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Comparing practice- and results-based agri-environmental schemes controlled by remote sensing: An application to olive groves in Spain

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Abstract

Farmers' preferences toward practice- and results-based agri-environmental schemes (AES) are analysed using a labelled choice experiment. The analysis focuses on schemes involving an innovative satellite-based monitoring system, with different environmental objectives. Olive groves in southern Spain are used as a case study. Results show no statistically significant differences in farmers' willingness to accept (WTA) payment for participating in practice- versus results-based AES when the scheme targets carbon sequestration. By contrast, farmers require a significantly higher WTA payment for results-based AES when targeting biodiversity (using bird species as an indicator), mostly due to the uncertainties related to its provision and monitoring. WTA significantly increases with provision level and remote sensing monitoring, regardless of the type of scheme. Significant preference heterogeneity is observed, partly explained by farmers' attitudes toward risk and their beliefs about environmental service provision and monitoring capacity. The results suggest useful policy implications, including the potential of making use of joint provision of environmental services in the design of results-based AES and accompanying them with uncertainty mitigating measures.

KEYWORDS

actions-based schemes, discrete choice experiments, outcome-based payments, payments for ecosystem services, willingness to accept

JEL CLASSIFICATION
Q18, Q57

1 | INTRODUCTION

Incentive-based schemes consisting of payments to reward land managers for providing public-good environmental services (ES) are widespread, especially in Western countries (OECD, 2020). They are typically focused on establishing a set of practices or actions to be implemented by land managers, under the assumption that the adoption of these prescribed practices will result in the provision of ES at the desired levels. One of the best-known examples of this practice-based approach are the agri-environmental schemes (AES) implemented as part of the European Union's Common Agricultural Policy (CAP) (Hasler et al., 2022). The design of practice-based AES (pAES) responds to the need to promote the use of certain agricultural practices linked to the provision of ES at levels beyond the minimum standard represented by CAP conditionality. It is a policy approach that is both easy for the implementing agency to monitor and manage and attractive to farmers in terms of execution and understanding. However, after three decades of application of pAES, they often perform poorly in terms of cost-benefits (ECA, 2022) and fostering ecological provision (Jones et al., 2017; Pe'er et al., 2020), fuelling the policy debate on the need to develop and implement alternative instruments that can improve on the performance of practice-based approaches. In this sense, results-based approaches have been proposed as possible complements to or substitutes for pAES, on the basis that they are theoretically preferable in terms of policy efficiency and coherence (Burton & Schwarz, 2013).

Results-based AES (rAES) represent a significant shift from a prescription-type policy to instruments more directly targeting the ES provided by land managers, putting the focus on the effective levels of provision of these services and their measurement. The implementation of rAES may entail substantial benefits, including the mitigation of adverse selection bias, higher cost-effectiveness, dynamic efficiency, greater societal legitimation, and, as such, greater policy coherence (Burton & Schwarz, 2013; Vainio et al., 2021; White & Hanley, 2016). They also provide farmers with greater flexibility to achieve policy objectives, thus harnessing their specific on-the-ground knowledge (White & Hanley, 2016). Ultimately, farmers can more easily integrate the function of ES provision as another aim of their agribusiness management, changing from a passive, practice-taker role to a more proactive, practice-developer role. However, there are a number of notable barriers to rAES implementation, some related to farmers (including higher risks, due to factors outside their control, and higher transaction costs) (Burton & Schwarz, 2013; Derissen & Quaas, 2013; Tanaka et al., 2022) and others to the implementing agencies (e.g., difficulty of monitoring and financial planning) (Herzon et al., 2018). Due to the voluntary nature of the instrument and its novelty, information is needed on farmers' preferences toward possible alternatives for rAES implementation and on factors that influence farmers' adoption (Dessart et al., 2019).

There is abundant literature on farmers' preferences toward pAES that focuses on eliciting their willingness to accept (WTA) for participation in the schemes (Schulze et al., 2024; Villanueva et al., 2017). Conversely, there are relatively few studies that investigate farmers' preferences toward rAES and provide quantitative estimates of their WTA for such schemes, although the number has been growing recently. For example, Niskanen et al. (2021) analyse Finnish farmers' preferences for a general rAES targeted at improving the provision of biodiversity, climate mitigation, water quality and landscape. They observe a willingness to reform the pAES, although the current pAES were generally preferred to the new rAES. Opposite results are reported by Šumrada et al. (2022), who find that Slovenian farmers prefer rAES, especially when a collective bonus aimed at incentivising coordination is employed. Salazar-Ordóñez et al. (2021) focus on the use of a one-time bonus for environmental results (in terms of biodiversity and prevention of soil erosion), observing that farmers are largely indifferent to the inclusion of such a bonus (especially compared to other scheme attributes focusing on practices). Finally, Tanaka et al. (2022) estimate farmers' preferences for rAES in Japan, focusing not only on attributes related to ecosystem services but also on contract implementation characteristics such as monitoring, technical assistance, and outcome certification. These authors find that most farmers are willing to participate in rAES and, once they have decided to participate, the quantity of farmland enrolled is only influenced by the per-hectare payment.

A common finding in previous studies is that rAES are problematic in terms of applicability due to the difficulty of efficiently monitoring the expected results (Bartkowski et al., 2021; Zabel & Roe, 2009). The use of remote sensing-based monitoring can help to overcome this challenge, due to lower costs and the availability of frequent and large-scale data (Finger, 2023). However, this adds another layer to the uncertainty faced by farmers, who are not normally familiar with this kind of monitoring. To the best of the authors' knowledge, there are no previous studies that analyse farmers' opinions of this monitoring system, in either rAES or pAES. In an attempt to reduce verification costs in rAES, Tanaka et al. (2022) suggest involving farmers in outcome monitoring, finding that farmers would demand increased payments (compared to hiring external experts for the monitoring). The present paper aims to add to the few previous studies focusing on farmers' preferences for rAES, by providing deeper insights into the use of remote sensing-based monitoring systems, in addition to other attributes such as the level of ES provision and the type of ES monitored (biodiversity, carbon sequestration and both).

The analysis relies on a labelled discrete choice experiment (DCE) application, enabling a comparison between preferences for rAES and pAES. To the authors' knowledge, this is the first study using labelled alternatives of practice-based and results-based schemes and including remote sensing-based monitoring as a scheme attribute. The use of labelled DCE allows us to present both pAES and rAES to the farmers, and estimate separate coefficients for the same AES characteristics, enabling us to determine whether farmers' WTA estimates differ for rAES and pAES, in general and by scheme attribute. Schemes focusing on improving ES in sloping olive groves (SOG)—an extensive agricultural system that is widespread in the Mediterranean region—are used as a case study. Significant policy implications can be drawn from the study, including the importance of the schemes' environmental objective (biodiversity and carbon sequestration) and monitoring as determinants of enrolment, coupled with the role of attitudes in shaping farmers' preferences toward both rAES and pAES.

2 | METHODS

2.1 | Case study context

SOG is one of the most prominent types of olive groves, accounting for more than 3 million hectares worldwide (IOC, 2015). SOG are usually rain-fed olive groves located on plots with steep slopes, and are typically characterised by low to moderate intensification levels (with tree densities typically lower than 140 olive trees/ha), relatively high production costs, and a high potential of ES provision (Colombo & Camacho-Castillo, 2014; Stroosnijder et al., 2008; Villanueva et al., 2018). In the present analysis, the focus is made on SOG in Andalusia (southern Spain), the most productive olive growing region in the world. SOG is one of the main agricultural uses of land in the region, accounting for around half a million hectares (considering

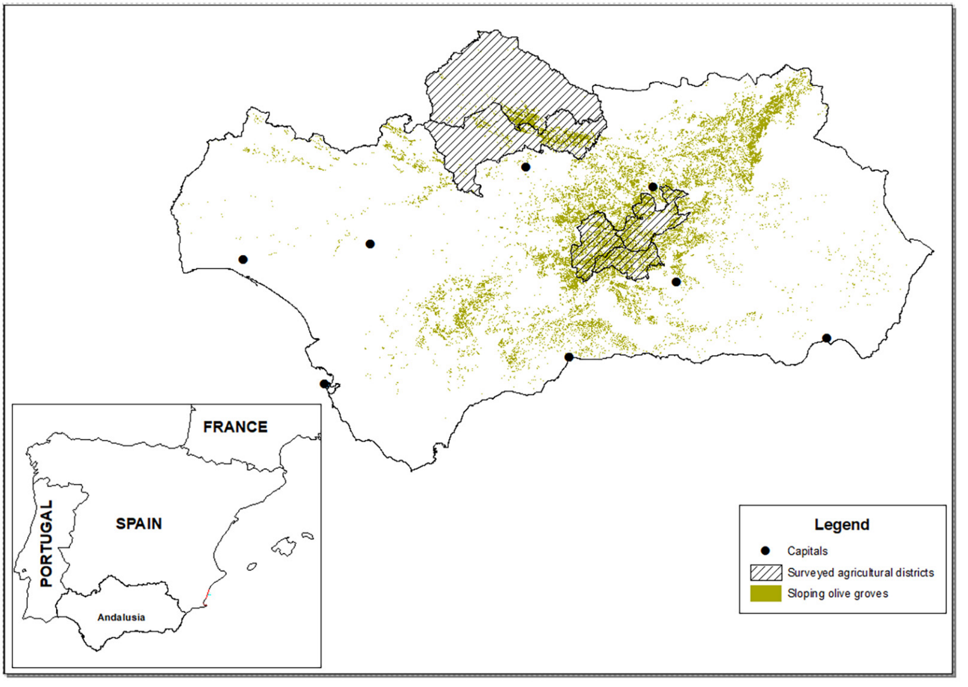

FIGURE 1 Distribution of sloping olive groves (SOG) in Andalusia. [Colour figure can be viewed at wileyonlinelibrary.com]

an average slope equal to or higher than 15%). This system is mainly located in the mountain ranges of the north and centre of Andalusia—Sierra Morena and Sierras Béticas (see Figure 1).

Notable among the ES provided by SOG are those related to biodiversity and carbon sequestration. With regard to the former, given the abovementioned extensification level of this agricultural system, including a greater extent of ecological areas, they are often associated with higher levels of biodiversity than other types of olive grove (Carpio et al., 2016; Stroosnijder et al., 2008). However, there is still room for improvement in terms of the provision of this type of ES, especially through the implementation of suitable agricultural practices for this purpose (Carpio et al., 2019; Castro-Caro et al., 2014).

With regard to carbon sequestration, olive groves, like other permanent crops, store significant carbon stocks in their woody fraction (IPCC, 2014) and soil (López-Bellido et al., 2016). Notwithstanding, the ES provision in SOG largely depends on the implementation of appropriate agricultural practices such as the use of herbaceous cover, the spreading of shredded pruning residues, or the conservation of natural edges and vegetation by means of mechanical treatments. These actions limit the soil erosion rates and the use of herbicides, thus boosting the provision of biodiversity and carbon sequestration by olive groves (Carpio et al., 2019; Gómez, 2009; Rey et al., 2019), with the application of either pAES or rAES being particularly appropriate in these areas.

2.2 | Choice experiment: Attributes and levels

The current study relies on the analysis of DCE data. DCE is a stated preference valuation technique based on the Lancasterian consumer theory of utility maximisation (Lancaster, 1966), the econometric basis of which lies in the random utility theory

(McFadden, 1974). The use of DCE to analyse land managers' preferences toward policy design has sharply increased in recent years thanks to its suitability for estimating welfare measures (usually WTA) associated with policy participation (Schulze et al., 2024; Villanueva et al., 2017). Basically, the underlying assumption in this kind of study is that land managers' choices about participating in the policy scheme options on offer are determined by the scheme attributes (including payments).

DCE attributes included in the current study are shown in Table 1. The experiment is based on a labelled design, with alternatives labelled according to the type of AES: practice-based and results-based. Three attributes are presented on both of the labelled alternatives: the level of provision of ES, the monitoring type and the payment. Previous literature shows the importance of these attributes in guiding farmers' preferences toward participation in AES, for the level of provision both in practice-based (Villanueva et al., 2015) and results-based approaches (Niskanen et al., 2021), and the monitoring type (Tanaka et al., 2022). In addition, the results-based alternatives include a fourth attribute related to the scheme's environmental objective (carbon sequestration and biodiversity conservation), which has previously been found to be a determinant of participation in AES (Villamayor-Tomas et al., 2019). Regarding the contribution to the existing literature, the DCE was designed to provide new insights into these attributes, especially due to their novel application to a results-based policy approach, and the comparison with preferences toward practice-based approaches.

To define the attribute levels, a literature review was conducted as well as a focus group composed of expert researchers[1] on the different dimensions of the scheme under valuation. The Provision level attribute (PR) included two levels, Moderate and High (PRM and PRH, respectively). For pAES, they are defined as the use of herbaceous cover strips between rows of olive trees (perpendicular to the maximum slope), managed using shredding and/or grazing. There is abundant literature indicating that the use of this practice has a significant impact on the ES provided by olive groves (Gómez, 2009), including carbon sequestration (Castro et al., 2008) and biodiversity (Castro-Caro et al., 2014). Since the area of herbaceous cover determines the environmental benefits (Barranco et al., 2017), the two levels differ solely in the width of the strip, with 2 and 3.5 m wide strips for Moderate and High levels (pPRM and pPRH), respectively. The first level was set based on the eco-schemes proposed in a draft version of the CAP Spanish Strategic Plan (MAPA, 2021), while the second was based on the greatest width specified in an AES currently in effect for the Andalusian olive groves.

For the rAES, the PR levels were defined as the equivalent environmental improvements expected for extensive use of the practices considered for pPRM and pPRH. As there is no information about average levels of provision of the two ES considered in the agricultural district selected for the study, we used information from previous surveys in the region (although not specifically administered in the same districts). Based on that information, we determined that improvements of around 10% and 20%, respectively, would be expected from extensive use of the practices at the pPRM and pPRH levels in the agricultural districts selected for the survey. This correspondence was subsequently validated in the focus group (composed of researchers and senior technicians knowledgeable about the agricultural system). The respondent was given an explanation of this equivalent improvement as well as the fact that, depending on the environmental objective(s) of the scheme—that is, the Environmental objective(s) attribute—farmers were free to use the practices they considered suitable to comply with the provision level specified in the scheme on offer. The environmental objective(s) included were

[1]Including experts on farm management, carbon sequestration and biodiversity in farmland, agricultural and environmental economics and policy, and satellite-based monitoring. All of them had produced significant scientific output focusing on the case study.

TABLE 1 Attributes and levels of the choice experiment [acronyms in square brackets].

Attribute	Description	Levels[a] Practice-based labelled alternative (pAES)	Results-based labelled alternative (rAES)
Provision level [PR]	Level of the environmental services in question provided by farmers	• Moderate level [pPRM]: use of 2 m-wide herbaceous cover strips between olive trees managed by shredding or grazing • High level [pPRH]: same as pPRM but using 3.5 m-wide strips	• Moderate level [rCAM, rBIM, or rCBM]: achieve a provision level at least 10% higher than the average of the agricultural district (this is expected to provide a similar environmental benefit as from a wide use of pPRM, but with farmers given flexibility on how to achieve it) • High level [rCAH, rBIH, or rCBH]: same as the Moderate level, but at least 20% higher than the average of the agricultural district (equivalent to the improvement expected from a wide use of pPRH)
Environmental objective(s) [EO]	Environmental service(s) on which the scheme is focused		• Carbon sequestration [rCA]: measurement of the organic carbon sequestered • Biodiversity [rBI]: measurement of the number of bird species • Carbon sequestration and biodiversity [rCB]: measurement of both, rCA and rBI
Monitoring system [MO]	Type of monitoring system	• Field-monitoring [pFIE]: 3%–5% of enrolled farms are monitored once a year using field control by a technician • Satellite-based monitoring [pSAT]: all farms are monitored once a week using satellite information	• Field-monitoring [rFIE]: 3%–5% of enrolled farms are monitored once a year using field control by a technician • Satellite-based monitoring [rSAT]: all farms are monitored once a week using satellite information
Yearly payment [PA]	Yearly payment per ha for a 5-year AES contract	• €75/ha/year • €150/ha/year • €225/ha/year • €300/ha/year • €375/ha/year • €450/ha/year	

[a]The status quo level implies the farmers' non-participation in AES and thus non-compliance with all provision attribute requirements, no monitoring, and zero yearly payment.

carbon sequestration, biodiversity or both. The indicators selected to measure them were the organic carbon sequestered (in t/ha) for carbon sequestration and the number of bird species (per farm) for biodiversity, as they are suitable measures of these two environmental services in the context of policy implementation (Grondard et al., 2021) and are particularly valued by the general public. Thus, for the Moderate level in rAES, according to the environmental objective(s) established, organic carbon sequestered (rCAM), biodiversity in terms of the number of bird species (rBIM), or both (rCBM) should be 10% higher at farm level than the average of the agricultural district where the farm is located. The corresponding value for the High level (that is, for rCAH, rBIH, and rCBH, respectively) is 20%. Respondents were clearly informed by means of numerical examples about the likely absolute values (in t/ha/year and bird species/farm for carbon sequestration and biodiversity, respectively) behind these percentages, as detailed in Appendix S1 (where an English version of the information sheets and the questionnaire is included).

With regard to the Monitoring system attribute, two levels were defined: Field and Satellite-based monitoring. They are defined to convey the different aspects related to satellite-based as compared to field monitoring—that is, not only the use of remote sensing information, but also the fact that it can (and, eventually, very likely will) be used on a higher control frequency and for a larger area (ECA, 2020). Consequently, Field monitoring is basically defined as the traditional monitoring system for AES, consisting of technicians monitoring 3%–5% of enrolled farms by visiting the monitored farms once a year. The Satellite-based monitoring level consists of the near-exclusive use of satellite information to monitor practices or environmental results, respectively, for pAES and rAES (the attribute levels are denoted as pSAT and rSAT). The respondent was informed that this type of monitoring allows for weekly monitoring of all farms, but with a lower degree of precision. Consequently, if a default was detected using satellite-based information, this would have to be confirmed by a field visit. For rSAT, further explanations included a brief description of the proxy indicators to be used to measure results in terms of carbon sequestration and biodiversity, as detailed in Appendix S1. The description of the proxy indicators implicitly acknowledges the current technological limits existing for detecting biodiversity and carbon sequestration by satellite sensors (Abdi et al., 2021; Gómez-Giráldez et al., 2019).[2]

Lastly, the Payment attribute represents the yearly payment per ha, including six levels from €75/ha/year to €450/ha in increments of €75. These levels were set based on the current AES and results from similar studies focusing on olive growers in the region (especially, Salazar-Ordóñez et al., 2021; Villanueva et al., 2016).

The DCE included eight choice sets per respondent. Each choice set consisted of a dichotomous question where an AES (pAES or rAES) option was offered, and the respondent gave a yes/no answer. Hence, it implicitly encompasses two alternatives: an AES and a no contract or status quo option[3] (see Figure 2 for an example of choice set), with the former being built from combinations of the attributes and levels presented in Table 1. Though the valuation here is arguably focused on a private good, meaning no fully incentive-compatible elicitation mechanism is available (Lloyd-Smith & Adamowicz, 2018), we consider that the use of an approach involving two alternatives can reduce potential strategic bias (Carson & Groves, 2007), along with other biases related to misestimated preferences for the status-quo alternative (Collins & Vossler, 2009), and high cognitive burden and fatigue (Rose et al., 2009). In addition, honesty priming together with reminders of the opt-out option were used to further mitigate hypothetical bias. In this sense, it is also worth noting that while olive growers are familiar with applying for CAP programmes, the novelty of the type of scheme under valuation (i.e., rAES and/or including satellite-based monitoring) made the use of simpler choice sets advisable.

[2]While yet not generally implemented in policies, scientific studies are increasingly showing that the use of satellite-based information can provide accurate estimation of organic carbon (through measuring net primary production) (Gómez-Giráldez et al., 2019) and, to some extent, bird diversity (through combining remote-sensing, existing inventories, expert-information, and modelling) (Jetz et al., 2019). It is not the aim here to prove these technologies, but to assess farmers' views on a potential use of them, especially by differentiating two indicators of different kind (focusing on non-movable and movable resources). Yet, this attribute was realistically defined, for example explaining to farmers that a proxy based on landscape-complexity was considered to measure biodiversity using satellite information, following the findings from Rey et al. (2019) who show the significant relationship between olive farmland complexity and birds diversity.

[3]It should be noted that the valuation context refers to the new policy framework (2023–2027). Therefore, the AES implemented at the time of the survey were to be no longer available in the new framework. As a result, farmers could only compare the suggested AES with the no-AES option.

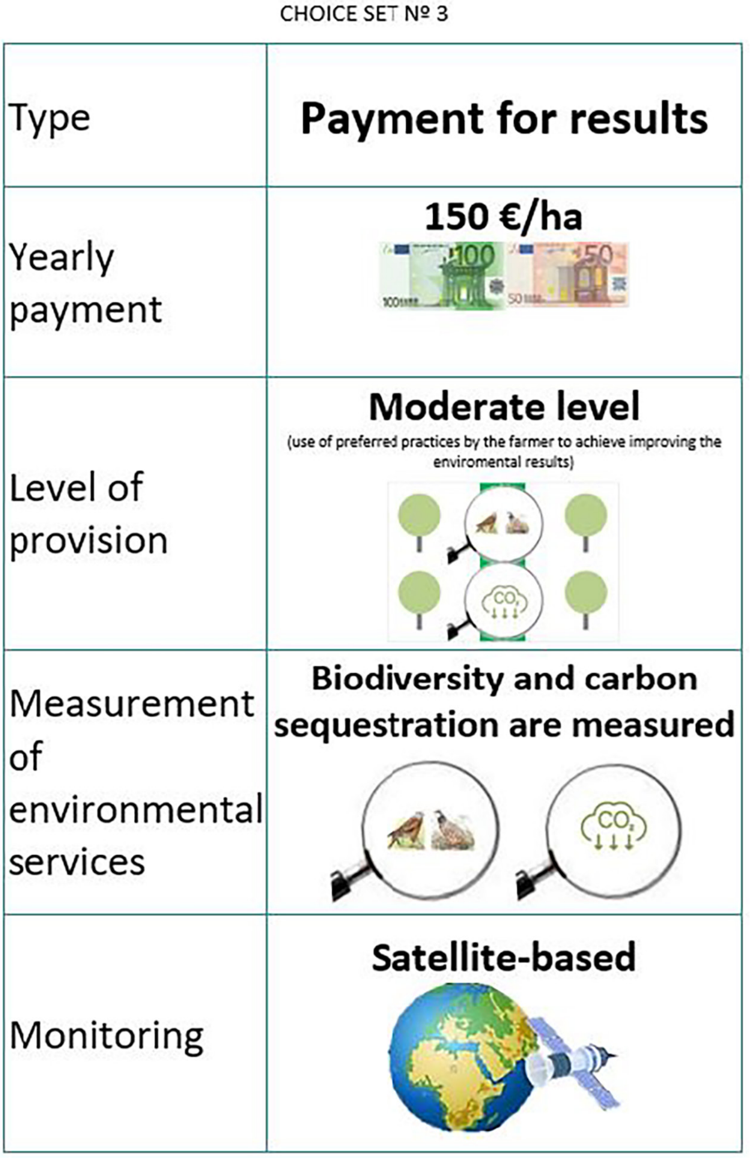

FIGURE 2 Example of a choice set (for each choice set, the interviewer asked the respondent: 'Would you be willing to participate in the following program?'). [Colour figure can be viewed at wileyonlinelibrary.com]

2.3 | Experimental design and data collection

Regarding the experimental design, a Bayesian efficient design optimised for a multinomial logit specification was used (Bliemer & Rose, 2011). The priors were set on the basis of previous studies also focusing on Andalusian farmers with SOG (especially Salazar-Ordóñez et al., 2021; Villanueva et al., 2016), assuming uniform distributions for the coefficients. Given the number of alternatives used (i.e., 2), a constrained design using an extended Modified Federov algorithm was employed (ChoiceMetrics, 2018). The D-error of the experimental design used was 0.005, and it included 24 choice sets, with 3 blocks of 8 choice sets each. Once the first 40 questionnaires had been filled in, the design was checked, and, given the good results in terms of consistency with the priors set previously, the decision was made not to alter it. NGENE 1.1.1 was used to obtain the efficient design.

A specific questionnaire was drawn up and verified before being used to carry out an ad hoc survey. The questionnaire included six sets of questions: (i) structural characteristics of the farm, (ii) structural characteristics and management variables of the olive groves, (iii) the valuation application (especially the choice experiment), (iv) questions about farmer attitudes and opinions related to the agri-environment-and-climate policy, (v) questions about digitalisation, and (vi) farmer socio-demographic characteristics.

To build the sample, multi-stage cluster sampling was used. The first stage was the selection of target agricultural districts, using the absolute and relative area of the SOG as selection criteria. Five agricultural districts (La Sierra, Los Pedroches and Penibética in the province of Córdoba, Sierra Sur in the province of Seville and Montefrío in the province of Granada) were selected as primary sampling units, as each has over 15,000 ha of SOG and more than two thirds of their olive grove area is SOG. These agricultural districts represent 27% of the SOG area in Andalusia. In the second stage, villages located in these districts were randomly taken as secondary sampling units,[4] using the random route procedure to carry out the interviews. The survey was conducted between November 2021 and February 2022, yielding a total of 320 filled-in questionnaires (with a minimum of 50 per agricultural district). Interviews lasted 30 min on average.

2.4 | Modelling approach

To analyse farmers' preferences for different AES, we use a mixed logit model (MXL) in WTA-space. This type of model is preferable to models in preference-space, since it allows the direct estimation of the WTA of the different attributes, rather than having to derive it from the distribution of the utility coefficients, which, depending on the parameter distribution, may be difficult or impossible (Daly et al., 2012).[5] The final MXL specification used here includes an error component, aimed at capturing the error variance common to non-status quo alternatives (Scarpa et al., 2005).

We start with a conventional specification of the utility function in preference space for n individuals and t choice cards for the AES (which could correspond either to a practice-based U_{ntpAES} or to a result-based U_{ntpAES} programme) and the status quo (U_{ntSQ}) alternatives:

$$U_{\text{ntpAES}} = \lambda_{\text{np}} p_{\text{ntpAES}} - \boldsymbol{c}_{\mathbf{np}} \boldsymbol{\chi}_{\mathbf{ntpAES}} + \varepsilon \tag{1a}$$

$$U_{\text{ntrAES}} = \lambda_{\text{nr}} p_{\text{ntrAES}} - \boldsymbol{c}_{\mathbf{nr}} \boldsymbol{\chi}_{\mathbf{ntrAES}} + \varepsilon \tag{1b}$$

$$U_{\text{ntSQ}} = \vartheta + \varepsilon \tag{1c}$$

where p_{ntpAES} and p_{ntrAES} are the AES premium for the practice and results alternatives respectively; $\boldsymbol{\chi}_{\mathbf{ntpAES}}$ and $\boldsymbol{\chi}_{\mathbf{ntrAES}}$ are vectors with the attributes and levels for the pAES and rAES alternatives in the choice cards; λ_{pn} and λ_{rn} are the premium coefficients; $\boldsymbol{c}_{\mathbf{rn}}$ and $\boldsymbol{c}_{\mathbf{pn}}$ are the utility

[4]There is no register of farmers that would have allowed random sampling. Here the conceptualisation of 'SOG farm' differs from that of the official statistics (e.g., of CAP beneficiaries), as we consider 'farm' as a single decision-making entity regardless of its legal status. Because farmers typically live in villages with their farms located in the surrounding areas, within-villages random routes were used as the second-stage sampling method (conducting the interviews in different public places, such as fuel stations, town halls, producer cooperatives or agri-input shops, and at different times of the day).

[5]The use of more complex models such as hybrid choice models, which can reduce potential endogeneity issues, was discarded following Mariel and Meyerhoff (2016), who do not recommend them when the main objective of the analysis focuses on general preferences (rather than preference heterogeneity).

coefficients vectors for the other attributes (including the alternative specific constants, ASC), which vary randomly across farmers; ϑ is the error component (distributed with $N\left(0,\sigma^2\right)$); and ε is a random term representing all unobserved components of the utility function, which is assumed to be i.i.d. type-one extreme value and follows a Gumbel distribution, with constant variance $\pi^2/6$. Note that farmers are expected to experience an increase in utility by receiving the AES premium; hence, a positive sign is specified for the λ_n coefficient. Conversely, they are expected to experience a decrease in utility for carrying out the AES practices; thus, a negative sign is included for the $\boldsymbol{c_n}$ coefficients.

Farmers' WTA for the different attributes is obtained by dividing the coefficients of the attribute (c_n) by the premium coefficient (λ_n). As a result, the previous expression can be modified as follows:

$$U_{\text{ntAES}} = \lambda_n p_{\text{njt}} - \lambda_n \boldsymbol{w_n} \chi_{\textbf{njt}} + \varepsilon \tag{2}$$

with $\boldsymbol{w_n}$ being the WTA for these attributes, randomly distributed over farmers, as the λ_n coefficient.

In order to further explore the heterogeneity of farmers' preferences, $\boldsymbol{w_n}$ can be decomposed into $\boldsymbol{w_n} = \boldsymbol{w} + \boldsymbol{w_z Z_n}$, in which $\boldsymbol{w}$ is the vector of individual WTA, randomly distributed across farmers following a density function $f(w|\theta)$, with θ representing the parameters of the distribution; and $\boldsymbol{w_z Z_n}$ encompasses the heterogeneity in the mean of the WTA associated with each attribute and level, with $\boldsymbol{w_z}$ being the vector of coefficients to be estimated and $\boldsymbol{Z_n}$ a vector of farmer characteristics.

Farmers respond to eight choice cards each. A panel structure is thus used, which implies that the probability integral is composed of a product of logistic formulae. As this integral does not have a closed form, it is solved using an iterative process (Train, 2003). The model has been estimated using 1000 Modified Latin Hypercube Sampling (MLHS) draws (Hess et al., 2006), assuming a normal distribution in all the parameters.[6]

To account for the heterogeneity of farmers' preferences toward participation in the proposed AES, we include interactions between the different attributes of the AES and farmers' socio-economic characteristics, as well as attitudes and opinions related to the design of the AES and ES provision. In a first step, individual interactions of all the variables (related to farm characteristics and management, and farmer characteristics and attitudes and opinions) with the related attributes were included to check for significance. Next, we included all the interactions that turned out to be significant in a single multiple interaction model. Finally, a sequential process was followed, excluding one-by-one the least significant interaction until all the interactions included in the model were significant. Apollo R package, version 0.2.7 (Hess & Palma, 2019, 2022) was used for all model estimates.

Table 2 shows the descriptive of the variables used for interactions in the final model.

3 | RESULTS

In the DCE tasks, based on responses to follow-up questions, 22 respondents were identified as non-valid, with 20 protest responses (following Villanueva et al., 2017),[7] and 2

[6] The payment parameter was assumed to be normally distributed due to a non-zero proportion of the farmers currently complying with the practices or results required in the proposed programme. This implies a non-zero proportion of farmers participating at zero payment, which is supported by results from Colombo et al. (2021), particularly, concerning the lower costs that some farmers show for maintaining herbaceous cover. This fact would not have been reflected in the case of using a strictly non-negative distribution, such as a log-normal distribution. This was actually observed in worse model goodness of fit statistics when such a distribution for the payment parameter was used as compared to normal distribution.

[7] Protest responses were defined as systematic status quo choices stating protest reasons as main motivation. The main reasons respondents gave for protesting included the rejection of any subsidy (though farmers yearly apply for and receive significant CAP subsidies) and a lack of trust in the public implementing agencies.

TABLE 2 Descriptive data on farmer characteristics included in the analysis.

Variable (acronym in italics)	Units	Rate
Hcover20: Area of herbaceous cover as a percentage of total olive grove area is above 20%	1 = Yes/0 = No	0.68
Satreno: Disagreement with the statement 'The environmental results produced in the farm can be measured adequately using satellite images'	1 = Yes[a]/0 = No	0.80
Appyes: Agreement with the statement 'A smartphone application reporting on the environmental results produced in the farm is useful for helping the farmer to comply with the scheme requisites'	1 = Yes[a]/0 = No	0.67
Carbio: Farmer believes that the provision levels of carbon sequestration and biodiversity in his/her farm are slightly (10%) above the average of the agricultural district	1 = Yes/0 = No	0.22
Rbrisky: Agreement with the statement 'It is very risky to commit to achieving certain environmental results because they do not entirely depend on the farmer'	1 = Yes[a]/0 = No	0.66

[a]These variables result from recoding Likert variables with the following levels: 1 = Absolutely disagree, 2 = Very much disagree, 3 = Tend to disagree, 4 = Neither agree nor disagree, 5 = Tend to agree, 6 = Very much agree, 7 = Absolutely agree. 'Yes' covers levels 5–7 and 'No' covers 1–4, except for Satreno for which 'Yes' overs 1–3 and 'No' covers 4–7. There are no missing values in any of them, so $N = 298$ for all variables.

incomplete questionnaires. Hence, the final sample used for model estimation comprises 298 respondents. Respondents' choices indicate that 62% of farmers chose to participate in practice-based programmes and 53% in results-based programmes, with the difference in participation levels being statistically significantly (χ^2 *p*-value <0.001). However, this result is contingent on the environmental objective set in results-based programmes: participation rates are 59% when carbon sequestration is the only objective (not statistically different from that for pAES; χ^2 *p*-value <0.436), and 43% when the only objective is biodiversity (statistically different from that for pAES; χ^2 *p*-value <0.001). Table 3 shows the final MXL model used for the analysis.[8] The model is highly statistically significant and shows a good fit to the data. All the model coefficients are significant, except for the moderate provision level of carbon sequestration, and show the expected sign. Despite the fact that the model incorporates heterogeneity in the mean, coefficients related to standard deviations are highly significant, suggesting a high degree of preference heterogeneity in addition to that shown by the interactions. Since the MXL model is estimated in WTA-space, coefficients directly represent WTA values—divided by 100 as they have been rescaled. However, the mean WTA estimates for the attribute levels, taking into account the interactions, are shown in Table 4.

We now comment on the mean WTA results, shown in Table 4, and the results of the related interactions, shown in Table 3. Starting with the pAES, the estimated mean WTA of €112.5/ha/year derived for the ASC (pASC) represents farmers' WTA to enrol in the entry level for this type of scheme, in this case involving the use of herbaceous cover at moderate level (2 m wide strips), managed using mower and/or grazing, and a control system based on field evaluation (for the usual control rate of 3%–5% of farms every year). The pASC value is also affected by the interaction with the percentage of vegetal cover (pASC × HC20 interaction), showing that the WTA is reduced by €70.2/ha/year for farmers that already have (compared to those that do not) herbaceous cover over at least 20% of the total olive grove area. As expected, farmers demand higher compensation to provide ES at a higher level or to be subject to a stricter verification system. The mean WTA increases by €56.6/ha/year for the high level of practice use

[8]We also explored the use of an MXL allowing for correlated parameters but found only a very small improvement in model fit compared to the one with uncorrelated parameters. For reasons of parsimony, we preferred to keep the latter for the final analysis. Results from the former are available upon request.

TABLE 3 MXL model.

	Mean		SD	
Parameter mean values	**Coef.**	**SE**	**Coef.**	**SE**
Practice-based				
pASC	1.606***	0.419	−1.269***	0.127
pPRH—Provision level: high	0.567**	0.336	1.619***	0.196
pSAT—Satellite control	0.514**	0.304	−1.352***	0.177
Results-based				
rASC	1.219***	0.409	0.345***	0.103
rCAM—Environmental results: carbon sequestration-moderate level	−0.097	0.258	0.835***	0.126
rCAH—Environmental results: carbon sequestration-high level	0.466**	0.276	−1.355***	0.191
rBIM—Environmental results: biodiversity-moderate level	0.647***	0.217	−1.803***	0.116
rBIH—Environmental results: biodiversity-high level	0.899**	0.512	2.176***	0.225
rSAT—Satellite control	0.575***	0.215	−1.261***	0.129
PAY—Payment attribute	4.737***	1.177	3.577***	0.907
Error component			−6.638***	1.546
Heterogeneity in the mean				
pASC × HC20	−0.702***	0.251		
pSAT × Satreno	0.646**	0.279		
rASC × Carbio	−0.810***	0.218		
rASC × Appyes	−1.063***	0.209		
rASC × Rbrisky	0.974***	0.259		
rBIH × Rbrisky	0.613*	0.475		
rSAT × Satreno	0.352*	0.245		
Model fit statistics				
LL		−1085.5		
Pseudo-R^2		0.343		
AIC/N		0.934		
Observations (individuals)		2384 (298)		

Note: ***, **, *Significance at 1%, 5%, and 10% level, respectively. Attribute coefficients are rescaled 1:100.

(i.e., pPRH with 3.5 m wide herbaceous cover strips), and by €64.7/ha/year if a satellite-based remote sensing control system (pSAT) is to be used to inform the implementing agency on the level and duration of the herbaceous cover—implying a higher control frequency and a full coverage of farms (100% control rate). With regard to the latter, we find that those who do not agree that using satellite information is an appropriate way to measure environmental results (pSAT × Satreno interaction) report an additional WTA of €64.6/ha/year, compared to those who agree or are indifferent.

Turning to the analysis of the rAES, the estimated mean WTA for rASC (i.e., €96.7/ha/year) represents the premium required by farmers to participate in an entry level of this kind of scheme, here defined as achieving the expected outcomes with the commitment that ES provision would be at least 10% greater than the average provision in the agricultural district and using field evaluation as the control system. In our case, the scheme must focus

TABLE 4 Farmers' mean willingness to accept (WTA) for attribute levels.

Attribute levels	Mean	Conf. int. (95%)
$pASC_{int}$—Entry level practice-based AES	112.54***	43.82, 181.26
pPRH—Provision level: high	56.65**	−9.13, 122.43
$pSAT_{int}$—Satellite control	64.65**	2.75, 126.55
$rASC_{int}$—Entry level for results-based AES	96.72***	38.16, 155.28
rCAM—Environmental results: carbon sequestration-moderate level	−9.74	−60.35, 40.87
rCAH—Environmental results: carbon sequestration-high level	46.57**	−7.53, 100.67
rBIM—Environmental results: biodiversity-moderate level	64.73***	22.24, 107.22
$rBIH_{int}$—Environmental results: biodiversity-high level	130.44***	66.00, 194.88
$rSAT_{int}$—Satellite control	64.72***	25.28, 104.16

Note: *** and **Significance at 1% and 5% level, respectively. Estimations were obtained using the delta method with the coefficients shown in Table 3 (MXL model) and the rate values shown in Table 2. $pASC_{int}$ and $rASC_{int}$ correspond to the moderate provision levels, which serve as reference. The "int" subscript indicates that the values are calculated taking into account the associated interaction terms.

on at least one ES, carbon sequestration and/or biodiversity. The lack of significance of the rCAM attribute level reveals that the WTA would not change—compared to the entry level (rAES) described above—in the case of carbon sequestration for this moderate level. However, it would significantly change for biodiversity, as shown by the rBIM coefficient, indicating an increase in the mean WTA for scheme participation of €64.7/ha/year. At a high level of provision (i.e., at least 20% above the average provision in the agricultural district), farmers' mean WTA for a rAES focusing on carbon sequestration (rCAH) would be €46.6/ha/year, much lower than the mean WTA estimated for biodiversity (rBIH), which is €130.4/ha/year.

With regard to the attribute related to the control system, no statistically significant differences (tested using the delta method) are found for the mean WTA for a satellite remote sensing control system rSAT compared to that for the pAES, reflecting the respondents' similar perception of monitoring practices or outcomes by this control system. As happens for pAES, those who are sceptical of the adequacy of such control system show an increase in WTA of €35.2/ha/year (rSAT × Satreno interaction).

Further preference heterogeneity is found in the general preferences toward participating in rAES at the entry level (captured by rASC) and specific preferences regarding high levels of provision of biodiversity (rBIH) (shown in Table 3). As for pAES, we find that the initial situation (represented by the variable Carbio, which takes the value 1 if the farmer states that his/her level of provision of carbon sequestration and biodiversity is 10% above the average in the agricultural district, and 0 otherwise) also influences WTA for scheme participation. Indeed, as with the pASC × HC20 interaction, the result for the rASC × Carbio interaction suggests that those who believe they are providing such services at a level at least moderately higher than the average would require lower WTA (−€81.0/ha/year, compared to those who do not believe this) for participating in this kind of scheme. Similarly, the result for the rASC × Appyes interaction indicates that those who agree with the usefulness of a smartphone application to support compliance with scheme requirements would also require lower payments in general (estimated at −€106.3/ha/year, compared to those who do not agree with it or are indifferent). In addition, farmers' perception of the risk of not achieving the expected results due to circumstances beyond their control impacts their WTA to participate in a rAES (see rASC × Rbrisky interaction). In particular, respondents who firmly agree that rAES are risky because the payment is contingent on factors not under farmers' control demand €97.4/ha/year more to enrol in this kind of scheme. Similarly, the result for the rBIH × Rbrisky interaction suggests an

TABLE 5 Farmers' mean willingness to accept (WTA) for policy scenarios of practice- and result-based AES.

Scenarios (attribute-levels included)	Detailed description	Mean	Conf. int. (95%)
pAES1	pASC+HC20_m*pASC×HC20	112.54	43.82, 181.26
pAES2 (pASC, pPRH)	Same as pAES1 plus pPRH	169.20	133.23, 205.17
pAES3 (pASC, pPRH, pSAT)	Same as pAES2 plus pSAT + Satreno_m*pSAT × Satreno	233.85	172.19, 295.51
rAES1 (rASC, rCAM)	rASC + Carbio_m*rASC × Carbio + Appyes_m*rASC × Appyes + Rbrisky_m*rASC × Rbrisky + rCAM	86.99	50.12, 123.86
rAES2 (rASC, rCAH)	Same as rAES1 plus rCAH	133.56	75.99, 191.13
rAES3 (rASC, rCAH, rSAT)	Same as rAES3 plus Satreno_m*rSAT × Satreno	198.28	158.47, 238.09
rAES4 (rASC, rBIM)	rASC + Carbio_m*rASC × Carbio + Appyes_m*rASC × Appyes + Rbrisky_m*rASC × Rbrisky + rBIM	161.45	107.43, 215.47
rAES5 (rASC, rBIH)	rASC + Carbio_m*rASC × Carbio + Appyes_m*rASC × Appyes + Rbrisky_m*rASC × Rbrisky + rBIH	291.89	246.08, 337.70
rAES6 (rASC, rBIH, rSAT)	Same as rAES5 plus Satreno_m*rSAT × Satreno	356.61	299.10; 414.12
rAES7 (rASC, rCAH, rBIH)	Same as rAES5 plus rCAH	328.73	285.37, 372.09
rAES8 (rASC, rCAH, rBIH, rSAT)	Same as rAES7 plus Satreno_m*rSAT × Satreno	393.45	341.75, 445.15

Note: All values are significantly different from zero at a 1% level. Estimations were obtained using the delta method with the coefficients shown in Table 3 (MXL model) and the rate values shown in Table 2. HC20_m, Satreno_m, Carbio_m, Appyes_m, and Rbrisky_m stand for the latter.

added effect (estimated at €61.3/ha/year) of the perception of risk when the scheme is aimed at achieving a significantly higher level of biodiversity, probably due to the greater uncertainty related to this ES.

Using the results from the MXL model, the WTA for different policy scenarios can be estimated, as shown in Table 5. These results firstly depict a general trend, which basically reveals a positive relationship between the stringency of the scheme and the compensation needed to promote farmer participation. At the least stringent level (pAES1 and rAES1, with the latter focused on carbon sequestration), mean WTA estimates for practice-based and results-based scheme scenarios are €112.5/ha/year and €87.0/ha/year, respectively, with no statistically significant differences (tested using the delta method) found between them. Similarly, no significant differences are found for schemes involving a high level of provision (attribute-levels pPRH and rCAH), with mean estimates increasing to €169.2/ha/year and €133.6/ha/year for pAES2 and rAES2, respectively, for the case of field control system, and €233.9/ha/year and €198.3/ha/year for pAES3 and rAES3, for the case of a satellite-based control system (represented by attribute-levels pSAT and rSAT). When considering biodiversity as the environmental objective of the scheme, WTA estimates significantly increase for the three aforementioned levels (i.e., moderate and high level, and the latter with remote sensing-based control), which for this ES are named rAES4, rAES5, and rAES6, respectively, showing mean values of €161.5/ha/year, €291.9/ha/year and €356.6/ha/year. When a high level of provision of the two ES (carbon sequestration and biodiversity) was defined as the scheme objective (related to scenarios rAES7 and rAES8), results indicate that the mean compensation needed to promote farmer participation would be the highest of all the scenarios considered, registering mean WTA values of €328.7/ha/year and €393.5/ha/year for scheme scenarios including field and satellite-based control systems, respectively. It is worth mentioning that all the WTA estimates are of the same order of magnitude as the expected per-hectare amount for the eco-schemes in permanent crops in Spain (€165.17/ha for the year 2023) (MAPA, 2022), as well as the payments for both the AES for olive groves (between €110.28/ha and €277.15/ha, depending on slope, width and type of the herbaceous cover and management of pruning residues) and organic farming in SOG (€362.04/ha, resulting from the sum of a premium for organic farming of €247.9/ha and a specific AES for organic SOG of €114.14/ha) included in the Andalusian Rural Development Program until 2023 (Junta de Andalucía, 2015).

4 | DISCUSSION

In this paper farmers' preferences toward participation in AES is analysed, providing for the first-time explicit comparative estimates of farmers' WTA for participating in pAES and rAES. To that end, a labelled DCE was designed and applied to provide new comparative insights into farmers' preferences toward both types of scheme. Results indicate that farmers prefer pAES to rAES, with a significantly larger percentage of farmers being willing to participate in a pAES, although this depends on the environmental objective established for the rAES; no statistically significant difference is found when carbon sequestration is the only environmental objective. This result is in line with Vainio et al. (2021), who found that Finnish farmers perceive the pAES as preferable, but contrasts with the findings of Šumrada et al. (2022), who found that the majority of farmers in Slovenia preferred the rAES approach over the pASC scheme. This result may be due to context-specific factors underlying the general preferences for each approach, as also observed by Šumrada et al. (2022). Possible explanations in our case are that farmers are resistant to change because they feel more comfortable with the known and certain than with something new and unexplored (Dessart et al., 2019). This is confirmed by farmers' general opinion that the use of herbaceous cover strips is a practical soil management practice to enhance the environmental performance of olive groves, as observed by Colombo et al. (2021).

In this context, it should be borne in mind that farmers' preferences toward pAES are contingent on the required practices, so the comparative preferences for rAES could be different if the practice required for pAES were negatively perceived by farmers. Thus, the implementation of pAES requires prior analysis of farmers' preferences toward the proposed practices (ideally comparing information on perceived and real cost-effectiness, as shown by Alcon et al. (2021)). Importantly, the results show that WTA values for pAES and rAES focused on carbon sequestration, at either moderate (entry) or high level, are found to be not statistically different. This demonstrates that results-based instruments focused on carbon sequestration are well accepted by farmers and opens the door to a possible widespread implementation of rAES in the forthcoming agri-environmental policy. Additionally, when the rAES focuses on biodiversity, WTA significantly increases, especially at high levels of provision and when combining the two environmental objectives. These results are in keeping with Niskanen et al. (2021), who observed that farmers' WTA for the biodiversity-related attribute was significantly higher than the WTA for the one related to climate change.

The higher WTA for rAES focusing on biodiversity probably reflects farmers' greater uncertainty about their capacity to provide biodiversity-related services (in this case, measured as the number of bird species) compared to those related to carbon sequestration. Said uncertainty may be due to the mobility of the targeted species, which could jeopardise contract fulfilment at the moment of inspection. This result also suggests that environmental indicators subject to temporal issues should be avoided in rAES, given the uncertainty and the lack of specificity with regard to compliance with the required environmental levels (Zabel & Roe, 2009). This implies that the higher compensation required due to the inherent uncertainty and the extra risk typically associated with rAES (compared to pAES) (Burton & Schwarz, 2013) may be largely mitigated by targeting the policy at an appropriate environmental objective (carbon sequestration) using suitable indicators well understood by the farmer. Furthermore, the joint provision of biodiversity and carbon sequestration means that many practices—such as the use of herbaceous cover (Gómez, 2009)—help in the provision of both services; a clear policy implication is that the design of rAES should focus on carbon sequestration (and its related indicators) rather than biodiversity (and its related indicators), to increase farmers' scheme acceptance and overall policy efficiency concerning environmental improvements. Having said that, some restrictions would be required to guarantee the joint provision of biodiversity through practices aimed at carbon sequestration, such as the mechanical management of the herbaceous cover, as has been established for the eco-schemes in the forthcoming CAP in Spain.

In our study, farmers' willingness to enrol in either pAES or rAES depends mainly on AES features; namely, the level of provision, the scheme's environmental objective(s) (in the case of rAES), and the monitoring system. With regard to the latter, it is worth noting that monitoring costs represent a major challenge in the implementation of AES. Currently, only a small proportion of the farms enrolled in pAES (<5%) are ultimately monitored by the administration, reducing the efficiency of scheme implementation. When it comes to rAES, this issue is exacerbated by the fact that the measurement of results often involves the use of expensive monitoring and measuring devices (Herzon et al., 2018). To overcome this issue, previous research suggests either involving farmers in the monitoring of the outcomes (Tanaka et al., 2022) or switching to a modelling approach, instead of direct measurement, to determine whether the farmer is fulfilling his/her commitments (Bartkowski et al., 2021). In this study we proposed the use of satellite-based information to verify compliance with AES obligations, due to the relatively lower monitoring costs associated with such a control system. We found that farmers significantly prefer the current 'in-field' monitoring system, which—as defined here—entails the use of another type of information (in situ vs. satellite-based), a lower control frequency (once a year vs. once a week), and a lower control rate (<5% vs. 100% potentially). This may be due to the farmers' lack of familiarity with/knowledge about the new monitoring system, they may not fully trust it, and they may prefer lower levels of control pressure. Regarding the latter, previous results show that farmers may be indifferent to diverse control rates (Villanueva et al., 2015). In addition, qualitative information provided by the interviewees suggests that the control frequency may not be a determinant of participation, especially because a higher control frequency may help (average) compliers minimise the risk of default due to an in-field control visit at the 'wrong' moment. We thus infer that the lack of familiarity with and trust in the monitoring approach may be behind the significantly higher mean WTA estimated for the surveyed farmers. In support of this idea, we point to our results about the significant additional premium for participation in schemes (either practice- or results-based) using satellite-based monitoring systems required by those who do not agree with the suitability of such a system for measuring environmental results. Given the role of the farmers' beliefs about the adequacy of this kind of monitoring system, information campaigns could be implemented to educate farmers about the capability of remote sensors and the indicators to be used.

The uncertainty and higher risks associated with participation in rAES (especially when focusing on biodiversity enhancement and/or using remote sensing-based monitoring) calls for complementary measures to increase the likelihood of enrolment. Our results suggest the usefulness of policy-making options relating to the development of digital tools to support farmers' participation and the use of hybrid approaches combining pAES and rAES. With regard to the former, the finding that a smartphone application to assist farmers reduces the WTA for participation in rAES opens up an opportunity to facilitate participation. This significant effect—which partly contradicts results reported by Tanaka et al. (2022) indicating farmers' indifference to technical assistance in rAES (most probably due to the different types of assistance considered)—could be interpreted as reflecting farmers' perception that such a tool may reduce the uncertainty and risks associated with these schemes, particularly in designs extensively relying on remote sensing monitoring. In the same vein, we find that farmers who perceive high risks of defaulting in rAES require much higher WTA (in general, and particularly with schemes focusing on high levels of biodiversity), thus lending support to the idea that perceived (and real) uncertainty associated with rAES participation strongly determines the payments eventually required by farmers (Burton & Schwarz, 2013; Massfeller et al., 2022; Tanaka et al., 2022). In this respect, a multifaceted online application where farmers can upload real-time information about the implemented practices, administrative issues, and so on, and receive feedback from technicians, exchange information with other farmers (enhancing the related social capital) and have access to comprehensive explanations on monitoring, among other aspects, may be a convenient way to assuage farmers' uncertainty and increase their willingness to participate in rAES. The application could also be used to inform farmers about any reduction in the requirements of the rAES, in the event that external causes (adverse climatic conditions, for instance) make it impossible to achieve the expected results. In this context, a good complementary instrument to reduce farmers' uncertainty could be the inclusion of specific insurance policies in the rAES contracts, administered by means of objective and cheap-to-measure indexes, such as weather index insurance based on satellite observation (Kölle et al., 2020). Future research should analyse possible forms of implementing online platforms for the management of rAES and explore farmers' opinion about them.

In addition, the use of hybrid AES combining approaches based on both practices and results may also serve to reduce uncertainty (Herzon et al., 2018). As suggested by Colombo and Rocamora-Montiel (2018), in a hybrid scheme, farmers can receive a base payment for adhering to the (entry-level) conditions of a pAES, and a progressively larger payment according to the results provided. This system would stimulate farmers to innovate by employing their knowledge to fine-tune the implemented practices, something that is context specific, heterogeneous, and subtle (Swagemakers et al., 2009). Results from Derissen and Quaas (2013) actually indicate that hybrid schemes may be more efficient under environmental uncertainty and information asymmetry (which often characterise real-world applications). However, early insights into farmers' preferences toward hybrid designs (with pAES and a bonus for results to be received in the final year of the multi-annual commitment) seem to show that farmers pay more attention to practices than to results (Salazar-Ordóñez et al., 2021). Clearly, further research should investigate farmers' opinion and acceptance of hybrid AES.

This paper has some limitations that must be acknowledged. First, the high WTA for the biodiversity objective may be due to the use of the number of bird species as the indicator. While this indicator may be justified for reasons of enhancing societal legitimation (Granado-Díaz et al., 2020), as described above, the mobility of the species may increase farmers' uncertainty about their capacity for provision of this ES and thus their WTA for enrolling in the scheme. On the other hand, the use of less mobile animal species such as arthropods, amphibians or reptiles may be rejected by farmers since the presence of such species is often considered harmful. Thus, biodiversity indicators not based on negatively perceived or mobile species—such as an indicator of the variety of key plant species—could be a good way to overcome these issues. At the same time, the uncertainty related to the measurement of biodiversity through satellite sensors might also have increased the WTA for this indicator. Second, the use of the mean agricultural district value as the reference level for carbon sequestration and biodiversity in rAES may have disincentivised those farmers who think that the values they currently register are far below the district average (something which is arguably shown by the interactions with the variables pCV20 and Carbio). In this sense, the use of the agricultural district level may introduce a sort of selection bias toward agents that are already complying (*adverse selection*), reducing the efficacy of the AES (Gómez-Limón et al., 2019). However, the rAES must be based on the application of the 'providers get' principle, meaning it would be unfair not to compensate farmers who are currently providing ES at high levels. Therefore, this trade-off between AES efficiency and social legitimacy clearly deserves further research, preferably also considering demand-side welfare estimates to leverage costs and benefits from policy action (Alcon et al., 2020). Third, while the remote sensing monitoring system was defined anticipating forthcoming applications, the observed farmers' preferences toward it implicitly gather several aspects, namely frequency of monitoring, coverage and precision. Future research should separately assess preferences for these aspects, using the specific characterisation that remote sensing monitoring systems will present once they are fully developed.

5 | CONCLUSIONS

This study is the first to explicitly provide comparative estimates of land managers' WTA for participation in practice- and results-based policy approaches. To that end, a labelled choice experiment is applied to analyse farmers' WTA for agri-environmental schemes focusing on biodiversity and carbon sequestration using equivalent levels of environmental provision for both approaches. The overarching message from the results is that the relative efficiency—in terms of farmers' participation—of results- over practice-based schemes depends on establishing the environmental objective and the related indicators (e.g., organic carbon sequestered vs. the number of bird species), the type of monitoring (remote sensing-based vs. in-field), the targeted level of environmental provision, and the capacity to reduce the farmers' uncertainty about whether or not they will be able to accomplish the expected outcomes.

Although we find a general preference for practice- over results-based policy approaches, the results show that this strongly depends on the environmental policy objective. Specifically, the results suggest that farmers are indifferent to the type of scheme when the results-based scheme targets carbon sequestration (and its related indicator of carbon sequestered), whereas significantly higher payments would be needed to promote participation when biodiversity (and its related indicator of bird species) is targeted. Due to the complementary joint provision of both ES, a clear take-away message would be that by focusing the results-based schemes on carbon sequestration, biodiversity (as well as other ES) could also be enhanced but at a lower compensation requirement. By doing so, issues with measuring biodiversity outcomes of changes in farm management would also be overcome.

Concerning the monitoring of the results in an efficient and economical way, the use of satellite-based information is a promising avenue. However, the implementation of a remote sensing monitoring system would introduce a new paradigm where the percentage of control and verification is fully established. Our results indicate higher compensation requirements for schemes using this type of monitoring, hinting at the farmers' perceived uncertainty around it and lack of familiarity with it. Clearly, the shift to a remote sensing-based monitoring system requires trust between the actors involved in the implementation of the policy schemes; it would thus be advisable to implement actions aimed at reducing farmers' uncertainty regarding commitment achievements (e.g., developing online support systems facilitating information exchange between users and the implementing agency) and fostering genuine collaboration between the two parties. In this context, the support of collaborative approaches—such as bridging organisations that contribute to conflict resolution and negotiation of diverging interests—is a possible way to build trust between the parties.

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DATA AVAILABILITY STATEMENT

Data available on request from the authors.

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