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Beyond carbon sequestration: Swedish farmers' preferences and trade-offs between co-benefits of climate change mitigation measures

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ABSTRACT

The mitigation of greenhouse gas emissions is a central policy concern in agriculture, reflected through voluntary contractual measures in the Common Agricultural Policy. The literature suggests that farmers' motivation for participating in mitigation measures does not necessarily originate in climate consciousness nor a sense of responsibility for mitigation, but rather in the co-benefits that they can bring. This paper investigates farmers' preferences for climate-related and non-climate co-benefits of mitigation measures, specifically carbon sequestration, biodiversity and soil health, using the cover cropping eco-scheme as a case study. We elicit trade-offs between monetary and non-monetary utility values associated with the co-benefits, alongside farmers' attitudes and identities, using a survey among Swedish farmers ($n = 179$). Results reveal two distinct classes: class 1 reflects "responsive farmers" due to their greater sensitivity to the non-monetary attributes in the utility function and their positive and significant attitudes towards cover cropping, while class 2 refers to "conventional farmers", with a stronger preference for the status quo and monetary utility values. Responsive farmers are prepared to incur costs, such as accepting reductions in subsidy payments, to support agri-environmental and climate outcomes. Soil health emerges as the most preferred co-benefit, likely due to its more immediate and tangible private returns, including improved yields, compared with the broader public goods associated with biodiversity and carbon sequestration. Farmers' underlying attitudes towards the cover cropping eco-scheme, alongside farmers' age, are the main source of unobserved heterogeneity in preferences and trade-offs.

1. Introduction

Successive reforms of the EU's Common Agricultural Policy (CAP) have progressively included more climate objectives, becoming a central focus since 2014. Although significant funding was allocated to climate change mitigation (henceforth, mitigation) between 2014 and 2020, specific targets for reducing agricultural emissions were not clearly set at either the EU or national level. Consequently, the CAP was criticized for making limited progress in reducing emissions from agriculture (European Court of Auditors, 2021). As a response, the CAP reform 2023–2027 requires Member States to prioritize climate needs in their Strategic Plans and offers a range of instruments to support more widespread and effective mitigation efforts using EU and national funds and specific measures from both Pillar 1 (i.e. eco-schemes) and Pillar 2 (i.e. agri-environment-climate measures) (McDonald et al., 2021). For example, Sweden (the empirical focus of this study) has introduced in its Strategic Plan an eco-scheme which compensates farmers for the implementation of cover crops on their farm, which is aimed at mitigating climate change through increased carbon sequestration in agriculture (European Commission, 2022). Such measures incentivize farmers to voluntarily go beyond legal requirements or traditional practices to support the provision of public goods that might otherwise be neglected (Bazzan et al., 2023; Martin and Hine, 2018; Opdenbosch et al., 2024). Hence, policy success and effectiveness heavily depend on farmers' voluntary participation (Persson and Alpízar, 2013) and the measures' practical relevance and how well measures align with farmers' values, experiences, and needs are often the first aspects considered by farmers (Canessa et al., 2024; Pannell et al., 2006; Whitten et al., 2013).

Climate considerations are not always central to farmers' decision-making regarding mitigation practices (Davidson et al., 2019; Farstad

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et al., 2022). Instead, a growing body of literature underscores the importance of non-climate co-benefits as key motivators in farmers' decision-making (Buck and Palumbo-Compton, 2022; Mattila et al., 2022; McGuire et al., 2022; Moerkerken et al., 2020; Shanmuga Surya et al., 2023), as well as in shaping broader climate policy (Bain et al., 2016; Karlsson et al., 2020). Co-benefits refer to how a single policy measure can positively impact multiple objectives (Pisoni et al., 2023; Shindell et al., 2017) and encompass various advantages across the environmental, social, and economic dimensions of sustainability (McGuire et al., 2022). They often overlap, as the benefits for farmers are also benefits for society and nature, and vice versa (Gutiérrez-Briceño et al., 2024). Hence, co-benefits influence how farmers perceive policy objectives (Dessart et al., 2019) and can play a critical role in shaping both the acceptability of such policies and farmers' understanding of the advantages of participating in them (Dessart et al., 2019). However, farmers' preferences for co-benefits and how they trade-off between them are not well understood, but a better understanding would help efficient policy design.

In this paper, we investigate farmers' preferences for climate-related and non-climate co-benefits of mitigation measures, specifically carbon sequestration, biodiversity and soil health, using the cover cropping eco-scheme as a case study. We focus on eliciting trade-offs between monetary and non-monetary utility values associated with these co-benefits, alongside farmers' attitudes and identities. We conduct a survey among Swedish farmers ($n = 179$) and apply an identity-augmented utility framework and hybrid Latent Class Models (LCM) to explain unobserved heterogeneity derived from the underlying farmer attitudes and environmental, social, and economic identities. Attitudes towards a behaviour refer to an individual's overall evaluation of its desirability, which may influence their decisions (Fishbein and Ajzen, 2011), while environmental, social, and economic identities refer to the extent to which a farmer feels connected to sustainability concerns and impacts their utility maximization (Oyinbo and Hansson, 2024).

This paper makes three-fold contributions to the growing literature on the role of co-benefits from mitigation practices in farmers' decision-making (Buck and Palumbo-Compton, 2022; Mattila et al., 2022; McGuire et al., 2022; Moerkerken et al., 2020; Shanmuga Surya et al., 2023). Firstly, non-monetary benefits are less commonly addressed in empirical studies, despite their potential to increase participation in voluntary contractual measures (Canessa et al., 2024; Dessart et al., 2019). There is a need to express trade-offs between the effects on different ecosystem services through economic valuation that help navigate them and are relevant for policy making (Bartkowski et al., 2020). Hence, we provide novel empirical estimates in farmers' preferences for different agri-environmental and climate outcomes by measuring the extent to which farmers are willing to forgo subsidy payments for their improvements. To date, only one study (Kragt et al., 2016) has empirically examined values for these co-benefits, but only through public preferences. Secondly, understanding the behavioural factors that shape farmers' intentions to participate in voluntary contractual measures is essential for promoting sustainability in agriculture (Baaken et al., 2025; Dessart et al., 2019; Schaub et al., 2023). Accordingly, the study adds to the emerging body of research that complements neoclassical economic models with behavioural insights to better understand farmers' decisions (Barreiro-Hurle and Rommel, 2026; Howley and Ocean, 2021; Owusu-Sekyere et al., 2022, 2024; Oyinbo and Hansson, 2024). In this study, we consider attitudes and environmental, social and economic identities using the identity-augmented utility framework established by Oyinbo and Hansson (2024) to capture monetary and non-monetary values in utility. Thirdly, the study builds on broader research that has examined policy objectives and their compatibility with (i) farmers' awareness of environmental issues (Dessart et al., 2019), (ii) farming objectives and socio-economic factors (Lastra-Bravo et al., 2015; Leonhardt et al., 2022), and (iii) production systems (Persson and Alpízar, 2013; Whitten et al., 2013). Overall, we move beyond existing literature by examining the compatibility of mitigation objectives through farmers' trade-offs between co-benefits, as shaped by their socio-demographics, attitudes, and environmental, social and economic identities.

2. Conceptual framework

Recent literature suggests that profit maximization is not the sole motivation in farmers' decision-making (Howley, 2015; Opdenbosch and Hansson, 2023), with observed choices revealing non-monetary utilities in addition to pecuniary ones (Leduc et al., 2023; Musshoff et al., 2013; O'donoghue and Howley, 2012; Schaub et al., 2023; Zemo and Termansen, 2022). In consequence, integrated choice models have been introduced to complement neoclassical economic frameworks with behavioural insights by combining choice and latent variable models (Owusu-Sekyere et al., 2022, 2024; Oyinbo and Hansson, 2024). Hence, this study not only draws on random utility theory (McFadden, 1972) to explain farmers' preferences and trade-offs, but applies the identity-augmented utility framework established by Oyinbo and Hansson (2024) (Fig. 1) to establish the impact of environmental, social, and economic identities, defined as the extent to which a farmer feels connected to environmental, social, and economic sustainability concerns. This framework, rooted in identity economics theory (Akerlof and Kranton, 2000), integrates identity as a latent variable to explain decision-making, particularly in settings where choices involve trade-offs between costs and benefits. Beyond identity, attitudes towards a behaviour i.e., an individual's overall evaluation of its desirability can influence their decisions and is therefore included in the framework (Fishbein and Ajzen, 2011; Mariel and Arata, 2022).

The latent variable component in Fig. 1 captures two behavioural constructs. The first behavioural construct capture the farmer's identity, based on Stryker's identity theory (Stryker, 1968), which represents an individual's sense of self, self-concept, or self-image (Howley and Ocean, 2021). It assumes that individuals gain or lose utility by taking actions that align with, or deviate from, the norms and ideals tied to their identity. It also assumes that individuals possess multiple, non-mutually exclusive identities, resulting in different clusters, each with distinct norms and ideals (Oyinbo and Hansson, 2024). As a result, the utility gained from actions varies across these clusters, with differences explained by identity distinctions along the three dimensions of sustainability. For instance, environmental identity clusters are formed based on farmers' attachment to the environmental benefits of cover crops, allowing farmers to be grouped according to their level of pro-environmental disposition. The second behavioural construct consider farmers' attitudes (positive or negative) towards the implementation of cover crops. This depends on farmer subjective beliefs regarding the value of participating in the eco-scheme in terms of improving environmental, social, and/or economic sustainability impacts (Fishbein and Ajzen, 2011). Furthermore, while identity and attitude constructs are conceptually different, they are related in the sense that an individual's attitudes formation process is partially shaped by their identity, and the latter is partially expressed through their attitudes (Cullen et al., 2020; Hallajow, 2018).

To bridge the conceptual framework with the methodological approach adopted in this study, indicators were used to measure latent variables capturing environmental, economic, and social identities, as well as attitudes towards cover cropping, since these variables cannot be directly observed without measurement error. The identity and attitude constructs are operationalised using multiple measurement items, which enter the model as scores on the indicators of the corresponding latent variables. Environmental, economic, and social identity were measured using the scale proposed by Oyinbo and Hansson (2024), with each sustainability dimension represented by three five-point bipolar items (see Appendix Table A1). Attitudes towards cover cropping were measured using a well-established scale grounded in the Theory of Planned Behaviour (Fishbein and Ajzen, 2011) based on four five-point bipolar items (see Appendix Table A2). Descriptive statistics (Appendix

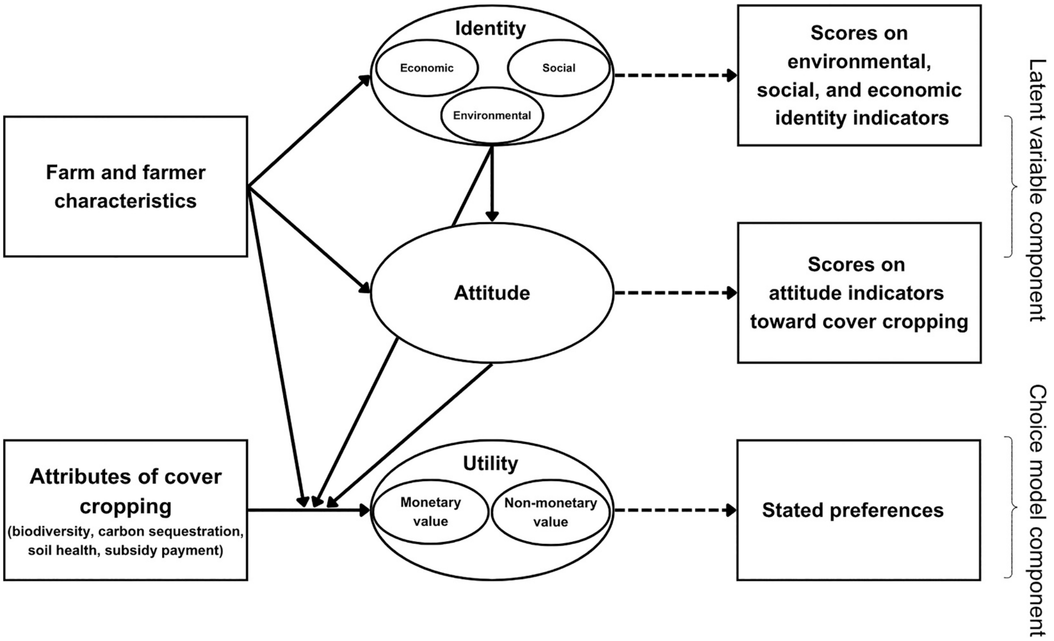


Fig. 1. Conceptual framework showing the links between identities, attitudes and preferences for cover cropping. Adapted from Oyinbo and Hansson (2024). Notes: Oval and rectangular shapes represent the latent variables and their indicators, respectively. The solid and dashed arrows represent structural and measurement relationships, respectively.

Table A3) and correlations among the measurement indicators for identities and attitude variables (Appendix Table A4) are reported in the Appendix.

The choice model component incorporates farm and farmer characteristics, attitude and identity constructs, and attributes of the cover cropping eco-scheme, including co-benefits such as carbon sequestration, biodiversity, and soil health improvement. The overall utility is derived from the sum of monetary and non-monetary values associated with cover cropping (Owusu-Sekyere et al., 2022, 2024; Oyinbo and Hansson, 2024). As such, the motivation to participate in the eco-scheme depends on farmers' expected utility, which may value pecuniary, agri-environmental or climate outcomes, or a combination thereof.

3. Methods and materials

3.1. Sampling and data

Our sampling frame was drawn from a register of 4000 farms listed on Sweden's official agricultural register, administered by Statistics Sweden (SCB). After excluding farms without usable contact details, institutional farms, and farms without arable land, the sampling frame comprised 2362 farms across the 21 counties of Sweden.

Data were collected through an online survey conducted in January 2025 and active for 3 weeks. 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 and Navrud, 2011). Farmers were invited to participate in the survey through emails stating the aims of the survey and providing a link to the questionnaire. The survey consisted of three components: a discrete choice experiment (DCE) to capture farmers' preferences and trade-offs between co-benefits, farm and farmer characteristics, and attitudes and identity indicators.

After two email reminders, 338 farmers (14.3%) clicked the survey link. Among them, 293 gave consent to participate, while 38 explicitly declined, and 7 did not indicate either consent or non-consent. Of those who consented, 95 did not start the survey, leaving 198 participants (8.4%) who began the survey. Nineteen farmers did not complete the survey, resulting in 179 fully completed surveys (7.6% response rate).

The descriptive statistics (Table 1), show a strong similarity between the sample and the population of Swedish farmers, as reported by the Swedish Board of Agriculture (2024). The average age in the sample is 57 years, closely matching national data, where 67.6% of Swedish farmers are aged 50 or older. Gender distribution is also very similar, with 83% of the sample identifying as men compared to 80% in the population. Shares of production types (45.25% for crops and 32.4% for animal production) highlight the balanced distribution of farms in the population. The share of certified organic farms in the sample is 15.2%, which is slightly lower than the national figure of 18% reported in 2023.

Table 1
Descriptive statistics of farm and farmer characteristics.

Variable	Description	Mean	SD	Percent
Age	Age of farmer (years)	57.39	12.23	
Gender	Gender of the producer (dummy variable):	0.83	0.375	
	Female			16.95
	Male			83.05
Education	Education level of the producer (ordinal variable):	3.24	1.30	
	Primary school			8.67
	High school			25.43
	Agricultural high school			22.54
	University			19.65
	Agricultural university			23.7
Production	Type of production (categorical variable):	2.02	0.95	
	Crop production			45.25
	Animal production			32.4
	Mixed			19.55
Organic certification	Certification (categorical variable):	1.35	0.70	
	Conventional system			76.02
	Certified organic			15.2
	Mixed			6.43
	Transitioning to organic			2.34
Size	Total land area (hectares)	186.09	605.72	

Farm sizes in the sample are larger, with an average of 186 ha (188 for crops, 136 for animals), compared to the national average of 147 ha, where 91% of arable land is on farms with over 100 ha.

3.2. Discrete choice experiment design

We elicited farmers' trade-offs between co-benefits in the cover cropping eco-scheme using a DCE. In the DCE design process, we identified several co-benefits associated with the practice of cover cropping, based on a detailed review of the literature (Table 2). To minimise design complexity, we focused on three agri-environmental and climate co-benefit attributes, biodiversity, carbon sequestration, and soil health, each directly aligned with one of the CAP's key policy objectives: enhancing biodiversity, tackling climate change, and protecting natural resources, respectively (Government of Sweden, 2023). Additionally, a monetary attribute, i.e., a subsidy payment, was included in the DCE to capture farmers' willingness-to-accept (WTA) estimates, i.e. trade-offs. Variations in some co-benefits, as demonstrated by the levels, from no to high improvement, are explained by context dependant conditions such as soil and climatic conditions (Acharya et al., 2022; Huys et al., 2022), cropping systems (Tautges et al., 2019), management history (Bai et al., 2019; Liang et al., 2022), and cover crop species type or component species in mixtures (Thapa et al., 2021). Due to monitoring challenges and valuation difficulties, we intentionally defined the levels to allow for farmers' personal interpretation. The final attributes, their descriptions, and levels are provided in Table 2.

The design was generated using Ngene, resulting in 18 paired choice sets randomly distributed in groups of six to the farmers. Due to the limited sample size, an orthogonal design was used, as we could not do extensive piloting for obtaining reasonably precise priors. Each choice set had two unlabelled hypothetical alternatives of cover cropping systems with differing levels of improvements as argued from context and system dependency (alternatives A and B) and an opt-out option (alternative C) (Fig. 2). An opt-out option reflecting non-adoption was included to represent real-world participation choices in the voluntary eco-scheme, where farmers can choose not to participate if it offers greater utility than the proposed options (Hensher et al., 2015). Before respondents made their choices, they were provided with a brief explanation of the different attributes and levels of alternatives A and B. We instructed them to evaluate hypothetical alternatives carefully and select the option they would most likely adopt on their farm, with no right or wrong answers. We also used an opt-out reminder to reduce the risk of hypothetical bias.

3.3. Econometric modelling

Based on Lancaster (1966) and random utility theory (McFadden, 1972), the respondents were assumed to make the choice that maximises their utility. Following the identity-augmented utility framework applied in previous studies (e.g. Owusu-Sekyere et al., 2022, 2024; Oyinbo and Hansson, 2024; Zemo and Termansen, 2022), we further assume that the overall utility from participation is derived from the sum of the monetary and non-monetary utilities associated with cover cropping.

The overall utility U_{ijs} of farmer i associated with the alternative j from a choice set s is determined by a deterministic component V_{ijs} and an error term ε_{ijs} which is assumed to be independent and identically distributed (i.i.d.), which can be described as:

$$\begin{aligned} U_{ijs} &= V_{ijs} + \varepsilon_{ijs} \\ &= ASC + \sum_{k=1}^{K} \beta_{ik} x_{ijks} + \varepsilon_{ijs}, i = 1, \dots, I; j = 1, \dots, J; s = 1, \dots, S. \end{aligned} \tag{1}$$

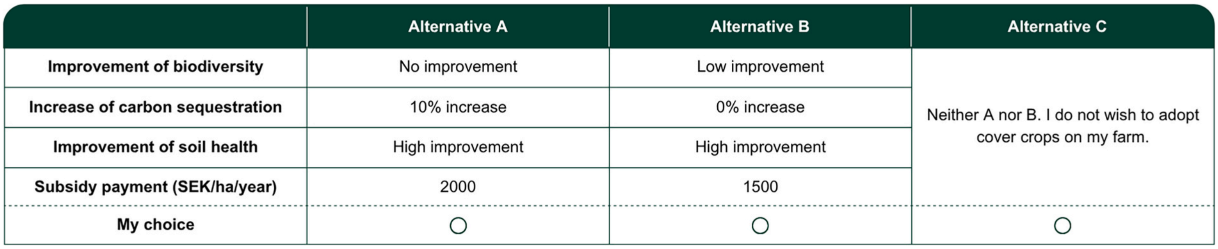
Where ASC is an alternative-specific constant representing preferences for the status-quo, which takes a value of one for the status-quo alternative and zero for the hypothetical participation. x_{ijks} denotes attribute k in alternative j of choice set s faced by farmer i. $\beta_{ik}$is the marginal utility associated with attribute k for farmer i.

We first estimated a mixed logit model (MXL) to examine farmers' preferences and trade-offs between utilities by allowing utility parameters in Eq. (1) to vary randomly across individuals (Table 3) (Hensher et al., 2015). Although MXL captures random taste heterogeneity, it does not explicitly explain the underlying unobserved sources of this heterogeneity. Accordingly, models that jointly represent individual choices, observed characteristics, and latent behavioural factors are more appealing theoretically. In this context, LCM capture discrete unobserved preference heterogeneity by segmenting individuals into classes that differ in their utility parameters and may reflect underlying behavioural differences (Hess, 2012). In addition, LCM relax the Independence of Irrelevant Alternatives assumption of the multinomial logit model (McFadden, 1972).

However, directly incorporating latent behavioural factors into choice models is challenging. Although our survey elicited indicators of farmer identities and attitudes, their direct inclusion in the utility specification could raise some concerns related to measurement error and endogeneity bias (Oyinbo and Hansson, 2024). Measurement errors may arise because the indicators are functions of underlying latent variables and not the variables themselves. Endogeneity may also arise if

Table 2
Attributes, descriptions, and levels.

Attribute	Description	Levels	References
Biodiversity	Cover crops support native plant and wildlife species, attract beneficial insects, and provide habitat for pollinators. They boost below-ground biological activity, outcompete weeds to reduce herbicide use, and disrupt pest cycles, leading to fewer infestations.	No improvement, low improvement, high improvement.	(Bradshaw et al., 2013; Desjardins et al., 2005; George et al., 2012; Lal, 2004; Perring et al., 2012; Thapa et al., 2021)
Carbon sequestration	Cover crops help mitigate climate change by capturing carbon dioxide through photosynthesis and storing it in the soil. Their deep root systems enhance carbon sequestration by adding biomass belowground, improving soil structure, and preventing carbon release. This process supports long-term carbon storage and helps reduce greenhouse gas emissions.	0%, 10%, 20% increase	(Ding et al., 2006; Frasier et al., 2016; Kaye and Quemada, 2017; Kragt et al., 2016; Lal, 2016; McGuire et al., 2022; Rosolem et al., 2016; Thapa et al., 2021; Zhou et al., 2012)
Soil health	Cover crops improve soil health by enhancing its structure, increasing organic matter, and promoting beneficial microbial activity. They prevent soil erosion, improve water retention, and reduce evaporation, helping to conserve moisture. Cover crops also enhance nutrient cycling, fix nitrogen, and reduce the need for chemical fertilizers. Overall, they contribute to long-term soil fertility and increased agricultural productivity.	No improvement, low improvement, high improvement.	(Blanco-Canqui et al., 2015; Frasier et al., 2016; Gutiérrez-Briceño et al., 2024; Hubbard et al., 2013; Lal, 2016; O'Reilly et al., 2012; Paye et al., 2022; Thapa et al., 2021; Wick et al., 2017)
Subsidy payment	Compensation level within the eco-scheme for covering costs incurred by implementing cover crops.	0, 500, 1000, 1500, 2000, 2500 (SEK/ha/year)	(Swedish Board of Agriculture, 2024)



	Alternative A	Alternative B	Alternative C
Improvement of biodiversity	No improvement	Low improvement	Neither A nor B. I do not wish to adopt cover crops on my farm.
Increase of carbon sequestration	10% increase	0% increase	
Improvement of soil health	High improvement	High improvement	
Subsidy payment (SEK/ha/year)	2000	1500	
My choice	○	○	○

Fig. 2. Example of a choice set shown to respondents.

Table 3

Results of the mixed logit model including marginal utilities and trade-offs.

Attributes	Marginal utilities		Trade-offs
	Mean (standard error)	Std. Dev. (standard error)	Mean in SEK/ha/year (lower and upper bound of 95% CI)
ASC	2.421***		−1722.7
	(0.362)		(−2158.2, −1373.1)
Biodiversity: low improvement	0.507**	1.333***	−360.8
	(0.201)	(0.404)	(−664, −82.7)
Biodiversity: high improvement	0.606***	1.747***	−430.9
	(0.213)	(0.469)	(−792.7, −144.6)
Carbon sequestration: 10% increase	0.516**	1.656***	−366.9
	(0.238)	(0.437)	(−727.9, −40.3)
Carbon sequestration: 20% increase	0.600**	2.924***	−427.1
	(0.277)	(0.506)	(−858, −41)
Soil health: low improvement	0.239	1.871***	−170
	(0.217)	(0.325)	(−495.3, 121.3)
Soil health: high improvement	1.039***	3.419***	−739
	(0.305)	(0.641)	(−1231.5, −294.3)
Subsidy payment	0.001***		
	(0.0002)		
N	179		
N_{obs}	3222		
Log likelihood	−940.515		
AIC	1909.03		
BIC	1994.118		

Note: Significance * $p < .1$, ** $p < .05$, *** $p < .01$. The MXL model uses 1500 Halton draws for the full sample. We use the Krinsky Robb (parametric bootstrap) method to construct the confidence intervals for the trade-offs with 2000 number of repetitions.

unobserved behavioural factors influencing choice behaviour are correlated with responses to the indicators, implying correlation between the deterministic and random components of utility.

Accordingly, in line with a growing body of empirical applications (Owusu-Sekyere et al., 2022, 2024; Oyinbo and Hansson, 2024; Sok et al., 2018; Zemo and Termansen, 2022), we estimated a hybrid LCM that incorporates a latent variable model to a choice model (Fig. 1). This hybrid model addresses potential measurement errors and endogeneity bias and allows a better behavioural representation of unobserved heterogeneity. 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 LCM.

The MIMIC model produces scores for the latent 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 variables (attitudes and environmental, social and economic identity) and their indicators. The scores of the attitudes and identity indicators are expressed as the effects of the scores on their corresponding latent variables:

$$y_{ikl} = \vartheta_{kl}\delta_{ikl} + e_{ikl}, i = 1, \dots, I; k = 1, \dots, K; l = 1, \dots, L. \quad (2)$$

y_{ikl} is the score for farmer i for the kth reflective indicator of the latent variable δ_l. ϑ_{kl} denotes the factor loadings capturing the effect of δ_l on y_{kl}. e_{ikl} denotes the measurement error associated with a given score and is assumed to be i.i.d and uncorrelated across indicators.

The structural model tests the effects of farm and farmer characteristics on latent attitude and identity variables.

$$\delta_{il} = \sum_{n=1}^{N} \varphi_{ln} z_{in} + \epsilon_{il}, i = 1, \dots, I; n = 1, \dots, N; l = 1, \dots, L. \quad (3)$$

here, φ_{ln} is a parameter capturing the effects of the nth farm and farmer characteristic z_n on latent variable δ_l. The error term ϵ_{il} is assumed to be normally i.i.d. and allowed to correlate freely across latent variables.

LCM 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). Building on Eq. (1), the probability of farmer i choosing the alternative j from a choice set s is conditional on their membership in latent class c. With S choice sets, the probability of the farmer's sequence of feed choices can be expressed in terms of a logistic distribution:

$$P_{ijs}|c = \prod_{s=1}^{S} \frac{exp(\boldsymbol{\beta}_c \boldsymbol{x}_{ijs})}{\sum_{j}^{J} exp(\boldsymbol{\beta}_c \boldsymbol{x}_{ijs})} \quad (4)$$

where β_c is a vector of class-specific marginal utilities. Given that class membership is probabilistic, we model the probability that farmer i belongs to latent class c using a multinomial logit specification (latent class membership function) as follows:

$$\pi_c = \frac{exp(\gamma_{0c} + \gamma_{1c}\delta_i + \gamma_{2c}z_i)}{\sum_{c=1}^{C} exp(\gamma_{0c} + \gamma_{1c}\delta_i + \gamma_{2c}z_i)} \quad (5)$$

where δ_i is a vector of the latent variables of farmer i with associated parameters γ_{1c}. z_i is a vector of observable farm and farmer characteristics of farmer i with associated parameters γ_{2c}. γ_{0c} are class-specific intercepts. Based on Eq. (5) and the latent variable of δ_i, we estimated different model specifications. First, we estimated a standard LCM without considering identity or attitudes. Based on the assumption that feed choices reflect underlying identities linked to attitudes, the first hybrid model included only the latent attitude variable. The second hybrid model tested how differences in farmer identities (environmental, social and economic) relate to utility from cover crop alternatives, excluding attitudes. Finally, the third hybrid model included both latent identity and attitude variables to assess whether identity effects are partially reflected through attitudes. The joint (unconditional) probability of farmer *i* making a sequence of choices over *C* latent classes is the product of Eq. (4) and Eq. (5), namely the sum of the conditional probabilities over the classes weighted by the probability of belonging to each class.

$$P_i = \sum_{c=1}^{C} \pi_c \cdot \left[P_{ijs} \middle| c\right] = \sum_{c=1}^{C} \left[\frac{exp(\gamma_{0c} + \boldsymbol{\gamma}_{1c}\boldsymbol{\delta}_i + \boldsymbol{\gamma}_{2c}\boldsymbol{z}_i)}{\sum_{c=1}^{C} exp(\gamma_{0c} + \boldsymbol{\gamma}_{1c}\boldsymbol{\delta}_i + \boldsymbol{\gamma}_{2c}\boldsymbol{z}_i)} \right] \left[\prod_{s=1}^{S} \frac{exp(\boldsymbol{\beta}_c \boldsymbol{x}_{ijs})}{\sum_{j}^{J} exp(\boldsymbol{\beta}_c \boldsymbol{x}_{ijs})} \right] \tag{6}$$

The log-likelihood for the sample of *I* farmers is defined as follows:

$$LL = \sum_{i=1}^{I} \ln P_i = \sum_{i=1}^{I} \ln \sum_{c=1}^{C} \left[\frac{exp(\gamma_{0c} + \boldsymbol{\gamma}_{1c}\boldsymbol{\delta}_i + \boldsymbol{\gamma}_{2c}\boldsymbol{z}_i)}{\sum_{c=1}^{C} exp(\gamma_{0c} + \boldsymbol{\gamma}_{1c}\boldsymbol{\delta}_i + \boldsymbol{\gamma}_{2c}\boldsymbol{z}_i)} \right] \left[\prod_{s=1}^{S} \frac{exp(\boldsymbol{\beta}_c \boldsymbol{x}_{ijs})}{\sum_{j}^{J} exp(\boldsymbol{\beta}_c \boldsymbol{x}_{ijs})} \right] \tag{7}$$

The selection of the optimal number of classes was performed based on the Log-Likelihood (LL), Akaike information criterion (AIC), Bayesian information criterion (BIC) and Constant Akaike information criterion (CAIC) (Boxall and Adamowicz, 2002). We can calculate sample level WTA as the weighted sum across classes where the weights are the unconditional class probabilities (Eq. (5)). The negative value reflects a reduction in the subsidy payment.

$$WTA = -\sum_{c=1}^{C} \pi_c \frac{\beta_{c,intrinsic\ k}}{\beta_{c,extrinsic\ k}} \tag{8}$$

4. Results

4.1. Descriptive results

Results highlight a relatively even distribution of choices across the alternatives in all choice sets, with 36.4% for alternative A, 31.3% for alternative B, and 32.3% for the status quo (alternative C), i.e. not to participate in the cover cropping eco-scheme (See Appendix Table A5). The number opt-out choices per respondent (mean = 1.81; sd = 2.37) is highly skewed. In total, 49.2% of respondents ($n = 88$) chose to opt-out at least once while 18.4% of respondents ($n = 33$) consistently chose to opt-out. Respondents who opted out in all choice sets were asked, in an open-ended question, to explain their decision. Their choices clustered into four main categories. First, other production priorities or incompatibility with current production systems hindered cover crops adoption, particularly for farms focused on perennial ley or pasture. Second, time constraints, with several respondents stating they lack the capacity to establish and manage cover crops. The third category highlighted a lack of knowledge about growing and managing cover crops. Fourth, biophysical and management constraints, including too short growing seasons, particularly in northern Sweden, and a preference for autumn ploughing, all of which limit the perceived feasibility of introducing cover crops.

4.2. Mixed logit results

Table 3 presents the MXL estimates of the marginal utilities and the implicit trade-offs and monetary valuations of the attributes. The positive and significant ASC for the status quo alternative indicates that, on average, respondents exhibit an inherent preference for not participating in the cover cropping eco-scheme. However, the estimates further indicate that respondents, on average, derive positive and significant utilities from the attributes associated with low or high improvement in biodiversity, 10% or 20% increase in carbon sequestration, and high improvement in soil health, relative to no improvement (base category), thereby increasing the likelihood of participating in the eco-scheme. The implicit trade-off values indicate that, on average, respondents would accept a minimum of 1723 SEK/ha/year (11 SEK ≈ 1 Euro at the time of the study) to participate in the eco-scheme. The estimated average WTA slightly exceeds the fixed compensation of 1500 SEK/ha/year eco-scheme for cover crops, already implemented in Sweden. However, agri-environmental climate outcomes could effectively reduce the compensation required to achieve participation, potentially closing the gap between the estimated average WTA and the current policy payment. Compared with no improvement in biodiversity and carbon sequestration, respondents are willing to accept reductions (i.e. trade-off) of 361 SEK/ha/year and 431 SEK/ha/year, and 367 SEK/ha/year and 427 SEK/ha/year for low and high improvements, respectively. Most notably, the respondents are willing to forego approximately 739 SEK/ha/year for high improvement in soil health compared with no improvement.

The statistically significant standard deviation estimates for the different attribute levels indicates the presence of preference heterogeneity among farmers, suggesting that the average WTA estimates cannot be assumed to represent the entire sample. Another way to account for heterogeneity is LCM to identify distinct clusters of farmers within the sample. These clusters are defined by preferences for the attributes, farm and farmer characteristics, and the underlying attitudes and identities, as captured using the MIMIC model. The results are presented in the next sections.

4.3. MIMIC model results

Table 4 presents the results from the MIMIC model, including estimates of the measurement and structural components of the latent identity and attitude variables that explain the sources of farmers' heterogeneity in preferences for the attributes. Although environmental, economic, and social identity variables were initially specified in the identity construct of the conceptual framework, the social identity latent variable was excluded from the MIMIC model. While the social identity latent variable showed valid measurement properties (see Appendix Table A6), it displayed a moderate latent-level association with the environmental identity (see Appendix Table A7). Excluding the social identity led to a clear improvement in goodness-of-fit indices (see Appendix Table A8) without altering the interpretation of the remaining latent variables. The final specification, therefore, omits the latent social identity variable to reduce model complexity while remaining aligned with the non-monetary utility value in the conceptual framework.

We assessed the validity of the retained latent variables using average variance extracted (AVE), composite reliability (CR), and squared correlation (SC) among the latent variables (Hair et al., 2017). The AVE statistics for environmental and economic identities and attitudes (0.65, 0.51, and 0.82, respectively) are above the recommended threshold of 0.5. The CR statistics (0.85, 0.74, and 0.95, respectively) are above the recommended threshold of 0.7. Thus, the AVE and CR statistics indicate good convergent validity of the latent variables (see Appendix Table A6). The AVEs are above the SCs among the latent variables, indicating good discriminant validity. Overall, the estimated model exhibits a good fit according to relevant statistics (RMSEA = 0.07, CFI = 0.94, TLI = 0.91, SRMR = 0.03), well within the acceptable ranges (see Appendix Table A8) (Bagozzi and Yi, 2012; Hu and Bentler, 1999).

The estimates of the measurement component indicate that the latent environmental and economic identity and attitude variables are positively and significantly correlated with all corresponding indicators. The structural component estimates suggest that farmer age, education level, and (transition to) organic certification have a positive and significant correlation with the latent environmental identity variable, while male gender, animal production (or mixed crop-animal farming), and farm size show a negative association. Conversely, male gender, education

Table 4
Results of the MIMIC model including the measurement and structural component for the latent attitudes and environmental and economic identity variables.

	Environmental identity	Economic identity	Attitudes
	Coefficient	Coefficient	Coefficient
Measurement item			
Environmental identity 1	0.724***		
	(0.014)		
Environmental identity 2	0.685***		
	(0.015)		
Environmental identity 3	0.695***		
	(0.015)		
Economic identity 1		0.887***	
		(0.009)	
Economic identity 2		0.891***	
		(0.009)	
Economic identity 3		0.611***	
		(0.013)	
Attitude 1			0.897***
			(0.004)
Attitude 2			0.951***
			(0.003)
Attitude 3			0.891***
			(0.005)
Attitude 4			0.877***
			(0.005)
Structural component			
Age	0.152***	−0.201***	−0.135***
	(0.021)	(0.020)	(0.020)
Gender	−0.224***	0.239***	0.144***
	(0.021)	(0.020)	(0.021)
Education	0.056***	0.046**	0.100***
	(0.021)	(0.021)	(0.021)
Production	−0.125***	−0.025	0.028
	(0.021)	(0.021)	(0.021)
Organic certification	0.435***	−0.158***	0.019
	(0.019)	(0.020)	(0.020)
Size	−0.096***	0.142***	−0.012
	(0.020)	(0.020)	(0.020)
R^2	0.28	0.13	0.05
Disturbance term intercorrelations			
Environmental identity	1		
Economic identity	−0.081***	1	
	(0.025)		
Attitudes	0.264***	0.095***	1
	(0.023)	(0.022)	
$N_{obs} = 3222$			

Note: Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$.

level, and farm size are positively and significantly correlated with the latent economic identity variable, whereas age and (transition to) organic certification are negatively associated with the latent economic identity variable. Education and male gender are positively and significantly linked to attitudes, while age shows a negative and significant correlation.

Observable characteristics explain the limited variability in each latent variable, which ranges from 5% to 28%. The unexplained variance captured by the disturbance terms is shared between the latent variables, as indicated by the significant intercorrelations of the disturbance terms. This suggests that farmer identities and attitudes are correlated in explaining their choices, which aligns with the conceptual framework. Specifically, attitudes are positively correlated with both environmental and economic identities, highlighting that the more one positively appraises cover crops, the more one feels connected to environmental and economic concerns. Results also suggest a trade-off between the latent economic and environmental identity variables, such that stronger identification with economic concerns is associated with weaker identification with environmental ones, supporting the presence of contrasting intrinsic motivations.

4.4. Standard and hybrid LCM results

Based on the relevant information criteria (LL, BIC, AIC, and CAIC), we selected a two-class model (Table A9). We further estimated four model specifications based on latent variables: Model (1) is a standard LCM, Model (2) is a hybrid LCM that includes attitudes, while Model (3) includes economic and environmental identities, and Model (4) includes all latent variables to assess their interrelation. The results of the standard and hybrid LCMs are presented in Table 5. Respondent probability of belonging to class 1 is 75% and 25% for class 2, on average. Likelihood ratio tests showed that hybrid LCMs generally fit better than the standard LCM, leading to the selection of the best-fitting hybrid LCM, model (4), as the focus of our discussion beyond its theoretical appeal. The estimates remained consistent across models, confirming the robustness of the results.

In both classes of model (4), farmers demonstrated a preference for the status quo at the 1% significance level, indicating a reluctance to participate in the cover cropping eco-scheme. However, farmers in both classes remain sensitive to the payment attribute in their choices, reflecting strong monetary utility values. Farmers in class 1, in addition to having lower status quo bias than in class 2, further attain positive and statistically significant utility from all non-monetary attributes and levels. Class 2 farmers, in contrast, derive negative and statistically significant estimates from both low and high improvements in biodiversity compared to no improvement. These findings suggest that Class 1 farmers value the non-monetary benefits higher than those in Class 2. Accordingly, we refer to class 1 as the “responsive farmers” to reflect their greater sensitivity to the non-monetary attributes in the utility function linked to the adoption of cover crops and class 2 as the “conventional farmers” due to their stronger preference for the status quo and monetary utility values.

To further explain the sources of preference heterogeneity between the two classes, we focus on the estimates of the latent class membership function. Notably, the coefficient of the latent attitude variable is positive and statistically significant at the 1% level. This implies that farmers with positive attitudes towards cover crops are more likely to respond positively to the eco-scheme than conventional farmers. It is worth mentioning, however, that environmental identity is positive and statistically significant in Model (3) but loses significance once attitudes are included in Model (4). Farm and farmer characteristics did not significantly explain the latent class membership or preferences of farmers, except for farmer age, which is negatively and statistically significant, suggesting that younger farmers are more likely to belong to the responsive farmers and therefore show preferences for the agri-environmental and climate outcomes.

4.5. Implicit trade-offs and monetary valuation

Fig. 3 illustrates the implicit trade-offs between utilities in farmers' preferences and the monetary valuation of the attributes. Both classes assign monetary value to the status quo alternative, but the trade-off is more pronounced for conventional farmers than responsive farmers, who require substantially greater compensation to increase their likelihood of participating in the eco-scheme (3173.4 and 747.7 SEK/ha/year, respectively). Comparing these estimates to the actual Swedish eco-scheme compensation of 1500 SEK/ha/year, the current payment level falls considerably short of what conventional farmers require, while it substantially exceeds the compensation required by responsive farmers. These results indicate that conventional farmers do not perceive co-benefits to the same extent as the responsive farmers and may be more profit-sensitive in their management decisions. Notably, conventional farmers require additional compensation of 690 SEK/ha/year and 624 SEK/ha/year for low and high biodiversity improvements respectively. In contrast, responsive farmers seek a balance between

Table 5
Results of the standard and hybrid LCMs.

	Standard LCM		Hybrid LCMs					
	Model (1)		Model (2)		Model (3)		Model (4)	
	Class 1	Class 2	Class 1	Class 2	Class 1	Class 2	Class 1	Class 2
Class probability	0.748	0.252	0.748	0.252	0.748	0.252	0.749	0.251
Utility function								
ASC	1.207***	4.602***	1.211***	4.578***	1.206***	4.627***	1.212***	4.601***
	(0.313)	(1.248)	(0.312)	(1.249)	(0.313)	(1.252)	(0.312)	(1.252)
Biodiversity: low improvement	0.418***	−1.836**	0.418***	−1.871***	0.418***	−1.839**	0.418***	−1.876***
	(0.149)	(0.734)	(0.148)	(0.724)	(0.149)	(0.733)	(0.148)	(0.725)
Biodiversity: high improvement	1.026***	−1.619	1.026***	−1.658	1.027***	−1.651*	1.026***	−1.691*
	(0.196)	(1.006)	(0.196)	(1.026)	(0.196)	(0.994)	(0.195)	(1.011)
Carbon sequestration: 10% increase	0.400**	−1.446	0.395**	−1.423	0.400**	−1.458	0.395**	−1.439
	(0.191)	(0.939)	(0.190)	(0.961)	(0.191)	(0.938)	(0.190)	(0.961)
Carbon sequestration: 20% increase	0.738***	−0.298	0.737***	−0.288	0.737***	−0.280	0.737***	−0.274
	(0.194)	(0.841)	(0.194)	(0.848)	(0.194)	(0.835)	(0.194)	(0.844)
Soil health: low improvement	0.776***	−1.755	0.778***	−1.855	0.776***	−1.748	0.778***	−1.861
	(0.174)	(1.339)	(0.174)	(1.315)	(0.174)	(1.335)	(0.174)	(1.319)
Soil health: high improvement	1.634***	1.140	1.636***	1.113	1.635***	1.148	1.636***	1.119
	(0.209)	(0.824)	(0.209)	(0.814)	(0.209)	(0.828)	(0.209)	(0.820)
Subsidy payment	0.001***	0.002***	0.001***	0.002***	0.001***	0.002***	0.001***	0.002***
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
Class membership function								
Age	−0.050**		−0.058**		−0.060***		−0.061**	
	(0.019)		(0.026)		(0.022)		(0.027)	
Gender	0.808		0.419		1.090*		0.519	
	(0.551)		(0.705)		(0.610)		(0.785)	
Education	0.080		−0.055		0.042		−0.069	
	(0.160)		(0.203)		(0.165)		(0.205)	
Size	0.000		0.000		0.000		0.000	
	(0.000)		(0.000)		(0.000)		(0.000)	
Production	0.018		−0.086		0.126		−0.030	
	(0.219)		(0.279)		(0.229)		(0.292)	
Organic certification	0.102		0.196		−0.254		0.098	
	(0.300)		(0.384)		(0.361)		(0.461)	
Attitudes			1.938***				1.894***	
			(0.363)				(0.368)	
Environmental identity					1.206**		0.393	
					(0.538)		(0.686)	
Economic identity					0.387		0.174	
					(0.262)		(0.317)	
Constant	2.865*		4.743**		3.276**		4.784**	
	(1.492)		(1.972)		(1.585)		(1.971)	
N_{obs}	2646		2646		2646		2646	
Log-Likelihood	−636.386		−611.511		−632.966		−611.246	
AIC	1318.771		1271.021		1315.932		1274.591	
BIC	1454.030		1412.161		1462.952		1427.392	

Note: Standard errors in parentheses. Significance * $p < .1$, ** $p < .05$, *** $p < .01$. The constant 0.000 estimate for farm size is due to rounding.

profit maximization and agri-environmental and climate outcomes, reflecting differences in farmers' attitudes towards the eco-scheme. They are willing to trade off subsidy payments for both low and high improvements in biodiversity, carbon sequestration, and soil health compared to no improvement. The highest monetary valuation is associated with improvements in soil health, with farmers willing to forgo approximately 620 SEK/ha/year for low improvement and 1255 SEK/ha for high improvement. This is followed by biodiversity (308 SEK/ha/year for low and 842 SEK/ha/year for high improvement) and carbon sequestration (276 SEK/ha/year for low and 587 SEK/ha/year for high increase). These findings indicate that responsive farmers place the highest value on soil health when adopting cover crops.

5. Discussion and conclusions

In this paper, we investigated farmers' preferences for climate-related and non-climate co-benefits of mitigation measures, specifically carbon sequestration, biodiversity and soil health, respectively, using the cover cropping eco-scheme as a case study. We focus on eliciting trade-offs between monetary and non-monetary utility values associated with these co-benefits, alongside farmers' attitudes and identities. We conduct a survey among Swedish farmers ($n = 179$) and apply an identity-based utility framework. The MXL model indicated significant heterogeneity in preferences within the sample, motivating the use of an LCM. Two distinct classes of farmers were identified based on their preferences for the attributes of the cover cropping eco-scheme, i.e., responsive (average class probability of 75%) and conventional (average class probability of 25%) farmers, which also reflect differences in their underlying attitudes.

While respondents showed a preference for the status quo, with around 50% of respondents ($n = 88$) opting out at least once, a pattern consistent with Opdenbosch and Hansson (2023), who found that half of surveyed Swedish farmers chose not to adopt agroforestry practices despite the prospects of compensation, we nonetheless find positive and statistically significant estimates for subsidy payments across both classes. This indicates that higher compensation levels increase the likelihood of farmers' participation in the cover cropping eco-scheme. This is particularly evident among conventional farmers, who

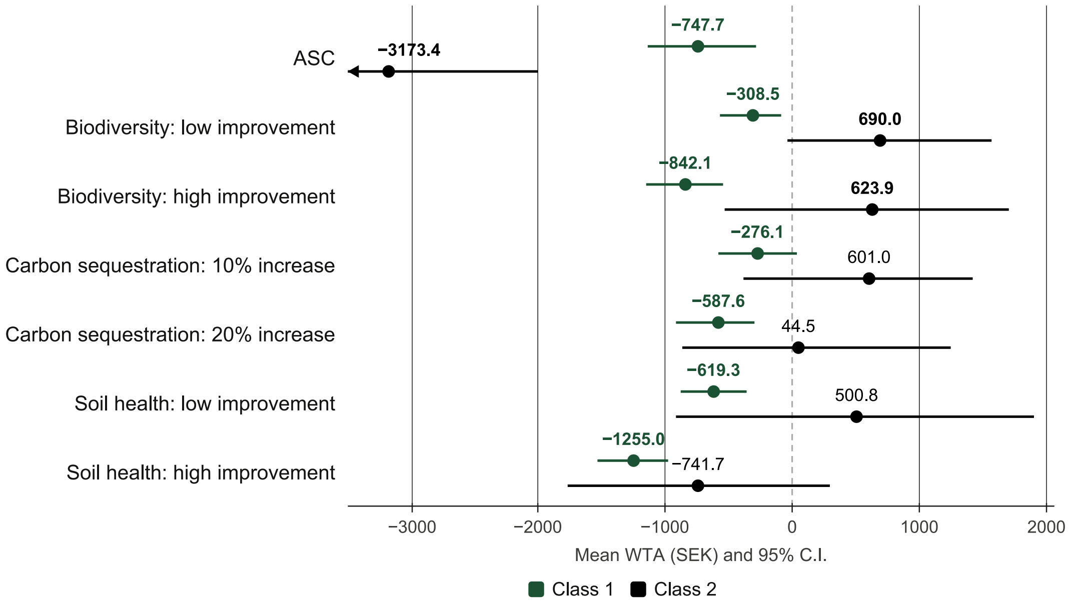


Fig. 3. Implicit trade-offs and monetary valuation of the attributes. Note: Mean WTA were estimated based on the coefficients in Table 5 (Model 4) and statistical significance is highlighted in bold. ASC (class 2) lower C.I. is −5432.1. We use the Krinsky Robb (parametric bootstrap) method to construct the confidence intervals for the trade-offs with 2000 number of repetitions.

primarily maximised utility in the profit-related attribute. In contrast, responsive farmers further demonstrated a strong interest in the agri-environmental and climate co-benefits of participating in the eco-scheme, deriving both monetary and non-monetary values from cover cropping in their utility-maximising process. These findings are consistent with the literature (Cullen et al., 2020; Dessart et al., 2019; Howley, 2015; Leduc et al., 2023; Opdenbosch and Hansson, 2023; Owusu-Sekyere et al., 2022, 2024; Oyinbo and Hansson, 2024), suggesting that for most respondents, the decision to adopt mitigation practices is not driven solely by pecuniary incentives. Non-monetary values in utility also play a significant role, and these align with the actual behavioural choices observed among farmers.

Specifically, our results suggest that most farmers' willingness to participate in the eco-scheme increases with improvements in biodiversity, carbon sequestration, and soil health. Among the attributes, soil health is the most preferred, likely because it offers more immediate and tangible private benefits compared to the broader public goods of biodiversity and carbon sequestration. While agri-environmental and climate outcomes may yield long-term economic gains, farmers tend to view soil health as directly improving yields, reducing reliance on mineral fertilizers, and increasing land value. As such, healthy soils contribute to both monetary and non-monetary values in utility, reducing the need for compensation to adopt cover crops. The literature similarly highlights a strong preference for soil health relative to other attributes (Braito et al., 2020; Buck and Palumbo-Compton, 2022; Dumbrell et al., 2016; Mattila et al., 2022; Moerkerken et al., 2020; Shanmuga Surya et al., 2023).

Another important finding reveals that farmers' underlying attitudes and age are the main drivers of observed heterogeneity in preferences and trade-offs. It is worth mentioning, however, that organic certification does not significantly predict class membership, suggesting that formal organic production does not necessarily translate into stronger preferences for agri-environmental outcomes. This finding aligns with Swedish literature showing that holding a KRAV or EU organic certification does not determine farmers' profile affiliation (Höglind et al., 2021). Overall, solely focusing on socio-economic characteristics to explain preferences would produce limited insights into the drivers of adoption (Oyinbo and Hansson, 2024), supporting the role of behavioural factors in farmer decisions (Schaub et al., 2023; Wuepper et al., 2023). Furthermore, our findings support that the effects of farmers' environmental identity on preferences (which is significant in Model (3)) are partly reflected through their attitudes once all latent variables are included in model (4) (Table 5). This result is consistent with our conceptual framework, suggesting that the effect of identity is reflected through farmer attitudes, in line with the literature arguing that identity and attitudes are correlated in explaining behaviour (Cullen et al., 2020; Hallajow, 2018; Oyinbo and Hansson, 2024).

Findings suggest three main policy implications. First, policy framing seems to matter in how decisions are made on farms (Fleming et al., 2019). In recent years, the combination of stricter environmental regulations and increasing market pressures has led to heightened tensions between farmers and policymakers, as evidenced by recent farmer protests across Europe and legal disputes against governments in countries like Switzerland over a lack of climate accountability (Finger et al., 2024). Many farmers feel they are not only disproportionately affected by the impacts of climate change but also pressured and held responsible for delivering mitigation outcomes. As a result, it prompts the question as to what motivates farmers to implement measures to mitigate climate change, which has direct implications for how CAP instruments are communicated to farmers, as illustrated by the Swedish cover cropping eco-scheme, currently promoted for its carbon sequestration benefits. While Davidson et al. (2019) indicate that motivation for mitigation measures does not necessarily originate in climate consciousness nor a sense of responsibility for mitigation, our findings tend to support that it is rather in the non-climate co-benefits that they bring. Specifically, for their benefits to farm operations (such as healthier soil and subsidy payments), in which climate action is seen as a “by-product” of investments aimed at improving farm management and performance, rather than for their role in addressing climate change alone (Farstad et al., 2022). Achieving non-climate co-benefits as a direct consequence of mitigation activities could therefore help farmers unconvinced or unconcerned about climate change to recognise that participation can align with (rather than take away from) their personal values and the objectives of their farm (Bain et al., 2016; Fleming et al., 2019). Our results suggest that respondents with an average class probability of 75%, representing a large share of the target population, may already be receptive to such reframing, making this a low-cost and potentially high-impact lever for increasing participation.

Second, while our results suggest that farmers' decision-making is shaped by non-monetary utility values, subsidy payments remain a significant determinant of participation. On average, farmers require approximately 1723 SEK/ha/year to participate in the eco-scheme (Table 3), which slightly exceeds the actual policy payment of 1500 SEK/ha/year. However, when the trade-off values associated with carbon sequestration (consistent with how the scheme is currently promoted) and biodiversity improvements are factored in, the existing payment may in fact be sufficient to encourage participation on average. Moreover, if soil health benefits were also explicitly communicated alongside carbon sequestration, the required compensation would decrease further, potentially making participation financially attractive at current payment levels. However, the latent class results reveal important heterogeneity in this regard: while the current payment appears sufficient to incentivize participation among responsive farmers (around 750 SEK/ha/year), it falls considerably short of what conventional farmers require (around 3170 SEK/ha/year) (Fig. 3). This underscores the critical role of payment levels in ensuring participation among conventional farmers, who exhibit a strong reliance on financial incentives (Le Coent et al., 2017). It also points to the risk that insufficient economic incentives, particularly those that fail to compensate for rising implementation and opportunity costs, may discourage farmers from enrolling in or maintaining participation in such schemes (Opdenbosch et al., 2024). In contrast, since most farmers (class 1; 75% average probability) can be incentivized at or below the current payment level due to the non-monetary utility they derive from participation, uptake among this group may be further facilitated through relatively low-cost interventions such as improved advisory services (Opdenbosch et al., 2025), training programs, and technical assistance through demonstration sites (García De Jalón et al., 2018). Accordingly, these results highlight the usefulness of LCM for uncovering unobserved heterogeneity for policy design purposes and suggest that a uniform payment scheme may not be optimal for achieving broad adoption across heterogeneous farmer groups. Targeting farmers based on their preferences and underlying attitudes may therefore offer a more cost-effective approach. However, future research is needed to assess how preference- and behaviour-based interventions may inform policy targeting across farmer classes, while carefully considering equity concerns, particularly with respect to financial instruments under the CAP.

Third, our results point to a win-win situation between societal and producer preferences for policy objectives. Despite the theoretical equivalence of WTA and willingness-to-pay approaches (Haab and McConnell, 2002), accurately valuing co-benefits often requires direct perception or experience (Boogen et al., 2022). Accordingly, our findings suggest that farmers place a high value on soil health among the co-benefits of mitigation measures, whereas Kragt et al. (2016) found that the public prioritized co-benefits such as native vegetation and carbon storage, with soil erosion not being significant in shaping public preferences. In other words, although farmers may prioritize private benefits tied to soil health, such as farm productivity and economic viability, the public tends to emphasize public goods with more tangible climate and environmental features like vegetation and less-known issues such as soil degradation often go unnoticed or unappreciated (Kragt et al., 2016). These findings reflect a potential synergy rather than a conflict in priorities, as measures aimed at mitigating climate change in agriculture simultaneously address both private and societal benefits. While measures are implemented directly at the farm level, positioning farmers as central actors in climate action (Sorvali et al., 2021), public legitimacy from taxpayers and consumers is essential, especially as agriculture receives substantial governmental support across Europe (El Benni et al., 2024). This highlights the need to integrate co-benefits in policy design and decision-making, as complementary, not competing, strategies, so that addressing climate change delivers the broader benefits that both the public and farmers value (Bain et al., 2016). An interesting avenue for future research would be to investigate both producer and public preferences for the same co-benefits and related policy objectives within a single study, allowing for a more comprehensive understanding of potential trade-offs and synergies across the food system.

As such, the use of an identity-augmented utility framework and a hybrid LCM proved appropriate for addressing the aims of this study. However, certain limitations remain and should be acknowledged. Firstly, individual-level heterogeneity in perceptions of improvements in co-benefit attributes may lead to potential subjective bias, causing responses to reflect subjective evaluations. This may confuse real differences in valuations with differences in perceptions, and WTA estimates derived from these coefficients should be understood as conditional on respondents' subjective reference points. Secondly, the response rate is relatively low compared to recent surveys conducted in Sweden (e.g., Ha et al., 2024). The sample consists of 179 respondents, each completing six choice tasks, yielding 1074 observed choices (3222 observations in long format). 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 (Slijper et al., 2026). In addition, LCM relies on complete-case observations, resulting in a reduction from 3222 to 2646 rows due to missing values. Although this reduction is not uncommon in LCM, it may affect statistical power and the precision of parameter estimates, particularly given the model's degrees of freedom (26). The limited number of observations further prevented fitting separate models for crop and livestock farmers. Accordingly, we acknowledge that using pooled data from both groups frames the interpretation of our results across production systems, reducing generalizability. However, for robustness check, we tested the sensitivity of our results assuming that class membership probabilities of the respondents are predicted solely by their sequence of choices of attributes without the inclusion of farm and farmer characteristics and latent identity and attitude variables, restoring the full set of 3222 observations. We found that the utility estimates in Table A10 in the Appendix, which account for respondent sequences of choices without the latent class membership covariates are qualitatively similar to the estimates in Table 5, thereby confirming the robustness of our main results.

CRediT authorship contribution statement

Harold Opdenbosch: Writing – review & editing, Writing – original draft, Visualization, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Emilia Mattsson:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Formal analysis. **Oyakhilomen Oyinbo:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Methodology, Data curation, Conceptualization. **Jens Rommel:** Writing – review & editing, Validation, Supervision, Methodology, Formal analysis, Data curation. **Helena Hansson:** Writing – review & editing, Visualization, Validation, Supervision, Project administration, Methodology, Funding acquisition, Data curation, Conceptualization. **Gordana Manevska-Tasevska:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration, Funding acquisition, 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.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecolecon.2026.109066.

Data availability

The data that has been used is confidential.

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