020, p.26). The agroforestry practice of silvopasture that combines foraging pastures and trees into a single integrated system for raising livestock has been suggested as a solution to both challenges, with prospects of remaining viable and competitive in the long term (Gold et al. 2000; Clason and Sharrow 2000; Raj et al. 2020, p.26; Bussoni et al. 2021; da Silveira Pontes et al. 2021). Silvopasture either describes systems where forage is deliberately introduced in timber productions, i.e., grazed woodlands, or systems where timber is deliberately introduced in forage productions (Klopfenstein et al. 1997). Consequently, by storing carbon in both soil and tree biomass, silvopastoral systems are estimated to have a carbon sequestration capacity that is five to ten times higher than treeless pastures (Lal et al. 2018) and are demonstrated to provide many resources and refuges to wildlife and native plant species (Alavalapati and Nair 2001; Jose et al. 2017). Additionally, farmers are considered better protected from income risks under silvopastoral systems, as those systems represent a strategy for income diversification and enhanced resilience (Kurtz et al. 2000; da Silveira Pontes et al. 2021), in particular by providing diversified sources of income on different time horizons (Hawken 2017). Furthermore, silvopastoral systems are appealing from an animal welfare perspective, as they provide shade and shelter (Broom et al. 2013; da Silva and Maia 2013).

Silvopastoral systems have received little attention in practical agriculture (den Herder et al., 2016) and lack visibility in both the Common Agricultural Policy (CAP) and in European member states' individual rural development programs (Mosquera-Losada et al. 2017). This lack of implementation is especially true in that silvopasture operates against farming norms and is not only slow to implement but also costly (Hawken 2017; Davis and Rausser 2020). While the environmental benefits of silvopasture are external to farmers, the investment and maintenance costs are often covered by the farmers (Shrestha and Alavalapati 2003), which can negatively affect their willingness to adopt silvopasture practices. Although a well-managed silvopasture can offset some of its costs in the long term, the benefits of silvopasture are unlikely to offer full and immediate compensation (Shrestha and Alavalapati 2003).

As the need for agroforestry systems in agriculture has grown more urgent in recent years, an increasing amount of literature has focused on farmers' perception of such systems, silvopasture included (e.g., Calle et al. 2009; Gregory et al. 2012; Jerneck and Olsson 2013; Meijer et al. 2015; Smith et al. 2022). These studies acknowledge the complexity of silvopasture implementation and try to assess what determinants influence adoption. However, this work has, so far, mostly focused on case studies in tropical climates. In Europe, literature about agroforestry systems, and silvopastoral systems in particular, has remained relatively scarce until García de Jalón et al. (2017) and Schaffer et al. (2019) demonstrated their usefulness within European agricultural systems. Both studies concluded that farmers might have poor interest in adopting silvopastoral systems unless monetary incentives are provided to overcome the high complexity of implementation and internalize the external benefits. Yet less than a handful of studies have tried to empirically assess such economic incentives (e.g., Davis and Rausser (2020) and Shrestha and Alavalapati (2003) for farmers in the USA; Buckley et al. (2012) for farmers in the UK). The results obtained in these papers, while confirming the choice of methods to investigate silvopasture adoption, are set in specific settings (e.g., in Texan ranches, the adoption of riparian buffer zones) and mainly misrepresent the process of pastoral reforestation. Furthermore, while behavioral characteristics have been primarily used in previous perception studies (e.g., Meijer et al. 2015), such psychological factors are equally relevant concerning farmers' willingness to adopt silvopastoral systems and their subsequent compensation claims, i.e., payments paid to the farmers to compensate the up-front costs of implementation, as supported by Buckley et al. (2012) and Davis and Rausser (2020).

The objectives of the present study are to assess farmers' willingness to adopt silvopastoral systems, their compensation claims related to adoption, and how both are affected by their attitudes towards silvopastoral systems. Particularly, we focus on the psychological constructs described by the Theory of Planned Behavior (TPB; Ajzen 1991). TPB is one of the most widely used approaches for understanding determinants of behavior (Hansson et al. 2019), thereby suggesting that pecuniary concerns may not be the only concerns of relevance in farmers' economic decision-making (e.g., Hansson et al. 2012; Läpple and Kelley 2013; Borges et al. 2014; Meijer et al. 2015; Senger et al. 2017). Finally, we discuss scaling-up possibilities of silvopasture implementation. This study uses an open-ended contingent valuation method (CVM; Ciriacy-Wantrup 1947; Davis 1963) to elicit the value of farmers for the implementation of silvopastoral systems. CVM is a well-known method for estimating non-use values, especially for the valuation of ecosystems and environmental services (Carson et al. 2001). The method includes a survey to gather data from Swedish cattle producers and is followed by the Heckman two-step estimation method (Heckman 1979) to quantitatively analyze cattle producers' willingness to adopt silvopasture, their related compensation claims, and the impacts from TPB's psychological constructs.

This study contributes to scientific literature on silvopasture adoption in Europe in three specific ways. First, silvopastoral systems are defined here as treeless pastures that are reforested in cattle production systems that are most found in Europe. Whereas silvopasture is often referred to as a general term defining the combination of trees and foraging pastures, this study specifically adds knowledge to the process of pastoral reforestation and its economic implications. Second, this paper contributes to existing literature by bringing the psychological constructs of TPB (Ajzen 1991) to the study of farmers' adoption of silvopastoral systems. In doing so we can highlight how behavioral drivers affect adoption and show that not only pecuniary drivers may be relevant to explain adoption. Third, the present paper illustrates primary estimates in related compensation claims to silvopasture adoption in Sweden. As such, results can be used for policy recommendations and scaling-up possibilities in Sweden but may also be relevant for similar European cattle production systems by acting as an initial reference point.

Conceptual framework

CVM is rooted in welfare economics and more particularly, in the neoclassical concept of economic value under the framework of individual utility maximization (Hoyos & Mariel 2010). The indirect utility function of a producer is defined as the following:

$$V(I(l), Q(l), X) \quad (1)$$

where l is the farmer's land uses,[1] $I(l)$ captures the farmer's income, i.e., net-revenues from any kind of market activities, including monetary benefits from land uses, $Q(l)$ represents non-market land use factors such as environmental factors and X is a vector that accounts for other demographic, social and property characteristics that affect decisions on agricultural practices.

The value of the adoption of silvopasture relates to the impact that it has on the farmer's welfare, measured in monetary terms. Amongst the Hicksian welfare measures of economic value holding utility constant, the compensating surplus (CS) measures losses relative to initial utility levels (Hicks 1943). Thus, CS is the change in income that will decrease the farmers' initial welfare position after adopting silvopasture. This way, the farmer's indirect utility function after adoption can be rephrased in terms of willingness to accept (*WTA*) silvopasture as the CS measure:

$$V0(I(l0), Q(l0), X) = V1(I(l1) + WTA, Q(l1), X) \quad (2)$$

where *WTA* is the minimum compensation required by farmers to change from conventional grazing to silvopastoral systems. Here, silvopasture hectares are assumed to be perfect substitutes in utility terms for conventional grazing hectares, such that the producer does not have any interest in having both types of pastures simultaneously. Thus, the adoption of silvopasture implies a change in land uses from its current pasture $l0$ to silvopasture $l1$. Accordingly, a switch from conventional grazing to silvopasture leads to changes in income, from $I(l0)$ to $I(l1)$ where $\Delta \mathrm{I} = I(l0) - I(l1) \geq 0$ is the income loss from adopting silvopasture, and changes in non-market factors, from $Q(l0)$ to $\mathrm{Q}(l1)$ that, although beneficial e.g., to the environment, are external to the farmer.

The farmer is now faced with two options: (1) non-adoption of silvopasture and continuing to manage pastures according to current practices, holding utility at $V0$; (2) adoption of silvopasture practices conditional to compensation. In the latter case, the

[1] For simplicity, the farmer, being a cattle producer, is assumed to only manage grasslands. Land uses, therefore, relate to the management and productivity of pastoral systems.

selection of silvopasture over conventional grazing implies a sufficient compensation level so that the utility of adopting silvopasture is equal to or greater than the initial utility function:

$$V1(I(l1) + WTA, Q(l1), X) \geq V0(I(l0), Q(l0), X) \quad (3)$$

The farmer's utility is heterogeneous and determined by various factors. Socio-demographic factors like age, gender, education, income, etc., as well as farm characteristics such as size, biodiversity, access to the nearest city, etc., have been found to be important determinants in previous contingent valuations (e.g., Shrestha and Alavalapati 2003; Buckley et al. 2012; Lindhjem & Mitanib 2012; Mäntymaa et al. 2018; David and Rausser 2020). Yet these factors alone may not have sufficiently strong explanatory power in analyzing decision-making for agroforestry innovations (Meijer 2015). Focusing solely on explaining how factors relating to property and socio-demographic characteristics that influence decisions would, therefore, ignore other factors, such as the social and psychological influences on farmers' decision-making.

Hence, to represent farmer's behavior towards silvopasture adoption, we utilize underlying psychological constructs from the well-known Theory of Planned Behavior (Ajzen 1991). TPB establishes that adoption behavior emanates from the farmer's intention to adopt, which is consecutively determined by three psychological constructs: attitude, subjective norm, and perceived behavioral control (Ajzen 1991). Capturing both the level of understanding and appreciation of a behavior, 'attitude' refers to an individual's positive or negative evaluation of the behavior; the 'subjective norm' is the individual's perception of the social pressure put upon him/her to perform the behavior; and finally, 'perceived behavioral control' relates to the individual's perception of his/her own ability to successfully perform the behavior (Ajzen 1991). As argued by Hansson et al. (2012), studies based on the TPB framework provide useful insights into farmers' behavior. Indeed, previous applications of TPB have demonstrated its effective use in agriculture, from studies related to organic farming (Läpple and Kelley 2013) to diversification (Hansson et al. 2012; Senger et al. 2017). The use of the TPB has also been proven to successfully contribute to understanding farmers' intentions as to whether to adopt modern sustainable practices (e.g., Buckley et al. 2012; Borges et al. 2014), as well as demonstrating the decisive role of the attitudinal construct in tree planting by smallholder farmers (Meijer et al. 2015). TPB has not, however, been used to explore farmers' willingness to adopt silvopastoral systems. In the following paper, the behavioral intention that emanates from the psychological constructs will therefore contribute to understanding adoption drivers. Accordingly, the attitudes, subjective norms, and perceived behavioral controls, refer to the possibility of, respectively, describing farmers' evaluations of silvopasture adoption, measuring the importance of perceived social pressure put upon farmers to adopt silvopasture, and identifying the farmers' perceptions of their ability to adopt and implement silvopasture.

Additionally, monetary characteristics of silvopasture like maintenance costs, alternative sources of income, etc., should be considered. Such factors remain significant in decision-making and contribute to a balanced representation of farmer's behavior surrounding adoption (Howley 2015). Finally, the farmer's utility depends on the compensation payment (*WTA*) received from adopting silvopasture. Therefore, by rearranging Eq. (3) depicting the decision whether to adopt silvopasture, we obtain the following equation:

$$WTA \geq V0(I(l0), Q(l0), X) - V1(I(l1), Q(l1), X) \quad (4)$$

illustrating the condition for the sufficient compensation payment level. Eq. (4) highlights that the factors that determine the adoption decision also determine the farmer's compensation payment. Although it is possible to use the same factors to explain both the decision to accept silvopasture and the compensation payment, it is more likely that some factors will have deeper impacts on either one of these (Mäntymaa et al. 2018). In fact, it is expected that the intention to adopt, i.e., the attitude, subjective norm, and perceived behavioral control, will have a stronger influence on the decision to adopt silvopasture than the level of compensation, as demonstrated by Borges et al. (2014), who found that the presence of various factors in each TPB construct facilitate adoption. Inversely, monetary factors (e.g., income, maintenance costs, etc.) will likely have a stronger influence on compensation payment, as suggested in Mäntymaa et al. (2018).

Materials and methods

Data

Data were collected through a survey which was designed in accordance with the open-ended contingent valuation method (Ciriacy-Wantrup 1947; Davis 1963). The survey consisted of four sections. The first section consisted of a brief introduction to the study, including a description of the questionnaire's objective and an explanation of silvopasture and the practice's potential benefits. The description was purposely short, since an extensive and detailed explanation of what silvopastoral systems entail and require from producers may have biased the results. The second section included questions related to farm and farmer characteristics. In the third section, respondents were asked to provide behavioral information concerning their intention of adopting silvopastoral systems. Finally, in addition to including questions related to monetary characteristics, the fourth section aimed to collect data on respondents' willingness to adopt silvopasture and the compensation payment the respondent would claim for converting their current pastures to silvopastoral systems.

Sample and procedure

The sample frame from which the sample was drawn was obtained from the agricultural register administered by Statistic Sweden and accessed from the LIFT[2]-project. The sample frame consisted of a list that included a total of 1500 livestock producers located within a geographical selection purposely made in the context of prior studies included in the LIFT-project. This geographical selection was made by randomly drawing 750 farmers in the North of Sweden and 750 farmers in the South. As a result, 14 out of the 21 counties of Sweden were included in the sample frame. Namely, the counties of Blekinge, Gävleborg, Halland, Jämtland, Norrbotten, Örebro, Skåne, Södermanland, Stockholm, Uppsala, Västerbotten, Västernorrland, Västmanland, and Västra Götaland. After removing all non-cattle producers from the list, our sample frame included a total of 1121 cattle producers. The sample then consisted of 663 cattle producers as all cattle producers within the sample frame were not reachable by email and could not be included in the survey. No selection was made concerning whether the producers only managed cattle or cattle mixed with other livestock productions and/or land uses, like crops. Furthermore, no selection was made regarding the producers' holdings, as silvopasture is considered feasible on all pasture sizes. Only grazing cattle is represented in the survey as the Swedish animal health and welfare legislation ensures that all cows are allowed outside during the grazing season. Accordingly, the holdings represented in the sample variated between 3 and 600 ha.

The survey was implemented through electronic questionnaires sent out via email. The use of online survey modes is convenient for data collection, and in contingent valuation studies as well. Previous literature has confirmed that this mode of data collection does not bias results compared with data collected from face-to-face interviews (Lindhjem and Navrud 2011). Furthermore, it has been estimated that as much as 98% of the Swedish population has access to internet in the household (Internetstiftelsen 2019). This confirms that the use of online survey modes is not likely to bias the sample due to poor internet access. The survey was implemented in March 2021 and active for 2 weeks. After two email reminders, the survey achieved a response rate of 17%. A total of 30 questionnaires contained significant numbers of missing values and were deleted from the final dataset. After eliminating unusable questionnaires, the survey achieved an overall adjusted response rate of 12%, resulting in a completed sample of 84 observations. This is somewhat low compared with other WTA surveys (e.g., Lindhjem & Mitanib 2012; Mäntymaa et al. 2018).

Elicitation method

An open-ended WTA question asking about the minimum compensation payment was chosen to elicit the respondents' compensation claims. The open-ended questions format consists of directly asking the respondents to state freely the minimum compensation value they would require for a hypothetical good or

[2] Low-Input Farming and Territories (LIFT) is a research project aiming to identify and understand how socio- economic and policy drivers affect the development of ecological approaches to farming and assess the performance and sustainability of such approaches. https://www.lift-h2020.eu

Table 1 Statements, scales, and descriptive statistics used to measure attitude (ATT), subjective norm (SN) and perceived behavioral control (PBC)

Statements		Scale (1–5)	Mean	Std. Dev
ATT1	For you, the adoption of silvopasture is:	Extremely bad – extremely good	2.93	0.833
ATT2	For you, the adoption of silvopasture is:	Not at all – extremely advantageous	2.76	0.97
ATT3	For you, the adoption of silvopasture is:	Not at all – extremely possible	3.06	1.004
ATT4	For you, the adoption of silvopasture is:	Not at all – extremely important	2.53	1.074
ATT5	For you, the adoption of silvopasture is:	Not at all – extremely necessary	2.23	0.992
SN1	Most people who are important to you think that you should adopt silvopasture	Strongly disagree – strongly agree	2.25	1.157
SN2	Most people whose opinion you value would approve that you adopt silvopasture	Strongly disagree – strongly agree	2.19	1.047
SN3	Most farmer like you will eventually adopt silvopasture	Strongly disagree – strongly agree	2.01	1.018
PBC1	If you want to adopt silvopasture, you have sufficient knowledge	Strongly disagree – strongly agree	2.28	1.179
PBC2	If you want to adopt silvopasture, you have sufficient resources	Strongly disagree – strongly agree	2.41	1.058
PBC3	How confident are you that you could overcome barriers that prevent you to adopt silvopasture?	Not at all – extremely confident	2.77	1.034
PBC4	The adoption of silvopasture depends only on you	Strongly disagree – strongly agree	3.79	1.269
PBC5	The decision to adopt silvopasture is totally under your control	Strongly disagree – strongly agree	3.57	1.327

service (Walker and Mondello 2007). The open-ended format was chosen over dichotomous choice or payment cards method to obtain better precision in compensation claims, especially given the small completed sample size. Accordingly, the open-ended elicitation format provides point estimates and does not restrict the respondents with defined intervals (Boyle et al. 1996). The open-ended method also minimizes the risk of vehicle biases like cognitive bias and strategic bias (Boyle et al. 1996). However, the main disadvantage of an open-ended format is often characterized by a significant amount of missing and zero responses due to the cognitively demanding task of responding with a specific amount (Bateman et al. 2002; Walker and Mondello 2007).

Additionally, to facilitate the respondents' elicitation task, they were asked to express an amount per hectare and per year. An annual payment, being the most common form of compensation in practice, was used over a one-time payment (Lindhjem & Mitanib 2012).

Scale development–theory of planned behavior constructs

TPB psychological constructs attitude, subjective norm, and perceived behavioral control can either be elicited from individual behavioral, normative and control beliefs, or by using statements to assess each construct (Läpple and Kelley 2013). The second approach was chosen and a total of 13 statements were developed and used as measurement indicators to measure attitudes (5), subjective norms (3) and perceived behavioral control (5) (See Table 1).

Statements were formulated based on the wording used in Borges et al. (2014) and Senger et al. (2017). A five-point Likert-like scale was used to assess respondents' level of agreement with the statements, with one being the most negative answer and five, the most positive. Five-point scales have been effectively used in other agricultural literature (Hansson et al. 2012; Senger et al. 2017).

Assessing type of measurement model

The use of measurement indicators implies a causal relationship between measures and the underlying latent psychological constructs (Götz et al. 2010). Depending on this causal link, the model can be considered either reflective or formative (Hansson and Lagerkvist 2014). Specifically, the reflective measurement model assumes causality proceeds from the latent constructs to indicators whereas the formative measurement model assumes the opposite; i.e., causality going from the indicators to the latent

Table 2 Significant factor loadings of theory of planned behavior statements

Statements		Factor 1 *Attitude*	Factor 2 *Subjective norm*	Factor 3 *Perceived behavioral control*
ATT1	For you, the adoption of silvopasture is good	**0.841**	0.229	−0.162
ATT2	For you, the adoption of silvopasture is advantageous	**0.863**	0.298	−0.006
ATT3	For you, the adoption of silvopasture is possible	**0.644**	0.34	−0.079
ATT4	For you, the adoption of silvopasture is important	**0.751**	0.527	−0.056
ATT5	For you, the adoption of silvopasture is necessary	**0.612**	0.581	−0.023
SN1	Most people who are important to you think that you should adopt silvopasture	0.384	**0.825**	−0.089
SN2	Most people whose opinion you value would approve that you adopt silvopasture	0.323	**0.877**	0.003
SN3	Most farmers like you will eventually adopt silvopasture	0.323	**0.704**	−0.05
PBC3	How confident are you that you could overcome barriers that prevent you to adopt silvopasture?	0.162	**0.552**	0.007
PBC4	The adoption of silvopasture depends only on you	−0.058	−0.061	**0.805**
PBC5	The decision to adopt silvopasture is totally under your control	−0.101	−0.01	**0.799**
	Range of item-to-total correlations	0.7964 – 0.9142	0.7249 – 0.9137	
	Range of item-to-item correlations	0.6829 – 0.8601	0.5239 – 0.8290	0.7255 (avg)
	Cronbach's alpha	0.9169	0.8633	0.8409

constructs (Rositter 2002; Podsakoff et al. 2003). Here, because latent constructs are causing measurement indicators, the model is considered reflective.

Exploratory factor analysis

Following the reflective measurement model, exploratory factor analysis was used to reduce TPB statements to underlying constructs. The results of the significant factor loadings can be found in Table 2. As in Hansson et al. (2012), three factors were kept, considering that TPB suggests three latent constructs, respectively: attitude, subjective norms and perceived behavioral control. Given the number of respondents, the criteria for determining significant factor loadings was set so that pattern coefficients ≥ 0.5 were considered statistically significant.

Statements that did not load significantly on any factor were removed from the analysis, one at a time, until significant pattern coefficients remained, as in Hansson et al. (2012). Consequently, two statements, i.e., PBC1 and PBC2, did not load significantly on any factor and were therefore excluded from the final analysis. PBC3, which covered respondents' confidence in overcoming barriers preventing silvopastoral system adoption, did not load significantly on the factor relating to perceived behavioral control, but rather factor 2, "subjective norm". Hypothetical explanations may be that barriers to adoption can be associated with producers' social networks or that their social network can help them in overcoming such barriers.

Bartlett's test of sphericity (Bartlett 1954) indicated that the correlation matrix was not random, with a Chi-square of 693.623, $p < 0.001$, and a KMO statistic of 0.8092, therefore determining that the correlation matrix was appropriate for factor analysis. Orthogonal Varimax rotation, being the most common rotational method used in factor analysis, was used to provide uncorrelated factors and easier interpretation of results (Williams et al., 2010). Item-to-total correlations, as well as item-to-item correlations, were all well above the cut-off values of 0.5 and 0.3 respectively, and all Cronbach's alpha (Cronbach 1951) values were above the cut-off value of 0.7 (Hair et al. 2010). Taken together, these indicators suggest that the measurement scales are reliable.

Table 3 Variables included in the model, definitions, and descriptive statistics

Variables	Definitions	Mean	Std. Dev
Dependent variables			
Adoption model			
Adoption	Dummy variable: intention to adopt silvopasture: 1 if yes; 0 if no	0.524	
Compensation model			
Claims	Compensation claims for the adoption of silvopasture (SEK/ha/year)	3107.17	2620.395
Independent variables			
Socio-demographic characteristics			
Gender	Dummy variable: gender of the producer: 1 if female; 0 if male	0.23	
Education	Ordinal variable: education level of the producer: 1 if primary school; 2 if high school; 3 if agricultural high school; 4 if university, 5 if agricultural university	3.02	1.219
Production	Dummy variable: type of cattle production; 1 if dairy; 0 if meat	0.32	
Income	Ordinal variable: income before tax of the producer	4.09	1.733
Farm characteristics			
Size	Total size of the pastures (ha)	51.77	98.748
Organic	Ordinal variable: organic production: 1 if yes; 2 if no, 3 if under transition	1.68	0.519
Vegetation zone	Categorical variable: Farm localization within Sweden's three principal vegetation zones: 1 if Boreal; 2 if Boreonemoral; 3 if Nemoral	1.51	0.722
TPB constructs			
Attitude	Solution factor of the attitude statements	−3.06	0.938
Subjective norm	Solution factor of the subjective norm statements	2.43	0.947
Perceived behavioral control	Solution factor of the perceived behavioral control statements	3.12	0.87
Monetary characteristics			
Maintenance costs	Categorical variable: expected increase of maintenance costs of silvopasture: 1 if strongly agree; 2 if agree; 3 if neutral; 4 if disagree; 5 if strongly disagree	2.32	0.925

Econometric approach

Based on the conceptual framework outlined above, the Heckman two-step estimation method (Heckman 1979) was used to quantitatively analyze cattle producers' willingness to adopt silvopasture and their respective compensation claims. The fact that only the respondents who were willing to adopt silvopasture revealed their compensation claims in the survey can lead to selection bias arising, as only the outcomes of treated observations are observable (Greene 2008). Therefore, to control for selection bias, the Heckman two-step estimation method (Heckman 1979) calls for the estimation of a correction term; i.e., the inverse Mills ratio, and later uses it as an additional explanatory variable (Heckman 1979). Accordingly, in the first step of the Heckman two-step estimation method (Heckman 1979), also called the selection model, the decision to adopt silvopastoral systems was analyzed with a probit model on independent variables. In the second step, named the "outcome model", the compensation claim was regressed using ordinary least squares (OLS) on independent variables and the inverse Mills ratio (Wolfolds and Siegel 2018). In the following, the selection model and outcome model will respectively be named the "adoption model" and the "compensation model". The Heckman two-step estimation method (Heckman 1979) has been previously proven successful in contingent valuations, especially in the context of voluntary forest landscape conservation (Mäntymaa et al. 2018).

Variables

The variables used in the two-step model, as well as their definitions and descriptive statistics regarding the two models are reported in Table 3. The dependent variable of the adoption model (*Adoption*) describes the cattle producer's intentions of adopting silvopasture. The dependent variable of the compensation model (*Claims*) is a continuous variable corresponding to the logarithm of the compensation levels claimed by producers for silvopasture adoption.The first set of explanatory variables described socio-demographic characteristics which may play a role in both the dependent determination of a farmer's adoption and compensation claims. Most variables included here such as *Gender*, *Education*, and *Income* are commonly used in standard contingent valuation studies (e.g., Lindhjem and Mitanib 2012). Additional dummy variables that specify whether the producer is specialized in dairy or meat products (*Production*) is included. The second set of variables are farm characteristics related to the logarithm of the total pasture area (*Size*), the farm's organic certification (*Organic*), and the farm's localization within Sweden's three main vegetation zones (*Vegetation zone*). The third set of variables represents the intention to adopt silvopastoral systems, captured by the psychological constructs of TPB, and consists of 13 statements, all summarized by the factor solution into three factors, each reflecting one underlying construct, i.e., *Attitude*, *Subjective norm*, and *Perceived behavioral control*. Finally, one monetary variable is added to depict the respondents' beliefs that silvopastoral systems will lead to economic loss due to high maintenance costs *(Maintenance costs*).

An important condition for the use of the Heckman two-step estimation method (Heckman 1979) is that variables of both models are only partially explained with the same independent variables. Previous literature suggests that the selection model must contain at least one variable unrelated to the dependent variable in the outcome model (e.g., Lalonde 1986; Greene 2008). If this condition was not respected, dependency between the sample of the two models and the dependent variables could cause problems of multicollinearity. Moreover, the addition of the correction term to the outcome equation may have led to estimation difficulties and unreliable coefficients (Briggs 2004). Accordingly, the compensation model is a reduced form of the adoption model where requested compensation is assumed to be a function of *Size, Maintenance costs, Production, Education and Income.* The adoption model is a function of *Organic, Vegetation zone, Attitude, Subjective norm, Perceived behavioral control,* and implicitly, compensation claims via the inclusion of their independent variables.

Results

Willingness to accept, compensation claims and respondents' demographics.

The survey achieved an adjusted response rate of 12%, corresponding to a completed sample size of 84 observations. Out of those, 52% of respondents were willing to adopt silvopastoral systems, conditional to some compensation claims. However, not all respondents provided their related compensation in the surveys. A total of 32% of claims accounted for missing responses, i.e., when respondents do not answer due to a lack of knowledge or the cognitively demanding task of the open-ended elicitation format (Bateman et al. 2002; Yu and Abler 2010). For instance, some respondents may know that they have a positive compensation claim but due to limited information about their own preferences, cannot give a specific amount (Yu and Abler 2010). Such missing responses, viewed as incomplete observations, are often dropped in the literature, and were accordingly removed from the analysis. Besides missing responses, only one zero answer was given by the respondents. A zero answer can either represent a protest zero, i.e., when a respondent does not accept some aspect of the hypothetical scenario described in the survey (Ready et al., 1996) or a valid zero, i.e., when a respondent is willing to accept the hypothetical scenario without compensation. As in Yu and Abler (2010), in which the authors showed that people with lower incomes are more likely to bid zero, the respondent asking for no compensation indicated earning less than SEK 100,000 (9,308€) annually from their agricultural activities. Given that all other responses were non-zero claims, this zero answer was categorized as a valid zero answer. Overall, 30 compensation claims were useable for the analysis, corresponding to 68% of total claims. This result is similar to Lindhjem and Mitanib (2012), in which the authors obtained 65% of non-protest and non-missing WTA values. Accordingly, the mean compensation payment claimed by respondents to adopt silvopastoral systems

Table 4 Descriptive statistics of compensation claims

	Sample	Mean	Median	Std. dev	Min	Max
Compensation claims	30	3,107.167	2,250.00	2620.395	0	15,000.00

Table 5 Regression results

	Compensation model					Adoption model
	Coef	*p*-value	95% CI	Coef	*p*-value	95% CI
Size	0.039	-0.695	(–0.155, 0.232)	–0.040	-0.815	(-0.380, 0.299)
Maintenance costs	-0.035	-0.739	(–0.244, 0.173)	–0.649	(0.010)*	(-1.141, -0.158)
Production	-0.246	-0.214	(–0.633, 0.141)	0.366	-0.439	(-0.562, 1.295)
Education	0.243	(0.003)**	(–0.081, 0.406)	0.439	(0.016)*	(0.082, 0.797)
Income				0.284	(0.027)*	(-0.032, -0.537)
Gender				–1.293	(0.041)*	(-2.535, -0.052)
Organic				0.708	-0.111	(-0.164, 1.579)
Vegetation zone				0.159	-0.606	(-0.443, 0.760)
Attitude				1.165	(0.000)***	(0.597, 1.733)
Subjective norms				0.257	-0.252	(-0.183, 0.698)
Perceived behavioral control				–0.296	-0.263	(-0.816, 0.223)
Constant	6.99	(0.000)***	(6.026, 7.953)	–2.884	-0.067	(-5.975, 0.207)
Mills (λ)	0.023	-0.92	(–0.417, 0.462)			
Rho	0.0516					
sigma	0.439					
Wald $\chi2$ (5) = 13.91, $p = 0.0162$						

p-value s in parentheses, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

is SEK 3107.167 (308€) per year and per hectare (See Table 4).

By comparing the respondents' demographics and farm characteristics (Table 3) to those of the population of interest, i.e., all cattle producers within the geographical selection of the sample frame, we find that the sample resembles the population. Descriptive statistics in Table 3 and in the appendix report that the respondents' average pasture size is 51.5 ha which can be compared with 48.9 ha for all cattle producers within the geographical selection (Swedish board of agriculture 2018). Furthermore, the respondents are mostly located in the Boreal vegetation zone (62%, $n = 52$), which is similar to the population of interest, among which cropping farms dominates the central and southern parts of Sweden (Swedish board of agriculture 2018). The cattle producers represented in the completed sample are predominantly male (77%; $n = 64$), meat producers (68%, $n = 57$), not organic (66%, $n = 53$) and with an average age of 57, with 74% ($n = 62$) of the respondents being older than 50. While the population shows similar patterns regarding farmers' average age, with also 74% being older than 50 years (Swedish board of agriculture 2020), the share of self-employed women entrepreneurs (29%), dairy producers (17%) and farms operating under organic certification (23%) differ slightly in the population although tendencies are similar (Swedish board of agriculture 2018).

Regression results

Regression results on (1) cattle producer's adoption model and (2) the related compensation model is presented in Table 5. The low Wald Chi-square test statistic (Wald $\chi2$ (5) = 13.91, $p = 0.0162$) illustrates that the model's explanatory variables are significant and that the model is consequently not overfitted, especially given the completed sample size.

The coefficient of inverse Mills ratio is reported as λ. Its insignificant test-statistic (z-score = 0.10; *p*-value = 0.920), suggests that selection bias is not a significant issue. No significant selection bias is also indicated by the correlation coefficient rho = 0.0516, which is close to zero.

Adoption model

Results first indicate that *Maintenance costs* is negative and significant. This suggests that if a cattle producer thinks that silvopastoral systems will lead to high maintenance costs, e.g., for fencing trees, he or she will be less inclined to adopt silvopastoral systems. The potential economic loss for converting and maintaining silvopastoral systems is therefore seen as a strong barrier to adoption, even with potential compensation. Furthermore, it can be interpreted that the economic weight of silvopasture impacts farmers' decision-making more greatly than potential economic benefits, e.g., from diversified sources of income. The socio-demographic variables *Gender*, *Education* and *Income* were found to be statistically significant. The negative sign of the *Gender* coefficient suggests that female cattle producers have a lower adoption probability, while the positive sign of the *Education* and *Income* estimates respectively suggest that the higher the level of education and income, the more positively they affect the decision to adopt. No farm-related characteristics emerged as statistically significant in the adoption model. Finally, results suggest that the use of TPB variables was sufficient to explain how underlying psychological constructs influence farmers in their decisions to adopt silvopastoral systems, with the attitudinal construct showing a positive and significant estimate. Accordingly, the more positively one values and perceives silvopastoral systems, the higher the intention to adopt.

Compensation model

Findings from the second stage of the model, i.e., the compensation model, only indicate a positive and significant relationship with the *Education* variable. *Education*, being significant in both models, suggests that higher education levels, in addition to increasing the intention to adopt silvopastoral systems, also increases related compensation claims. This highlights the importance of education, not only in increasing environmental consciousness, but perceptions of economic and labor requirements. As was the case in previous literature, the effects of the socio-demographic factors were found to be mixed across models, while the education level appeared to have a consistently positive influence (Tey and Brindal 2012; Lastra-Bravo et al., 2015; Mozzato et al. 2018; Liu et al. 2018).

Discussion and conclusions

This study contributes to the scientific literature on silvopasture adoption in Europe in three major ways. First, silvopastoral systems considered here are treeless pastures that are to be reforested. Even though grazed woodlands are essential, particularly in the process of establishing new pastures, the need for a transition towards sustainable animal production in Europe primarily requires that already existing grasslands are converted to silvopastoral systems (Hawken 2017). In fact, paired with growing trends in plant-based diets, the space dedicated to livestock production need not expand further (Erb et al. 2016) and reforestation of current treeless pastures should be a priority. Accordingly, this study specifically adds knowledge to the hypothetical process of pastoral reforestation and its economic implications. Second, this paper contributes to existing literature by bringing the psychological constructs of TPB (Ajzen 1991) to the study of farmers' adoption of silvopastoral systems. In doing so we can highlight how underlying psychological constructs affect adoption and that not only pecuniary drivers (such as concerns about revenues and costs) may be relevant to explain adoption. Third, this paper illustrates initial estimates of compensation claims related to silvopasture adoption in Sweden. As such, results can be used for policy recommendations and scaling up possibilities in Sweden, but may also be relevant for similar cattle production systems in Europe by acting as a beginning reference point.

Findings reported here indicate that 52% of the surveyed producers are willing to adopt silvopastoral systems and that the related mean compensation claim is SEK 3107.167 (308€) per year and per hectare. As is the case of many WTA studies, only a few dependent variables are statistically significant (Lindhjem and Mitanib 2012). This is rooted in part in the cognitively demanding task of respondents in defining a compensation claim (Bateman et al. 2002). Additionally, it may also result from the completed sample size of 84 observations, in that only large true effects are detectable. Nevertheless, in the adoption model, several variables were significant in explaining cattle producer's decisions to adopt silvopastoral systems. In addition to socio-demographic and monetary characteristics—namely *Education*, *Gender, Income,* and *Maintenance costs*—the attitudinal construct from TPB was found to significantly affect respondents' adoption decisions. This result is in line with previous studies such as Meijer et al. (2015), in which the authors found that attitude had a significant positive influence on smallholder farmers' behavior surrounding tree planting. It is noteworthy that among TPB psychological constructs, only the attitudinal construct emerges as significant. The attitudinal construct is often found among TPB constructs to have the most significant influence in farmer decision making (e.g., Hansson and Lagerkvist 2014; Meijer et al. 2015). This is true because the attitudinal construct captures the individual's understanding of the value of silvopastoral systems and the individual's level of appreciation of said value. Still, the subjective norm and perceived behavioral control constructs, not being statistically significant, offer valuable information in that cattle producers do not consider their peers' pressure and their ability to adopt silvopastoral systems as decision drivers, thus confirming the results previously reported by Gregory et al. (2012). Consequently, we interpret these findings as highlighting that producers' decision-making regarding silvopasture adoption is not only driven by economic considerations (through concerns related to investment and maintenance costs of adoption), as it signals that farmers' understanding and appreciation levels (measured via the attitudinal construct) toward silvopastoral systems are of significant influence.

Regarding factors influencing related compensation claims, these results indicate that only the socio-demographic characteristic of *Education* is statistically significant. Overall, compensation claims seem less influential in the adoption decision, meaning that if respondents are not inclined toward adoption, the prospect of being compensated is of little importance, regardless of the amount. This is suggested by the high percentage (48%) of unwilling respondents.

As such, CVM successfully circumvented the absence of markets for valuation of the environmental benefits of silvopastoral systems. However, the use of CVM still faces some limitations. First, revealing compensation claims may be cognitively demanding for respondents and our results should be interpreted in light of this difficulty. Similarly, the potential presence of strategic biases implies that some respondents may have responded strategically, e.g., by inflating their compensation claims. Hence, future research has an important task in evaluating how compensation claims may be affected by the type of elicitation method, by comparing the open-ended format used here with other types of elicitation methods (such as the payment card method). The limited completed sample size in this study should also be acknowledged. This is notably caused by the common removal of questionnaires that include missing answers from the open-ended elicitation method. Nonetheless, it should be highlighted that the remaining completed sample size of 84 observations resembles the population of interest, when comparing based on demographics such as average producer age, farm localization and pasture size. While the shares of self-employed women entrepreneurs, dairy producers and farms operating under organic certification differ slightly in the completed sample compared with the population, tendencies remain similar (Swedish board of agriculture 2018). Furthermore, based on results from Austin and Steyerberg (2015), two subjects per variable tend to permit accurate estimation. Still, considering the limited completed sample size, it is important to highlight that results should be considered to depict an illustration of what silvopasture may mean in terms of WTA and compensation claims, rather than as proven values. Additionally, this study characterizes the adoption of silvopasture as a complete land conversion from conventional grazing to silvopasture. Yet, this differs in practice as Smith et al. (2022) found that 96% of the producers who implemented silvopasture in the USA reported using a combination of both open and reforested pastures. Perhaps the share of unwilling respondents towards silvopasture adoption and the compensation claims may have been found lower if farmers had the choice of the amount of land to convert. Future research has thus the important task of investigating changes in the results if that is the case. It should also be acknowledged that other variables not considered in this study may play a role in determining adoption, such as facilitating advice from advisors. As found in this research, economic incentives are but one of the many levers to impact producers' interest into adopting silvopasture and future studies will have an important task in furthering the understanding about determinants of silvopasture. Finally, given that not many people in Sweden have adopted silvopastoral systems, it is not possible to study actual behavior. Accordingly, this study represents respondents' intention to adopt silvopastoral systems, thus allowing for a prediction of future uptake. Nevertheless, the potential presence of hypothetical biases, so that actual behavior might differ from intentions, could be an interesting avenue for future research.

In conclusion, the findings reported in this study are useful for the purposes of policy design, in particular for discussing and illustrating scaling-up possibilities of silvopastoral systems. Hence, the survey analysis first suggests that half of the respondents are motivated to adopt silvopasture, despite the lack of knowledge surrounding the practice. This may imply that the potential of trees to mitigate emissions and protect and enhance biodiversity in pastural landscapes is consistent with the reasons they own and manage agricultural land (Kline et al. 2000). Silvopasture implementation of at least a portion of cattle producers could thus be feasible through advice and relatively low-cost training programs to provide technical assistance and education, as our results suggest. Similarly, García de Jalón et al. (2017) argue that education is necessary not only to promote novel agroforestry systems, but also to increase farmers' environmental awareness. Additionally, demonstration sites are equally important in introducing farmers to real life applications of agroforestry systems (García de Jalón et al., 2017). In turn, such programs can enhance farmers' levels of understanding and appreciation for silvopastoral systems and consequently improve farmers' attitudes towards the practice. Most importantly perhaps, is to increase advisors' leverage in supporting the uptake of agroforestry practices. Farmers generally have little extra time to invest. Having specialized and knowledgeable advisors who not only recommend agroforestry systems as direct solutions to farmers' concerns and problems, but also facilitate implementation, may therefore be needed. However, by placing producers' goals and needs first, economic incentives must also be considered if silvopasture implementation is to achieve greater acceptance and cooperation in the adoption process. In fact, because it is the non-market characteristic of the many environmental benefits of silvopastoral systems that has mainly led to the current sub-optimal situation in silvopasture and agroforestry adoption (Shrestha et Alavalapati 2003; García de Jalón et al. 2017), there is a clear necessity to compensate farmers' up-front costs of implementation for the environmental and social benefits that they provide. Accordingly, for silvopasture to become a more widespread approach, changes must be made at the regime level (Schaffer et al. 2019). These changes provide an opportunity for achieving targeted environmental objectives set by the Swedish Parliament, such as Sweden's long-term strategy for reducing greenhouse gas emissions as per the Paris Agreement, and the new FIT 55 package in the EU, especially concerning the regulations on Land Use, Forestry, and Agriculture to achieve an overall EU target for carbon removal by natural sinks of 310 million tons of CO_2 emissions by 2030 (European Commission 2021). Findings reported here provide an illustration of the initial compensation claims required to support silvopasture adoption in Sweden. Results may also be relevant for indicative compensation claims for similar production systems in Europe, by functioning as a reference point.

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Declarations

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

Appendix

See Figs. (1, 2, 3, 4, 5, 6 and 7).

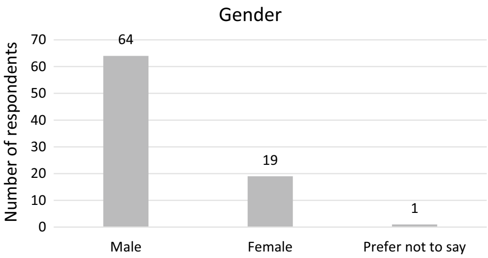

Fig. 1 Gender distribution of the respondents

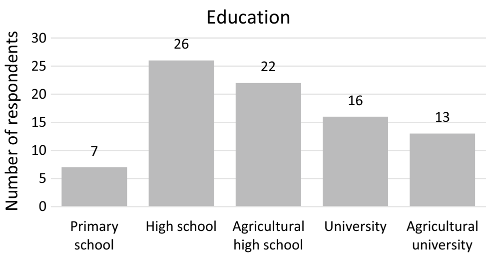

Fig. 2 Distribution of the respondents' level of education

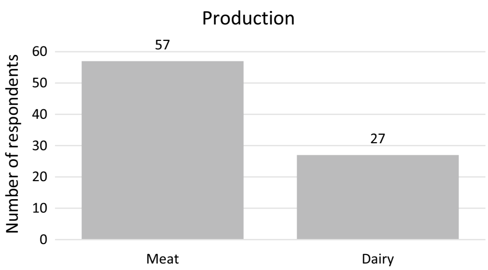

Fig. 3 Distribution of the respondents' type of production

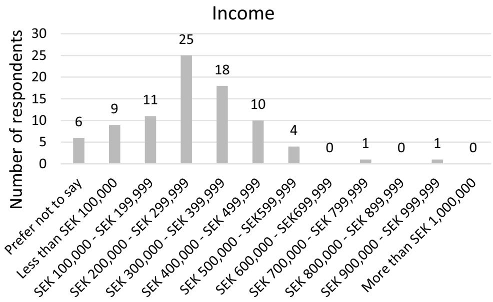

Fig. 4 Distribution of the respondents' level of income

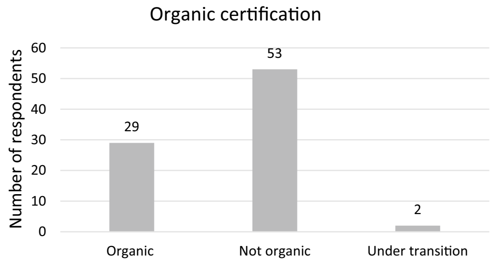

Fig. 5 Distribution of the respondents' organic certification

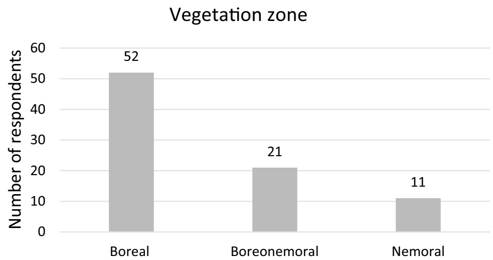

Fig. 6 Distribution of the respondents' localization within Sweden's three main vegetation zones

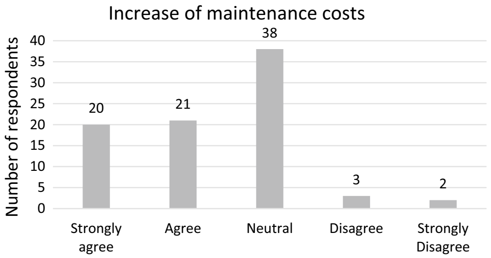

Fig. 7 Distribution of the respondents' level of agreement with the statement that silvopasture leads to higher maintenance costs

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III

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Upscaling carbon farming practices: perceived advisor leverage in farmer decision-making using Q-methodology

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ABSTRACT

Purpose: This study aims to assess the role of advisors in facilitating the upscaling of carbon farming (CF) in Swedish agriculture.
Methodology: Q-methodology is used with a sample of 32 livestock producers, complemented by a participatory approach involving stakeholder engagement.
Findings: Three perspectives are identified, each highlighting a specific upscaling challenge: 1) insufficient information, echoing the lack of awareness, incentives, and advice surrounding new policy objectives; 2) implementation challenges, underscoring the complexities in managing and following up on innovations; and 3) competing priorities, highlighting how economic considerations influence farmers' decision-making.
Practical implication: The results provide policy recommendations aimed at building technical capacity in advisory services, developing robust monitoring, reporting, and verification systems, and strengthening incentives and communication strategies.
Theoretical implication: The Triggering Change Model is expanded to include the role of advisors at each stage of the decision-making process that farmers experience when adopting innovations, increasing the understanding of their significance in mitigation efforts.
Originality/value: CF has recently gained significant policy attention in the Common Agricultural Policy due to the urgency of climate change, with advisors expected to play a crucial role in their upscaling within the Agricultural Knowledge and Innovation System, making this study particularly relevant for its achievement.

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Agricultural knowledge and innovation system; advisory services; lcimate mitigation; innovation; livestock production; triggering change model

1. Introduction

The potential for agriculture to serve as a carbon sink has attracted significant attention from both public and private sectors as a cost-effective strategy to mitigate climate change (Tang et al. 2016; 2019). One key development has been the introduction of carbon credits as tradable financial instruments available in voluntary markets (or compliance markets, e.g. the EU Emissions Trading Scheme), to allow (or require) businesses

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to offset their emissions (Raina, Zavalloni, and Viaggi 2024). These markets provide financial incentives for farmers to adopt carbon farming (CF) practices (Tang et al. 2016), which refers to land-use and farm management practices aimed at facilitating soil carbon sequestration (Smith et al. 2008). Such practices include agroforestry, wetland and peatland restoration, biochar application, reduced tillage, and the use of cover crops, among others (McDonald et al. 2021).

As such, CF has been increasingly recognized as an important policy tool both globally and in the EU (Raina, Zavalloni, and Viaggi 2024). Governments worldwide have introduced programs to support the development of national carbon markets such as Australia's Emission Reduction Fund (Badgery et al. 2021) and the U.S. Growing Climate Solutions Act (Bomgardner and Erickson 2021). In the European Union, efforts are underway to scale up CF as a green business model that rewards farmers and land managers for implementing practices that promote carbon sequestration (McDonald et al. 2021). These efforts are supported through EU-funded initiatives such as the Horizon program and Farm to Fork Strategy and by a range of policy instruments under the EU's Common Agricultural Policy (CAP) (McDonald et al. 2021). Specifically, the CAP reform 2023–2027 requires EU member states to prioritize climate objectives in their national Strategic Plans and offers interventions through both Pillar 1 and Pillar 2 to support broader and more effective mitigation strategies, including CF (McDonald et al. 2021).

The EU further relies on the Agricultural Knowledge and Innovation System (AKIS) to underpin the implementation of the CAP's objectives (Andrés et al. 2022). AKIS fosters collaboration among advisory services, research institutions, professional organizations, and other stakeholders in the agricultural sector (EU SCAR AKIS 2019) by providing timely and relevant information, knowledge, and innovation support to farmers (TAP 2016). Through the AKIS, member states will ensure advice and knowledge transfer on environmental aspects, thereby potentially facilitating CF upscaling (European Commission 2021). Within the AKIS, agricultural advisors are heavily relied upon (Andrés et al. 2022; Ingram and Mills 2019; Labarthe and Beck 2022; Schomers, Sattler, and Matzdorf 2015; Sutherland et al. 2022), especially since societal demand for environmental management has risen, resulting in stringent regulations and complex information for farmers (Ingram and Mills 2019; Klerkx and Proctor 2013). However, there is a discrepancy between AKIS's expectation for advisors to promote public goods and farmers' private goals, such as increased productivity (McCann et al. 2015), leading to competing demands (Farstad, Forbord, and Klerkx 2024). This raises potential tensions regarding advisors' roles in balancing environmental and economic concerns, which is particularly the cases where there are tradeoffs between them, integrating scientific knowledge with farmers' expertise, and ensuring incremental change at the farm-level (Farstad, Forbord, and Klerkx 2024). To address evolving challenges, such as reducing emissions, advisors must acquire new and increasingly specialized skills and demonstrate the flexibility to adapt and assume different responsibilities depending on the situation (Dockès et al. 2019; Farstad, Forbord, and Klerkx 2024; Ingram and Mills 2019; Klerkx and Jansen 2010; Krafft et al. 2022; Laurent et al. 2021).

An increasing amount of literature has focused on the role of advisory services in the knowledge exchange process, encompassing the generation, integration, and sharing of knowledge, as this process has become more intricate (e.g. Klerkx and Proctor 2013; Krafft et al. 2022; Kvam, Hårstad, and Stræte 2022; Labarthe et al. 2013; Labarthe et al.

2018; Laurent et al. 2021; Madureira, Barros, and Fonseca 2021; Sutherland et al. 2022). While advice from advisory services is increasingly diverse (Klerkx and Proctor 2013), a range of literature assessed advisors' role on sustainability issues (e.g. Ingram and Mills 2019; Klerkx and Jansen 2010; Wijaya and Offermans 2019), but only to a limited extent for climate mitigation (Farstad, Forbord, and Klerkx 2024; Stål and Bonnedahl 2015). While Stål and Bonnedahl (2015) found unclear mitigation goals in agricultural extensions to align with farmers' conventional economic objectives, Farstad, Forbord, and Klerkx (2024) recognized the increasing influence of advisors in promoting climate mitigation.

The aim of this study is to assess the role of advisors in facilitating the upscaling of CF practices. This study uses Q-methodology (Stephenson 1993) to explore livestock producers' perceptions of the information and support offered by advisors to promote CF practices. Additionally, the Triggering Change Model (TCM; Sutherland et al. 2012) is used to describe the decision-making process farmers undergo when faced with innovations. Q-Methodology has recently been used to understand perspectives on agri-environmental questions such as ecosystem services (Hermelingmeier and Nicholas 2017), nature-based solutions (Pätzke et al. 2024), environmental sustainability and resource efficiency (Curry, Barry, and McClenaghan 2013), conservation research (Zabala, Sandbrook, and Mukherjee 2018), food labeling (Schulze et al. 2024) and food system transformation towards socioeconomic and ecological sustainability (Belisle-Toler, Hodbod, and Wentworth 2021; Piso et al. 2019; Röös et al. 2023). Empirical applications of TCM include investigations of how farmers perceive the role of their personal network during the adoption of digital technologies (Kvam, Hårstad, and Stræte 2022; Mrnuštík Konečná and Sutherland 2022). This study adapts TCM to describe perceived advisor leverage in farmers' decision-making processes, given their expected engagement with advisors throughout the various stages of TCM (Labarthe et al. 2018).

The contributions of this study are threefold. First, the study contributes to scarce literature on the role of advisory services in supporting climate mitigation efforts. Second, it applies TCM to assess the perceived leverage of advisors throughout different stages of farmer decision-making, thereby increasing the understanding of their significance for the adoption and implementation of innovations. Third, by identifying distinct perspectives and highlighting upscaling challenges within each, this study offers actionable research for policymakers and advisory services. Given the current pivotal role of advisors for the provision of information, these findings hold relevance for scaling up innovations.

2. Conceptual framework: advisor leverage in farmer decision-making

Advisory services in countries across the EU have transformed in response to the ongoing restructuring of the agricultural sector and subsequent new challenges (Ingram and Mills 2019; Krafft et al. 2022). This change has resulted in pluralistic advisory services with trends towards privatization, decentralization, and more demand-led systems. These advisory services differ in objectives, priorities, and delivery approaches (Ingram and Mills 2019). In Sweden, the empirical area of this study, most advisors are productivity-oriented, working on a 'fee for service' basis or providing advice linked to product sales, generally focused on helping farm businesses navigate and optimize their commercial activities (Nordlund and Norrby 2021). However, as publicly funded environmental advice gain importance in meeting new climate and environmental objectives, such as *Greppa Näringen* in Sweden, the evolving roles of advisors across all advisory systems within AKIS are both necessary and well-intentioned. Advisors must adapt and assume various responsibilities to address these goals effectively (Dockès et al. 2019; Ingram and Mills 2019; Klerkx and Jansen 2010; Krafft et al. 2022; Laurent et al. 2021). This change is particularly evident within the framework of Labarthe et al. (2018), who introduced a conceptual cycle of farm management decision-making, based on the Triggering Change Model by Sutherland et al. (2012). TCM involves five stages: path dependency, trigger event, active assessment, implementation, and consolidation. According to the model, farmers adhere to their established farm management practices (path dependency stage) until a significant event prompts a need for change (trigger event stage), after which they actively seek and evaluate new options (active assessment stage). Following this, farmers implement a new course of action (implementation stage) before consolidating successful practices into their farm operations (consolidation stage). If not, farmers return to the active assessment stage in search of other options. Figure 1 conceptualizes advisor leverage during each stage of farmer decision-making, based on TCM.

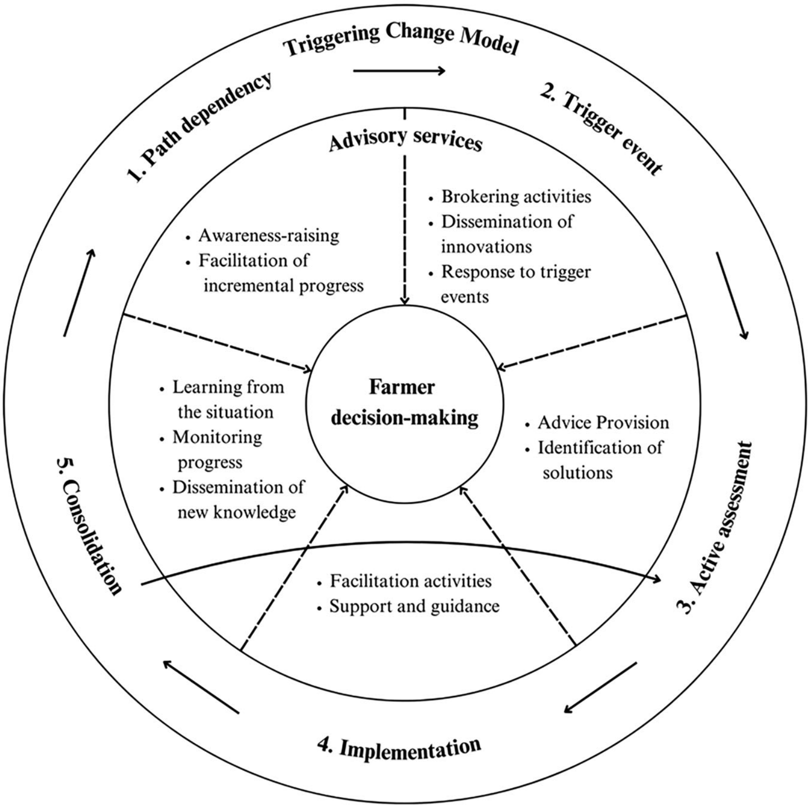

Figure 1. Framework for analysis of advisor leverage in farmer decision-making based on the 'Triggering Change Model', adapted from Sutherland et al. (2012) and Labarthe et al. (2018).

As farmers are ultimately the ones making the decisions, understanding farmers' decision-making, particularly from the perspective of those who have adopted CF practices, lies at the center of the framework. The outer layer of the framework depicts the five stages of TCM's cycle management of change at the farm level (Sutherland et al. 2012). Between the different stages of the TCM and farmers' decision-making lie advisory services. They have a key role to play in all stages and have direct leverage on farmers' decision-making in various ways (Labarthe et al. 2018). In the Path dependency stage, advisors are needed for general awareness-raising (Ingram and Mills 2019; Labarthe et al. 2018; Madureira, Barros, and Fonseca 2021). As farmers are also expected to undergo a certain level of incremental changes to farm operations (Sutherland et al. 2012), advisors must enhance farmer skills and access to knowledge and information (Dwyer et al. 2007; Labarthe et al. 2013). In the trigger event stage, advisors have a responsibility to develop brokering activities to make farmers aware of activities and performance issues, disseminate innovations, and (co-)create trigger events (Ingram and Mills 2019; Labarthe et al. 2018; Madureira, Barros, and Fonseca 2021). Advisors must also have the capacity to respond to trigger events, as they are supposed to have the highest impact during such response periods (Labarthe et al. 2018). Triggers – and more specifically, climate triggers – are also linked to accurate risk perceptions (Mahmood et al. 2021). Accordingly, advisors have the responsibility to increase farmers' perceptions of such risks by raising awareness. Advisors are traditionally the most important during the active assessment and implementation stages (Labarthe et al. 2018). The active assessment stage involves advisors and farmers engaging in active learning through dialogue and discussion about new management practices. This process includes gathering information from diverse sources, translating it, and repacking it into terms that farmers can understand and act upon (Ingram and Mills 2019). Then advisors have a responsibility to support farmers in implementing new management practices by delivering advice and carrying out facilitation activities (Madureira, Barros, and Fonseca 2021). During the consolidation stage, advisors are needed to learn from the situation, monitor progress, evaluate the implementation, and disseminate any new knowledge that has been created. For advisors to fully resonate with farmers in a way that leads to sustained action, efficiency at every stage of the TCM is essential.

3. Q-methodology

Q-methodology (Stephenson 1993) offers an intuitive yet structured approach for assessing stakeholder perceptions of complex phenomena (Herrington and Coogan 2011; Lien, Ruyle, and López-Hoffman 2018). It explores how stakeholders perceive relationships among various elements within complex issues (Brown 1980; McKeown and Thomas 2013; Stenner and Watts 2012), and identifies both differences and similarities in their viewpoints (Durning 2006; Zabala, Sandbrook, and Mukherjee 2018). By integrating qualitative methods, such as textual analysis and interviews, with quantitative factor analysis (Sneegas et al. 2021), Q-methodology provides robust statistical support for qualitative insights (Brown 1980; Stenner and Watts 2012). The approach is especially suited for studying human subjectivity, as it requires participants to critically engage with predefined opinion statements, thereby indirectly uncovering their subjective values.

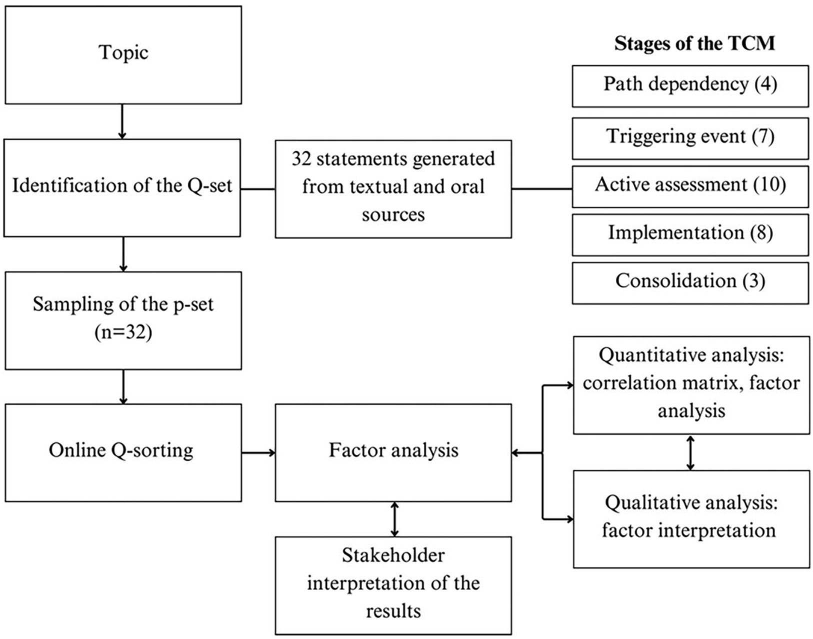

Figure 2. Q-methodology flow diagram of the study.

Figure 2 illustrates the standardized steps of Q-methodology used in the study, starting with the identification of the research topic and the development of the study concourse and Q-set, which consists of representative subjective statements related to each stage of the TCM. The following steps include sampling study participants, collecting data through participants' rank-ordering of Q-set statements in the form of Q-sorts, and conducting a factor analysis on the Q-sorts. Additionally, a workshop was conducted with 16 participants to introduce the findings and engage stakeholders in a discussion about the interpretation of the results, with the workshop outcomes utilized for further analysis of the study results.

3.1. Identification of the concourse and Q-set

The term 'concourse' refers to a comprehensive and representative collection of all relevant ideas and opinions pertaining to a specific subject (Brown 1993). In the construction of the concourse for this study, a variety of sources were incorporated, including policy documents, reports, scientific literature, webpages from organizations, and these texts were supplemented by a naturalistic approach pulled from sources such as conversations with experts (Sneegas et al. 2021). To ensure a balanced representation of the Q-set, a structured inductive approach was used to divide the concourse into dimensions based on the TCM (Dieteren et al. 2023; Sneegas et al. 2021). Consequently, the Q-set was designed based on the five stages of the TCM as outlined in Figure 1; namely, path dependency, trigger event, active assessment, implementation, and consolidation. Each dimension was accompanied by a set of statements reflecting the range of opinions and perspectives found in the concourse (Brown 1993). The concourse was narrowed down to a total of 32 statements. The intention was to provide participants with a wide array of statements that encompassed different opinions and attitudes towards the dimensions. The statements were elaborated in Swedish and selected to be both 'natural' in the language of the participants and 'comprehensive' in their representation of the topic (McKeown and Thomas 2013). This ensured that individuals had the best opportunity to express their personal opinions (Stenner and Watts 2012). Prior to being presented to participants, the statements underwent testing and validation with a collaborator from the farming industry to ensure their accuracy and appropriateness.

3.2. Sampling of the respondents

Following the construction of the Q-set, the next step involved identifying respondents and inviting them to participate in the sorting exercise. It is crucial to acknowledge that Q-methodology does not require a large sample size (Wijaya and Offermans 2019). Instead, the method is particularly suitable for exploratory research with the P-set typically ranging from 10 to 40 respondents (Dieteren et al. 2023). In Q-methodology studies, the primary objective is not to achieve statistical generalization to the broader population. Instead, the focus is on capturing a diverse range of perspectives and fostering a comprehensive understanding of various viewpoints, rather than striving for statistical representativeness (Wijaya and Offermans 2019; Zabala 2014), as participants function as variables in the estimation rather than items (Brown 1980). In this study, livestock producers collaborating with advisory services were chosen as the target participants, and a random sampling approach was employed among the food company KLS Ugglarps contacts (Dieteren et al. 2023). In total, 32 farmers participated in this study, using a ratio of one participant per statement (Dieteren et al. 2023). Most respondents from this study possess over 20 years of experience in farming and are engaged in meat production. The respondents offer diverse expertise in CF practices. Organic farming, cover crops, ley farming, permanent pasture, rotational grazing, reduced tillage, agroforestry, and manure management are all highlighted as the primary measures implemented by the respondents.

3.3. Q-sorting task

The respondents proceeded to rank the Q-set based on their level of agreement with each statement compared to the others. It is important to note that the rankings are not based on the 'correctness' of the statements but rather on the participants' individual degree of agreement or disagreement relative to each statement. This approach allows the sorting task to be entirely subjective, reflecting each participant's specific point of view and preferences (Brown 1993). For this study, the Q- Method Software (www.app.qmethodsoftware.com) online tool was utilized to facilitate data collection in an intuitive two-stage process (Dieteren et al. 2023; Röös et al. 2023). First, statements, presented in a randomized order, were sorted into three categories: 'Disagree', 'Neutral', and 'Agree'. In the second stage, the sorting of statements was further refined into a nine-level agreement scale, following a normal distribution pattern with each level having a designated

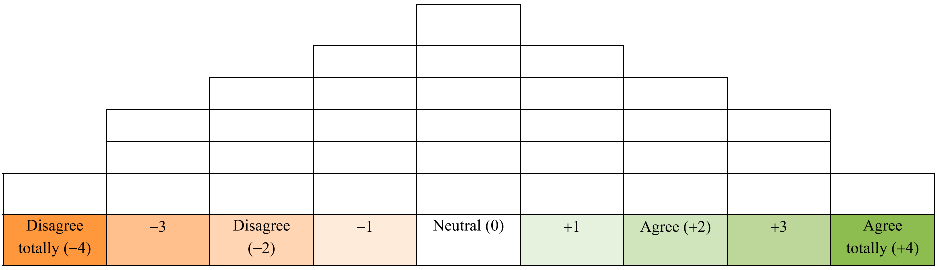

Figure 3. Graphical visualization of the Q-sorting distribution. Ranking values range from − 4 to + 4. A total of 32 statements can be accommodated in the illustrated distribution.

number of spaces to place the statements: completely agree +4 (one space), +3 (three spaces); agree +2 (four spaces), +1 (five spaces); neutral 0 (six spaces), −1 (five spaces); disagree −2 (four spaces), −3 (three spaces); and completely disagree −4 (one space), see Figure 3. This forced a normal distribution of the statements, which is a standard practice in Q methodology (Dieteren et al. 2023; Webler, Danielson, and Tuler 2009), prompting participants to discriminate between statements. This reduces the likelihood of socially desirable, politically correct, or conventional responses (Hausner et al. 2023). Participants were asked to rank the 32 statements based on the following prompt: '*Based on your personal experience, evaluate the following statements regarding how advisors can support the adoption of the practices listed above on your farm*'. To introduce CF, a new and unknown term to farmers, a list of practices was listed for them to aid in understanding.[1] Invitations to respondents were sent via email, together with a short introduction to the study, as in Röös et al. (2023). At the end of the survey, the respondents' demographic information, such as age, education, work experience, established CF practices and advisory services involvement was also collected.

3.4. Factor analysis

After the completion of the Q-sorting task, the collected data were subjected to a factor analysis to identify different clusters of similarly arranged statements across Q-sorts, each of which representing a distinct perspective (Brown 1993). In this way, each person's subjectivity remains intact in the analysis, allowing insight into not just what farmers think, but also into how their perspectives are interconnected. The *qfactor* command (Akhtar-Danesh 2018) in the statistical software Stata (StataCorp 2017) was used to analyze the data. Factor loadings of each Q-sort were generated for each factor using principal component analysis, determining the number of factors to retain. While a definitive number of factors cannot be established (Röös et al. 2023; Sneegas et al. 2021), a simpler approach characterized by fewer factors is typically favored over a more complex alternative. Once a factor solution is determined, the factor loadings of the rotated factor solution were used using Varimax rotation in the *qfactor* command, which represents the level of association between each Q-sort and the factors. A factor array was then generated for each extracted factor, which shows the distribution of statements of a hypothetical 100% factor loading on that factor (Table 2).

3.5. Interpretation of the results

After completing the statistical analysis, stakeholders were invited to participate in a workshop to discuss and verify the results. Stakeholder engagement in environmental research is gaining attraction (Höglind, Hansson, and Manevska-Tasevska 2021) and is perceived as bringing significant benefits to the process of knowledge generation (Phillipson et al. 2012). Actively engaging with a range of stakeholders with multiple perspectives is crucial during research to facilitate knowledge exchange, joint learning, and the generation of integrated solutions (Šūmane et al. 2018). Geertsema et al. (2016) also points out that interaction between researchers and stakeholders supports the effective implementation of measures for the sustainable use of ecosystem services. Accordingly, the identified perspectives were described and disseminated to stakeholders before discussing them one at a time. In total, 16 stakeholders attended the workshop, including advisors, researchers, policymakers, and other practitioners from the agricultural sector. The workshop discussions were recorded, documented, and used in further interpreting the perspectives.

4. Results

The principal component analysis returned twelve factors with eigenvalues larger than one (Kaiser-Guttman Criterion). After inspection of the scree plot, factor loadings, and overall interpretability of the factors, three factors were retained. The factors account for a total of 34.4% of the variation, distributed as follows: Factor 1: 14.9%; Factor 2: 10.7%; and Factor 3: 8.7%. In the literature, the explained variance of the selected factor solution in Q-methodology studies ranges between 29% and 75% (Dieteren et al. 2023). Accordingly, a 5-factor solution, explaining 49.5% of the variance, is included in the appendix for robustness check (see Appendix, Table A1). In total, 22 out of the 32 Q-sorts loaded on the retained factors and no Q-sorts loaded on multiple factors. Specifically, 8 Q-sorts loaded on Factor 1, and 7 Q-sorts loaded on both Factor 2 and Factor 3. Table 1 provides summaries of the three interpreted factors, including labels, number of Q-sorts, eigenvalues, explained variances, and type of advisory services involved.

Table 2 presents the factors array, with rankings of statements across the three factors and categorized per stage of the TCM. The rankings were used as a basis to characterize

Table 1. Overview of the perspectives identified through Q-methodology. Values in brackets indicate number of Q-sorts for each advisory services.

	Label	No. of Q-sorts	Eigenvalue	Explained variance	Advisory services involved
Factor 1	Perspective 1: *Insufficient information*	8	4.78	14.93%	Commercial advisory service #1 (5) Other/Private advisory services (3)
Factor 2	Perspective 2: *Implementation challenges*	7	3.43	10.73%	Commercial advisory service #1 (5) Commercial advisory service #2 (1) Commercial advisory service #3 (1)
Factor 3	Perspective 3: *competing priorities*	7	2.79	8.72%	Commercial advisory service #1 (3) Commercial advisory service #4 (4)

Table 2. Factors array.

Stage	No.	Statement	Perspective		
			1	2	3
Path dependency	1	My advisor considers my needs.	2	4	4
	2	My advisor focuses on providing short-term advice, rather than long-term advice (i.e. advice that directly benefits the farmer's business).	4	3	0
	3	My advisor promotes general awareness on climate issues in agriculture.	–1	3	0
	4	My advisor primarily helps me to improve my farm's economic situation.	0	2	3
Trigger event	5	My advisor helps to strengthen my willingness to adopt CF practices.	3	–2	–1
	6	My advisor's primary motivation for conveying information about CF practices is to increase carbon storage and reduce greenhouse gas emissions from agriculture.	3	0	–2
	7	Based on the information I have received from my advisor about CF practices, I consider it necessary to adopt these methods.	0	1	–4
	8	Based on the information I have received from my advisor about CF practices, I believe that using these practices will make me a better farmer.	1	1	–3
	9	My advisor contributes to increasing my awareness of the risks associated with CF practices.	–1	0	–3
	10	Based on the information I have received from my advisor about CF practices, I consider the implementation of these methods advantageous from various perspectives, such as economic, ecological, and/or social.	–2	2	–1
	11	Based on the information I have received from my advisor about CF practices, I understand the importance of working with these practices.	–1	0	–3
Active assessment	12	My advisor provides more information about CF practices compared to other sources of information (e.g. social networks, the internet, scientific literature, etc.).	2	–3	1
	13	My advisor makes accurate assessments of the need for CF practices and the specific benefits for my farm (agricultural system, soil type, and land cover, including any peatlands and existing tree-based systems).	2	2	1
	14	My advisor offers current information on the economic and environmental benefits of CF practices in agriculture.	1	–1	1
	15	My advisor provides information about CF practices that facilitates a more comprehensive adoption of these practices.	0	1	–1
	16	My advisor listens to and considers my preferences and experiences regarding CF practices (two-way communication).	–1	–1	3
	17	My advisor describes CF practices as a side effect during advice on actions with wholly or partially different purposes (e.g. 'by increasing the farm's biodiversity, the measures also contribute to CF').	–2	1	–1
	18	My advisor offers information about the need for CF practices in agriculture.	–2	–1	0
	19	My advisor is reliable concerning questions related to CF practices.	–4	0	3
	20	My advisor helps to identify the co-benefits of CF (such as increased biodiversity, improved- yield, soil and water quality, animal welfare, etc.).	–3	0	0
	21	My advisor delivers a comprehensive compilation of knowledge about CF practices by engaging with various stakeholders.	–3	1	2
Implementation	22	My advisor is crucial in supporting the implementation of CF practices.	2	0	–2
	23	Based on the information I have received from my advisor about CF practices, I believe it is possible to implement these methods on my farm.	3	3	0
	24	My advisor provides various suggestions for integrated CF efforts to implement on my farm, from which I can choose.	0	–1	0
	25	My advisor offers administrative support related to the implementation of CF practices (e.g. bureaucratic requirements, regulations, etc.).	1	–4	2
	26	My advisor explains any potential risks associated with the implementation of CF practices.	1	–3	–2
	27	My advisor provides practical support for the implementation of CF practices.	0	–2	1
	28	My advisor informs me about how to effectively utilize agricultural payment schemes related to CF practices.	0	–2	2

(*Continued*)

Table 2. Continued.

Stage	No.	Statement	Perspective 1	Perspective 2	Perspective 3
	29	My advisor offers information about alternative financial incentives for the adoption of CF practices, such as carbon credits.	–2	–1	–1
Consolidation	30	My advisor helps facilitate communication with inspectors regarding CF practices.	1	–3	1
	31	My advisor fosters knowledge exchange on CF practices by establishing contacts and networks among farmers.	–1	2	2
	32	My advisor provides methods for measuring and monitoring CF practices.	–3	–2	–2

each factor in detail and to highlight similarities and differences between them. As such, the factors are interpreted as distinct perspectives. The factors array shows a large dispersion amongst the 32 Q-sorts, as there is no consensus found with respect to at least one statement. This implies that no single statement has been sorted similarly among the three factors.

4.1. *Perspective 1:* insufficient information

In the first perspective, advisors are seen as unreliable in addressing CF questions (Statement #19, value –4), leading to insufficient information across various stages of the TCM. This includes a lack of reaction in the trigger event stage, as farmers are failing to grasp the advantages and importance of adopting CF practices based on the information provided by advisors (#10, –2; #11, –1), and a notable absence of information during the active assessment stage, where the majority of statements receive negative evaluations (#16, –1; #17, –2; #18, –2; #19, –4; #20, –3; #21, –3). Although climate information remains limited, partly because farmers tend to seek short-term advice (#2, 4), advisors are still seen as essential (#22, 2), as farmers believe CF measures could possibly be implemented on their farms (#23, 3). Statements related to more practical implementation, however, are neutral (#24, 0; #25, 1; #26, 1; #27, 0; #28, 0). Additionally, advisors are perceived as not contributing to generating new information through monitoring (#32, –3) nor to facilitating the exchange of such new information among farmers (#31, –1) during the consolidation stage.

4.2. *Perspective 2:* implementation challenges

The second perspective underscores a positive contribution of advisors during the path dependency, with all four statements reflecting favorable aspects (#1, 4; #2, 3; #3, 3; #4, 2). This implies that advisors are found suitable when they recommend choices that align with existing practices, especially those focusing on farmers' needs, and economic concerns (#1, 4; #2, 3; #4, 2). Advisors also demonstrate a high level of awareness regarding environmental issues (#3, 3) which further conveys the necessity and benefits of adopting CF practices (#7, 1; #8, 1; #10, 2). Consequently, advisors appear to provide reasonable information to farmers about CF practices (#15, 4), particularly related to specific farm conditions (#13, 2). However, a noticeable gap persists in practical and technical information for their implementation, as evidenced by six out of eight negative ratings in statements related to the implementation stage (#24, −1; #25, −4; #26, −3; #27, −2; #28, −2; #29, −1), especially those related to administrative support (#25, −4), payment schemes (#28, −2) and associated risks (#26, −3).

4.3. *Perspective 3:* competing priorities

The third perspective emphasizes advisors' role in supporting farmers for economic reasons (#4, 3), closely aligning with their needs (#1, 4), owing to the path dependency. Consequently, a lack of interest is demonstrated in triggering change towards CF practices, driven by economic concerns, as highlighted by the negative evaluation of all statements from this stage (#5, −1; #6, −2; #7, −4; #8, −3; #9, −3; #10, −1; #11, −3). There is, however, a desire for practical knowledge (#12, 1; #13, 1; #14, 1; #21, 2) derived from a high level of collaboration and trust between farmers and advisors (#16, 3; #19, 3). Yet, economic priorities overshadow the implementation of CF practices, with advisors perceived as non-crucial during the implementation stage (#22, −2). However, statements related to administrative support and payment scheme receive positive evaluations (#25, 2; #28, 2), reflecting their relevance to farm economics.

5. Discussion and conclusions

CF practices have received significant policy attention in recent years, especially concerning the mitigation of livestock emissions (McDonald et al. 2021; Tang et al. 2018). Advisors, as key actors within the AKIS, are crucial in supporting the upscaling of CF practices through the provision of information (Andrés et al. 2022; Ingram and Mills 2019; Labarthe and Beck 2022; Schomers, Sattler, and Matzdorf 2015; Sutherland et al. 2022). However, there is a discrepancy between CAP expectations for advisors to promote climate mitigation efforts and farmers' private objectives (Farstad, Forbord, and Klerkx 2024). This study provides novel evidence into the challenges underlying this discrepancy. By evaluating farmers' perceptions on the role of advisors in promoting CF practices using Q-methodology and analyzing their perceived leverage in farmers' decision-making processes using the TCM, three perspectives were identified. Each perspective highlights a specific upscaling challenge.

The first perspective, *insufficient information*, highlights a timing concern in which climate mitigation is still a relatively new policy objective for many farmers. Over time, CAP reforms have increasingly prioritized climate action, making it a key objective since 2014 (EU Court of Auditors 2021). However, despite significant climate funding between 2014–2020, the lack of clear targets led to limited progress and criticism (EU Court of Auditors 2021). As a result, CF has only recently started receiving support through new intervention measures under both Pillars 1 and 2, such as the eco-scheme for cover cropping, while advisory services are still in the early stages of incorporating it into their services. In this context, perspective 1 highlights a situation where advisors are perceived as providing insufficient information related to CF despite being recognized as crucial for possible implementation. While market-based initiatives in Sweden exist, such as '*Svensk Kolinlagring*', CF remains in its early stages and has yet to gain widespread acceptance. This sentiment was echoed during the workshop, where stakeholders acknowledged the necessity of CF but also highlighted a clear absence of structure in their respective activities.

The second perspective, *implementation challenges*, highlights that while advisors help raise climate awareness (Farstad, Forbord, and Klerkx 2024), they struggle to provide practical advice on CF due to its complexity and variability across farming systems and conditions (Ingram and Mills 2019; McDonald et al. 2021). Such diversity and complexity make it difficult to provide clear, farm-specific guidance, highlighting the need for advisors to have better access to evidence and tools for credible, tailored support (Ingram and Mills 2019). This is especially challenging given the complexities of managing soil organic carbon including the monitoring, reporting, and verification (MRV) of climate mitigation efforts (McDonald et al. 2021). Monitoring tracks emission reductions or increases in carbon sequestration, reporting communicates these findings, and verification checks their accuracy and reliability, and together, they form the backbone of a robust MRV system (McDonald et al. 2021; Raina, Zavalloni, and Viaggi 2024). However, implementing such a system is not without its own challenges. One major concern is ensuring that mitigation outcomes are truly permanent and not simply temporary carbon storage that may be reversed in the future (Raina, Zavalloni, and Viaggi 2024). Similarly, verifying additionality, whether the mitigation would have happened anyway, remains a complex task (McDonald et al. 2021; Oldfield et al. 2022). This issue is exacerbated by one of the main features of the post-2020 CAP: the shift to a new delivery model aimed at moving the entire CAP towards a results-based approach (COWI 2021; McDonald et al. 2021). This approach can offer both increased profitability and greater risk for farmers (Raina, Zavalloni, and Viaggi 2024), as measuring changes in SOC is difficult due to slow accumulation and high spatial variability, complicating the quantification and verification of real emission reductions (Oldfield et al. 2022). These challenges underscore the need for well-designed MRV systems to ensure the integrity and reliability of CF practices.

In the third perspective, *competing priorities*, economic considerations highlight how advisors are seen to be closely following farmers' needs and primarily contributing to the farm economy, supporting the findings from Stål and Bonnedahl (2015). Farmers are increasingly caught between rising pressure to maintain farm incomes and growing public expectations to lead on climate action. This tension has fueled widespread protests across Europe in 2023 and 2024, and, in some cases like Switzerland, led farmers to take their governments to court over inadequate climate accountability (Finger et al. 2024). As a result, many farmers do not view CF as a priority, as long-term farm viability outweighs environmental and climate concerns (Kathage et al. 2022). However, studies show that environmental practices are also economically viable (e.g. Nilsson et al. 2022). While CF primarily aims to mitigate climate change, the practices involved often yield additional environmental, economic, and social benefits (McGuire et al. 2022). This corroborates that climate objectives are set on a macro level by national authorities, while farmers do not necessarily regard carbon sequestration to be a priority (Brobakk 2018; Farstad, Forbord, and Klerkx 2024). Measures aligned with farmers' needs or priorities may result in higher adoption rates (Canessa et al. 2024). Specifically, practices offering (or perceived as offering) private co-benefits, such as improved soil structure and fertility, erosion mitigation, soil moisture retention, water quality, and nutrient storage capacity (Bradshaw et al. 2013; Desjardins et al. 2005; George et al. 2012; Lal

2004; McGuire et al. 2022; Perring et al. 2012), are more likely to be adopted by farmers. In turn, such production advantages enhance farm income, productivity, resilience, aid in diversification, utilize marginal land, and mitigate risk (Brown et al. 2021; Lienhoop and Brouwer 2015; Świtek and Sawinska 2017; Von Unger and Emmer 2018), reflecting economically rational choices (Lienhoop and Brouwer 2015). However, stakeholders emphasized the predominance of commercial advisors who prioritize farmers' short-term economic interests and often relegate climate objectives to the background. This further decentralizes advisory systems into a multi-pluralism of advisory services with varying objectives, priorities, and delivery approaches (Ingram and Mills 2019). For example, the government-funded advisory institution Greppa Näringen is tasked with filling this gap, offering farmers free environmental and climate advice that aligns with long-term public objectives.

As such, Q-methodology was successful in identifying farmers' perspectives on advisor leverage in supporting the upscale of CF practices. Yet, it is important to acknowledge some limitations. Firstly, the overall distinction between the producers, facilitators, and users of knowledge is fluid and ambiguous (Phillipson et al. 2012). This is particularly true in the context of the Swedish AKIS, in which all stakeholders, including farmers, play a complex role during the knowledge exchange process (Nordlund and Norrby 2021). However, due to the strong emphasis that is given to advisory services, this study narrows its focus to advisors, thus excluding other potential information networks such as peer-to-peer interactions. The statement in the Q-set regarding whether advisors provide the most information on CF compared to other source of advice was assessed neutrally among the respondents. This suggests that while other sources of information may also contribute to the upscaling of CF practices, advisors still hold relevance among farmers. Future research has an important task in evaluating how the upscale of CF practices among farmers may be affected by the source of advice. Secondly, it is necessary to acknowledge that the factor analysis of Q-methodology is open to interpretation, making each perspective prone to subjective assessments. To address this, the statements and their evaluations used to construct the perspectives are explicitly highlighted in the results section. Additionally, stakeholders were invited to participate in a workshop to discuss and validate the perspectives. The outcomes of the workshop were used to further interpret the results and contributed to the discussion. Nevertheless, validating the perspectives with complementary statements from those used in this study could be an interesting avenue for future research. Thirdly, data collection using Q-methodology proved challenging in this study, as farmers did not recognize the method and contested the uniform distribution of the ranking scale. To address such challenges, it was crucial to clearly communicate to farmers the purpose of the survey and the importance of their participation. This is particularly important for environmental topics in rural contexts, as such instruction and structure are often assumed less relevant when designing questionnaires (Coon et al. 2020).

This study offers several contributions. Firstly, the study contributes to existing literature on the role of advisory services in supporting climate mitigation efforts. While the literature covers the evolving role of advisors on sustainability issues (e.g. Ingram and Mills 2019; Klerkx and Jansen 2010; Wijaya and Offermans 2019), research on climate mitigation remains particularly scarce. Secondly, it applies TCM to encompass the perceived leverage of advisors across different stages of farmer decision-making process, thereby enhancing the understanding of their significance in facilitating the upscale of innovations. While it is argued that advisors have a key role to play during each stage of the TCM (Labarthe et al. 2018), this study provides evidence regarding the different ways through which advisors can leverage farmer decision-making. Finally, through the identification and discussion of three policy relevant perspectives: *insufficient information*, *implementation challenges*, and *competing priorities*, this study provides actionable research for policymakers and advisors, with results used as policy recommendations for the upscaling of CF practices. To start with, increasing technical assistance and education is crucial, and can be achieved through training programs for both farmers and advisors on CF practices and their benefits (García de Jalón et al. 2016). Building technical capacity in advisory services through training and specialized tools will enable advisors to provide effective advice on mitigation efforts (Farstad, Forbord, and Klerkx 2024; Ingram and Mills 2019). Hence, the development of robust MRV systems to measure, report, and verify CF impacts reliably is essential (Oldfield et al. 2022). Furthermore, developing and strengthening incentives and support systems to encourage CF adoption is needed, along with clear and consistent communication to reduce confusion. Aligning economic and climate objectives by promoting the co-benefits of CF practices can further motivate farmers' adoption decisions (Braito et al. 2020; Buck and Palumbo-Compton 2022; Dumbrell, Kragt, and Gibson 2016; Mattila et al. 2022; Surya et al. 2023). By addressing these areas, policies and advisors can better support the upscaling of CF practices, integrating them effectively into existing farming systems and contributing to broader climate mitigation efforts.

Note

1. CF practices considered for the analysis included organic farming, intercropping, crop rotation, permanent pasture, rotational grazing, reduced tillage, retention of organic materials, ley farming, manure management, application of biochar, avoidance of insecticides, fungicides, and herbicides, tree-based agriculture (agroforestry), and buffer zones.

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Appendix

Table A1. Factors array (5 factors).

Stage	No.	Statement	Perspective 1	2	3	4	5
Path dependency	1	My advisor considers my needs.	3	3	3	3	0
	2	My advisor focuses on providing short-term advice, rather than long-term (i.e. advice that directly benefits the farmer's business).	4	3	2	–1	–2
	3	My advisor promotes general awareness on climate issues in agriculture.	–2	2	0	–3	–1
	4	My advisor primarily helps me to improve my farm's economic situation.	2	1	3	3	–2
Trigger event	5	My advisor helps to strengthen my willingness to adopt CF practices.	3	–3	–1	4	1
	6	My advisor's primary motivation for conveying information about CF practices is to increase carbon storage and reduce greenhouse gas emissions from agriculture.	2	–2	–2	2	3
	7	Based on the information I have received from my advisor about CF practices, I consider it necessary to adopt these methods.	0	2	–4	0	–2
	8	Based on the information I have received from my advisor about CF practices, I believe that using these practices will make me a better farmer.	1	0	–3	0	–2
	9	My advisor contributes to increasing my awareness of the risks associated with CF practices.	–1	1	–3	0	1
	10	Based on the information I have received from my advisor about CF practices, I consider the implementation of these methods advantageous from various perspectives, such as economic, ecological, and/or social.	–1	1	–1	1	–3
	11	Based on the information I have received from my advisor about CF practices, I understand the importance of working with these practices.	–1	2	–2	–1	–1
Active assessment	12	My advisor provides more information about CF practices compared to other sources of information (e.g. social networks, the Internet, scientific literature, etc.).	1	–4	0	–1	2
	13	My advisor makes accurate assessments of the need for CF practices and the specific benefits for my farm (agricultural system, soil type, and land cover, including any peatlands and existing tree-based systems).	2	3	0	2	1
	14	My advisor offers current information on the economic and environmental benefits of CF practices in agriculture.	1	–1	0	–2	3
	15	My advisor provides information about CF practices that facilitates a more comprehensive adoption of these practices.	0	4	–1	–1	0
	16	My advisor listens to and considers my preferences and experiences regarding CF practices (two-way communication).	0	1	4	1	2
	17	My advisor describes CF practices as a side effect during advice on actions with wholly or partially different purposes (e.g. 'by increasing the farm's biodiversity, the measures also contribute to CF').	–2	1	–2	1	–1
	18	My advisor offers information about the need for CF practices in agriculture.	–2	–2	–1	3	2
	19	My advisor is reliable concerning questions related to CF practices.	–4	–1	2	1	0
	20	My advisor helps to identify the co-benefits of CF (such as increased biodiversity, improved- yield, soil and water quality, animal welfare, etc.).	–3	–2	2	–1	–3
	21	My advisor delivers a comprehensive compilation of knowledge about CF practices by engaging with various stakeholders.	–3	0	1	0	0

(*Continued*)

Table A1. Continued.

Stage	No.	Statement	Perspective 1	2	3	4	5
Implementation	22	My advisor is crucial in supporting the implementation of CF practices.	1	−1	−3	2	4
	23	Based on the information I have received from my advisor about CF practices, I believe it is possible to implement these methods on my farm.	3	−1	−2	1	3
	24	My advisor provides various suggestions for integrated CF efforts to implement on my farm, from which I can choose.	0	−1	1	−2	−1
	25	My advisor offers administrative support related to the implementation of CF practices (e.g. bureaucratic requirements, regulations, etc.).	0	−2	1	−3	1
	26	My advisor explains any potential risks associated with the implementation of CF practices.	0	0	0	−4	0
	27	My advisor provides practical support for the implementation of CF practices.	−1	0	1	−2	2
	28	My advisor informs me about how to effectively utilize agricultural subsidies related to CF practices.	1	0	3	−3	1
	29	My advisor offers information about alternative financial models for CF practices, such as industry initiatives, labeling, credits, and more.	−2	0	−1	−2	−3
Consolidation	30	My advisor helps facilitate communication with inspectors regarding CF practices.	2	−3	2	0	0
	31	My advisor fosters knowledge exchange on CF practices by establishing contacts and networks among farmers.	−1	2	1	2	−1
	32	My advisor provides methods for measuring and monitoring CF practices.	−3	−3	0	0	−4

IV

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Farm-level acceptability of contract attributes in agri-environment-climate measures for biodiversity conservation

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ABSTRACT

Farmers are key to preserving and restoring semi-natural pastures (SNPs) while maintaining their environmental and cultural significance. To support these efforts, it is essential to create favorable conditions that encourages voluntary participation of farmers in agri-environment-climate measures (AECM) for SNP management. This study aims to assess acceptability of contract attributes within AECM for SNP management at the farm-level, including supported activity, payment, inspection, and sanction. Using a qualitative document analysis on data from semi-structured interviews, scientific literature, and policy documents, this study provides insights into farmers' perceptions of how these attributes affect effective implementation, along with recommendations for alternative solutions, and the potential of the Strategic Plan (SP) 2023–27. Results highlight concerns with current AECM, such as: i) misunderstandings between authorities and farmers on stipulated practices and conflicts with other regulations; ii) growing importance and reliance on payments; iii) apprehensions concerning potential interactions with unfavorable inspectors and punitive financial measures. Farmers expressed a strong desire for increased management flexibility, underscoring its significance over stringent contract attributes, and convey a need for improved communication with authorities. The SP 2023-27 offers an opportunity for improvements, mainly through administrative modifications via service digitalisation. As such, the results contribute to governance debates linked to contractual design and have implications for policy effectiveness, addressing both the appropriateness of AECM as a policy instrument and the capacity of governmental agencies to implement them effectively.

1. Introduction

Semi-natural pastures (SNPs), rich in natural and cultural values, are characterized by centuries without soil cultivation, heavy fertilization and sowing of forage crops (Swedish Board of Agriculture, 2023). In Sweden, the empirical focus area of this study, SNPs were common at the start of the 20th century (Cousins et al., 2007; Eriksson and Cousins, 2014; Waldén, 2018). They significantly contribute to the cultural heritage of Sweden and play an important role for the development of sustainable animal production (Waldén and Jakobsson, 2017). Nowadays, SNPs are among the most species-rich habitats of Sweden and encompass a wide range of semi-natural grazing lands, including outlying areas, forest, freshwater and coastal grazing lands (Swedish Board of Agriculture, 2023). SNPs create favorable conditions for wildlife, plant species, and crop pollination, increase carbon sequestration, ensure access to clean water, and serve as a natural forage source for grazing animals (Bengtsson et al., 2019; Eze et al., 2018; Hauck et al., 2014; Sollenberger et al., 2019). However, the provision of such public goods is facing negative trends, particularly in regions where historical human-environment interactions have created unique ecosystem services (European Environment Agency, 2021; D'Alberto et al., 2024; Debolini et al., 2018). Over the years, the area of SNPs in Sweden has significantly decreased due to intensification of arable land use and afforestation (Stoate et al., 2009), now representing only 10% of the total grassland area that once existed (Government of Sweden, 2023). Despite this rapid decline, SNPs still contribute to approximately 50% of

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the area accounted for reaching biodiversity goals, making their preservation a prominent policy objective in Sweden (Government of Sweden, 2023).

Farmers are primarily responsible for preserving and restoring SNPs and upholding their environmental and cultural values (Gaymard et al., 2020; Nitsch, 2009; Sollenberger et al., 2019). As such, it is crucial to create a supportive environment that facilitates their efforts to implement these activities (Buitenhuis et al., 2022; Divanbeigi and Saliola, 2016; Mathijs et al., 2022). In the European Union, the Common Agricultural Policy (CAP) provides agri-environment-climate measures (AECM) as a form of Payment for Ecosystem Services (PES), encouraging farmers to adopt management practices that preserve SNPs (Swedish Board of Agriculture, 2023). AECM incentivize voluntary participation, prompting farmers to go beyond legal requirements or traditional grazing practices to support the provision of public goods that might otherwise be neglected (Bazzan et al., 2022; Martin and Hine, 2018). For AECM to function effectively, contract attributes—such as supported activity (i.e., conditions attached to payment), payment, inspection, and sanction—must be carefully established by governmental agencies (Bali et al., 2019). However, research indicates that restrictive or inadequate contractual design can discourage farmer participation in these payment schemes (Eksvärd and Marquardt, 2018; Jamieson and Hessle, 2021; Nordberg and Asplund, 2020). For example, Nordberg and Asplund (2020) found that about 50% of Swedish farmers engaged in AECM for SNP management do not fully utilize the available area, and approximately 20% would opt out of future AECM under the same conditions. This reluctance threatens the stewardship of SNPs and may hinder policy goals (Waldén and Lindborg, 2018), casting uncertainty on the future of SNP and its associated cultural and environmental values (Pe'er et al., 2022).

The aim of this study is to assess farm-level acceptability of contract attributes within AECM for SNP management. While previous research highlights concern regarding restrictive conditions in AECM for SNP management in Sweden (Eksvärd and Marquardt, 2018; Jamieson and Hessle, 2021; Nordberg and Asplund, 2020), successful policy design depends on a clear understanding of where adjustments are needed and the best strategies for addressing these challenges (Bali et al., 2019; Hysing and Lidskog, 2018; Mack et al., 2024). By analyzing key contract attributes such as supported activity, payment, inspection, and sanction (Guerrero, 2021; Koop and Lodge, 2017; Yang et al., 2021), this study provides insights into farmers' perceptions of how these attributes affect effective implementation, along with recommendations for alternative solutions and the potential of the Strategic Plan (SP) 2023-27 for improved SNP management. An exploratory, qualitative approach using qualitative document analysis (QDA) systematically examines data from semi-structured interviews, scientific literature, and policy documents (Wach and Ward, 2013).

This study draws upon prior research that has identified individual attributes influencing farmers' participation in agri-environmental contracts. These features include payment amounts (Le Coent et al., 2017), policy complexity and administrative burdens (Brown et al., 2019), flexibility in implementation (Peerlings and Polman, 2009), the legitimacy of monitoring and auditing authorities (Kovács, 2015; Micha et al., 2015), and the effectiveness of sanctions (Zinngrebe et al., 2017). Additionally, this study aligns with more recent research on agri-envrionmental governance that uses structured approaches and consistent frameworks to evaluate key attributes such as innovative contract solutions (D'Alberto et al., 2024), the interaction between contract features and successful implementation (Bazzan et al., 2022; Gutiérrez-Briceño et al., 2024), and the development of a taxonomy for characterizing, organizing, and comparing agri-environmental contracts (Guerrero, 2021). It also builds on established methodologies using multiple data sources as exemplified by Bazzan et al. (2023). In contributing to this body of literature, this study specifically addresses the gap in research related to the context of agri-environmental contracts for SNP management. While previous studies have focused on farmers' perceptions regarding restoration outcomes, eligibility criteria, implementation difficulties, and simplification strategies under prior CAP reforms (Dahlström et al., 2013; Eksvärd and Marquardt, 2018; Nordberg and Asplund, 2020; Waldén and Lindborg, 2018), this study aims to fill this gap by providing new insights within the context of the SP 2023–27, considering ongoing policy changes.

The findings of this study enrich the existing literature on agri-environmental governance (e.g., Bazzan et al., 2022; D'Alberto et al., 2024; Gutiérrez-Briceño et al., 2024) by providing a comprehensive analysis of key contract attributes through a multi-source and structured approach. These findings have important implications for policy effectiveness, particularly in assessing the appropriateness of AECM as a policy instrument and the capacity of governmental agencies to implement them effectively (Bali et al., 2019), contributing to governance debates linked to contractual design regarding AECM acceptability (D'Alberto et al., 2024).

2. Conceptual framework: policy design for SNP management

AECM, funded under the CAP's second pillar, are part of the broader category of PES, which involve voluntary transactions between service users and providers contingent upon stipulated environmental management practices aimed at generating public benefits (Canessa et al., 2024; Wunder, 2015). AECM encourage farmers, through voluntary participation, to exceed the requirements of mandatory environmental regulations, which typically address issues like environmental pollution, animal welfare, and food safety violations (Martin and Hine, 2018). However, enforcing controls on practices deemed "normal" by the public, such as feed-intensive cattle production, can be politically or socially challenging. Therefore, payments are often necessary to incentivize farmers to adopt sustainable practices that deliver diverse ecosystem services beyond conventional farming (Bazzan et al., 2022; Martin and Hine, 2018). Depending on their objectives, AECM can support the extensification or intensification of management practices or encourage changes or maintenance of existing practices (Hasler et al., 2022). These payments should cover both the direct costs of implementing the practices and compensate for opportunity costs (Canessa et al., 2024). Incentives are generally categorized into action-based and result-based measures, or a combination of both. Action-based measures involve payments for implementing specific sustainable practices, while result-based measures reward achieving positive environmental outcomes (Coglianese and Lazer, 2003; Herzon et al., 2018). Action-based measures are the most established, compensating farmers for prescribed actions with the expectation that these will lead to the desired environmental outcomes (Canessa et al., 2024; Gaymard et al., 2020).

The voluntary nature of AECM means that effective participation, encompassing the number and types of farmers engaged, is a crucial indicator of both their success and overall effectiveness (Canessa et al., 2024; Persson and Alpízar, 2013). Despite the long-standing existence and benefits of action-based AECM (Hasler et al., 2022), participation has been inconsistent, and evidence of their effectiveness in biodiversity or ecosystem services is limited (Ait Sidhoum et al., 2023; Batáry et al., 2015; Díaz and Concepción, 2016; Gaymard et al., 2020; Pe'er et al., 2020). AECM are defined within regional Rural Development Programmes (RDP) and are tailored to local farming systems and ecosystems (Canessa et al., 2024). In Sweden, action-based AECM for SNP management reveal successful farmer engagement with the SNPs area (approx. 450,000 ha) remaining relatively stable since 1990 (Larsson et al., 2020). The Swedish SP 2023-27 allocates 640 million euros (10.5% of the total budget) to AECM for SNP management, covering approximately 423,000 ha per year—about 14% of Sweden's total agricultural land (Government of Sweden, 2023). The AECM for SNP management in Sweden vary significantly depending on land characteristics and management techniques. Grazing lands with special values, such as high natural or cultural significance, qualify for higher payment compared to lands with more general values. These attributes may include ground cover, tree layers, and cultural heritage aspects (County Administrative Board, 2023). AECM for SNP management are action-based, emphasizing prescribed actions such as maintaining specific grass heights and keeping tree and bush densities below designated thresholds. However, despite significant effort for SNP conservation within Sweden's RDP, issues such as declining pasture quality and the loss of valuable areas continue to persist (Larsson et al., 2020).

Policymakers need to understand the underlying reasons for the declining quality of SNPs and identify the most effective ways to address them (Hysing and Lidskog, 2018; Mack et al., 2024). Understanding how AECM contract attributes interact with agricultural activities, which this paper aims to achieve, is a crucial step toward improving policy design (Mack et al., 2024). Indeed, attaining intended outcomes is not always straightforward when putting public policies into practice (Berman, 1978; Matland, 1995). Even if a policy appears to facilitate smooth application of sustainable practices, it does not necessarily imply that the target population perceives the policy as doing this (Buitenhuis et al., 2022; Nilsen et al., 2013). Multiple policies may interact, producing synergies or trade-offs that impact farmers' participation (Buitenhuis et al., 2022). Furthermore, policy effectiveness varies spatially due to differences between regions (Dabrowski, 2013). So, whereas authorities can influence the policy output, they can hardly control how the local-level context will affect farmers' implementation of the policy (Berman, 1978). This underscores the necessity to examine how policies are designed to achieve their intended goals and how well they align with farmers' perceptions and practices, to ensure their acceptability and effectiveness (Buitenhuis et al., 2022; Herzon et al., 2018).

Fig. 1 presents the policy design for SNP management in Sweden. Policy design is a deliberate effort to connect policy instruments, such as AECM, with well-defined policy objectives or a specific policy problem (Bali et al., 2019; Howlett, 2019). An effective policy is one that successfully addresses the identified problem (Peters et al., 2018). In this context, the policy objective of incentivizing SNP management is focused on biodiversity conservation, which underpins the use of AECM as a policy instrument. Farmers can voluntarily participate in AECM, typically for a five-year period, provided they follow the conditions specified in the funding guidelines. Then, to ensure the effective implementation of AECM, authorities enforce key contract attributes, including supported activity, payment, inspection, and sanction (Guerrero, 2021; Koop and Lodge, 2017; Yang et al., 2021). *Supported activity* determines the conditionality of the payment, meaning that farmers in the AECM receive the payment only if they implement the agreed actions or practices as specified in their contract (Guerrero, 2021). *Payment* highlights the importance of financial incentive for SNP management (Le Coent et al., 2017). Given the challenges associated with effectively enforcing farmers' production practices through administrative means, it is important to complement stipulated actions with payments (Yang et al., 2021). *Inspection* and *sanction* outline the actions that authorities employ to enforce the policy (Guerrero, 2021; Koop and Lodge, 2017; Zinngrebe et al., 2017). *Inspection* involves governmental agencies overseeing adherence to the stipulated actions, while *sanction* indicates the financial payback, with interest, for parts of or for the entire commitment period if farmers did not comply with the stipulated actions. Farm-level acceptability refers to the extent to which individual farmers are willing to comply with the contract attributes, based on how well they align with their specific needs, values, and operational circumstances (Canessa et al., 2024; D'Alberto et al., 2024). Acceptability is crucial for the adoption and effective implementation of AECM, as it directly influences farmer participation and, consequently, the overall effectiveness of the policy. In this context, effectiveness, measured by changes in biodiversity or ecosystem services that can be attributed to AECM implementation (Díaz and Concepción, 2016), is a function of the appropriateness of AECM, and the capacities of governmental agencies (Bali et al., 2019). It ensures a closer alignment between policy goals and AECM, ultimately contributing to more effective policy designs (Bali and Ramesh, 2018).

3. Methods and data

3.1. Qualitative document analysis

To fulfill the objective of this research, an exploratory, qualitative approach was adopted (Laurett et al., 2021). This method is suitable for understudied subjects and involves fieldwork to understand the perceptions, attitudes, and opinions of individuals involved (Creswell, 2009). QDA is employed to ensure a comprehensive and systematic examination of the gathered materials from various sources and individuals. This approach facilitates the extraction of relevant information, identification of patterns and themes, and the meaningful interpretation of the data (Wach and Ward, 2013). This study employs a combined QDA approach, using a triangulation process (Manevska-Tasevska et al., 2023). In-depth interviews were initially structured and further complemented using a review of scientific literature. The obtained findings were then compared with policy documents for further analysis. QDA used in this paper is further elaborated on under subheadings 3.1.1–3.1.3.

3.1.1. In-depth interviews

In-depth interviews gather qualitative data on individuals' perspectives regarding specific ideas, phenomena, or situations (Legard et al., 2003). In this study, eight farmers (one of them a representative of the Natural Pasture Meat Association of Sweden), as well as three advisors, contributed to the interviews. A combination of purposive and snowball sampling was used. This means that interview participants were selected based on relevance for the study, with the criterion for farmers specifying that they actively manage SNPs. For advisors, the criteria, in addition to working in an agricultural advisory capacity, were that they have had experience working with farmers who manage SNPs. Advisors had different focus areas—both animal health and production were of interest for this study.

The selection process consists of two parts. In the first part, sampling is of the purposive variety, with the Swedish Farmers' Association recommending advisors that fulfilled the required criteria (Etikan and Bala,

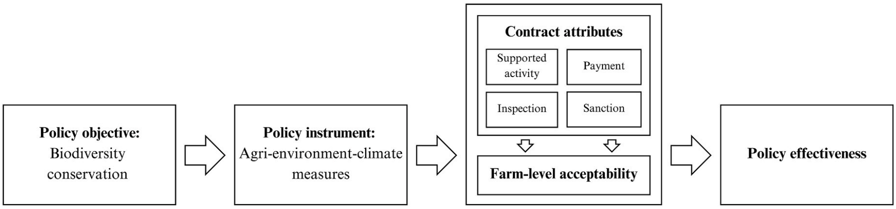

Fig. 1. Conceptual framework of the policy design for SNP management. From policy objective via AECM and farm-level acceptability of contract attributes to policy effectiveness.

2017). In the second part, sampling is of the snowball variety, with advisors who participated in the study recommending farmers to be interviewed (Etikan and Bala, 2017). A regional stratification based on the distribution of SNPs in Sweden was implemented to ensure proportional representation among the participants. Accordingly, six farmers and two advisors were selected from southern Sweden and two farmers and one advisor from northern Sweden. Farmers were interviewed both from farms with general and with special values in SNPs. Farmers who participated in the study mainly had their land grazed by cattle, but sheep were also present on some farms. The farms varied in size and production. Four farms focused on meat production and three farms focused on milk production. The number of grazing animals ranged from 50 to 500.

The in-depth interviews were conducted using a semi-structured format and an interview protocol to ensure consistency in the questions asked across the interviews (see Appendix, Table A1). Following the conceptual framework depicted in Fig. 1, the respondents shared their experiences with the contract attributes, namely, supported activity, payment, inspection, and sanction. Additionally, the respondents revealed how these attributes affect AECM acceptability and provided suggestions for alternative solutions. While all farmers shared their personal experiences, the advisors and the representative from the Natural Pastures Meat Association of Sweden contributed with a broader perspective and experiences from multiple farms they had been in contact with. All interviews were conducted digitally by one researcher and lasted for approximately 45 min, with audio recordings made with participants' consent and transcribed verbatim.

Qualitative thematic analysis (QTA) was undertaken on the transcripts for identifying, analyzing, and reporting patterns (themes) within the data (Braun and Clarke, 2006; Creswell, 2013), using NVivo 12.7 software (Jackson and Bazeley, 2019). The coding involved aggregating text fragments according to axial (deductive) and thematic (inductive) codes (Coopmans et al., 2021). Deductive coding involves applying pre-existing concepts or theories to the data, while inductive coding involves developing new concepts or theories based on the data (Linneberg and Korsgaard, 2019). Combining deductive and inductive coding approaches can result in a more comprehensive and nuanced understanding of the data by validating pre-existing concepts, while also allowing for the emergence of new ones. Our set of deductive codes was established corresponding to the four contract attributes illustrated in Fig. 1. The codes were then expanded inductively (see Appendix, Table A2). The results obtained inductively from the interviews were triangulated with previous literature and policy documents to ensure that the discussed attributes were aligned (Manevska-Tasevska et al., 2023). To minimize researcher bias, three researchers collaboratively coded and interpreted each transcript.

3.1.2. Scientific literature

A QTA of nation-specific studies was conducted to identify design issues with agri-environmental contracts for SNP management under prior CAP reforms. This review of scientific literature was used to structure the in-depth interviews while also providing complementary findings to those from the respondents. In total, 11 studies (reports and articles) were selected based on the following criteria: i) studies on the payment scheme for managing SNPs in Sweden relevant for the policy period after 2013; and ii) all studies containing evidence, gathered via interviews, surveys, literature review, on farmers' experience with management of SNPs (see Appendix, Table A3). QTA on the nation-specific studies consisted of two steps, data extraction and coding. The coding process followed the procedure outlined in section 3.1.1.

3.1.3. Policy document analysis

Qualitative content analysis (QCA) was undertaken on policy documents to investigate the extent to which the SP 2023-27 further constrains or enables SNP management in Sweden (Buitenhuis et al., 2022; Manevska-Tasevska et al., 2021). QCA is a systematic approach for coding and categorizing textual data to explore significant trends and patterns, without interfering with the information (Gbrich, 2007; Mayring, 2000; Pope et al., 2006). Contrary to QTA, the purpose of QCA is to depict the attributes of the document's content by examining "who says what, to whom, and with what effect" (Bloor and Wood, 2006). Nine documents were selected based on the following criteria: i) CAP payment schemes supporting the management of SNPs, and ii) relevant Swedish laws, legal cases, and documents outlining the application of these schemes in Sweden. The documents were sourced from the European Commission (ec.europa.eu), the Swedish law platform (lagen.nu), and the Swedish Board of Agriculture (jordbruksverket.se). These included: i) the SP 2023–27; ii) agri-environmental support, direct support, and basic conditions from 2022, with amendments from 2021; and iii) animal welfare regulation (Djurskyddsförordning 2019:66; Government Offices, 2020) (see Appendix, Table A4). QCA on the policy documents consisted of two steps, data extraction and coding. The coding process followed the methodology outlined in section 3.1.1.

3.2. Limitations

It is important to acknowledge that the methods and data face some limitations. First, it is crucial to acknowledge that the primary objective is not to achieve statistical generalization to the broader population. Instead, the in-depth, semi-structured interviews on a limited sample size facilitated a thorough exploration of participants' subjective perspectives. The interview protocol (see Appendix, Table A1) ensured coverage of all planned topics while the open-ended format allowed participants to guide the discussion towards the areas that they deemed important, resulting in a comprehensive understanding of their personal viewpoints. Data saturation was achieved when multiple interviewees raised similar issues, improving the study's robustness (Sim et al., 2018).

Second, the combination of purposive and snowball sampling may introduce a selection bias by only including farmers that have interactions with external advisors, which may favor more knowledgeable participants. To minimize such bias, findings from interviews with advisors who draw upon their experiences working with a diverse range of farmers during their visits have been included. Additionally, since the Swedish Farmers' Association recommended advisors who then promoted farmers for interviews, there is a potential risk that the association may have pushed their own agenda. However, the Swedish Farmers' Association is predominant in Sweden, with over 80% of Swedish farmers being active members.

Third, this study primarily gathers insights from farmers and advisors, representing the policy's target population. However, involving other key stakeholders, such as inspectors and local and national policymakers, would foster a more inclusive and participatory process that reflects the needs and perspectives of all actors involved in policy implementation (Dabrowski, 2013; Gutiérrez-Briceño et al., 2024; Nilsen et al., 2013). Both in literature and practice, the participation of multiple stakeholders in designing agri-environmental contracts remains insufficient (Gutiérrez-Briceño et al., 2024). Engaging in participatory backcasting to explore alternative solutions (Reidsma et al., 2023) could provide further valuable insights and open new pathways for improvement.

4. Results

The results are structured around the four contract attributes as illustrated in the conceptual framework: supported activity, payment, inspection, and sanction. Each section includes insights into farmers' perceptions of how these attributes affect effective SNP management, gathered from both interviews and existing literature. Additionally, each section presents alternative solutions for improving AECM acceptability, as suggested by respondents, and evaluates the potential impact of the proposed changes under the SP 2023–27.

4.1. Supported activity

4.1.1. Conflict with other regulations

The primary concern highlighted by the interviews arises from the prohibition of supplementary feeding on SNPs with special values (SJVFS 2022:29; Swedish Board of Agriculture, 2022b). This condition also forbids rotational grazing between cultivated land and SNPs with special values. The goal is to prevent the introduction of nutrient supplementation into the soil, which is believed to negatively impact biodiversity (Government of Sweden, 2023). However, scientific literature indicates that the degree of harm resulting from supplementary feeding remains uncertain (Envall and Scharin, 2019), while rotational grazing is not found to compromise biodiversity (Pelve et al., 2020). The following quote from respondent #6 located in the south of Sweden alludes to this issue:

> "One tries to supplement feed as best as possible with concentrate feed … even though it is not allowed … one still does it" (R6-south).

Results from interviews and previous analyses (Eksvärd and Marquardt, 2018) show that the prohibition on supplementary feeding has adverse effects on animals, as there may not be sufficient grazing land available. As a result, animals suffer from a shortage of feed, and in some instances, farmers may violate animal welfare regulations (Commission delegated regulation 2022/126; European Commission, 2021) if they fail to take corrective measures. To protect the animals and maintain the farm's economic viability, some farmers choose to confine the animals to stalls, relocate them to nutrient-rich pastures, or transfer them to SNPs with general values, where supplementary feeding is allowed. In some cases, farmers with SNPs with special values choose not to apply for support because they want to retain the autonomy to feed their animals as they see fit.

> "I try to follow the rules, but not everywhere. Sometimes I know that this will go to hell anyway, and then I do as I please and do not seek support for it" (R3-south).

Farmers desire more flexibility, such as the ability to supplement feed their animals in limited amounts and within a restricted time frame, or the freedom to move their animals between different types of land, including cultivated farmland and SNPs with special values.

> "You would like to be able to mix a little more. It has been documented for almost 100 years that animals have moved between cultivated meadows, forest grazing, and natural grazing on shorelines" (R12-north).

Presently, farmers can request exemptions in exceptional circumstances, such as drought, by notifying the authorities and explaining their farm's situation (SJVFS 2022:28; Swedish Board of Agriculture, 2022a). However, this process is time-consuming and may result in delayed decisions. Additionally, exemptions can only be sought in specific circumstances, and they are not available during normal growth variations that may result in feed shortages at certain times. The current conditions allow for some flexibility in supplementary feeding during two weeks before animal release in the spring and before cessation in the fall, referred to as "transition feeding" (SJVSF 2022:28; Swedish Board of Agriculture, 2022a), but not during the summer and growth season. The SP 2023-27 has introduced no further changes regarding supplementary feeding, and no changes have been undertaken to reduce or prevent conflicts with animal welfare regulations.

> "I am not going to wait to provide feed support to my animals because I am waiting for a permit. I will provide feed support to my animals anyway because I think it is much more important that they get something to eat than for me to get a permit" (R7-south).

4.1.2. Complexity and misunderstandings

Most respondents find the conditions attached to payment to be complex and difficult to understand and implement. Findings from previous studies (Eksvärd and Marquardt, 2018) indicate that farmers often feel constrained by these conditions, which negatively affects their compliance. They perceive the requirements as overly detailed, causing anxiety about whether they are interpreting them correctly and in line with inspectors' expectations.

> "It has mostly been a headache. When you try to read or interpret something, you can sometimes experience that there is a bit of double meaning" (R10-south).

Consequently, the supported activity for maintaining SNPs are often misunderstood by farmers. For instance, the grazing pressure requirement dictates that SNPs with general and special values should be heavily grazed during the growth season (SJVFS 2022:28; Swedish Board of Agriculture, 2022a). The interviews reveal a misunderstanding among farmers that animals should graze continuously throughout the entire grazing season, even when vegetation growth is insufficient. According to the regulation on animal welfare (Djurskyddsförordningen 2019:66; Government Offices, 2020), the number of days that animals must graze (i.e., at least 60 days) is considerably fewer than the entire grazing season.

> "Animals need to graze even if the grazing does not provide as much as the animals need, causing them to lose weight" (R1-south).

Nonetheless, most respondents discussed the boundary conditions for the grazing season requirement and expressed their desire for them to be more locally adapted based on climatic conditions (Buitenhuis et al., 2022; Dabrowski, 2013). Farmers are presently expressing dissatisfaction and frustration with the current schedule within which animals should be on SNPs, desiring an extended grazing season in the south and a shortened season in certain northern areas. While farmers in the southern regions are eager to maximize available feed, starting the grazing season too early in the north presents a significant danger to the animals and results in difficulties to meet the desired outcomes. In consonance with prior research that has highlighted the challenges of policy implementation resulting from regional disparities (Dabrowski, 2013), the current requirement is seen as restrictive and inadequately adapted to local conditions and needs.

> "Those dates, I am very, very irritated about … should I have the animals walk there with basically nothing to eat?" (R12-north).

Additional misunderstandings between authorities and farmers may emerge due to differing interpretations of biodiversity and the requirements for controlling overgrowth of trees and bushes (SJVFS 2022:28; Swedish Board of Agriculture, 2022a). The purpose of the requirement is to preserve endangered species (listed on the Swedish Species Information Centre's red list in the vulnerable, critically endangered, or endangered categories), and to protect species marked in the Species Protection Ordinance (Artskyddsförordning 2007:845; Government Offices, 2020) that are found on SNPs (SJVFS 2022:28; Swedish Board of Agriculture, 2022a). There is a consensus, both in the interviews and in the scientific literature (Jakobsson and Lindborg, 2015; Nitsch, 2009; Waldén and Lindborg, 2018) that overgrowth should be prevented to preserve SNPs, but there are different opinions on how many trees and bushes should be allowed to exist. This raises concerns among farmers regarding the impact on biodiversity, animal welfare, and the cultural value of the landscape as highlighted in Jakobsson and Lindborg (2015). It also generates negative sentiments due to the additional costs associated with the increased workload. The concept of overgrowth and the number of trees and shrubs allowed in SNPs has changed over the years, making it more difficult for farmers to participate in the revival of trees and shrubs, without the resulting plants being labeled as overgrowth.

"We have chosen to manage SNPs ourselves because we want our ecosystems to be healthy and look that way, so there we have made the effort" (R4-south).

In the SP 2023–27, there are no planned changes regarding the boundary dates for the grazing season or new requirements for the management of trees and shrubs. However, there are planned changes aimed at clarifying the supported activity and avoiding any misinterpretation of the requirements through increased support for competence development, knowledge exchange, and information dissemination for SNPs with special values (Government of Sweden, 2023). The development of e-services (Government of Sweden, 2023) will also lead to reduced complexity for farmers, especially in the workload related to the administrative burden through streamlining for support-seeking and handling authorities. The development of e-services will therefore increase accessibility and queries customization. Further, changes in the SP 2023-27 also involve replacing farm-specific with generic management plans for areas with special values (Government of Sweden, 2023). This new approach will be applicable to all areas falling under the same land classification, to provide more accurate compensation payments for the management of different habitats (considering the vast variation in SNPs appearance in Sweden). Instead of farm-specific management plans, SNPs with special values will now adhere to the same requirements as all land within the same land classification. Increased advice on biodiversity can also be expected from the SP 2023–27 (Government of Sweden, 2023).

4.2. Payment

Respondents considered payments essential for covering the costs of SNP management and indicate an increasing dependence on support systems to manage these activities effectively. This aligns with previous research (Eksvärd and Marquardt, 2018; Le Coent et al., 2017; Waldén and Lindborg, 2018), which highlights that insufficient economic incentives may lead farmers to withdraw from payment schemes, potentially resulting in the loss of SNPs and a negative impact on societal environmental goals.

"If we had not received compensation, it would never have happened …"(R11-north).

The SP 2023-27 indicates that governmental agencies have acknowledged the necessity to increase payments for SNP management. Specifically, compensation for SNP management with general and special values has increased from 1300 SEK to 1850 SEK per hectare and from 3250 SEK to 3950 SEK per hectare (10 SEK ≈ 1 euro), respectively (Government of Sweden, 2023). To promote greater equity and foster positive impacts on both fodder supply and the maintenance of biodiversity, the compensation levels for less favored areas have also been raised in selected geographical areas, particularly in the northern parts of Sweden. However, it is important to note that the simultaneous decrease of 500 SEK/ha in direct support undermines the rise in environmental support. Additional support aimed at fortifying biodiversity for meadows, as well as area-based support for the restoration of SNPs and the care and management of Natura 2000 areas, will now be strengthened through national funds (Government of Sweden, 2023).

4.3. Inspection

The interviews have highlighted a significant concern related to inspections. While most interactions between the respondents and inspectors are described positively, farmers still express unease about encountering inspectors who are overly strict or unfair. Respondents fear the excessive power held by inspectors, which creates an imbalance in their relationship. Compared with findings from previous studies (Bergström Nilsson et al., 2020; Nitsch, 2009), improvements regarding inspections have been made over the years. This suggests that these concerns, despite being mostly remnants from the past, still influence farmers' anxieties and overshadow the fact that inspections generally seem to be functioning well.

"I have only positive things to say about my inspections so far, but one is terrified of encountering someone who does not understand what we're doing" (R3-south).

While farmers recognize the need for strict conditions, they seek flexibility that would allow for reaching compromises when inspections are carried out. This need for flexibility often arises from situations where farmers do not want to choose between prioritizing animal welfare or risking sanctions for neglecting SNPs. In such scenarios, farmers would prefer that inspectors exercise flexibility in their assessments and permit compromises without imposing sanctions.

"... that I won't be sanctioned for the weather that has affected if I did something wrong. Then, when there comes an inspection, it should be informative, educational, it should not be punitive" (R11-north).

Farmers also expressed a desire for improved collaboration and communication with inspectors to enhance the management of their lands and to help them comply with the conditions. To achieve this, suggestions have been put forward to facilitate dialogue between farmers and inspectors and allow for farmers to seek advice from them. In Waldén and Lindborg (2018), non-financial support from authorities in form of feedback and advice, as well as support from the local community and society, was also highlighted. However, the current AECM prevent inspectors from providing advice to farmers, which limits competence development.

"The inspections should be advisory, not judgmental" (R12-north).

The scientific literature emphasizes such needs for improved collaboration between authorities and farmers to facilitate mutual learning and joint planning for SNP management (Bergström Nilsson et al., 2020; Jamieson and Hessle, 2021). Long-term collaboration and a shared objective, as pointed out by Waldén and Jakobsson (2017), can reduce the demand for inspections, allowing for the reallocation of resources from inspectors to advisory services.

"It would have been so incredibly nice to go there [SNP] and plan and talk about how to take care of it, without having the thought looming in the back of your mind that it might become an issue later" (R2-south).

The SP 2023-27 does not include any immediate changes in the inspections. Nevertheless, the anticipated implementation of e-services is likely to modify the nature of communication between authorities and farmers.

4.4. Sanction

None of the interviewed farmers personally faced sanctions. Most respondents expressed satisfaction with the system, emphasizing the importance of taking good care of the land to qualify for AECM.

"If you are going to receive money, then you should take care of it [SNP]. So, I think sanctions can be okay" (R7-south).

However, farmers expressed concerns about potential consequences in cases where they have fulfilled their responsibilities but still fail inspections due to circumstances outside of their control, leading to sanctions that may include the repayment of support with interest. Such concerns are aligned with those highlighted in the scientific literature, as in Eksvärd and Marquardt (2018), in which farmers experience a lack of control of their finances. These concerns are compounded by the fact that approved grazing areas can be re-evaluated at any time during the five-year commitment period, potentially resulting in repayment obligations (Eksvärd and Marquardt, 2018). There is also anxiety about completing forms correctly to avoid mistakes that could lead to sanctions, along with concerns about potential conflicts affecting their eligibility for other forms of support (Eksvärd and Marquardt, 2018; Nitsch, 2009). Additionally, conflicts with other regulations can lead to further uncertainty and potential sanctions (Eksvärd and Marquardt, 2018; Jamieson and Hessle, 2021). To minimize this risk, some farmers apply for AECM for only a portion of their available grazing area, resulting in the potential abandonment of SNPs stewardship for the areas not covered by these payment schemes (Bergström Nilsson et al., 2020).

Nonetheless, the interviews underscored the desire for sanctions to promote results within a broader context, rather than rigidly adhering to strict rules. It was acknowledged that external factors beyond the control of farmers could significantly impact outcomes if strict compliance to rules were mandated, potentially leading to negative consequences. Therefore, allowing for flexibility to favor long-term outcomes was deemed preferable by the farmers.

The SP 2023-27 does not include any direct changes in the sanction system. However, as concerns from farmers mainly pertain to the proper implementation of the stipulated practices, the increased support for competence development, knowledge exchange, and dissemination of information for the management of SNPs with special values (Government of Sweden, 2023) is intended to alleviate such anxieties. Moreover, the development of e-services is promoted to improve clarity and transparency in administrative procedures.

5. Discussion and conclusions

Improving farm-level acceptability of agri-environmental contracts through effective policy design depends on a clear understanding of where adjustments are needed and the best strategies for addressing these challenges (Bali et al., 2019; Hysing and Lidskog, 2018; Mack et al., 2024). By analyzing key contract attributes, supported activity, payment, inspection, and sanction (Guerrero, 2021; Koop and Lodge, 2017; Yang et al., 2021), this study provides insights into farmers' perceptions of how these attributes affect effective AECM implementation for SNP management, alternative solutions, and the potential of the SP 2023–27. As such, the findings of this study have implications for policy effectiveness, particularly in evaluating the appropriateness of AECM as a policy instrument and the capacity of governmental agencies to implement them effectively (Bali et al., 2019), contributing to governance debates linked to contractual design regarding AECM acceptability (D'Alberto et al., 2024).

The supported activity defines the practices that farmers must implement under contractual agreements to qualify for AECM payments and thereby contribute to achieving the policy goals (Guerrero, 2021). However, as noted in previous literature, our results highlight that achieving intended outcomes with public policies is challenging, emphasizing the importance of designing policies that align with farmers' practices and local conditions (Berman, 1978; Matland, 1995; Buitenhuis et al., 2022; Nilsen et al., 2013; Dabrowski, 2013). Respondents highlight that policies are often incompatible with their views on how farming practices meet policy goals, citing issues such as misunderstandings related to biodiversity, regional differences, and conflicts with animal welfare regulations, particularly concerning requirements for managing the overgrowth of bushes and trees, regional grazing mandates, and the prohibition of supplementary feeding. Improving the acceptability of AECM for SNP management requires a reassessment of both targeting, to ensure alignment with local conditions and environmental objectives (Herzon et al., 2018), and compatibility at the farm level (D'Alberto et al., 2024). Respondents indicated that introducing greater flexibility through contract adjustment clauses, i.e., provisions that allow modifications in response to changing contexts and unforeseen circumstances (Guerrero, 2021), can address these needs. This approach supports adapting contract solutions to different situational challenges and conditions (Peerlings and Polman, 2009; Waylen and Martin-Ortega, 2018), rather than enforcing rigid conditions, which may prove ineffective or even counterproductive (Kingston et al., 2021).

Profitability and payment flexibility are additional factors that need to be reconsidered for AECM targeting SNP management (D'Alberto et al., 2024). The results underscore the critical role of payments in ensuring the successful management of SNPs, highlighting farmers' reliance on these financial incentives (Le Coent et al., 2017). Respondents expressed concerns that over the years, they have become increasingly dependent on financial support, raising the risk that payments may not keep pace with rising costs and thus affect profitability (D'Alberto et al., 2024). This issue is particularly significant in light of the reduction in direct support in the Strategic Plan 2023–27 (Government of Sweden, 2023). Lack of sufficient economic incentives for farmers' environmental efforts increases the risk that they may choose to opt out of the support system and that society subsequently will lose SNPs (Waldén and Lindborg, 2018). Additionally, farmers expressed a preference to be compensated based on outcomes and favored rewards over sanctions (D'Alberto et al., 2024). This sentiment highlights the need for a more advanced and innovative contractual approach, that connects payments directly to the measurable environmental benefits achieved, rather than to specific management practices (Matzdorf et al., 2008). Result-based incentives are expected to support positive reinforcement towards the stewardship of natural resources (Hamman et al., 2021), while improving targeting and cost-effectiveness (Bartkowski et al., 2021; Wuepper and Huber, 2022). Moreover, result-based incentives will provide farmers with greater flexibility in implementing practices and making management decisions (Herzon et al., 2018; Peerlings and Polman, 2009), potentially reducing long-term commitment costs (D'Alberto et al., 2024) and attract farmers who favor targeted and adaptable conservation programs (Schulze and Matzdorf, 2023; Shipley et al., 2024).

In the current action-based AECM, although respondents were generally satisfied with the inspections they had experienced so far, they feared encountering unfavorable inspectors in the future. They noted a power imbalance from inspectors' subjective assessments and expressed concerns about potential sanctions, despite understanding the need for compliance to receive compensation. However, results indicate a distinct contradiction between farmers' desire for flexibility and their aversion to subjective assessments. The key to the proposed solution is striking an optimal balance between flexibility required to achieve environmental objectives and the need for a sufficient level of certainty and enforcement to ensure compliance (Benson and Garmestani, 2011). Our results might be held to indicate that the current AECM have failed to strike such balance by granting too much weight to rigid monitoring and enforcement without the necessary counterweight of flexibility in implementation (Peerlings and Polman, 2009). Consequently, subjectivity and flexibility are both found to be linked to the power of inspectors themselves. As flexibility increases, the inspector gains more authority to make subjective judgments, potentially leading to heightened anxiety among farmers who fear encountering an overly strict or unjust inspector. The requested flexibility and trust in assessments regarding monitoring highlight the need to enhance feasibility, driven by support for implementation and improved capacities within governmental agencies (Bali et al., 2019). This is particularly crucial, as respondents emphasized the importance of increased communication during inspections to foster a more collaborative and transparent process. As indicated by the respondents and supported by the reviewed literature, the opportunity for open discussions, receiving advice, and explaining the relevance of restrictions can improve policy acceptability (Bergström Nilsson et al., 2020; Jamieson and Hessle, 2021; Mack et al., 2024; Waldén and Jakobsson, 2017).

In that respect, the development of e-services on the SP 2023–2027 is expected to transform the nature of communication between farmers and authorities, allowing for more customized queries and potentially reducing administrative delays. This may also facilitate more rapid and frequent requests for customized exemptions. However, a recent study examining farmers' perceptions of the effects of changes in e-services points to higher administrative workload for farmers, which already suggests counterproductive modifications (Mack et al., 2024). Our research strengthens the argument that transparent processes and two ways communication have the potential to transform inspections into learning opportunities for both parties, resulting in improved land management and a reduced risk of future sanctions (Mack et al., 2024). Results are also in line with the literature emphasizing farmers potential to be a vital resource, whose intrinsic pro-environmental motivations can be strengthened through the thoughtful design of contractual features. This involves their participation such as co-design, (Canessa et al., 2024; Gutiérrez-Briceño et al., 2024), in fostering a supportive culture with clear, consistent, sensible, and easily understandable rules (Kingston et al., 2021).

CRediT authorship contribution statement

Harold Opdenbosch: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Mark V. Brady:** Writing – review & editing, Validation, Supervision. **Ivan Bimbilovski:** Writing – review & editing, Validation, Supervision. **Rebecca Swärd:** Formal analysis, Data curation, Conceptualization. **Gordana Manevska-Tasevska:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

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

Data availability

The data that has been used is confidential.

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Appendix A. Supplementary data

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This thesis investigates institutional and behavioural drivers that shape farmers' adoption of environmentally sustainable production practices. Paper I examines farmers' trade-offs between co-benefits of climate change mitigation measures. Paper II elicit farmers' willingness to adopt silvopastoral systems. Paper III explores the role of advisors in supporting the upscaling of carbon farming practices. Paper IV investigates how farmers perceive the conditions of participation in the contractual measure for the management of semi-natural pastures.

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