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What matters most in determining European farmers' participation in agri-environmental measures? A systematic review of the quantitative literature

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ABSTRACT

Successful implementation of Europe's agri-environmental policies faces various obstacles, several of which are closely linked to participation. Effectively increasing adoption of agri-environmental-climate measures (AECM) requires a deeper understanding of farmers' motives. Various case-study research has targeted ex-post studies but offers context-specific recommendations. Earlier literature reviews provide certain insights, but have not yet clarified how the evidence on adoption can be optimally applied to AECM design. We explore farmer decision-making by synthetizing results from three decades of ex-post empirical studies on AECM adoption in Europe. Our approach applies a theoretically informed participation framework that offers practical insights for AECM design. We systematically scrutinize how different stage-specific constructs, grouped into 'alignment', 'opportunity', 'engagement', and 'contracting', influence farmer decisions. We identify eight determinants of participation and 38 variables capturing their contribution to decision-making. Variables explaining the role of social contexts and satisfaction with contract design are seldom observed but prove significant in around 60 percent of cases. Conversely, variables capturing the relevance of AECM to farmers and the opportunity of participation are frequently included, but often ineffective in explaining uptake. Enhancing the alignment of the measures with farmers' needs encourages adoption, but excessive alignment carries the risk of self-selection bias toward baseline-complying agents, which likely jeopardizes AECM additionality. Our findings highlight how crucial it is for adoption studies to properly account for farmers' opportunity costs and self-selection bias. We draw policy-makers' attention to the importance of carefully considering all four constructs during policy design.

1. Introduction

Over recent decades, there has been a growing interest among researchers and policymakers in understanding the factors that influence farmers' adoption of environmentally sustainable practices (Kabii and Horwitz, 2006; Pannell et al., 2006; Knowler and Bradshaw, 2007; Baumgart-Getz et al., 2012; OECD, 2012; Borges et al., 2019; Dessart et al., 2019; Prokopy et al., 2019). Due to the voluntary nature of agri-environmental-climate measures (AECM), adequate and effective participation of farmers in these initiatives is the first key indicator of their success and, eventually, their effectiveness. Effective participation refers to a certain number and well-targeted types of farmers implementing sustainable practices, which eventually provide additional environmental services that, counterfactually, would not have been supplied without the programme (Persson and Alpízar, 2013). This is also relevant for the larger-scale European Common Agricultural Policy (CAP), with AECM being funded under its second pillar as a voluntary market-based policy.

AECM are part of the broader category of payment for environmental services (PES), consisting of voluntary transactions between service users and providers that are conditional on agreed rules of natural resource management for generating offsite services (Wunder, 2015, p. 241). Payments should at minimum cover the income forgone (i.e., opportunity costs) and other costs incurred (i.e., direct costs of provision) by implementing a set of environmentally friendly management practices. To become AECM eligible, farmers would voluntarily agree to

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go beyond the requirements imposed by any compulsory environmental regulation. In the European Union, AECM are typically defined as part of each regional Rural Development Programme (RDP) and framed within the local farming systems and ecosystems. Depending on their objectives, AECM could support either an extensification or intensification of management practices, or encourage farmers to either change or preserve existing farming practices (Keenleyside et al., 2011; Hasler et al., 2022). The incentives can take two main forms (or hybrids thereof): payments for implementing pre-defined sustainable practices (action-based measures) or payments for demonstrating positive ecological results (result-based measures) (Herzon et al., 2018). Globally some countries have also introduced auctions (i.e., conservation tenders) to determine payments levels that accurately reflect farmers' opportunity costs (Rolfe et al., 2017). Others have implemented add-on incentives for spatial coordination or landscape level collaboration (Nguyen et al., 2022). Due to their voluntary nature and the heterogeneity of remunerated (in)action, assessing the additionality of AECM can be challenging in terms of counterfactual analysis. Consequently, AECM are among the most complex CAP instruments when it comes to evaluating their effectiveness (Zimmermann and Britz, 2016).

Action-based AECM are the most well-established and predominant type of contracts proposed to farmers (Herzon et al., 2018). Under these contracts, farmers receive a payment to implement pre-defined farming practices, which are expected to reduce negative environmental externalities or increase the provision of public environmental goods. The payments, which cover lost income and incurred costs, meet the World Trade Organization (WTO) requirements vis-à-vis trade distortions. WTO alignment, along with the ease of implementation, monitoring, and general acceptability by farmers, collectively favour a predominant farmer preference of action-over result-based AECM (Burton and Schwarz, 2013). However, despite their long-lasting existence and benefits, even action-based AECM have a mixed record of participation, as well as sparse and inconsistent evidence regarding their overall environmental effectiveness (Batáry et al., 2015; Pe'er et al., 2019; EC, 2021; Ait Sidhoum et al. 2023).

According to economic theory, the failure of PES initiatives can be attributed to inefficiencies that are directly related to participation. (Engel et al., 2008; Rolfe et al., 2021). Payments offered may be too small to compensate the cost incurred by the farmer, i.e. both direct costs of adopting environmentally friendly practices and the opportunity costs of participation as profits foregone from alternative land uses. Too small payments may imply failure to induce a socially desirable level of AECM adoption (Schaub et al., 2023). However, adverse self-selection biases often exist toward "baseline-complying agents", i.e. farmers who already (would) have adopted the AECM-induced practice without any payment, and thus have zero or negligible provision costs: pre-compliant actors stand first in line to join (Wunder et al., 2020). If 'too many' of these non-additional farmers participate, AECM will make little environmental difference vis-à-vis business as usual. An effective design and implementation for adequate AECM participation faces also other challenges, such as designing environmentally effective management practices that are acceptable to farmers, reducing asymmetric information, and minimizing transactions costs (Mettepenningen et al., 2013; Gómez-Limón et al., 2019).

Research on adoption of sustainable practices comes from different fields and methodological backgrounds (Borges et al., 2019). The participation in AECM in Europe has been investigated both qualitatively or quantitatively over the years (Brown et al., 2021; Leonhardt et al., 2022). Qualitative methods are mainly used to examine the context-specific motivations and perspectives of farmers or stakeholders (Kieninger et al., 2018; Walder and Kantelhardt, 2018; Schulze and Matzdorf, 2023), but often fail to produce generalizable results (Brown et al., 2021). Quantitative methods primarily capture how certain observable characteristics of the wider population of farms/farmers correlate with participation. This generalizable evidence is often complex to synthesize, and tells us little about the role farmer beliefs or archetypes play in their decision-making. To overcome such limitations, recent studies have tried to bridge these gaps by using a combination of approaches (i.e., Leonhardt et al., 2022). From a theoretical angle, the most commonly used bases are random utility theory or the theory of planned behaviour. The random utility assumes that farmers make rational choices among discrete alternatives, choosing the one that maximises their utility.[1] Most studies applying this approach explore how some individual socioeconomic and personal characteristics, as well as contract features, influence the utility derived from participation (Lastra-Bravo et al., 2015; Tyllianakis and Martin-Ortega, 2021). Yet, the theory of planned behaviour considers how individual intentions and behaviours are being influenced by personal attitudes, perceived social pressure (i.e., subjective norms), and perceived behavioural control (Ajzen and Fishbein, 2005). Building on this foundation, studies investigate how individual cognitive, emotional, and social factors influence farmers' intentions (Dessart et al., 2019). Until now, the scarce integration of these perspectives in adoption studies has resulted in a relatively simplistic conceptualisation of farmer decision-making process (Brown et al., 2021).

Previous academic attempts to synthesise the factors influencing farmers' adoption of sustainable farming practices offer valuable insights into behavioural, socioeconomic and structural determinants (Siebert et al., 2006; Lastra-Bravo et al., 2015; Bartkowski et al., 2019; Dessart et al., 2019; Tyllianakis and Martin-Ortega, 2021). Dessart et al. (2019) assessed 20 years of research on the behavioural factors that influence farmers' decisions to adopt environmentally sustainable practices, identifying several factors as predictors of sustainable farming adoption: personality, moral concern, risk tolerance, descriptive norms, and perceived control, among others. The authors suggest considering farmers' dispositional, social and cognitive factors in economic assessments of farmer decision-making for more realistic and effective agri-environmental policies (Dessart et al., 2019). Lastra-Bravo et al. (2015) conducted a meta-analysis of empirical studies and identified five groups of variables influencing adoption: economic factors, farm structure, farmer characteristics, farmers' attitudes towards AECM, and social capital. However, they found little evidence and contrasting guidance on how to design schemes for improved participation. Schaub et al. (2023) conduct a first attempt to review together the evidence on the role of behavioural factors and opportunity costs in farmers' participation in incentivized schemes across different regions. Despite identifying many influencing factors, a consistent and generalizable picture of adoption factors remains elusive. The authors emphasize the importance of considering jointly opportunity costs and behavioural factors for improved policy design. Mixed-evidence was also found by Tyllianakis and Martin-Ortega (2021) in their meta-analysis of studies examining the willingness to accept agri-environmental contracts (i.e., hypothetical adoption rather than actual adoption). They highlighted the need for an integrated understanding of how economic, behavioural and contractual factors act as both barriers and opportunities for participation in AECM, calling for a more comprehensive approach to account for the complexity of farmers' decision-making during the design of AECM (Tyllianakis and Martin-Ortega, 2021).

This gives rise to two gaps in the literature that this paper tries to address. Firstly, we aim to comprehensively synthesize the evidence from three decades of post-implementation studies on AECM adoption. Our analysis goes beyond looking at either behavioural or economic factors, but includes also demographic, farm structural, and contextual elements. Utilizing a vote-count method, we identify all the factors that

[1] The utility from AECM is typically tied to profit maximization, but research challenges the notion that farmers solely pursue profit. Farmers may have a broader array of goals, such as leisure time, simple management and low working capital Picazo-Tadeo et al. (2011). Additionally, environmental awareness is also suggested to positively impact farmer participation, as they find satisfaction in contributing to public goods Dupraz et al. (2003).

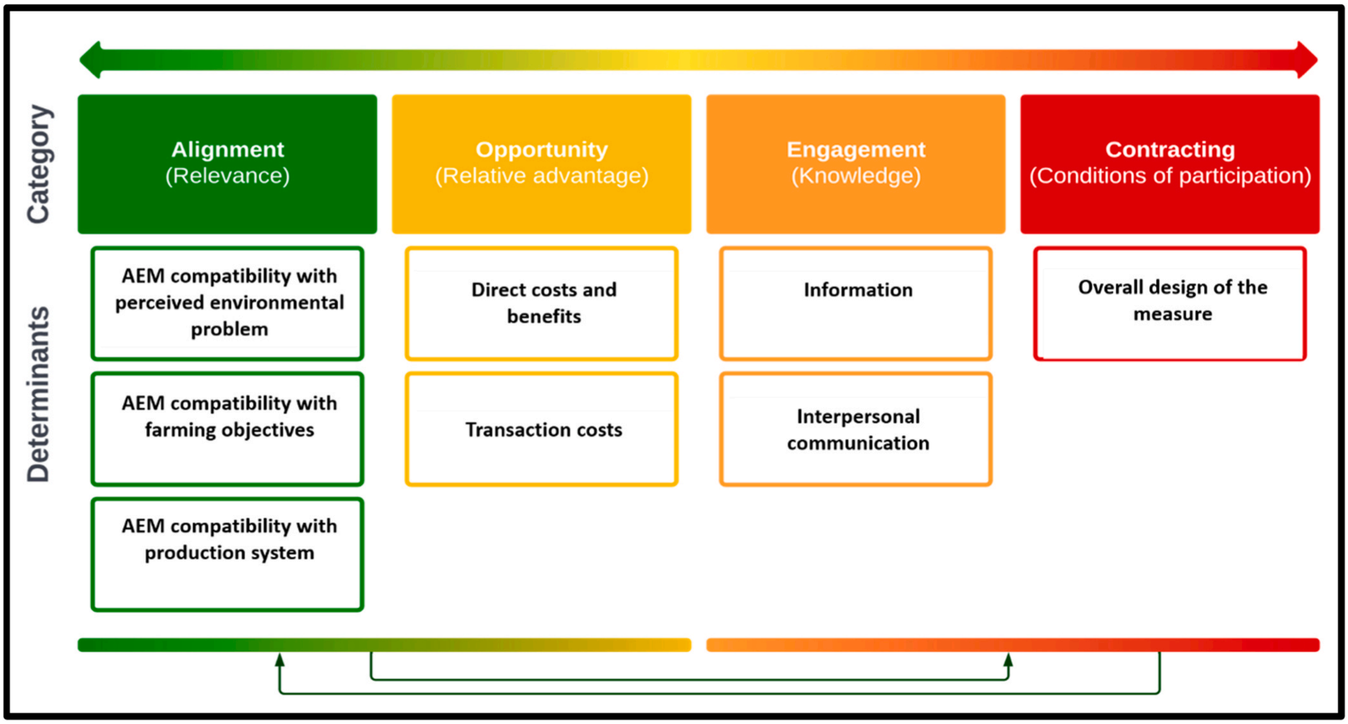

Fig. 1. Participation framework. Adapted from Whitten et al. (2013).

have been shown to affect uptake. We have chosen this approach for its synthesizing capacity and methodological transparency. It allows us to gauge the frequency with which a factor has been analyzed, and how often it has been shown to influence participation, providing valuable insights for researchers and policymakers. Secondly, we aim to enhance our understanding of how adoption factors, as observed in primary studies, influence farmers' decision-making. To achieve this, we analyze these factors within a theoretically informed participation framework. We draw upon the decision model introduced by Whitten et al. (2013) to comprehensively analyze factors influencing participation at various stages of the decision-making process, as it effectively integrates socio-economic and behavioural elements representing barriers and opportunities for farmer adoption of incentivized measures. We apply the proposed constructs, which are categorized into 'alignment', 'opportunity', 'engagement', and 'contracting', to examine their influence on farmers' decision-making processes. The application of this framework provides practical insights for the design of AECM by offering an integrated understanding of how the adoption factors are related to the decision process. To ensure a consistent interpretation of results and facilitate comparisons of factors that share a common framework, we focus on the adoption of voluntary agri-environmental-climate payments funded under the European Common Agricultural Policy (CAP).

This paper is organised as follows. In the next section, we present the conceptual framework used in our review. In Section 3, we provide a detailed description of our methodology. Section 4 presents the results, followed by a discussion in Section 5. The last section is devoted to concluding remarks and perspectives.

2. Conceptual framework

The starting point for our review was to elaborate a decision model for participation. To identify and classify the factors influencing adoption, we adapted the conceptual framework developed by Whitten et al. (2013) to the context of AECM in Europe. This multi-dimensional participation framework goes beyond conventional adoption and diffusion approaches, such as those proposed by Morris et al. (2000), Rogers (2003), Pannell et al. (2006), Knowler and Bradshaw (2007), Mills et al.(2013), and Dessart et al. (2019). It explains how various factors, such as farmer characteristics, the attributes of the farmer's decision-making unit, the decision environment, and the perceived opportunity to participate, interact in shaping farmers' choices. By drawing insights from behavioural economics, the adoption and contracting literatures, the framework comprehensively identifies barriers to participation, as well as practical measures to overcome them. Due to its multidimensional and multidisciplinary nature, the framework aligns well with the objective of this study. It allows for a holistic approach to complex farmer decision-making in response to AECM design options.

The main idea is that the farmer's decision to adopt is a dynamic process involving information acquisition and learning (Ghadim and Pannell, 1999). Throughout this process, 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). As shown in Fig. 1, we expanded upon Whitten et al. (2013) framework by identifying eight major factors and grouping them into four categories: alignment, opportunity, engagement, and contracting. These dimensions are the most important for farmers to consider when deciding whether or not to join a programme.

It is worth mentioning that none of the categories nor determinants exclusively explain the adoption decision (Whitten et al., 2013). For instance, the opportunity for participation is influenced by both the alignment of the measure with farmers' needs and the characteristics of the contracts (Pannell et al., 2006; Schaub et al., 2023). As a result, policy actions taken to address barriers or opportunities in one category are likely to have impact on others. For example, any improvement in knowledge regarding participation rules can affect farmers' perceived costs of changing production practices (Ducos et al., 2009). Similarly, increased management flexibility offered in contracts can reduce the expected costs of participation (Schaub et al., 2023). The arrows in Fig. 1 capture this dynamic dimension of the adoption decision process. The remainder of this section explains how the framework was used to assess empirical evidence of AECM participation.

2.1. Alignment

Alignment is the first aspect considered by farmers when deciding whether or not to join an AECM contract, and it refers to the farmer's assessment of the measure's practical relevance (Pannell et al., 2006; Whitten et al., 2013) or its compatibility with their values, past experiences, and needs (Rogers, 2003). The determinants influencing participation under this category are:

AECM compatibility with perceived environmental problem: Farmers' awareness of the problem being addressed and their level of environmental concern can influence the degree of AECM acceptability and the understanding of the potential environmental benefit of participation (Rogers, 2003; Dessart et al., 2019). Awareness variables are important descriptors of the perceived usefulness of the practice (Vanslembrouck et al., 2002; Baumgart-Getz et al., 2012). Previous studies have observed that farmers who deal with the most severe environmental issues (e.g., soil erosion) are the most likely to participate in the scheme (Agustín and Martínez, 2011). In this case, a measure that corresponds to the farmers' perceived environmental needs or priorities may result in higher participation. Nevertheless, this suggests a potential lack of additionality, as discussed in the previous section. Attitude variables, describing the importance that farmers place on the environment, also play an important role in affecting the perceived relevance of the measure (Dessart et al., 2019)

AECM compatibility with farming objectives: Farming objectives are diverse and can be economic, social, environmental, or a combination of these (Pannell et al., 2006; Dessart et al., 2019). Wynne-Jones (2013) observed that, whilst participation is mainly a business decision, other characteristics of the decision-making unit influence farmers' business strategies. Socio-economic and situational variables (e.g., household income or level of on-farm investments) are decisive in influencing both farming objectives and the farmer's decision to adopt the proposed measure (Pannell et al., 2006; Mills et al., 2013; Prokopy et al., 2019). Family priorities, such as keeping the farm property within the family or ensuring the farm's succession to descendants, influence farmers' participation decision (Lastra-Bravo et al., 2015). Household financial considerations, such as the need to secure a stable source of income, can also impact the decision to adopt (Wilson and Hart, 2000). Furthermore, profit-oriented farmers are considered to participate in AECM at a lesser rate compared to nature-oriented farmers (Leonhardt et al., 2022). Also, farmers' economic gains are often linked to innovation (Läpple and Thorne, 2019; Schulz and Börner, 2023), and farmers' aiming to innovate might be more willing to adopt entrepreneurial, production-target based AECM (Burton et al., 2008). They may perceive the benefits of adoption to outweigh the costs (see Section 2.2.). This implies, again, the possible existence of a self-selection bias toward "baseline-complying agents".

AECM compatibility with production system: This compatibility is considered an important determinant of adoption (Pannell et al., 2006), since it impacts the perceived benefit of participation and the perceived magnitude of change required by the AECM measure (Schaub et al., 2023). The characteristics of the production system, such as degree of specialisation and type of production practices in place, determine farmer availability for specific management actions, such as implementing extensification measures (Mozzato et al., 2018).

According to these definitions, the proposed AECM should be within the farmers' comfort zone and integrated with their production outcomes to be considered aligned (Whitten et al., 2013). Nevertheless, an excess of alignment might reduce additionality. This trade-off needs to be appropriately considered during AECM design to ensure that the desired environmental benefits are realised (Persson and Alpízar, 2013).

2.2. Opportunity

This category refers to the farmer's assessment of the relative advantage of participating in the measure (Pannell et al., 2006; Whitten et al., 2013). Relative advantage refers to "the degree to which an innovation [or new management practice] is perceived as being better than the idea [or practice] it supersedes" (Rogers, 2003, p.229). This perception can be influenced by the marginal costs and benefits of participation, which in turn are mainly determined by:

Direct costs and benefits: The scale of opportunity depends on the direct costs imposed by management changes (Wossink and van Wenum, 2003) . These include, for instance, the necessity of acquiring new inputs or specific equipment (Pannell et al., 2006), the cost of filling the knowledge gap for implementing a new measure (Ducos et al., 2009; Espinosa-Goded et al., 2013), or the additional working hours required for managing the new contract (Falconer, 2000). Other costs relate to the losses incurred as a result of adjusting to the new practice, the impacts on agricultural productivity, and the foregone option values as a result of limited management flexibility (Pannell et al., 2006; Ducos et al., 2009). If the AECM payment offsets output losses and other costs of provision, the cost of participation for farmers should theoretically be zero (OECD, 2012). However, opportunity costs of participation will vary across farmers, and can due to asymmetric information rarely be observed by AECM implementing agencies. Farm structural characteristics or farmers' attitudes toward risk and innovation are the most employed variables in adoption studies to capture participation opportunity costs. Previous studies observed that farmers with lower opportunity costs were more likely to participate in incentivized measures (Barreiro-Hurlé et al., 2010), implying the existence of a self-selection bias. The benefits of participation, in terms of environmental gains or self-image improvement, are generally less investigated by primary studies. However, tangible environmental benefits are considered to increase participation by influencing the perceived relative advantage (Dessart et al., 2019).

Transaction costs: Farmer transaction costs diminish the net gain of farmers from AECM payments. These costs may incur *ex-ante* during the decision to participate, e.g., to obtain the right information or compare between AECM alternatives, or *ex-post* when implementing the required monitoring activities (Mettepenningen et al., 2009). Ducos et al. (2009) refer to the categories of trust, bounded rationality, and uncertainty to assess the role of transaction costs on adoption. Trust is the expectation that the counterpart (in our case, the programming authority) behaves in a mutually beneficial manner (Sako and Helper, 1998) and pays according to contract clauses. The degree of reliability of the contracting agency has been shown to influence the decision process (Murphy et al., 2014). Bounded rationality means that the farmer might not be able to rationally rank all the solutions and opt for the one with the highest utility. Hence, the farmer may suffer additional costs by possibly making a wrong decision. While the degree of rationality and risk tolerance is influenced by personal characteristics, e.g., age and education (Dessart et al., 2019), the perceived risk and uncertainty are influenced by the degree of information made available to the farmers, and by the behaviour of other actors such as social organisations or neighbours (Whitten et al., 2013; Dessart et al., 2019).

2.3. Engagement

Before introducing changes to their farming system, farmers require a high degree of information (Pannell et al., 2006). Engagement refers to the process of information exchange, dissemination, and communication of the existence, function, and (dis)advantages of participating in AECM. The following determinants are considered to influence participation:

Information: It helps fill the gap between alignment and opportunity through effective communication and information exchange. This creates the conditions to increase the perceived alignment between the measures and farmer objectives, while reducing perceived opportunity costs by addressing knowledge gaps and building trust among agents (Taylor and van Grieken, 2015). From the farmer's perspective, it also allows for the reduction of transaction costs related to the time, effort and expense required to gather the necessary knowledge for successful participation in AECM.

Interpersonal communication: The literature on social and institutional capital observes that interpersonal communication, facilitated through the participation in different types of agricultural organisations (e.g., agri-unions or cooperatives) and access to information and technical advice (public and private), lowers transaction costs by increasing trust and enhancing knowledge around AECM (Unay Gailhard et al., 2012).

2.4. Contracting

The contractual framework can significantly influence participation as various elements of the agri-environmental contract can relate to the alignment and opportunity of participation, thereby influencing the perceived relative advantage of adopting the measure (Schaub et al., 2023).

Overall design of the measure: While certain contract attributes, such as increased payment, positively affect the probability of participation, other elements related to flexibility (e.g., plot or practice selection, withdrawal from the contract), bureaucracy, or monitoring can also influence farmers' decisions to participate in AECM (Raina et al., 2021). Monitoring, for instance, can impact both direct costs and perceived behavioural control (Dessart et al., 2019).

The influence of contract attributes is more often studied in contingent behaviour research than in empirical ex-post studies. According to theory, increased AECM complexity, both in terms of intensity of the management practice and increased risk or uncertainty, deters uptake (Rogers, 2003; Pannell et al., 2006). Farmers prefer simple, easily understandable and flexible forms of contracts. Economic compensation, reflecting opportunity costs of participation, plays a vital role in participation. In most action-based AECM, however, farmers receive a flat payment that is not customized to the heterogeneity of compliance costs. This can deter those with high compliance costs from participating.

3. Material and methods

3.1. Literature search

Our systematic review followed a structured approach consisting of four steps: identification of the main research question, shortlisting of relevant studies, data extraction and data analysis (Petticrew and Roberts, 2006; Moher et al., 2015). Our guiding questions were: "Which factors explain AECM uptake in ex-post primary adoption research?" and "Which aspects of the farmer decision-making process are most influential in decisions to participate?". To define inclusion and exclusion criteria for our review, we employed the Population-Intervention-Comparison-Outcomes-Study Design (PICOS) approach (CEE, 2022), used to narrow down research topics and develop structured literature search strategies. We included in our review: farm level primary studies (Population), investigating the adoption of incentivized AECM in Europe (Intervention) against non-adoption (Comparison), using *ex-post* (Outcomes) regression analysis (Study design). Since we aim to explore what studies on actual participation can capture about farmers' decisions, and compare their findings, this paper examines only quantitative studies investigating actual adoption of AECM; we excluded ex-ante analyses focusing on willingness to accept, stated preferences, and choice experiments. It is important to note that our choice to exclude these studies does not diminish the significance of qualitative or experimental studies, the contributions of which have been adequately addressed by other reviews (e.g., by Brown et al., 2021 or Tyllianakis and Martin-Ortega, 2021). We also excluded studies focusing on farmers adopting sustainable farming practices in general or participating in other types of programmes. To avoid mixing analyses with different research questions, we excluded studies focusing on the adoption of specific farming systems, such as organic agriculture, studies investigating the uptake of innovations or sustainable agriculture in the absence of payments, or studies concentrating exclusively on permanence, abandonment, or compliance.

As part of our search strategy, we looked through Scopus, ISI Web of Science and Google Scholar for studies published in English from January 1992 to June 2023. We also checked the reference sections of relevant articles to ensure that our systematic review was as thorough as possible. The online search was conducted using a Boolean search string that combined the keywords "agrienvironment*" and "agri-environment*" with "scheme" OR "measure" OR "contract" AND "adoption" OR "participation" OR "motivation" OR "acceptance". As outlined in Fig. 2, the web search uncovered 838 records, which became 431 once duplicates and completely irrelevant hits were removed. After reviewing the abstracts using the PICOS criteria, we obtained a list of 79 studies for eligibility evaluation. After the full-text assessment, we obtained a final list of 33 studies for inclusion (cf. Appendix A). Some studies included more than one model, resulting in 55 models to be evaluated. We collected information on the direction of effects and their significance for each of them. A variable was assumed to be statistically significant at the critical 5% level. During the full-text assessment, we identified two studies that did not meet our criteria for statistical significance at the 5% threshold; hence, we excluded them (Wynn et al., 2001; Peerlings and Polman, 2009). One of the 33 studies is a not peer-reviewed conference paper (Dupraz et al., 2002). After checking the quality of the analysis, we decided to include it due to its relevance in bringing valuable perspectives to the discussion. Dupraz et al. (2002) explore the role of targeted ecosystem services on AECM adoption.

3.2. Data collection and analysis

Building on our conceptual framework from the previous section, we grouped the independent study variables into eight adoption determinants explaining our four categories in the participation framework. An overview of the proposed categorisation is shown in Table 1. As argued by Prokopy et al. (2019), there is no specific mechanism to assign the variables to a given category. Indeed, no independent variable included in primary studies explains *per se* farmers' decisions to adopt. We consistently assigned the variables to our categories and determinants following the conceptual framework outlined in Section 2.

While all the studies attempt to describe farmers' decisions to participate in AECM, they differ in the selection of variables included in their models. Since not all models incorporate all variables, we relied on the criteria discussed in Borges et al. (2019) and Prokopy et al. (2019) to deal with multiple independent variables. First, we only included variables that corresponded to our conceptual framework, excluding for instance locational variables. Second, we grouped similar but not necessarily identical variables. For example, receiving information from private extension services or from financial entities were merged, reflecting the influence of receiving information from private entities. While this approach allowed us to synthesize information from various studies, it may have resulted in some loss of information regarding the individual indicators' ability to capture an effect on participation. To help readers understand the types of variables included in the primary studies, we provide definitions in Appendix B. In a few cases, certain variables were only briefly explored in a single study and did not fit into our predefined four categories (e.g., "farmer mental health" or "farmer's satisfaction with the farming lifestyle"). We chose not to include these variables in our analysis. Finally, since studies with multiple models averaged around three models, we included a variable in the final analysis only if it was used in at least four models. This ensured findings from at least two different studies to be observed.

To analyse and synthesize our results, we used a vote-count method, generating tables of significance counts from the analysed models (Bushman and Wang, 2009). We focused on direction and significance of observed effects rather than effect sizes: estimated coefficients were

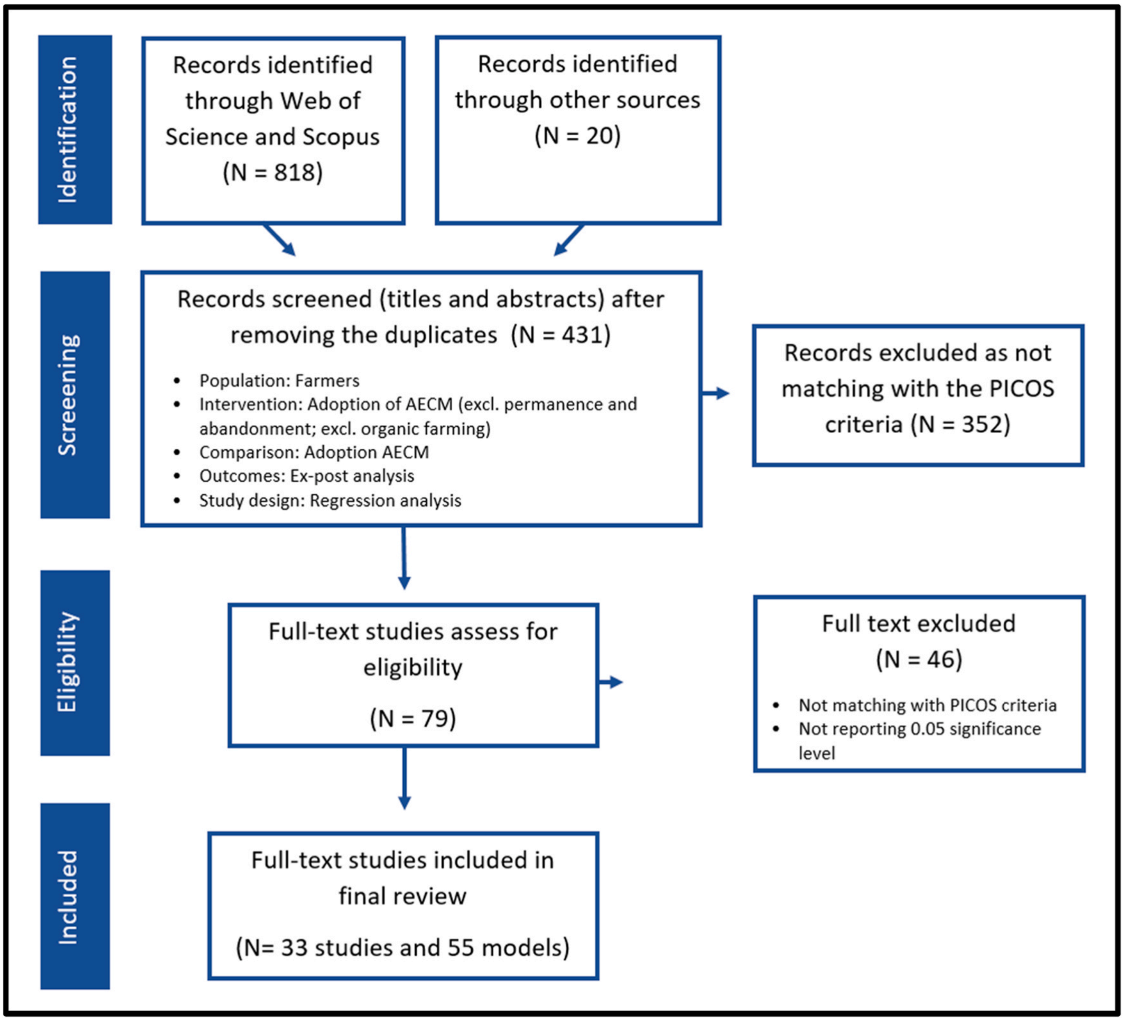

Fig. 2. PRISMA Flow outlining steps and results of article screening.

categorised as either significantly positive, significantly negative, or non-significant. We then calculated the frequency of significant and insignificant effects for a specific explanatory variable on the adoption decisions across all studies. While a meta-analysis of effect sizes would have been preferred approach, allowing us to assess the magnitude effects on adoption decisions (Borenstein et al., 2009), the limited number of studies, along with the heterogeneity in study designs and reported information, precluded the use of meta-regression techniques. The vote-count analysis is considered a valid alternative: it enables us to identify cases where the effect is probably not-zero, offering a transparent and informative overview of results from various studies (Prokopy et al., 2019). For our study, vote-counting allows to observe how frequently various constructs have been examined in primary research and assess the existing evidence regarding their role in farmers' adoption decisions. The method does not control for statistical power, thus, for a more accurate interpretation of results, we include information about the sample sizes in Appendix A. We also reference the papers in the results section, allowing readers to easily trace back to the original study and assess the effect size.

4. Results

4.1. Summary of articles

Italy and Ireland are the countries with the highest number of studies on AECM adoption (Fig. 3). Although most studies (97%) in this review were published after 2000 (Fig. 4a), some of the earlier studies (9%) used data from the 1990 s (Appendix A) (Crabtree et al., 1998; Damianos and Giannakopoulos, 2002; Dupraz et al., 2002). Predominant methodological approaches consist of logit and probit models (88% of the studies). As depicted in Figs. 4(c) and 4(d), there is some heterogeneity across studies regarding sample size and data source. Seventeen studies used survey data, while twelve illustrated their models using datasets from the European Farm Accountancy Data Network (FADN)[2] or other regional databases. The remaining four studies combined survey data with either FADN or spatial data. Sample sizes ranged from 72, 686 (Bartolini and Vergamini, 2019) to 103 observations (Espinosa-Goded et al., 2013).[3] Most models featured general AECM participation (38%) or measures promoting integrated agriculture (22%). Fewer models addressed the adoption of AECM for water (9%), low input use (7%), biodiversity (7%) or landscape (3%).

[2] FADN is a source of European farm-level microeconomic data, collected in each country using harmonised bookkeeping principles. It is based on national surveys and only covers EU agricultural holdings which, due to their size, can be considered commercial.

[3] Zimmermann et al. (2015) estimated 22 adoption country-level models using 155,516 observations; information about country model samples sizes is lacking.

Table 1
Vote-count frequencies of observed independent variables.

Category	Determinant	Variable[a]	# of studies	Signif. (+) %	Signif. (-) %	Insignif. %	# of models
Alignment	**AECM compatibility with perceived environmental problem**	Age	25	9%	53%	38%	34
		Education	16	43%	4%	52%	23
		Agricultural education	7	38%	0%	63%	8
		Awareness	13	41%	12%	47%	17
		Pro-environmental behaviour	15	53%	6%	41%	17
	AECM compatibility with farming objectives	Future of the farm	8	0%	14%	86%	14
		Full-time farming	4	25%	0%	75%	4
		Household Income	9	0%	58%	42%	12
		Farm income	10	14%	43%	43%	14
		Off-farm income	13	33%	14%	52%	21
		Mechanization	4	0%	100%	0%	7
		Investments	3	50%	17%	33%	6
	AECM compatibility with production system	Economic size	6	43%	14%	43%	7
		Farm size	27	45%	11%	45%	38
		Location in LFAs	17	59%	5%	36%	22
		Specialized farms	5	0%	86%	14%	7
		Mixed farms	12	27%	7%	67%	15
		Horticulture	4	0%	50%	50%	8
		Permanent crops	8	8%	0%	92%	12
		Dairy farming	9	15%	31%	54%	13
		Cattle farming	17	33%	15%	52%	27
		Grassland or forage	8	67%	22%	11%	9
		Livestock density	11	28%	22%	50%	18
		Sheep	6	63%	13%	25%	8
		Land productivity	7	57%	36%	7%	14
Opportunity	**Direct costs and benefits**	Capital	5	0%	13%	88%	8
		Risk/Innovation	9	50%	17%	33%	12
		Family labour supply	11	18%	29%	53%	17
		Total labour supply	6	22%	11%	67%	9
		Rented land	10	13%	13%	75%	16
	Transaction costs	Trust in the institutions and policy stability	5	57%	14%	29%	7
		Participation in previous (other) AECM	17	68%	4%	29%	28
		Neighbour participation	8	67%	0%	33%	12
Engagement	**Information**	Information from privates	7	50%	0%	50%	10
		Information from public organizations	5	71%	0%	29%	7
	Interpersonal communication	Participation in farmer organization	7	33%	17%	50%	12
		Participation in social organizations	5	56%	22%	22%	9
Contracting	**Overall design of the measure**	Satisfaction with the design	7	91%	0%	9%	11

[a]A detailed description of the variables is included in Appendix B.

4.2. Vote count

Our studies used a wide range of variables to explain AECM participation. This is consistent with previous reviews (Lastra-Bravo et al., 2015; Borges et al., 2019; Prokopy et al., 2019; Schaub et al., 2023). The initial list of over 60 variables used to explain adoption was narrowed to 38, applying the categorisation criteria from Section 3.2. In line with Borges et al. (2019), we note that the independent variables most frequently included in primary studies are those that are the easiest to measure, such as age, education, farm size or income. Variable selection is often based on practical, rather than theoretical considerations (Borges et al., 2019). For instance, 14 out of 33 studies used farm accountancy data, significantly constraining the range of researchable variables. Only Damianos and Giannakopoulos (2002) and Wąs et al. (2021) combined FADN with survey data to overcome this limitation. Table 1 shows the results from the vote-count and the frequency of the variables' effects on AECM adoption. Frequency was calculated based on number of models, rather than articles.

The vote-count analysis reveals that 16 out of the 38 variables have more often an insignificant effect on AECM adoption than a significant one (42% of all observed variables were insignificant in most models). It is important to notice that the absence of a statistically significant effect does not rule out the possibility that the variable would in fact have an effect, as it could reflect: i) small sample sizes and low statistical power; ii) variables being ill-conceptualised and measured; iii) multicollinearity between the independent variables (Borenstein et al., 2009). Yet, compared to previous reviews (Knowler and Bradshaw, 2007; Borges et al., 2019; Prokopy et al., 2019), our study identifies a smaller proportion of insignificant variables. Indeed, out of 38 variables examined, 14 (36%) have an increased likelihood of a positive and significant effect on adoption. Four variables (11%) show convergence towards a negative effect, while two variables have a significant positive effect in half of the models, and one variable a significant negative effect. This greater significance might be co-explained by our variable aggregation and shortlisting procedures, omitting variables tested only occasionally (e.g., gender, farming experience).

Even when a variable significantly affects adoption decisions, the signs of the effects are not always consistent across studies. This is especially true for variables such as farm income, dairy or cattle specialisation, land productivity and participation in social organization. Among the 38 variables, only 12 showed a consistent direction in their effect, reminding us of how heterogeneous and contextualised the settings are for farmers when deciding on AECM adoption. Upon closer examination, we observe that variables featuring alignment (e.g., age,

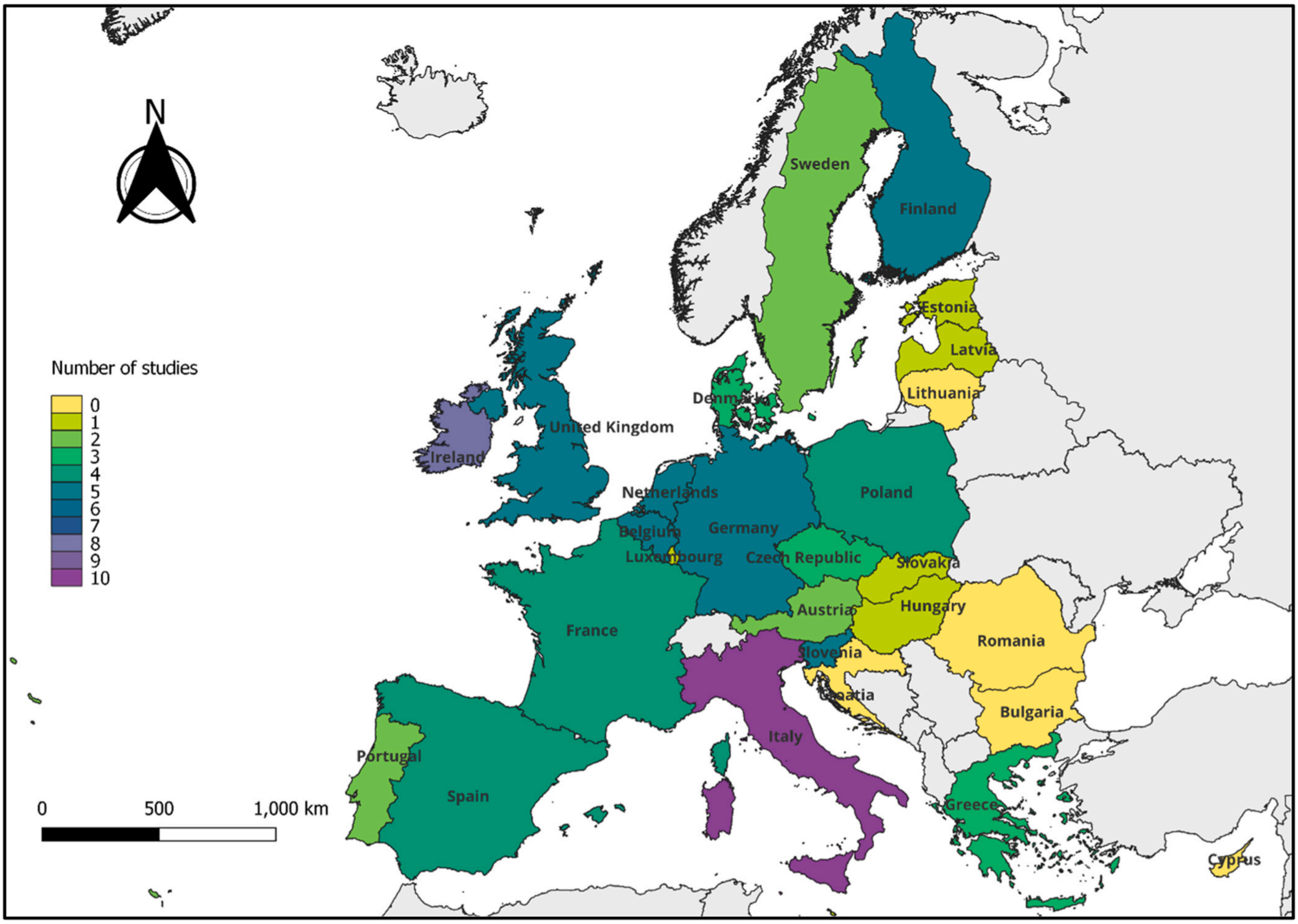

Fig. 3. EU countries in the review.

education, income, farm size, specialisation, and location) and opportunity (e.g., openness to innovation, tenure, family labour and participation in previous AECM) appear recurrently across models (Fig. 5). Conversely, variables explaining engagement or contracting are less frequently observed. These are prone to subjective, hard-to-aggregate interpretations of researchers. Yet, despite being occasionally observed, engagement and contracting variables hold a high share of significance, as do transaction cost variables (Fig. 6). The reverse is true for variables featuring alignment with the farming production system, or the cost and benefits of participation.

Next, we broke down our vote count into sub-samples addressing different environmental objectives (Keenleyside et al., 2011). Fig. 7 pairs the most frequently featuring variables to six objectives. An initial observation indicates a significant negative effect of farm size on the adoption of measures promoting integrated agriculture. This could be attributed to economies of scale, particularly the fact that larger farms often specialize in crops or livestock that can be managed more efficiently at a large scale (Lastra-Bravo et al., 2015). Similarly higher farm income seems to positively influence the adoption of water protection measures, confirming the idea that greater financial capacity encourages the adoption of innovations and technologies (Schulz and Börner, 2023). However, our results find no systematic pattern correlating significant AECM adoption variables to environmental objectives. It is likely that environmental objectives alone explain little about the management changes farmers would need to implement.

4.3. *Determinants of participation*

4.3.1. *Alignment*

AECM compatibility with perceived environmental problem: We now analyse the reviewed evidence on significant effects of adoption determinants. First, we used alignment variables describing farmers' knowledge, awareness, and environmental attitudes to capture AECM compatibility with the perceived environmental problems.

Farmers' age is examined in 62% of the models (34), assuming younger farmers are more likely to flexibly accept new ideas, including sustainable practices and AECM (Wynn et al., 2001; Mills et al., 2013). Indeed, despite widespread insignificance (38%), the observed models confirm a significant relationship between higher age and lower AECM participation (53%) (Damianos and Giannakopoulos, 2002; Hounsome et al., 2006; Mante and Gerowitt, 2007; Borsotto et al., 2008; Polman and Slangen, 2008; Hynes and Garvey, 2009; Capitanio et al., 2011; Giovanopoulou et al., 2011; Mettepenningen et al., 2013; Pascucci et al., 2013; Murphy et al., 2014; Bartolini and Vergamini, 2019; Cullen et al., 2021). Among the reviewed studies, only Barreiro-Hurlé et al. (2010), Zieliński et al. (2023) and Gachango et al. (2015) found that older farmers are more likely to adopt AECM. This is attributed to older farmers' preference for AECM that require traditional, easy-to-implement, and low-risk management practices (Potter and Lobley, 1992).

Well-educated farmers should understand agri-environmental challenges, thereby adapting better to new management techniques (Wilson and Hart, 2000). Again, despite the often insignificant correlations

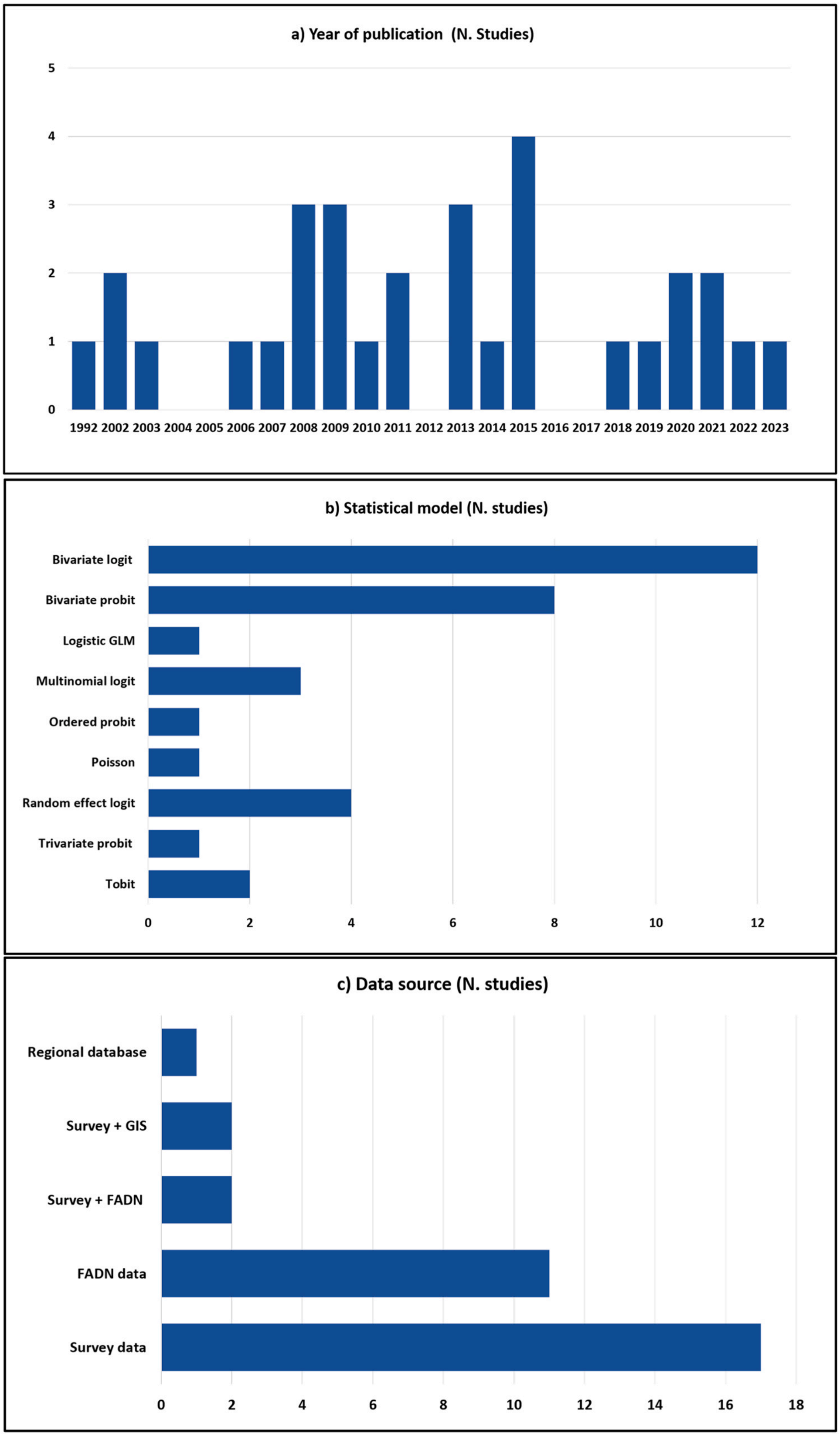

Fig. 4. Summary of studies included in the review.

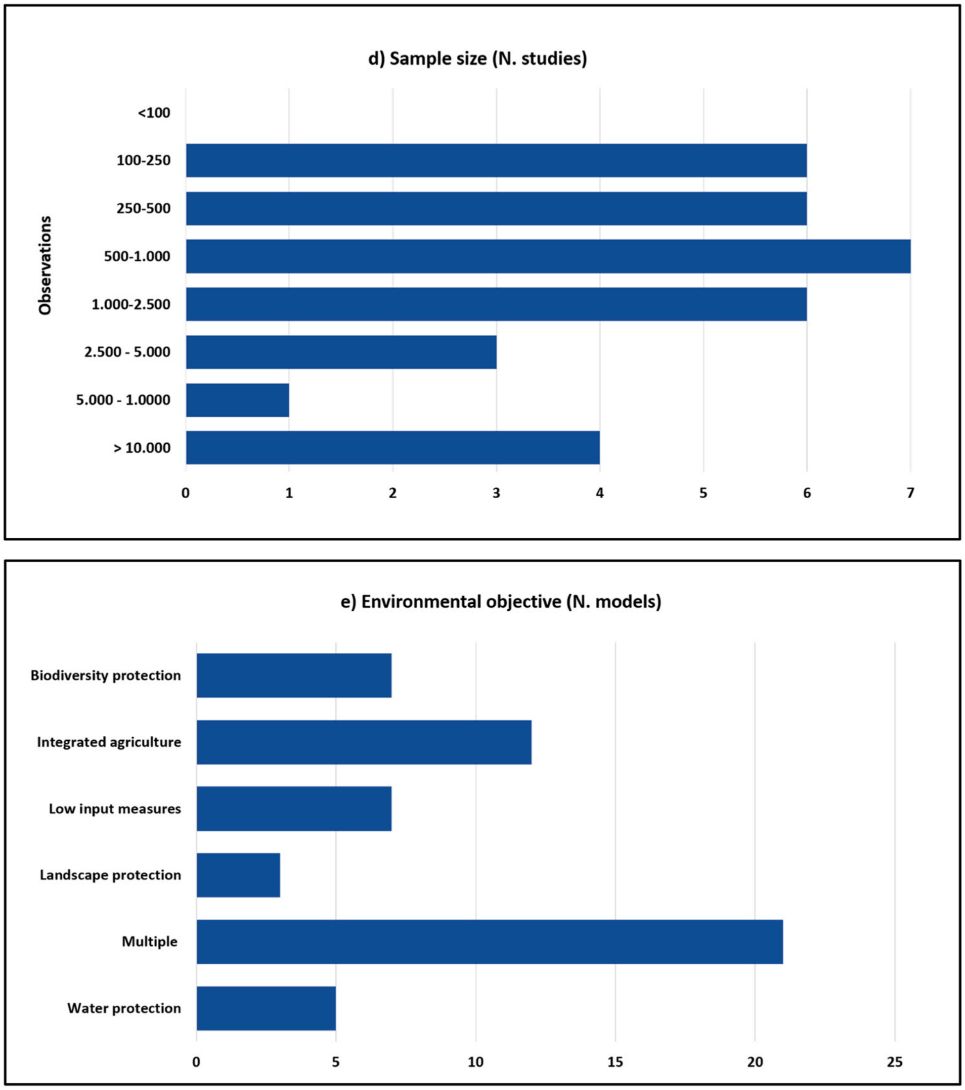

Fig. 4. (*continued*).

(52%), education converges towards a positive effect in 43% of the observed cases (Damianos and Giannakopoulos, 2002; Mante and Gerowitt, 2007; van Rensburg et al., 2009; Barreiro-Hurlé et al., 2010; Giovanopoulou et al., 2011; Špur et al., 2018; Bartolini and Vergamini, 2019; Wąs et al., 2021; Zieliński et al., 2023). However, educational effects may depend on farmers' attitudes towards adoption. For instance, in the case of passive adopters (e.g., joining just for financial reasons), higher education was found to diminish AECM uptake (Defrancesco et al., 2008). Pannell et al. (2006) suggest that the attendance of specific training courses may be a more important predictor of adoption compared to formal school education. Among the eight models that included agricultural education, five found no link to AECM adoption, while the remaining three observed a positive and significant effect (Damianos and Giannakopoulos, 2002; van Rensburg et al., 2009).

Environmental awareness should strongly boost perceived AECM relevance (Whitten et al., 2013; Dessart et al., 2019). Our studies measure awareness either by the extent of environmental damage farmers have already experienced (e.g., soil degradation or water pollution) or by their comprehension of environmental regulations (e.g., familiarity with Natura 2000 or low-input farming regulations). Most models show insignificant effects (47%) and 41% found a significant positive correlation (Wossink and van Wenum, 2003; Barreiro-Hurlé et al., 2010; Giovanopoulou et al., 2011; Špur et al., 2018; Pagliacci et al., 2020). Only Murphy et al. (2014) and Paulus et al. (2022) observed a reduced probability of adoption in the presence of soil erosion or nitrogen contamination. Their results might be related to endogeneity problems, as enrolment in certain AECM is often conditional on farmers meeting minimum environmental conditions. Similarly, pro-environmental attitudes were found to positively influence adoption in 53% of the 17 models (Mante and Gerowitt, 2007, 2009; Borsotto et al., 2008; Pascucci et al., 2013; Murphy et al., 2014).

AECM compatibility with farming objectives: Economic, environmental and socio-cultural farming objectives are thought to influence perceived AECM relevance (Dessart et al., 2019), with farm economic dimensions allegedly being key to adoption decisions AECM (Lastra-Bravo et al., 2015). Also, the expected farm future might influence uptake. Yet, having a successor or farm continuation plans was found to be significant only in one study over eight. Defrancesco et al. (2008) found farmers without future perspectives to be more likely to join AECM – opposed to more confident, profit-maximising farmers (Leonhardt et al., 2022). Likewise, investment plans for the future were found to reduce the probability of AECM adoption, particularly when measures require important changes in production practices (Barreiro-Hurlé et al., 2010). Conversely, a positive association between investments and

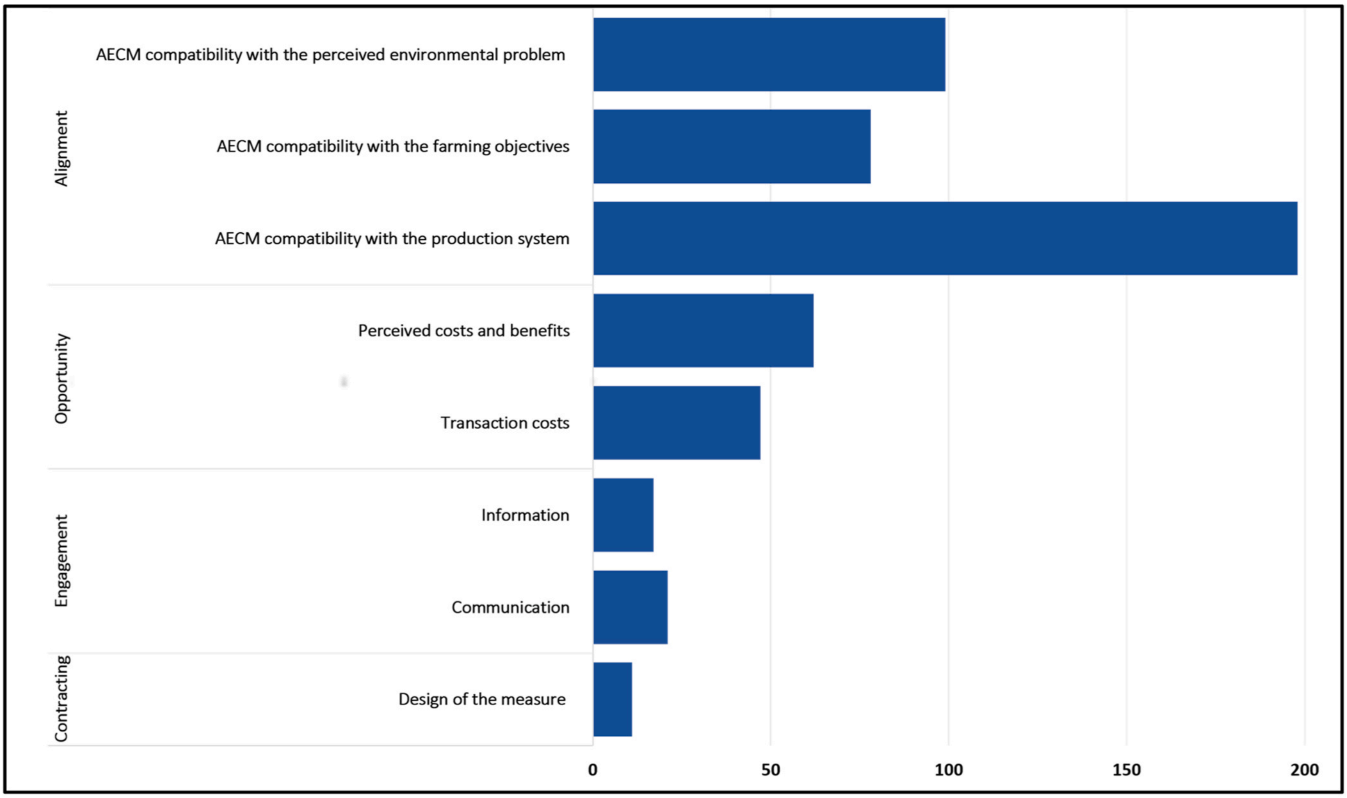

Fig. 5. Number of variables observed within determinant groups.

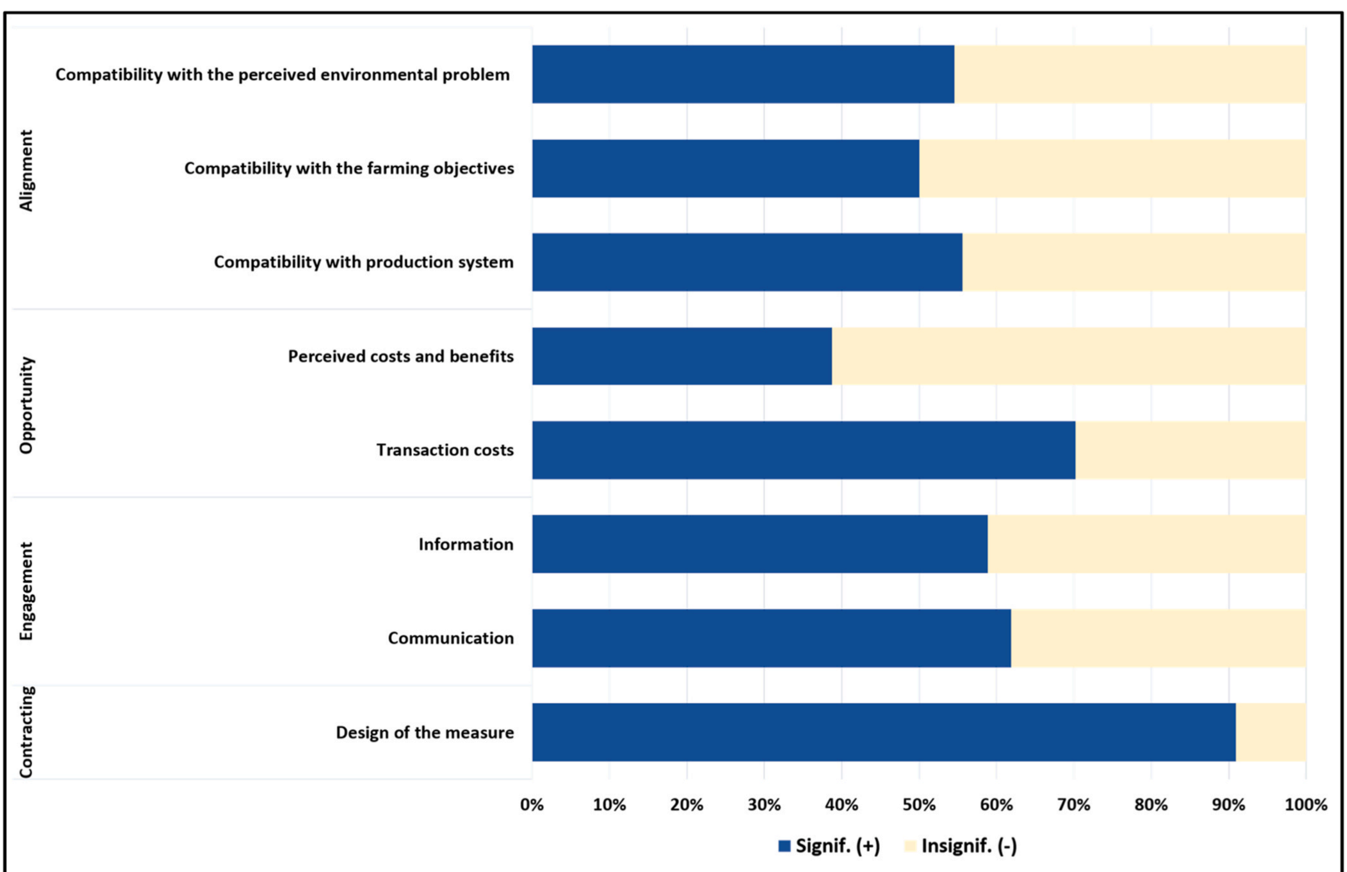

Fig. 6. Share of significant and insignificant variables within determinant groups.

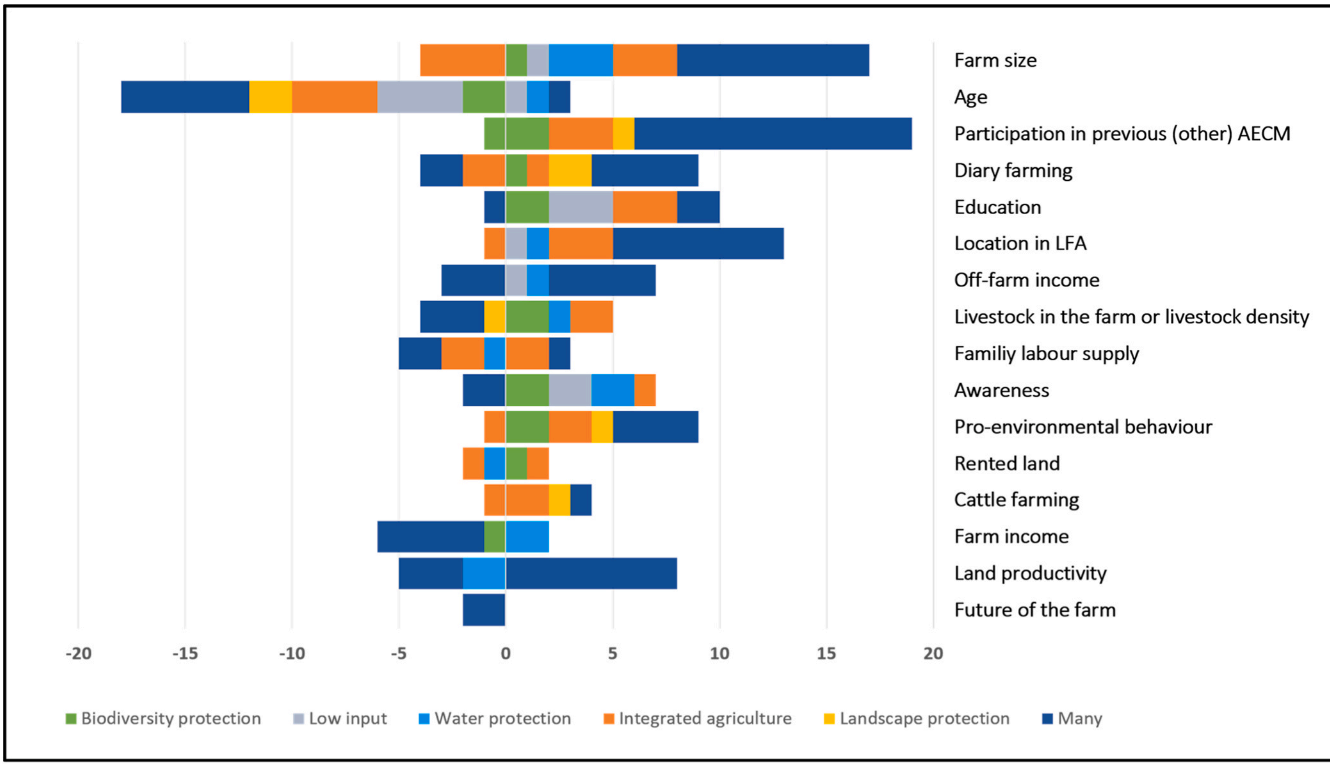

Fig. 7. Vote count by type of agri-environment objective: number of times a variable is found positive (right-hand) and negative (left-hand).[4].

AECM adoption was observed by Polman and Slangen (2008) and Ducos et al. (2009), especially in connection with changes in the agricultural management.

The literature on adoption of sustainable farming practices has consistently examined the role of farmers' income, often associating it with farming objectives (e.g., dependency on farming profits), flexibility and risk aversion (Pannell et al., 2006). Our picture here is mixed: of 12 studies evaluating the adoption effect of increased household income, 42% reported an insignificant effect, while 58% a significantly negative correlation. The latter argue that lower household and farm-related income can make participation in AECM more attractive to farmers, as income support enabled by lower opportunity costs (Defrancesco et al., 2008; Hynes and Garvey, 2009; Barreiro-Hurlé et al., 2010; Murphy et al., 2014; Cullen et al., 2020, 2021; Wąs et al., 2021). Conversely, Grammatikopoulou et al. (2016) found that a higher farm income may favour adoption, suggesting that wealthier and more commercially oriented farmers might be less risk-averse. Around 33% of the models investigating the role of off-farm income found a positive correlation between higher shares of non-farm income and adoption probability, while 52% failed to find an effect (Defrancesco et al., 2008; Polman and Slangen, 2008; Unay Gailhard et al., 2015; Unay Gailhard and Bojnec, 2015; Grammatikopoulou et al., 2016; Wąs et al., 2021). The observed correlation underscores the significant role played by risk preferences in agricultural decision-making (Dessart et al., 2019). Finally, Capitanio et al. (2011) observed that family farms are more reluctant to join an AECM compared to commercial farms, possibly because of the increased transaction costs associated with participation, which can be more easily managed by larger organizations.

AECM compatibility with production system: The effect of the farm economic size or economic performance (e.g., per-hectare margin) has attracted some research attention. Yet, our review found this variable to be positively correlated with participation in 43% of the seven models that include this variable (Crabtree et al., 1998; Zimmermann and Britz, 2016). This finding confirms the idea that wealthier and more structured farmers are more willing to adopt AECM (Grammatikopoulou et al., 2016).

Farm size, together with farmer's age, is considered in more than half of our studies. It was often found to be insignificant (45%) (e.g., Peerlings and Polman 2009 and Wąs et al. 2021), while in 45% of the models, it was found to have a positive relationship with AECM participation (Crabtree et al., 1998; Dupraz et al., 2002; Hynes and Garvey, 2009; Murphy et al., 2014; Gachango et al., 2015; Grammatikopoulou et al., 2016; Špur et al., 2018; Bartolini and Vergamini, 2019; Cullen et al., 2020, 2021; Paulus et al., 2022; Zieliński et al., 2023). The main argument for the positive correlation is that larger farms may have more areas available for low-intensive practices, thus areas with low opportunity costs of enrolment. Only Capitanio et al. (2011) and Pascucci et al. (2013) suggest a negative relationship for AECM promoting integrated agriculture.

Most examined models (59%) show that being located in productively less-favoured areas increases the probability of participation (Hynes and Garvey, 2009; Unay Gailhard et al., 2015; Unay Gailhard and Bojnec, 2015; Unay-Gailhard and Bojnec, 2016; Bartolini and Vergamini, 2019). Lower productivity often coincides with lower income and reduced opportunity costs, thus with the need for complementary farm-income support (Lastra-Bravo et al., 2015). The same effect is, however, not captured by the seven studies measuring the relationship between land productivity (e.g., gross output per hectare) and AECM participation. Indeed, 57% of the models report that increased land productivity has a positive effect on AECM (Murphy et al., 2014; Unay Gailhard and Bojnec, 2015; Wąs et al., 2021), while 36% observe a negative effect. The role of specialisation yields mixed results: out of eight models, specialisation in horticulture had a negative impact in all

[4] The figure shows only variables observed in >14 models

significant cases (50%) (Pascucci et al., 2013; Zimmermann and Britz, 2016), while specialisation in permanent crops was insignificant in 92% of the twelve models (Capitanio et al., 2011; Pascucci et al., 2013; Unay Gailhard and Bojnec, 2015; Cullen et al., 2020, 2021; Wąs et al., 2021). For dairy production and cattle production, specialisation effects were inconsistent across studies. Results were insignificant in 54% and 52% of cases, respectively. However, in the case of dairy farming, the majority of significant results revealed a negative correlation with participation (31%) (Polman and Slangen, 2008; Murphy et al., 2014; Zimmermann and Britz, 2016), while in the case of cattle farming, most significant results found a positive effect on participation (33%) (Dupraz et al., 2002; Borsotto et al., 2008; Capitanio et al., 2011; Unay Gailhard and Bojnec, 2015; Cullen et al., 2020, 2021). Dupraz et al. (2002) and Polman and Slangen (2008) identified a distinct effect for alternative measures: livestock farmers were more likely to adopt measures targeting biodiversity than low-input schemes. This could be attributed to the lower cost of altering management practices, as well as the specific requirements posed by the AECM. The effects of larger livestock density on participation are also mixed, as observed in 11 studies and 18 models: 50% of the models showed insignificant effects, 28% a positive effect (Defrancesco et al., 2008; Barreiro-Hurlé et al., 2010; Espinosa-Goded et al., 2013) and 22% a negative effect (Dupraz et al., 2002; Cullen et al., 2020, 2021). More generally, out of 15 models scrutinizing mixed production systems, 27% found that extensive production systems increased AECM participation (Dupraz et al., 2002; Espinosa-Goded et al., 2013; Unay-Gailhard and Bojnec, 2016; Bartolini and Vergamini, 2019). Similarly, having grassland and managing forage areas was also more often found to increase probability of participation (67% of models out of 9) (Mante and Gerowitt, 2007; Ducos et al., 2009; Wąs et al., 2021; Paulus et al., 2022).

4.3.2. Opportunity

Perceived costs and benefits: Capital is frequently used in empirical studies as an indicator of a farmer's capacity to make pre-investments. Farmers with increased assets value are presumed to be more likely to participate, due to their capacity to cover initial adoption costs (Unay-Gailhard and Bojnec, 2016). Our analysis did not support this assumption. Out of eight models observing this variable, seven did not find a significant effect (Borsotto et al., 2008; Capitanio et al., 2011; Unay Gailhard and Bojnec, 2015; Wąs et al., 2021). This suggests that the value of assets in different regions tells us little about farmers' willingness to take risks and participate in an AECM. Similarly, this indicator might not be a reliable proxy of farmers' participation costs and their capacity to bear them.

Farmers' risk tolerance and openness to innovation are often discussed as adoption factors (Borges et al., 2019; Prokopy et al., 2019), but were little tested in our sample. Only nine studies had explored the effect of such variables, and the evidence was mixed. (Wossink and van Wenum, 2003) and Wąs et al. (2021) found that pro-innovation attitudes among farmers negatively influenced participation, while the other studied found these to be positively correlated (Mante and Gerowitt, 2007, 2009; Barreiro-Hurlé et al., 2010; Capitanio et al., 2011; Giovanopoulou et al., 2011; Cullen et al., 2020).

While the availability of more farm labour is sometimes believed to increase farmers' adoption (Prokopy et al., 2019), our results are inconsistent likely because the relationship between labour and participation depends on the labour intensity of the required management practice. Both family labour and total farm labour were mostly having insignificant effects, with 53% and 67% of the cases out of 17 and 9 models, respectively. When the impact was significant, family labour more often had negative (29%) (Defrancesco et al., 2008; Capitanio et al., 2011; Pascucci et al., 2013; Unay Gailhard and Bojnec, 2015; Unay-Gailhard and Bojnec, 2016), rather than positive effects on AECM adoption (18%) (Pascucci et al., 2013; Wąs et al., 2021). The farming system and the differences in accessibility to AECM across farm types and regions, can explain this variability. Equally mixed results were found for the role of farm tenure. While 75% out of 16 reviewed models found it insignificant, Bartolini and Vergamini (2019) observed a significant positive effect, and Crabtree et al. (1998) a significant negative one. Defrancesco et al. (2008) found contrasting evidence across two models, one for adoption of biodiversity measures and the other of water protection measures. Their results suggest that the role of tenure on the adoption decision might relate to the level of investment required by the AECM on rented land.

Transaction costs: High transaction costs assumedly prevent especially small farmers from adopting sustainable practices (Ducos et al., 2009). The role of trust in influencing participation was observed only by five studies across seven models. While 29% of the observations did not show a significant effect, most of the significant results (57%) suggest that the perceived stability of policy instruments and favourable attitudes towards institutions are positively correlated with AECM uptake (Mante and Gerowitt, 2007; Polman and Slangen, 2008; Ducos et al., 2009). Participation in previous AECM or other types of subsidised programs was also found to increase the likelihood of participation in most of the observed models (68% out of 28 models), illustrating the importance of experience in reducing information asymmetry and improving trust in public policies (Dupraz et al., 2002; Borsotto et al., 2008; Ducos et al., 2009; Hynes and Garvey, 2009; Mante and Gerowitt, 2009; Pascucci et al., 2013; Murphy et al., 2014; Unay Gailhard and Bojnec, 2015; Unay-Gailhard and Bojnec, 2016; Cullen et al., 2020, 2021; Wąs et al., 2021). This would be consistent with transaction cost theory, stating that actors' opinions and previous experiences with government programmes influence uncertainty, and consequently transaction costs. For variables capturing the role of neighbouring or other farmers' opinions on AECM, whenever we found a significant adoption effect, it was positive (Damianos and Giannakopoulos, 2002; Dupraz et al., 2002; Cullen et al., 2020; Pagliacci et al., 2020; Zieliński et al., 2023).

4.3.3. Engagement

Information: Communication's role in farmers' uptake decisions has received less attention in the adoption literature compared to socio-economic and structural factors. Within the limited number of models incorporating variables associated with receiving information from extension services or financial entities, the results were mixed. Half of the studies concluded that this factor was insignificant, while the others indicated a positive effect on adoption (5 out of 10) (Barreiro-Hurlé et al., 2010; Capitanio et al., 2011; Espinosa-Goded et al., 2013; Grammatikopoulou et al., 2016). Four over five studies demonstrated that receiving information directly from public organisations or funding agencies significantly increases the adoption of AECM (Polman and Slangen, 2008; van Rensburg et al., 2009; Barreiro-Hurlé et al., 2010; Capitanio et al., 2011; Espinosa-Goded et al., 2013; Grammatikopoulou et al., 2016).

Interpersonal communication: A growing literature supports the idea that interpersonal communication boosts farmers' decisions to participate in agri-environment programmes. Our empirical results, drawn from twelve studies, were mixed. Only one third out of twelve models found that participating in agricultural unions or farmers' organisations increased the probability of participation in AECM (Ducos et al., 2009; Barreiro-Hurlé et al., 2010; Capitanio et al., 2011). Meanwhile, 50% of the models yielded insignificant results. The role of farmers' organisations may ultimately depend on the cultural and socio-political context, as well as on the organisational objectives (e.g., cooperative vs. union) (Unay Gailhard et al., 2012). Indeed, a negative effect on adoption was reported by Polman and Slangen (2008). Farmers' membership in civil society organisations was found to positively influence farmers' adoption, seemingly confirming the findings of Unay Gailhard et al. (2012) and Dessart et al. (2019) regarding the pro-adoption effect of interpersonal communication.

4.3.4. Contracting

Only a small number of our studies (7) included information on contract features or farmer perceptions of AECM design. This is because ex-post studies either rely on databases that lack information about the scheme's characteristics or they focus on the adoption of a single AECM, with no statistically significant variation. Nevertheless, some studies reported a positive impact on uptake from greater ease of implementation/ bureaucratic simplification (Defrancesco et al., 2008; Špur et al., 2018; Wąs et al., 2021), increased fairness and flexibility (Polman and Slangen, 2008), and higher compensation levels (Giovanopoulou et al., 2011; Pascucci et al., 2013).

5. Discussion

Our vote-count analysis is consistent with previous research findings (Borges et al., 2019; Prokopy et al., 2019; Schaub et al., 2023). Most of the stipulated adoption variables tend to have an insignificant effect on AECM adoption, with 42% of all observed variables proving to be insignificant in the majority of models. We cautioned that the lack of a statistically significant effect does not necessarily negate the effect's existence; it may rather reflect insufficient evidence to confidently assert its presence. Among the statistically significant results, certain variables consistently exhibit a positive influence on AECM adoption. For example, factors like receiving agricultural education, increased neighbour participation, access to more information, and satisfaction with the scheme's design have been found to positively impact AECM adoption. In contrast, high levels of specialization and income appear to have a negative association with participation. However, as Schaub et al. (2023) have also observed, the relationship between these variables and participation is not straightforward in most cases, highlighting the diversity of AECM adoption contexts. This diversity was not depicted by agro-ecological characteristics or targeted ecosystem services; rather it was deeply intertwined with a complex array of farms/farmers structural, socioeconomic, and socio-psychological influences (Leonhardt et al., 2022). This complexity underscored the importance of well-contextualized AECM designs, tailored to each case study and farmer population, as well as the specific nature of AECM being implemented.

In the development of well contextualized designs, key questions to consider include: What concrete changes in the farming system are being targeted? Which farmers are more likely to produce the desired results and what level of management change is required? How will the prevailing context shape the dimensions of alignment, opportunity, engagement, and contracting? Which of these dimensions should policymakers prioritise during the scheme design to ensure effective participation? Addressing these questions, has been made easier by the use of collaborative approaches (e.g., co-design), experimental techniques and semi-qualitative research methods, such as Choice Experiments, Q-methodology and Delphi studies. These approaches have proven to be promising tools to bridge the priorities of farmers vs. agri-environmental policy implementers (Walder and Kantelhardt, 2018; Canessa et al., 2022; Hurley et al., 2022; Kelemen et al., 2023; Schulze and Matzdorf, 2023). These methods facilitate the exploration of viewpoints and motives influencing adoption (or non-adoption) decisions, as well as the identification of contract features that enhance acceptance.

The framework proposed in this paper can assist assessing how different contexts influence the dimensions of alignment, opportunity, engagement, and contracting. It also allows determining which of these dimensions should be prioritized during the scheme's design. For each construct along the decision process, it is possible to derive which variables have shown to be most significant and the direction of the effect. Within the decision-making process, it's possible to identify: 1) aspects related to the underlying farm population that influence adoption decisions but are not easily changed by regulators (e.g., age, farm size, off-farm income, land productivity and location in LFA); 2) non-structural aspects that impact adoption and cannot be changed in the short run but should be considered when targeting participants in scheme design (e.g., level of education, trust in institutions, or past participation levels); 3) aspects affecting participation that can be addressed by AECM implementers in the medium-short term (e.g., information, engagement with organizations, and scheme design improvements).

Based on our analysis, alignment is particularly important for boosting participation. Those variables explaining the AECM alignment with farmers' attitudes and operations were found to have a significant effect on adoption in more than 50% of observed cases. As discussed, increasing alignment between the AECM and farmer objectives excessively could aggravate selection biases undermining the AECM's capacity to achieve environmental objectives. In other words, a singular focus on maximizing AECM participation through perfect alignment might lead to the unintended consequence of not getting enough of the 'right' farmers to join. For instance, in the case of AECM initiatives targeting agricultural extensification, a high share of participating well-aligned farmers might have complied even in the absence of the program (Canessa et al., 2023). In this context, Whitten et al.'s (2013) adapted participation framework offers a tool to account for trade-offs between AECM effectiveness and pragmatic delivery of the payments. For instance, programme implementers could deliberately opt for designing a less aligned AECM, allocating more resources to other decision-making aspects, such as increasing the perceived relative advantage of participation through engagement activities. By doing so, they would help mitigate inherent risks of self-selection biases among highly aligned farmers, reaching instead a farming population that would otherwise not have participated.

Despite being examined in a limited number of studies, the variables explaining the role of lower transaction costs, social contexts, and satisfactory contract design frequently appear to be significant (out of eight variables, six have a positive and significant effect on adoption in more than 50% of observed cases). These findings go by hand with the evidence from behavioural studies which stress the importance of social factors and cognitive factors in shaping farmers decision-making (Dessart et al., 2019). Given the positive role played by engagement in the decision-making process, we argue that particular importance should be given to reducing information asymmetries between farmers and authorities. Tools to improve understanding of how different farming practices affect the provision of public goods are needed to influence environmental awareness and pro-environmental attitudes. This could increase the alignment of AECM with farmers' needs, consequently increasing the perceived advantage of participation. Also, forms of farm-tailored advice could be considered for more environmentally ambitious AECM. The literature suggests that farmers frequently lack a complete understanding of the costs and benefits associated with alternative management practices, and thus, their perceptions of (dis) advantage of participation may be distorted.

While opportunity costs play a key role in the adoption decision, the variables describing AECM compatibility with the production system and the opportunity to participate were often insignificant. This could be attributed in part to the aggregation procedure, the heterogeneous indicators used by empirical studies, and the specific contextual factors that might influence how production systems integrate with the Rural Development Policy. For AECM implementers, the critical task lies in identifying who are the farmers with higher opportunity costs, and determining to which extent their participation in AECM is necessary to achieve specific environmental goals. To encourage the participation of farmers with higher opportunity costs, AECM implementers can either increase incentives through tailored methods like auctions or differentiated payments (Rolfe et al., 2021; Schaub et al., 2023), or invest in nudging and signalling strategies (Kuhfuss et al., 2016). For a more comprehensive understanding of farmers' opportunity costs, future research should enhance opportunity assessments, clarify interpretation and measurement of variables, consider external factors like political uncertainty and market conditions, and control for confounders in their analyses.

Ex-post adoption studies often differ in their consideration of variables contributing to the different constructs. On the one hand, variables related to alignment (e.g., age, education, income, farm size, specialisation, location) and opportunity (e.g., openness to innovation, tenure, participation in previous AECM) appear recurrently in different models. On the other hand, variables explaining engagement (e.g., sources of information and communication) or contracting (e.g., AECM design or features) are not always included throughout our studies. These findings suggest that many ex-post adoption studies fail in capturing all aspects of farmers' decision-making processes. By incorporating variables covering the whole participation spectrum, the proposed categorisation can guide the design of future adoption studies. To provide a more comprehensive picture of AECM adoption, farm accounting data could be combined with other data types (e.g., data about farmers' participation in organizations or access to information). The combinations with panel data or spatial data could be considered to capture potential additionality issues. This would expand the scope of the analysis beyond the most covered alignment and opportunity dimensions.

Primary studies using surveys should equitably include variables representing the different constructs/categories to capture how different aspects influence adoption. To minimize the risks of overfitting, the ideal approach would be to identify and include a concise yet comprehensive set of variables that can effectively cover a broad spectrum of decision-making dimensions.

Although many ex-ante studies assess farmers' willingness to adopt measures based on contract attributes, there is little ex-post research on whether farmers are influenced by contract design factors (e.g., monitoring systems, flexibility, and bureaucracy) in their decisions. Exploring this avenue of research would enhance the reliability of ex-ante adoption studies. To strengthen the external validity of observed results, researchers should work towards developing more standardized indicators for behavioural factors (e.g., awareness, environmental attitudes, openness to innovation, risk preferences) and transaction costs.

While our review of the ex-post quantitative literature on AECM provides valuable insights for shaping future measures and guiding ex-post adoption studies, we also need to acknowledge certain limitations. The use of a systematic review approach allowed for a comprehensive and transparent overview of findings; however, it also resulted in the aggregation of results without a systematic account for publication bias, heterogeneity in study designs, effect sizes, and variations between individual indicators. To address these challenges, we made efforts to enable readers to trace back to the original studies. We also implemented narrow inclusion and exclusion criteria to avoid aggregating heterogeneous studies and minimize information loss. While this approach facilitated a systematic comparison of findings from specific studies, it came at the expense of a more comprehensive survey of the literature that considers diverse disciplines and methods. Finally, it is important to note that the use of vote-count analysis prioritizes the frequencies of effects over effect sizes. While beneficial for our objectives in illustrating the relative importance of different constructs on participation decisions, it may overlook the strength of relationships between variables. Future research endeavours could delve into these relationships with greater detail.

6. Conclusion

Agri-environmental-climate measures (AECM) are among the most common policy-tools used to promote sustainability in agriculture worldwide. Due to the voluntary nature of these market-based initiatives, farmers' active participation is the first and quintessential indicator of their success and overall effectiveness. In addition, participation is also a key success indicator for a central AECM (implicit or explicit) side objective: grasping the AECM outreach to provide economic benefits and income support to as many farmers as possible. To increase AECM adoption while ensuring additional environmental benefits, research has called for a more integrated assessment of how economic, behavioural and contractual factors influence farmers' decision-making.

In this literature review, we employed a vote-count approach to synthesize three decades of evidence on farmer participation in agri-environmental-climates measures (AECM) in Europe, offering insights on the progress and findings of ex-post research on AECM adoption. To enhance our understanding of factors influencing decision-making, we systematically analysed stage-specific constructs, grouped into 'alignment', 'opportunity', 'engagement', and 'contracting', in relation to farmer's adoption decisions. All the proposed constructs appeared to be valuable for explaining participation, i.e., all four dimensions should be considered when designing a new measure and monitoring its uptake. Variables reflecting the role of information and interpersonal communication, as well as farmers' satisfaction with the AECM design, were more frequently significant and positively linked to adoption, even though this was observed in a smaller number of studies. This suggests that, independently from alignment and perceived opportunity, AECM implementers should pay adequate attention to engagement requirements and elements of contract design. Co-design, experimental and semi-qualitative approaches offer promising tools for guiding the institutional design of the schemes. Our review also offers insights for the improved design of ex-post studies. By incorporating variables covering the whole participation spectrum, our proposed categorisation can guide the design of future adoption studies. We recommend future studies to incorporate the entire framework while striving to depict the opportunity costs of participation and possible adverse selection. Furthermore, it would be beneficial to explore how the overall findings might be affected if the results of ex-ante studies are included in the proposed analysis.

CRediT authorship contribution statement

Canessa Carolin: Conceptualization, Methodology, Formal analysis, Writing – original draft. **Ait-Sidhoum Amer**: Methodology, Writing – original draft. **Wunder Sven**: Writing – review & editing. **Sauer Johannes**: Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

Data Availability

Data will be made available on request.

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Appendix A. Summary of the reviewed studies

N.	Reference	Year data	Country	Data	Sample size	Measure type	Focus	Statistical model
1	Barreiro-Hurlé et al. (2010)	2006	Spain	Survey	300	Environmental fallow measure Alternative crop in protected areas	Intensity of change	Bivariate probit
2	Bartolini and Vergamini (2019)	2010	Italy	Regional database	72.686	Organic Integrated production	Spatial agglomeration	Multinomial logit
3	Borsotto et al. (2008)	2004	Italy	FADN	2.149	Rural landscape conservation measures	Landscape conservation	Bivariate logit
4	Capitanio et al. (2011)	2009	Italy	FADN	4.652	Competitiveness measures Agri-environmental measures	Participation	Bivariate probit
5	Crabtree et al. (1998)	1998	UK	Survey	2.326	Tree planting - Woodland	Participation	Bivariate logit
6	Cullen et al. (2021)	1996–2018	Ireland	FADN	19.977	Many	Participation over CAP periods	Random effects logit
7	Cullen et al. (2020)	-	Ireland	Survey	904	Many	Role of self-identity and attitudes	Bivariate logit
8	Damianos and Giannakopoulos (2002)	1997	Greece	Survey/FADN	273	Nitrate reduction programme	Extent of participation	Bivariate probit
9	Defrancesco et al. (2008)	2008	Italy	Survey	139	Low input Grassland in water Grassland in Alps	Participation	Multinomial logit
10	Ducos et al. (2009)	2009	FR, IT, NL, BE, UK, DE, IR, FI; CZ	Survey	2.262	Many	Extent of participation	Tobit
11	Dupraz et al. (2002)	1998	AT, BE, FR, DE, EL, IT, SE, UK	Survey	1.638	Landscape management Biodiversity protection Restriction of intensive practices	Participation	Multinomial logit
12	Espinosa-Goded et al. (2013)	2007	Spain	Survey	103	Alternative crop measure	Role of fixed cost	Tobit
13	Gachango et al. (2015)	2013	Denmark	Survey	267	Water-pollution reduction technologies	Participation	Ordered probit
14	Giovanopoulou et al. (2011)	2006	Greece	Survey	125	Nitrate reduction programme	Extent of participation (ha enrolled)	Heckman
15	Grammatikopoulou et al. (2016)	2015	Finland	Survey + GIS national database	756	Water conservation measures	Active adopters (with payment) vs passive adopters (without payment)	Bivariate probit
16	Hynes and Garvey (2009)	1995–2005	Ireland	FADN	294	Many	Participation over time	Random effects logit
17	Hounsome et al. (2006)	2002	UK	Survey	111	Rural landscape conservation measures	Role of mental health on participation	Bivariate logit
18	Mante and Gerowitt (2007)	2006	Germany	Survey	941	Low input measures	Arable farms vs Grassland	Bivariate logit
19	Mante and Gerowitt (2009)	Not specified	Germany	Survey	849	Biodiversity	Adoption of field margins	Bivariate Logit
20	Mettepenningen et al. (2013)	2008	Belgium	Survey	138	Many	Influence of institutional organizations	Bivariate logit
21	Murphy et al. (2014)	1999–2010	Ireland	FADN	1.207	Many	Role of institutional change	Random effect logit
22	Pagliacci et al. (2020)	2007–2014	Italy	Regional database	463	Climate Smart Agriculture	Participation	Poisson
23	Pascucci et al. (2013)	2006	Italy	FADN	15.383	Competitiveness measures Agri-environmental measures	Regional priorities	Random effects logit
24	Paulus et al. (2022)	2019	Germany	Regional database	3.139	Many	Role of landscape context and farm structure	Logistic GLM
25	Polman and Slangen (2008)	2005	NE, BE, CZ, FI, FR, IT	Survey	990	Landscape management Biodiversity protection Restriction of intensive practices	Role of trust and social capital	Trivariate probit
26	Špur et al. (2018)	2016	Slovenia	Survey	198	Extensification for biodiversity protection	Participation in Natura 2000 sites	Bivariate logit
27	Unay-Gailhard and Bojnec (2016)	2004–2010	Slovenia	FADN	4.761	Many	Long-term sustainable behaviour - Participation for at least 5 years	Bivariate logit
28	Unay Gailhard and Bojnec (2015)	2004–2010	Slovenia	FADN	5.255	Many	Role of farm size	Bivariate logit

(continued on next page)

(*continued*)

N.	Reference	Year data	Country	Data	Sample size	Measure type	Focus	Statistical model
29	van Rensburg et al. (2009)	2009	Ireland	Survey	282	Biodiversity protection	Commonage land	Bivariate logit
30	Wąs et al. (2021)	2021	Poland	FADN + survey	594	Many	Participation	Bivariate probit
31	Wossink and van Wenum (2003)	2001	Netherland	Survey	2.050	Biodiversity Field margin measures	Biodiversity Field margin measures	Bivariate probit
32	Zieliński et al. (2023)	2016–2021	Poland	FADN	953	Many	Role of natural constraints on participation	Bivariate logit
33	Zimmermann and Britz (2016)	2000–2009	EU	FADN	155.516	Many	22	Bivariate probit

Appendix B. Description of variables used in the analysis

Determinant	Variable	Description
Alignment		
Compatibility with the perceived environmental problem	Age	Farmers' age
	Education	Years of education
	Agricultural education	Having received an agricultural education
	Awareness	Farmer is aware of the environmental problem
	Pro-environmental behaviour	Farmer has a pro-environmental behaviour
Compatibility with the farming objectives	Future of the farm	Farmer has a successor/farming activity will be maintained
	Full-time farming	Being full-time farmer
	Household income	Household income
	Farm income	Income from agricultural activities
	Off-farm income	Income from non-agricultural activities
	Mechanization	Level of mechanization / Owning machines
	Investments	Farmer has made investments on the farm
Compatibility with production system	Economic size	Farm economic value of production
	Farm size	Farm land area
	Location in LFAs	Location in Less Favoured Areas (LFAs) or areas where the landscape or environmental conditions result in higher production costs (e.g. poor soil or steep slopes).
	Specialized farms	Farm specialized in specific type of agricultural operations
	Mixed farms	Farm combining multiple types of farming activities
	Horticulture	Specialization in horticulture
	Permanent crops	Specialization in permanent crops
	Dairy farming	Specialization in dairy farming
	Cattle farming	Specialization in cattle farming
	Grassland or forage	Share of grassland or forage areas
	Livestock density	Livestock density
	Sheep	Farm is raising sheep
	Land productivity	Levels of land productivity
Opportunity		
Direct costs and benefits	Capital	Value of assets
	Risk/Innovation	Farmer is tollerant to risk / open to innovation
	Family labour supply	Amount of family labour
	Total labour supply	Amount of labour
	Rented land	Share of rented land
Transaction costs	Trust in the institutions and policy stability	The farmer believes that institutions are trustworthy and that policies are stable.
	Participation in previous (other) AECM	Farmer participated in previous / other AECMs
	Neighbour participation	Farmer's neighbours participate in AECMs
Engagement		
Information	Information from privates	Farmer receives information from extension services, financial services or other privates
	Information from public organizations	Farmer receives information from institutions or other public organizations
Interpersonal Communication	Participation in farmer organization	Farmer is a member of an agricultural organization
	Participation in social organizations	Farmer is involved in a social organization
Contracting		
Overall design of the measure	Satisfaction with the design	Farmer is satisfied with the design of the contract

References

Agustín, J., Martínez, F., 2011. Programas agroambientales de conservación del suelo en Andalucía: explicando las decisiones de participación y cumplimiento en el sector del olivar. Cuad. De. Econ. 34 (94), 9–19.

Ait Sidhoum, A., Canessa, C., Sauer, J., 2023. Effects of agri-environment schemes on farm-level eco-efficiency measures: empirical evidence from EU countries. J. Agric. Econ. 74 (2), 551–569.

Ajzen, I., Fishbein, M., 2005. The Influence of Attitudes on Behavior. The handbook of attitudes. Lawrence Erlbaum Associates Publishers,, Mahwah, NJ, US, pp. 173–221.

Barreiro-Hurlé, J., Espinosa-Goded, M., Dupraz, P., 2010. Does intensity of change matter? Factors affecting adoption of agri-environmental schemes in Spain. J. Environ. Plan. Manag. 53 (7), 891–905.

Bartkowski, B., Droste, N., Ließ, M., Sidemo-Holm, W., Weller, U., V. Brady, M, 2019. Implementing result-based agri-environmental payments by means of modelling. UFZ Discussion Papers (5).

Bartolini, F., Vergamini, D., 2019. Understanding the spatial agglomeration of participation in agri-environmental schemes: the case of the Tuscany region. Sustainability 11 (10), 2753.

Batáry, P., Dicks, L.V., Kleijn, D., Sutherland, W.J., 2015. The role of agri-environment schemes in conservation and environmental management (eng). Conserv. Biol.: J. Soc. Conserv. Biol. 29 (4), 1006–1016.

Baumgart-Getz, A., Prokopy, L.S., Floress, K., 2012. Why farmers adopt best management practice in the United States: a meta-analysis of the adoption literature (eng). J. Environ. Manag. 96 (1), 17–25.

Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H.R., 2009. Introduction to Meta-Analysis. Wiley.

Borges, R.J.A., Lansink, O.A.G.J.M., Emvalomatis, G., 2019. Adoption of innovation in agriculture: a critical review of economic and psychological models. Int. J. Innov. Sustain. Dev. 13 (1), 36/56.

Borsotto, P., Henke, R., Macrì, M.C., Salvioni, C., 2008. Participation in rural landscape conservation schemes in Italy. Landsc. Res. 33 (3), 347–363.

Brown, C., Kovács, E., Herzon, I., Villamayor-Tomas, S., Albizua, A., Galanaki, A., Grammatikopoulou, I., McCracken, D., Olsson, J.A., Zinngrebe, Y., 2021. Simplistic understandings of farmer motivations could undermine the environmental potential of the common agricultural policy. Land Use Policy 101, 105136.

Burton, R.J., Schwarz, G., 2013. Result-oriented agri-environmental schemes in Europe and their potential for promoting behavioural change. Land Use Policy 30 (1), 628–641.

Burton, R.J., Kuczera, C., Schwarz, G., 2008. Exploring Farmers' Cultural Resistance to Voluntary Agri-environmental Schemes. Sociol. Rural. 48 (1), 16–37.

Bushman, B.J., Wang, M.C., 2009. Vote-counting procedures in meta-analysis. The handbook of research synthesis and meta-analysis, 2nd ed. Russell Sage Foundation, New York, NY, US, pp. 207–220.

Canessa, C., Venus, T.E., Wiesmeier, M., Mennig, P., Sauer, J., 2023. Incentives, Rewards or Both in Payments for Ecosystem Services: Drawing a Link Between Farmers' Preferences and Biodiversity Levels. Ecol. Econ. 213, 107954.

Canessa, C., Vavvos, A., Triliva, S., Kafkalas, I., Vrachioli, M., Sauer, J., 2022. Implementing a combined Delphi and Focus Group qualitative methodology in Nexus research designs—the case of the WEFE Nexus in Apokoronas, Crete. PLOS ONE 17 (7), 1–24.

Capitanio, F., Adinolfi, F., Malorgio, G., 2011. What explains farmers' participation in Rural Development Policy in Italian southern region? an empirical analysis. N. Medit. 10, 19–24.

CEE, 2022. Guidelines and Standards for Evidence synthesis in Environmental Management. Version 5.1. Retrieved from: www.environmentalevidence.org/information-for-authors.

Crabtree, B., Chalmers, N., Barron, N.-J., 1998. Information for policy design: modelling participation in a farm Woodland incentive scheme. J. Agric. Econ. 49 (3), 306–320.

Cullen, P., Hynes, S., Ryan, M., O'Donoghue, C., 2021. More than two decades of Agri-Environment schemes: Has the profile of participating farms changed? (eng). J. Environ. Manag. 292, 112826.

Cullen, P., Ryan, M., O'Donoghue, C., Hynes, S., hUallacháin, D.Ó., Sheridan, H., 2020. Impact of farmer self-identity and attitudes on participation in agri-environment schemes. Land Use Policy 95, 104660.

Damianos, D., Giannakopoulos, N., 2002. Farmers' participation in agri-environmental schemes in Greece. Br. Food J. 104 (3/4/5), 261–273.

Defrancesco, E., Gatto, P., Runge, F., Trestini, S., 2008. Factors Affecting Farmers? Participation in Agri-environmental Measures: A Northern Italian Perspective. J. Agric. Econ. 59, 114–131.

Dessart, F.J., Barreiro-Hurlé, J., van Bavel, R., 2019. Behavioural factors affecting the adoption of sustainable farming practices: a policy-oriented review. Eur. Rev. Agric. Econ. 46 (3), 417–471.

Ducos, G., Dupraz, P., Bonnieux, F., 2009. Agri-environment contract adoption under fixed and variable compliance costs. J. Environ. Plan. Manag. 52 (5), 669–687.

Dupraz, P., Vermersch, D., Frahan, B.H., de, Delvaux, L., 2003. The Environmental Supply of Farm Households: A Flexible Willingness to Accept Model. Environ. Resour. Econ. 25 (2), 171–189.

Dupraz, P., Vanslembrouck, I., Bonnieux, F., van Huylenbroeck, G., 2002. Farmers' Participation in European Agri-Environmental Policies. International Congress, August 28-31, 2002, Zaragoza, Spain 24799, European Association of Agricultural Economists.

EC, 2021. European Structural and Investment Funds, European Agricultural Fund for Rural Development: Data. Retrieved from: https://cohesiondata.ec.europa.eu/funds/eafrd.

Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: An overview of the issues. Ecol. Econ. 65 (4), 663–674.

Espinosa-Goded, M., Barreiro-Hurlé, J., Dupraz, P., 2013. Identifying additional barriers in the adoption of agri-environmental schemes: the role of fixed costs. Land Use Policy 31, 526–535.

Falconer, K., 2000. Farm-level constraints on agri-environmental scheme participation: a transactional perspective. J. Rural Stud. 16, 379–394.

Gachango, F.G., Andersen, L.M., Pedersen, S.M., 2015. Adoption of voluntary water-pollution reduction technologies and water quality perception among Danish farmers. Agric. Water Manag. 158 (C), 235–244.

Ghadim, A.K.A., Pannell, D., 1999. A conceptual framework of adoption of an agricultural innovation. Agric. Econ. 21 (2), 145–154.

Giovanopoulou, E., Nastis, S.A., Papanagiotou, E., 2011. Modeling farmer participation in agri-environmental nitrate pollution reducing schemes. Ecol. Econ. 70 (11), 2175–2180.

Gómez-Limón, J.A., Gutiérrez-Martín, C., Villanueva, A.J., 2019. Optimal Design of Agri-environmental Schemes under Asymmetric Information for Improving Farmland Biodiversity. J. Agric. Econ. 70 (1), 153–177.

Grammatikopoulou, I., Pouta, E., Myyrä, S., 2016. Exploring the determinants for adopting water conservation measures. What is the tendency of landowners when the resource is already at risk? J. Environ. Plan. Manag. 59 (6), 993–1014.

Hasler, B., Termansen, M., Nielsen, H.Ø., Daugbjerg, C., Wunder, S., Latacz-Lohmann, U., 2022. European agri-environmental policy: evolution, effectiveness, and challenges. Rev. Environ. Econ. Policy 16 (1), 105–125.

Herzon, I., Birge, T., Allen, B., Povellato, A., Vanni, F., Hart, K., Radley, G., Tucker, G., Keenleyside, C., Oppermann, R., Underwood, E., Poux, X., Beaufoy, G., Pražan, J., 2018. Time to look for evidence: Results-based approach to biodiversity conservation on farmland in Europe. Land Use Policy 71, 347–354.

Hounsome, B., Edwards, R.T., Edwards-Jones, G., 2006. A note on the effect of farmer mental health on adoption: the case of agri-environment schemes. Agric. Syst. 91 (3), 229–241.

Hurley, P., Lyon, J., Hall, J., Little, R., Tsouvalis, J., White, V., Rose, D.C., 2022. Co-designing the environmental land management scheme in England: the why, who and how of engaging 'harder to reach' stakeholders. People Nat. 4 (3), 744–757.

Hynes, S., Garvey, E., 2009. Modelling Farmers' Participation in an Agri-environmental Scheme using Panel Data: An Application to the Rural Environment Protection Scheme in Ireland. J. Agric. Econ. 60 (3), 546–562.

Kabii, T., Horwitz, P., 2006. A review of landholder motivations and determinants for participation in conservation covenanting programmes. Envir. Conserv. 33 (1), 11–20.

Keenleyside, C., Allen, B., Hart, K., Menadue, H., Stefanova, V., Prazan, J., Herzon. I., Clement, T., Povellato, A., Maciejczak, M., Boatman, N., 2011. Delivering environmental benefits through entry level agri-environment schemes in the EU. Institute for European Environmental Policy. Retrieved from: https://ieep.eu/wp-content/uploads/2022/12/IEEP_Entry-level_AE.pdf.

Kelemen, E., Megyesi, B., Matzdorf, B., Andersen, E., van Bussel, L.G., Dumortier, M., Dutilly, C., García-Llorente, M., Hamon, C., LePage, A., Moruzzo, R., Prager, K., Riccioli, F., Yacamán-Ochoa, C., 2023. The prospects of innovative agri-environmental contracts in the European policy context: Results from a Delphi study. Land Use Policy 131, 106706.

Kieninger, P.R., Gugerell, K., Biba, V., Auberger, I., Winter, S., Penker, M., 2018. Motivation crowding and participation in agri-environmental schemes – the case of the Austrian Öpul-programme in vineyards. Eur. Countrys. 10 (3), 355–376.

Knowler, D., Bradshaw, B., 2007. Farmers' adoption of conservation agriculture: a review and synthesis of recent research. Food Policy 32 (1), 25–48.

Kuhfuss, L., Préget, R., Thoyer, S., Hanley, N., Le Coent, P., Désolé, M., 2016. Nudges, social norms, and permanence in agri-environmental schemes. Land Econ. 92 (4), 641–655.

Läpple, D., Thorne, F., 2019. The role of innovation in farm economic sustainability: generalised propensity score evidence from irish dairy farms. J. Agric. Econ. 70 (1), 178–197.

Lastra-Bravo, X.B., Hubbard, C., Garrod, G., Tolón-Becerra, A., 2015. What drives farmers' participation in EU agri-environmental schemes?: results from a qualitative meta-analysis. Environ. Sci. Policy 54, 1–9.

Leonhardt, H., Braito, M., Uehleke, R., 2022. Combining the best of two methodological worlds? Integrating Q methodology-based farmer archetypes in a quantitative model of agri-environmental scheme uptake (eng). Agric. Hum. Values 39 (1), 217–232.

Mante, J., Gerowitt, B., 2007. A survey of on-farm acceptance of low-input measures in intensive agriculture. Agron. Sustain. Dev. 27 (4), 399–406.

Mante, J., Gerowitt, B., 2009. Learning from farmers' needs: Identifying obstacles to the successful implementation of field margin measures in intensive arable regions. Landsc. Urban Plan. 93 (3-4), 229–237.

Mettepenningen, E., Verspecht, A., van Huylenbroeck, G., 2009. Measuring private transaction costs of European agri-environmental schemes. J. Environ. Plan. Manag. 52 (5), 649–667.

Mettepenningen, E., Vandermeulen, V., Delaet, K., van Huylenbroeck, G., Wailes, E.J., 2013. Investigating the influence of the institutional organisation of agri-environmental schemes on scheme adoption. Land Use Policy 33, 20–30.

Mills, J., Gaskell, P., Reed, M., Short, C., Ingram, J., Boatman, N., Jones, N., Conyers, S., Carey, P., Winter, M., Lobley, M., 2013. Farmer attitudes and evaluation of outcomes to on-farm environmental management. Countryside and Community Research Institute, Food and Environment Research Agency and Centre for Rural Policy, Exeter University. Retrieved from: https://eprints.glos.ac.uk/3229/7/FarmerAttitudesFinalReport.pdf.

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L.A., 2015. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement (eng). Syst. Rev. 4 (1), 1.
Morris, J., Mills, J., Crawford, I.M., 2000. Promoting farmer uptake of agri-environment schemes: the countryside stewardship arable options scheme. Land Use Policy 17 (3), 241–254.
Mozzato, D., Gatto, P., Defrancesco, E., Bortolini, L., Pirotti, F., Pisani, E., Sartori, L., 2018. The role of factors affecting the adoption of environmentally friendly farming practices: can geographical context and time explain the differences emerging from literature? Sustainability 10 (9), 3101.
Murphy, G., Hynes, S., Murphy, E., O'Donoghue, C., 2014. An investigation into the type of farmer who chose to participate in rural environment protection scheme (REPS) and the role of institutional change in influencing scheme effectiveness. Land Use Policy 39, 199–210.
Nguyen, C., Latacz-Lohmann, U., Hanley, N., Schilizzi, S., Iftekhar, S., 2022. Spatial Coordination Incentives for landscape-scale environmental management: a systematic review. Land Use Policy 114, 105936.
OECD, 2012. Farmer Behaviour, Agricultural Management and Climate Change. OECD.
Pagliacci, F., Defrancesco, E., Mozzato, D., Bortolini, L., Pezzuolo, A., Pirotti, F., Pisani, E., Gatto, P., 2020. Drivers of farmers' adoption and continuation of climate-smart agricultural practices. A study from northeastern Italy (eng). Sci. Total Environ. 710, 136345.
Pannell, D., Marshall, G., Barr, N., Curtis, A., Vanclay, F., Wilkinson, R., 2006. Understanding and promoting adoption of conservation practices by rural landholders. AUST. J. EXP. Agric. - AUST J. EXP AGR 46.
Pascucci, S., de-Magistris, T., Dries, L., Adinolfi, F., Capitanio, F., 2013. Participation of Italian farmers in rural development policy. Eur. Rev. Agric. Econ. 40 (4), 605–631.
Paulus, A., Hagemann, N., Baaken, M.C., Roilo, S., Alarcón-Segura, V., Cord, A.F., Beckmann, M., 2022. Landscape context and farm characteristics are key to farmers' adoption of agri-environmental schemes. Land Use Policy 121, 106320.
Pe'er, G., Zinngrebe, Y., Moreira, F., Sirami, C., Schindler, S., Müller, R., Bontzorlos, V., Clough, D., Bezák, P., Bonn, A., Hansjürgens, B., Lomba, A., Möckel, S., Passoni, G., Schleyer, C., Schmidt, J., Lakner, S., 2019. A greener path for the EU Common Agricultural Policy (eng). Sci. (N. Y., N. Y.) 365 (6452), 449–451.
Peerlings, J., Polman, N., 2009. Farm choice between agri-environmental contracts in the European Union. J. Environ. Plan. Manag. 52 (5), 593–612.
Persson, U.M., Alpízar, F., 2013. Conditional cash transfers and payments for environmental services—a conceptual framework for explaining and judging differences in outcomes. World Dev. 43, 124–137.
Petticrew, M., Roberts, H., 2006. Blackwell Publishing Ltd, Oxford, UK. Syst. Rev. Soc. Sci.
Picazo-Tadeo, A.J., Gómez-Limón, J.A., Reig-Martínez, E., 2011. Assessing farming eco-efficiency: A Data Envelopment Analysis approach. J. Environ. Manag. 92 (4), 1154–1164.
Polman, N., Slangen, L., 2008. Institutional design of agri-environmental contracts in the European Union: the role of trust and social capital. NJAS - Wagening. J. Life Sci. 55 (4), 413–430.
Potter, C., Lobley, M., 1992. Ageing and Succession on Family Farms: The Impact on Decision-making and Land Use. Sociol. Rural. 32 (2-3), 317–334.
Prokopy, L.S., Floress, K., Arbuckle, J.G., Church, S.P., Eanes, F.R., Gao, Y., Gramig, B.M., Ranjan, P., Singh, A.S., 2019. Adoption of agricultural conservation practices in the United States: Evidence from 35 years of quantitative literature. J. Soil Water Conserv. 74 (5), 520–534.
Raina, N., Zavalloni, M., Targetti, S., D'Alberto, R., Raggi, M., Viaggi, D., 2021. A systematic review of attributes used in choice experiments for agri-environmental contracts. Bio-Based Appl. Econ. 10 (2).
Rogers, E.M., 2003. Diffusion of Innovations. Free Press, New York.
Rolfe, J., Whitten, S., Windle, J., 2017. The Australian experience in using tenders for conservation. Land Use Policy 63, 611–620.
Rolfe, J., Schilizzi, S., Iftekhar, M.S., 2021. Increasing environmental outcomes with conservation tenders: The participation challenge. Conservation Letters 15 (3).
Sako, M., Helper, S., 1998. Determinants of trust in supplier relations: Evidence from the automotive industry in Japan and the United States. In. Journal of Economic Behavior & Organization 34 (3), 387–417.
Schaub, S., Ghazoul, J., Huber, R., Zhang, W., Sander, A., Rees, C., Banerjee, S., Finger, R., 2023. The role of behavioural factors and opportunity costs in farmers' participation in voluntary agri-environmental schemes: a systematic review. J. Agric. Econ. 74 (3), 617–660.
Schulz, D., Börner, J., 2023. Innovation context and technology traits explain heterogeneity across studies of agricultural technology adoption: A meta-analysis. J. Agric. Econ. 74 (2), 570–590.
Schulze, C., Matzdorf, B., 2023. The institutional design of agri-environmental contracts—how stakeholder attitudes can inform policy making. Q Open 3 (1), qoad001.
Siebert, R., Toogood, M., Knierim, A., 2006. Factors affecting European farmers' participation in biodiversity policies. Sociol. Rural. 46, 318–340.
Špur, N., Šorgo, A., Škornik, S., 2018. Predictive model for meadow owners' participation in agri-environmental climate schemes in Natura 2000 areas. Land Use Policy 73, 115–124.
Taylor, B.M., van Grieken, M., 2015. Local institutions and farmer participation in agri-environmental schemes. J. Rural Stud. 37, 10–19.
Tyllianakis, E., Martin-Ortega, J., 2021. Agri-environmental schemes for biodiversity and environmental protection: How we are not yet "hitting the right keys. Land Use Policy 109, 105620.
Unay Gailhard, I., Bavorova, M., Pirscher, F., 2012. The Influence of Communication Frequency with Social. Network Actors on the Continuous Innovation Adoption: Organic Farmers in Germany, p. 19.
Unay Gailhard, İ., Bojnec, Š., 2015. Farm size and participation in agri-environmental measures: Farm-level evidence from Slovenia. Land Use Policy 46, 273–282.
Unay Gailhard, İ., Bavorová, M., Pirscher, F., 2015. Adoption of agri-environmental measures by organic farmers: the role of interpersonal communication. J. Agric. Educ. Ext. 21 (2), 127–148.
Unay-Gailhard, İ., Bojnec, Š., 2016. Sustainable participation behaviour in agri-environmental measures. J. Clean. Prod. 138, 47–58.
van Rensburg, T.M., Murphy, E., Rocks, P., 2009. Commonage land and farmer uptake of the rural environment protection scheme in Ireland. Land Use Policy 26 (2), 345–355.
Vanslembrouck, I., Huylenbroeck, G., Verbeke, W., 2002. Determinants of the willingness of belgian farmers to participate in agri-environmental measures. J. Agric. Econ. 53 (3), 489–511.
Walder, P., Kantelhardt, J., 2018. The environmental behaviour of farmers – capturing the diversity of perspectives with a q methodological approach. Ecol. Econ. 143, 55–63.
Wąs, A., Malak-Rawlikowska, A., Zavalloni, M., Viaggi, D., Kobus, P., Sulewski, P., 2021. In search of factors determining the participation of farmers in agri-environmental schemes – does only money matter in Poland? Land Use Policy 101, 105190.
Whitten, S.M., Reeson, A., Windle, J., Rolfe, J., 2013. Designing conservation tenders to support landholder participation: a framework and case study assessment. Ecosyst. Serv. 6, 82–92.
Wilson, G., Hart, K., 2000. Financial imperative or conservation concern? EU farmers' motivations for participation in voluntary agri-environmental schemes. Environ. Plan. A 32, 2161–2185.
Wossink, G.A.A., van Wenum, J.H., 2003. Biodiversity conservation by farmers: analysis of actual and contingent participation. Eur. Rev. Agric. Econ. 30 (4), 461–485.
Wunder, S., 2015. Revisiting the concept of payments for environmental services. Ecol. Econ. 117, 234–243.
Wunder, S., Börner, J., Ezzine-de-Blas, D., Feder, S., Pagiola, S., 2020. Payments for environmental services: past performance and pending potentials. Annu. Rev. Resour. Econ. 12 (1), 209–234.
Wynn, G., Crabtree, B., Potts, J., 2001. Modelling farmer entry into the environmentally sensitive area schemes in Scotland. J. Agric. Econ. 52, 65–82.
Wynne-Jones, S., 2013. Ecosystem service delivery in Wales: evaluating farmers' engagement and willingness to participate. J. Environ. Policy Plan. 15 (4), 493–511.
Zieliński, M., Jadczyszyn, J., Sobierajewska, J., 2023. Predispositions and challenges of agriculture from areas particularly facing natural or other specific constraints in Poland in the context of providing environmental public goods under EU policy. Agric. Econ. - Czech 69 (8), 309–320.
Zimmermann, A., Britz, W., 2016. European farms' participation in agri-environmental measures. Land Use Policy 50, 214–228.