Do farmers prefer result-based, hybrid or practice-based agri-environmental schemes? *

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Abstract

This study assesses farmers' relative preferences for practice-based, result-based and hybrid agri-environmental schemes in three countries. The data comes from a choice experiment conducted by the Organization for Economic Cooperation and Development (OECD) with a focus on biodiversity, climate, and water quality. Our results show that result-based contracts were the least preferred option, and hybrid schemes were the preferred option only for low levels of biodiversity objectives and with a low share of payment conditioned to biodiversity results. In all other cases farmers preferred practice-based schemes. A cost-benefit analysis illustrates how these preferences impact the schemes' relative cost-effectiveness.

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1 Introduction

Globally, there is increased an interest in designing cost-effective policy tools to reduce the environmental footprint of agriculture. Agriculture, Forestry and Other Land Use (AFOLU) is responsible for 23% of global GHG emissions (IPCC, 2019). Agriculture is also a major cause of pesticide and nutrient water contamination, soil acidification, deforestation, biodiversity loss and freshwater and soil resources overuse and degradation (Campbell, 2017; Foley, 2011; OECD, 2013, 2019). To limit the impacts of agriculture on the environment, several countries have agri-environmental payment schemes (AES) in place. AES are voluntary payments that compensate farmers for the adoption of sustainable practices. Currently, the majority of OECD countries implement agri-environmental schemes and spend more than 20 billion dollars annually in these instruments, representing 8% of support to farmers (OECD, 2022a). However, many of these instruments lack proper targeting mechanisms (Guerrero, 2021) and tend to be ineffective at improving environmental outcomes (Batáry, 2015; Coderoni and Esposti, 2018; Engel, 2016).

There is renewed interest in the policy arena to improve the effectiveness of agricultural policies, with particular attention to AES. An example of this is the stronger emphasis on results and performance of the EU´s Common Agricultural Policy for the period 2023-2027 (Commission, 2022), which not only increases the share of funds allocated to climate and environmental objectives but also links those objectives to the mitigation and biodiversity targets put forward by the European Green Deal. Result-based payment schemes that pay farmers for the environmental outcomes obtained in their farms are increasingly used as a complement or alternative mechanism to improve the effectiveness of AES (Herzon et al., 2018). While hybrid schemes, which combine practice and result based payments, and result-based payments can be potentially more cost-effective than practice-based instruments (Wuepper and Huber, 2022), their use remains limited (Guerrero, 2021; OECD, 2022a).

Designing cost-effective result-based mechanisms requires evidence on farmers´ willingness to accept (WTA) for contracts of this type, i.e. the minimum payment required by farmers to accept to join a specific contract. Nevertheless, only a handful of papers have attempted to measure WTA for result-based schemes. Tanaka et al. (2022) calculated farmers' WTA for a result-based scheme in Japan that compensates farmers for the number of bird species found in paddy rice fields. Niskanen et al. (2021) estimate farmers´ WTA for achieving results in biodiversity, landscape, climate change mitigation and water quality domains in Finland. Šumrada et al. (2022) assess the relative preferences of Slovenian farmers of practice-based and result-based schemes for biodiversity conservation on grasslands. However, to the best of our knowledge, no paper directly assesses the relative preferences and WTA of farmers for result-based schemes in comparison with practice-based and hybrid schemes beyond biodiversity objectives. This paper aims to fill this gap by simultaneously estimating farmers' willingness to accept practice-based, result-based and hybrid contracts in three different countries (Finland, the Netherlands, and Sweden), for three different environmental objectives (biodiversity protection, climate change mitigation and water quality improvement).

The literature finds that, in general, practice-based payments yield poor environmental results per dollar invested, due to a lack of targeting and ability to tailor payments on heterogeneity in environmental benefits and/or compliance costs (Batáry, 2015; Coderoni and Esposti, 2018; Engel, 2016). Alternative payment mechanisms have therefore been proposed, in particular, a shift from practice-based to result-based approaches, as a way to improve environmental effectiveness and budgetary cost-effectiveness of agri-environmental payment schemes (Batáry, 2015; Burton and Schwarz, 2013; Engel, 2016; Guerrero, 2021; Lankoski, 2016; OECD, 2022a; Savage and Ribaudo, 2016; Shortle, 2012). Thus far result-based schemes have been used predominantly for biodiversity objectives and are claimed to be especially well suited for the maintenance of existing environmental status (Allen, 2014; Bertke et al., 2008; Herzon et al., 2018; Schwarz, 2008).

Three characteristics define the result-based payment approach: (i) direct link of the payment to the environmental results (for example, the number of indicator species in species-rich grassland or the amount of carbon sequestered in soils), (ii) payment level is differentiated according to the level of the environmental results, and (iii) the farmer is free to choose management practices to achieve the environmental results (Schwarz, 2008). Since result-based schemes directly link payments to environmental results, they have the potential to improve environmental effectiveness and budgetary cost-effectiveness. However, whether result-based schemes increase the budgetary cost-effectiveness of agri-environmental programmes, relative to practice-based schemes, will depend on how much more (or less) farmers are required to be paid to join result-based schemes. Indeed, result-based schemes increase the financial risk to farmers due to the impact of factors outside farmers' control, such as climate and weather conditions, that affect the level of environmental results achieved. Thus, participation into result-based schemes may require high risk premiums for specific farmers (Niskanen et al., 2021; OECD, 2022a). These schemes also require robust monitoring and evaluation programs that can be costly to set up and administer and that can be difficult for farmers to accept and follow (Birge et al., 2017). However, relative to practice-based payments, result-based payments have been found to increase social networking, knowledge sharing, and intrinsic motivation for environmental conservation (Andeltová, 2018; Burton and Schwarz, 2013; Herzon et al., 2018; Matzdorf et al., 2008), which could increase farmers' preferences for result-based schemes over practice-based alternatives. How, the positives and negatives of result-based schemes, relative to practice-based schemes, balance out in farmers' decision making, and how this impacts the schemes' relative cost-effectiveness, are the empirical questions this paper aims to address.

In this study we simultaneously assess farmers' willingness to accept to participate into practice-based, result-based and hybrid programs. The data used in this study comes from an online choice experiment conducted in March 2021 with farmers in Finland, the Netherlands and Sweden (OECD, 2022a) in the context of a project conducted by the Organization for Economic Cooperation and Development (OECD). We build on OECD (2022a) and extend the analysis through the use of a mixed logit model to elicit farmers' preferences and WTA and propose a cost-benefits analysis of alternative scheme designs: practice-, hybrid- and result-based schemes.

The survey targeted arable and mixed farms (both livestock and arable). A total of 731 farmers responded the surveys: 357 in Finland, 230 in Sweden and 144 in the Netherlands. Our results show that farmers will need to be compensated in order to participate into any of the proposed contracts. However, result-based contracts were the least preferred by farmers, regardless of the level of environmental outcomes stipulated by the contract. Hybrid schemes were the preferred option for low levels of biodiversity outcomes and when the share of payment linked to achieving biodiversity results was low (at 10%). When hybrid and result-based schemes included objectives to mitigate greenhouse gases emissions or improve water quality, farmers always preferred practice-based schemes. Finally, we show that net social benefits of these contracts (social benefits - social costs) increase with the number of practices or the level of results required by contracts, indicating that social benefits from improved environmental conditions tend to increase at a higher rate than social costs, as proxied by farmers' WTA, when contracts demand higher environmental commitments.

The structure of the paper is as follows: Section 2 presents the context of AES in the countries where we conducted the choice experiment. Section 3 describes the design of the survey and the data. Section 4 displays the mixed logit specification used. Section 5 presents the results, section 6 the cost-benefit analysis and Section 7 concludes.

2 Context

All three survey countries - Finland, The Netherlands and Sweden - are EU Member States, and thus are under the EU Regulations and Directives related to water quality, GHG emissions, and biodiversity. In addition to these regulations, the Common Agricultural Policy (CAP) provides variety of measures to address agri-environmental issues, such as environmental cross-compliance, greening and voluntary Agri-environmental Schemes (AES). Notably, AESs are the only measure in the second pillar of the CAP that is mandatory for Member States to implement, and they have become an essential mechanism for supporting environmentally friendly agricultural production practices in the region.

The countries in this study vary substantially in the design and adoption of AESs as well as their success in reducing the environmental damages due to agriculture. In Finland, where agriculture is responsible for roughly 60% of phosphorus runoff and 50% of nitrogen runoff to watercourses (Niemi et al., 2019) the primary objectives of AESs during the 2014–2020 programming period were to reduce emissions and nutrient runoff to waterways as well as increase biodiversity. Nevertheless, biodiversity has declined overall in recent years while the number of threatened species and habitats has risen due to increases in farm size, increased input use intensity and specialisation of production. One such habitat that has declined precipitously is traditional biotopes, such as semi-natural grasslands (Birge and Herzon, 2014).

Agricultural land covers just 8% of total area in Sweden, which has a wide range of AES that focus on improving biodiversity, as well as reducing nutrient runoff and leaching. Through a mix of policies, Sweden has made significant progress reducing nutrient imbalances since 1990 but continues to lose semi-natural grasslands and farmland biodiversity (OECD, 2022b). While pesticides risks have declined in Sweden, concentrations of active substances in waterways remain a source of concern in some areas (OECD, 2015).

In both countries, the payment schemes compensate farmers for income forgone as well as extra costs incurred from the adoption of practices and measures. In Finland, this includes a farm-level measure that captures the balanced use of nutrients, which is mandatory to all those committed to the scheme, as well as optional parcel-specific measures (Niemi et al., 2019). To receive payment, all participating farmers must comply with pre-specified limits on the use of nitrogen and phosphorus nutrients in arable farming. Parcel-specific measures include, for example, the plant cover on arable land in winter, promoting biodiversity in arable environments and recycling nutrients and organic matter. In Sweden, payments for reducing nitrogen runoff compensate farmers for adoption of catch crops, spring tillage, or both. Other relevant schemes include the implementation of buffer zones along waterways and management of wetlands and ponds. The AES has been adopted widely in Finland and covers more than 90% of the agricultural land area and 86% of Finnish farmers who applied for the basic payment system of the CAP (Niemi et al., 2019), while the rates of participation in any AES in Sweden are roughly 95%. Recent evidence from Sweden suggests that while the AES are widely adopted, their impacts on nutrient runoff, for example, as well as their cost effectiveness, are mixed (Grenestam and Nordin, 2018; Smith et al., 2016).

In contrast, the main focus of Dutch AES is to restore and improve landscapes for supporting biodiversity, including bird habitats. As an important component of the Dutch Rural Development Programme, AES in the Netherlands are offered to cooperatives since 2016, on the premise that it was the most efficient way to halt biodiversity loss. In doing so, the AES introduced flexibility amongst cooperative members and reduced administrative costs while being aligned to the production structure in the Netherlands (Terwan et al., 2016). Relative to Finland and Sweden, the Netherlands is relatively small (33,755 km2), though agricultural land represents 55% of total land area (OECD, 2022b). The Dutch agricultural sector is highly intensive and export-oriented (OECD, 2015) and ranks second in the world for total value of agricultural exports. As a result, the country faces significant challenges related to agri-environmental impacts. Driven primarily by livestock production, The Netherlands has some of the largest nitrogen surpluses in the OECD region (181 Nkg/ha in 2017, Table 1), though it has made tremendous progress at reducing those surpluses since the 1990s, where N surpluses were higher than 300kg/ha (OECD, 2022b).

Of particular concern amongst policy makers in the Netherlands is a rapid loss of bird species due to farming intensification (Grondard et al., 2023). The intensification of land use for agriculture resulted in an over 30% reduction in the farmland bird indicator since 2000, which is amongst the worst in Europe. Due to the destruction of bird habitats, numerous species are in danger of becoming extinct. While their management is based on local policy, agricultural landscapes in the country are internationally important for meadows birds and wader species, for which roughly 50% and 45% of the European populations breed in The Netherlands. A recent correlational analysis provides some evidence that the existing AES can be effective at supporting a subset of targeted species (Grondard et al., 2023), though the authors note that targeting should be based on local habitat characteristics.

Table 1: Selected agri-environmental indicators, average of 2017-2019 (OECD Agri-environmental indicators database)

Indicator	Finland	Netherlands	Sweden
N-balance kg per ha of agricultural land	51	181	44
N-use efficiency	0.5	0.6	0.6
P-balance per ha of agricultural land	5	4	1.5
P-use efficiency	0.7	0.9	0.9
GHG - emission intensity	2.1	1.5	1.8
Farmland birds biodiversity (index 2000 = 100)	82	61	81

Notes: Nutrient balances are measured as the nutrient inputs minus nutrient outputs and nutrient use efficiency (N-use and P-use) as the ratio of nutrient outputs to nutrient inputs. Greenhouse gas emission intensity is measured as kilograms of CO2-eq per USD value of production.

3 Data and Survey Design

3.1 Survey Design

To collect data on producer preferences for design characteristics of agri-environmental schemes, we incorporated a discrete choice experiment (DCE) into an online survey that was administered to farmers across three European countries between May and June, 2021. A discrete choice experiment presents respondents with a series of choices, in which respondents are asked to choose the option they prefer in each situation. In each situation, respondents make a choice amongst alternatives that are described by a set of attributes and attribute levels (Hensher et al., 2005). We collaborated with local research organizations and agricultural ministries to sample arable crop and mixed (livestock and crop) farmers in Finland (N=4,600), Sweden (N=3,078), and the Netherlands (N=1,300).[1] We adapted the questionnaires to each country context and implemented the survey in LimeSurvey. The partner institutions sent the invitation email and survey links to a large sample of representative producers that we sampled using administrative records from each institution. The sample was limited to farmers with at least one hectare of land and whose farms were characterized by specialization (i) arable farming (general field cropping of cereals, rapeseed and protein crops) or (ii) mixed farming (grazing bovines or sheep and crop production) to represent the two categories of farmers that would be targeted by the potential agri-environmental schemes. We employed a stratified random sampling method in which we stratified by specialization and over-sampled mixed farmers to have a nationally representative sample of farmers for each specialization with equal sample sizes. We performed an initial screening based on farm size and specialization using administrative records from the participating institutions and also used a series of screening questions in the survey to ensure that the farmers were eligible to participate based on the above criteria.[2] To ensure a geographically representative sample, the number of farmers sampled in each administrative district by strata was proportional to the share of farmers from the district in the administrative databases.

Prior to the survey, we conducted online focus groups with an initial draft of the questionnaire in Finland and the Netherlands.[3] In Finland, five farmers participated, with varying farm sizes and specializations and in the Netherlands, five farmers that raised livestock and cultivated crops participated. The focus groups were essential in improving the details of the communication of the different schemes and overall understanding. Farmers initially perceived the language of the survey to be excessively normative and noted that it included language that they perceived to be in favor of the result-based scheme. We further conducted pilot surveys in Sweden, Finland, Argentina, and Canada between November 2020 and January 2021 to test the questionnaire design and to calibrate the payments and parameters for the choice experiment (Mariel et al., 2021), based on a D_0 efficient design.[4] In Finland and Sweden, we sent the survey to 100 ran-

[1] The collaborating organizations are LUKE - Natural Resources Institute Finland (Finland), the Ministry of Economic Affairs and Climate Policy (Netherlands), and the Swedish Board of Agriculture (Sweden).

[2] In the questionnaire, we further screened respondents based on whether they were the person that makes decisions on the farm about enrollment in environmental schemes and whether they consented to participate.

[3] While focus groups were scheduled to be conducted physically, the Covid-19 pandemic prevented us from conducting them in-person.

[4] Argentina and Canada initially planned to be part of the full project, but were unable to proceed due to logistical

domly selected farmers and used monetary incentives to approximate response rates in the final survey implementation. We obtained a total of 115 responses to the pilot across the 5 countries (28 in Argentina, 34 in Canada, 21 in Finland, 30 in Sweden and 2 in the Netherlands). Initial findings from the pilot prompted us to shorten the introduction and improve the explanations of the schemes and practices due to low comprehension. A copy of the finalized questionnaire is attached in the appendix.

The survey instrument was structured into four sections: the first section gathered farmers' baseline agri-environmental practices and farm characteristics. The second section contained the choice experiment to elicit farmer preferences for the alternative scheme designs using the 6 choice-cards. The third section collects farmers' behavioural characteristics and preferences towards the environment. The fourth section includes socio-demographic questions including education, age, gender, and income sources. Two versions of the questionnaire were developed and implemented: a version for arable farms and a version adapted for mixed farming. The two questionnaires differed only by the third level of the practices attribute (see the practice-based description above). Farmers self-selected into the version that best corresponded to their farm specialisation through a screening question at the beginning of the survey.

Prior to the DCE, we provided an explanation of the three contract types, including the attributes and levels. Following this explanation, we included a two-question quiz to test respondents' comprehension of the schemes, which forced respondents to revise the material prior to moving to the choice experiment in the event that they answered at least one of the questions incorrectly. To minimize the effects of the choice order (Carson et al., 1994), we randomized the sequence of choice sets. Finally, the survey was designed to take roughly 30 minutes to complete in order to ensure that respondents understood completely the contracts while not placing an excessive burden on farmers' time. The average length of time that respondents took to complete the survey was 30.7 minutes.

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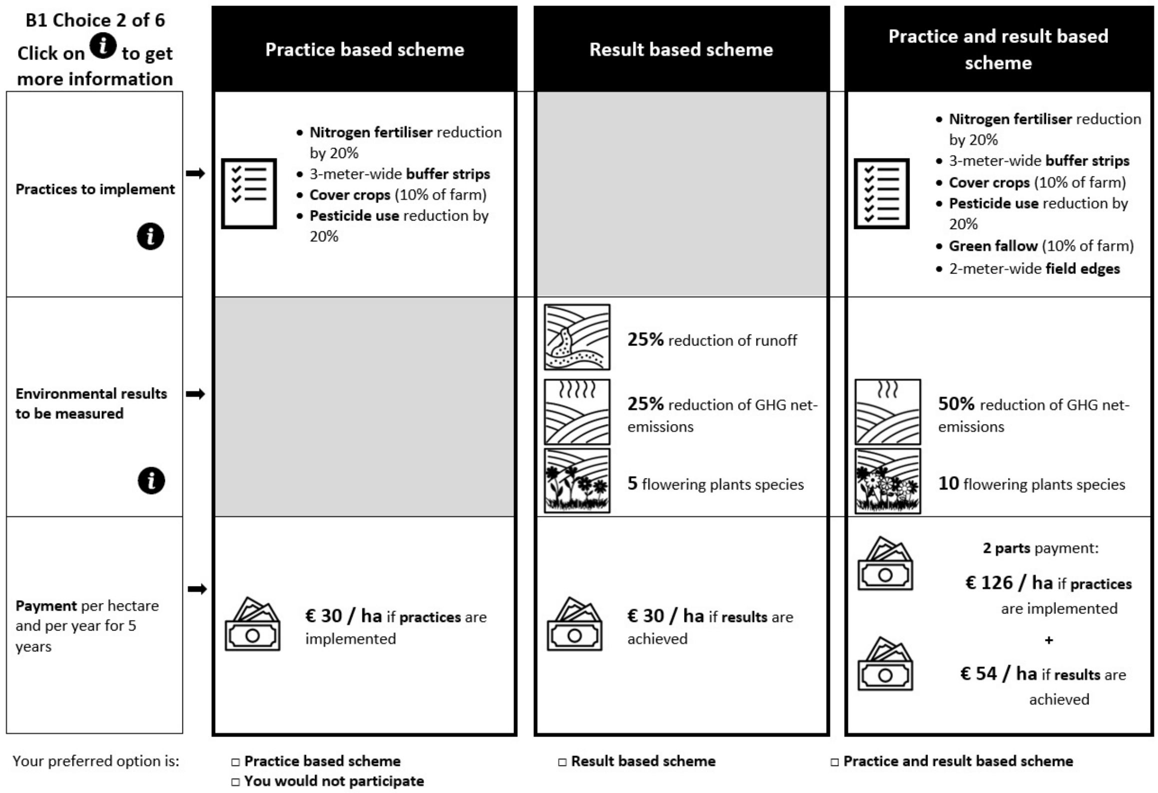
issues.

3.2 Choice experiment design

We collected data to estimate farmers' preferences using a discrete choice experiment, in which farmers were asked to make a series of 6 choices between three alternative hypothetical AES contracts, described by their main characteristics called attributes, and the option not to participate. The DCE method provides a flexible method to elicit preferences for future agri-environmental schemes and their attributes, highlighting the trade-offs between these attributes, before such schemes are implemented in policy and in the absence on observational data (Colen et al., 2016). On each choice card (see example in Figure 1), farmers were asked to choose between 3 labelled alternatives: a practice-based scheme, a result-based scheme, a hybrid scheme (called 'practice and result based' on the choice card) and the option not to participate.

Figure 1: Choice card example



The attributes used to describe the alternative schemes, and their levels, were defined with the help of the Expert Steering Group of the project. The set of practices for the practice-based schemes are common amongst voluntary AES programs under the Common Agricultural Policy and include, but are not limited to, fertilizer use reductions, buffer strips, cover crops, and enlarged field margins Schwarz (2008). Similarly, the result-based schemes include outcomes that measure improvements in GHG emissions, water quality, and biodiversity that have been included in existing result-based AES in Europe.[5]

The practice-based schemes are described by a combination of 2 attributes: the practice-based requirements, and the associated payment per hectare and per year conditional on adoption of the practices requirements. The practice-based requirements are based on a list of measures (Table 3). Depending on the alternative schemes, farmers could be required to adopt either the first two practices of the list (minimum requirement), or the first 4 practices or all 6 practices (i.e.

[5]See Schwarz (2008) for an overview of result-based schemes in Europe.

measures 1 to 6 in Table 3). The last two measures of the list were adapted to the farm specialisation. Result-based schemes are described by 4 attributes: 3 result-based objectives, one related to water quality objectives, one to climate change mitigation and one to biodiversity enhancement, and the associated payment conditional upon achieving the objectives. The hybrid schemes are described by the practice-based attribute, the 3 result-based attributes, the payment attribute and 1 additional attribute representing the share of the payment conditioned on results. A summary of the attributes and their levels is provided in Table 2. The choice cards presented the value of the payment conditioned on results and that of the payment associated with the adoption of practices for hybrid schemes (instead of the share in %), to simplify the choice task. However, the design and the data analysis are based on the share attribute coded in percentage terms. Below we describe the three alternative schemes in detail and their associated attributes.

The practices included in the list (Table 3) include both changes in practices relative to a farm's own previous practise (reduction in nitrogen fertiliser uses, pesticide uses, relative to previous 3 years), which ensure additionally of the changes and standard practices (establishment of buffer strips) which may be subject to windfall effects, if farmers already implement such practices. Similarly, the result objectives combine objectives that are relative to one's previous performance (reduction in GHG net emissions and runoff), and set objectives (number of flowering plant species).

In the overview of the schemes, we informed farmers that the reduction in water contamination (water quality objectives) would be measured by the estimated run-off of nutrients, pesticides and sediments at the edge of fields, based on the slope, soil type, and the recorded cultivation practices (cover crops, buffer strips, fertiliser and application, pesticide use), for all arable fields based on simulation models. Similarly, the reduction of greenhouse gases (GHG) net emissions would be estimated from recorded nitrogen fertilisers (mineral and manure) and fuel usage, and recorded cultivation practices (ploughing, cover crops, manure application) that impact soils carbon content, on the whole farm, using simulation models. Regarding the biodiversity objective, we informed farmers that they would be asked to record the number of flowering and vascular plant species, with the support of an established guidance. These plant species should be present on permanent grasslands for mixed farming systems or on a minimum of 10% of arable

Table 2: Attributes and their levels presented on choice cards

Attributes	Levels and variable coding
Alternative specific constants (ASC)	(1) No participation (ref.) (2) Practice Based (3) Result based (4) Hybrid Dummy coded
Practice-based requirements (See list below)	(1) Practices 1: First 2 practices to be implemented (ref.) (2) Practices 2: First 4 practices to be implemented (3) Practices 3: All 6 practices to be implemented Dummy coded
Water quality objectives: reduction of nutrient, pesticide and sediment runoff (measured at the edge of field)	(1) Payment will not depend on water quality (ref.) (2) Water 1: 25% reduction of runoff (3) Water 2: 50% reduction of runoff Dummy coded
Climate Change (CC) mitigation: reduction of GHG net-emissions from farm (GHG emissions minus soil carbon sequest.)	(1) Payment will not depend on CC mitigation (ref.) (2) CC 1: 25% reduction of GHG net-emissions (3) CC 2: 50% reduction of GHG net-emissions Dummy coded
Biodiversity objectives: number of specified flowering plant species present on 10% of the farm acreage	(1) Payment will not depend on biodiversity (ref.) (2) Biodiversity 1: 5 flowering plant species (3) Biodiversity 2: 10 flowering plant species Dummy coded
Share of payment conditioned upon results (Hybrid alternatives only)	(1) 10% of payment (2) 20% of payment (3) 30% of payment (4) 50% of payment (5) 70% of payment (6) 90% of payment Coded as a continuous variable [10, 90]
Payment in euros per hectare and per year	(1) 30 €/ha/year (2) 80 €/ha/year (3) 130 €/ha/year (4) 180 €/ha/year (5) 230 €/ha/year (6) 280 €/ha/year Coded as a continuous variable [30, 280]

land for arable farms.

Finally, hybrid schemes offer two annual payments for five years; one for the adoption of specific practices and an additional payment contingent on the achievement of environmental

Table 3: List of practices required in practice-based schemes

Specialization	Practice requirements (All fields unless specified otherwise)
Arable and Mixed	(1) 20% reduction in nitrogen fertiliser application compared to average over previous three years. (2) Establishment of 3m-wide buffer strips along main ditches and water courses. (3) Establishment of cover (or catch) crops. (4) 20% reduction in pesticide use compared to average over previous three years.
Arable only	(5) Establishment of green fallow on 10% of arable farm acreage. (6) Establishment and management of enlarged (2m-wide) field edges on at least 30% of cultivated fields.
Mixed only	(5) Application of all manure by injection instead of broadcasting. (6) Management of permanent grassland to favour biodiversity by imposing a stocking rate between xxx and yyy (country specific) livestock units per hectare and ensuring the removal of all brushwood.

Notes: The country specific stocking rates were: 0.5-1 (Finland), 1.5 – 2 (Sweden - South), 1 – 1.5 (Sweden - Non-South), and 1.5 – 2 (Netherlands)

results. In this scheme, the menu of environmental results comes from only result-based schemes and the menu of practices comes from only practice-based schemes.

Using these attributes and their corresponding levels (Table 2), a D_p-efficient Bayesian design was generated based on the priors estimated on the pilot data using a conditional logit model.[6] The final design contained 6 blocks of 6 choice cards. Each respondent was randomly allocated to 1 of the 6 blocks. Within a block, the 6 choice cards appeared in a random order, and the columns (alternatives) on the choice cards also appeared in a random order, but always in the same order for a same respondent to simplify choices.

3.3 Sampling and data collection

To determine the minimum sample size, we used two methods. First, we used the S estimate generated by NGene 1.2 when generating the experimental design. Depending on the assumptions made on values of the parameters, the S estimate indicated a minimum sample size between 231 and 293 observations. Furthermore, a power analysis (de Bekker-Grob et al., 2015) confirmed that a sample size around 300 observations would provide acceptable levels of power (Table A1).

[6] All designs were generated using NGene 1.2 (ChoiceMetrics, 2018)

Table 4: : Number of respondents per country and farm specialisation

Specialisation	Finland	Sweden	Netherlands	Total
Mixed farming	90	158	22	270
Specialised in crop production	267	72	122	461
Total	357	230	144	731

Notes: Values based on author calculations.

We sent survey invitations to the 8,978 sampled farmers between May and June, 2021. We used a variety of strategies to increase response rates, which are notoriously low amongst farmers (Palm-Forster and Messer, 2021). The initial email invitations were sent by the local collaborators which are well-known and respected institutions in their respective countries and we sent reminders in weeks one and three which have been shown to be effective for experimental designs with farmers (Weigel et al., 2021). We sent three reminders in the six weeks following the initial invitation (week 1, week 3, and week 6). The initial invitation email informed farmers about the purpose of the survey and the role it may play in the design of future agri-environmental schemes to increase consequentiality. In Finland and Sweden, we informed farmers that they would be entered into a lottery with 100 farmers to win an Amazon gift card worth 50 euros if they completed the survey. In the Netherlands, all farmers received a small fixed payment for their participation of 25 euros. Combining these strategies yielded response rates of 7.7% (Finland), 7.5% (Sweden), and 11.1% (the Netherlands).

Table 4 presents the distribution of responses per country and per version of the questionnaire. In total, 731 farmers completed the survey up to the penultimate or final screen including 270 responses for the mixed farming version of the questionnaire and 461 for the arable version of the questionnaire. The final sample was above the threshold of the power analysis when analysing data from all countries pooled together. In terms of participation per country, 357 farmers completed the questionnaire in Finland, 230 in Sweden and 144 in the Netherlands. Of the 731 farmers, 63% indicated that they specialized in crop production and over 80% were currently participating in or had ever participate in an agri-environmental scheme.

Table 5 presents summary statistics of demographic, socioeconomic, and farm characteristics of respondents in our sample by country. When available, we report corresponding values for the general agricultural population in each participating country. The average arable farm size within the sample was 70.82 hectares. Relative to average farm size based on national statistics, the respondents in our sample had larger farms. This is due in part to the fact that we oversampled mixed crop and livestock farms which tend to be larger on average. This is reflected also in the share of crop farmers in our sample. Despite the stratification, our respondents are quite similar on other dimensions including age, participation in AES, and the share that engage in organic production. In our sample, 74.4% of respondents had another source of income than the farm revenue for their household, and the farm income for those who had another source of income represented 36.7% of household income on average. The sample was largely composed of males (89.7%) and farmers over 55 years old (49.9%). Most respondents had specialised education in agriculture, from a high school diploma (14.9%) to a university degree in agriculture (12.7%), as well as vocational training in agriculture (24.1%). 58.2% were full-time farmers, while 36.7% were part-time farmers. In general, these findings suggest our study respondents tend to be slightly larger farms, though it is difficult to determine the likely impacts on our estimates. According to Schaub et al. (2023), the relationship between participation in AES and farm size is ambiguous and will depend on the degree of economies of scope and/or scale, as well as the requirements of the schemes.

A majority of farmers agreed that global warming is a serious threat (64%), and that farming using environmentally friendly practices can improve the health of the environment (69%). However, only 50% reported feeling responsible for local environmental issues and less than 30% feel responsible for global environmental issues such as global warming. Regarding the implementation and effectiveness of AES, only 39% of farmers were confident that they would be able to adopt the farming practices or achieve the environmental objectives in the choice cards over the next year. Rather, more than half thought the adoption of practices described in the survey would put their farm's profitability at risk (54%) and only 26% were confident that inspectors would be able to measure any environmental improvements they have achieved on their farm if they join the AES.

Table 5: Comparison of Farmer Characteristics in our Sample and National Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Finland		**Sweden**		**Netherlands**		**Full**
Variable	Sample	National	Sample	National	Sample	National	**sample**
Arable land (ha)	55.18	50.00	94.59	51.10	71.18	51.40	70.82
Crop farmer share	25%	74%	69%	61%	15%	38%	37%
Age (< 55 years)	54%	52%	42%	38%	40%	45%	48%
Participating in AES	88%	94%	76%	95%	34%	10%	74%
Organic=1	15%	14%	27%	20%	3%	4%	16%
Male=1	87%	.	87%	.	96%	.	89%
Post-secondary educ.	40%		56%	.	49%	.	63%
Full-time farming	56%	.	46%	.	79%	.	57%
N	357		230		144		731

Notes: Sample statistics are based on authors' calculations. National statistics by country are based on the EUROSTAT Agriculture, forestry and fishery statistics – 2021 edition (https://ec.europa.eu/eurostat/web/agriculture/data/database).

4 Modelling of farmers' choices

Farmers' choices made within the DCE were analysed using a standard choice modelling approach in which farmers are assumed to choose the AES contract that they expect will provide them with the highest level of utility amongst the available alternative contracts and the option not to join any AES (McFadden, 1974). We use a mixed logit (ML) model, otherwise known as a random parameter logit model, with a set of fixed and random parameters, to allow for heterogeneity in preferences across farmers in the sample (Train, 2009). Further, the ML model allows for the estimation of unbiased individual preferences and increases the reliability of model estimates by allowing for correlations between multiple choice observations by each farmer (Train, 2009). The utility provided by each alternative AES contract i to farmer n depends on the observable characteristics of contract i faced by farmer n in a choice situation Ct, X_{int}, and a random non-observable component, ε_{int}, such as:

$$U_{nit} = \beta_n' X_{nit} + \varepsilon_{nit} \tag{1}$$

With β_n a vector of parameters representing the weight of each observable contract characteristic contained in X_{int}.

The utility associated with a practice-based alternative by individual n on choice card t is a function of the practices to be implemented ($X_{pract,n,t}$), the level of payment ($X_{pay,n,t}$) and the Alternative Specific Constant (ASC) for practices-based scheme ($\delta_{pract,n}$) [7]:

$$U_{pract,n,t} = \delta_{pract,n} + \beta_{pract,n} X_{pract,n,t} + \beta_{pay,n} X_{pay,n,t} + \varepsilon_{pract,n,t} \quad (2)$$

with $\beta_{pract,n}$ and $\beta_{pay,n}$ the utility parameters associated with, respectively, the practices to be implemented ($X_{pract,n,t}$) and the level of payment ($X_{pay,n,t}$).

The utility associated with a result-based alternative is a function of the results to be achieved in terms of water quality ($X_{water,n,t}$), climate change mitigation ($X_{cc,n,t}$) and biodiversity ($X_{bio,n,t}$), the level of payment ($X_{pay,n,t}$) and the alternative specific constant for result-based schemes ($\delta_{result,n}$):

$$U_{result,n,t} = \delta_{result,n} + \beta_{water,n} X_{water,n,t} + \beta_{cc,n} X_{cc,n,t} + \beta_{bio,n} X_{bio,n,t} + \beta_{pay,n} X_{pay,n,t} + \varepsilon_{result,n,t} \quad (3)$$

$\beta_{water,n}$, $\beta_{cc,n}$, and $\beta_{bio,n}$ being the parameters associates with the result-based attributes for water quality improvement ($X_{water,n,t}$), climate change mitigation ($X_{cc,n,t}$) and biodiversity improvements ($X_{bio,n,t}$) respectively.

The utility associated with a hybrid scheme alternative is a function of both the practices to be implemented ($X_{pract,n,t}$), and the results to be achieved in terms of water quality ($X_{water,n,t}$), climate change mitigation ($X_{cc,n,t}$) and biodiversity ($X_{bio,n,t}$), in addition to the share of payment conditioned upon results (X_{share}), the level of payment ($X_{pay,n,t}$) and the alternative specific constant for hybrid schemes ($\delta_{hybrid,n}$). In addition, we expect interaction effects between the practices requirements and the results objectives, since the adoption of practices may reduce the

[7] Please note that the utility functions described here represent simplified description of the utility functions as the practices and result-based attributes are dummy coded in the estimation of the models.

efforts required to achieve the result. This is reflected in the utility function for the hybrid schemes alternatives:

$$U_{hybrid,n,t} = \delta_{hybrid,n} + \beta_{pract,n} X_{pract,n,t} + \beta_{water,n} X_{water,n,t} + \beta_{cc,n} X_{cc,n,t} + \beta_{bio,n} X_{bio,n,t} + \beta_{share,n} X_{share,n,t} + \beta_{pay,n} X_{pay,n,t} + \varepsilon_{hybrid,n,t} \quad (4)$$

In the context of the mixed logit model (Train, 2009), the probability that farmer n chooses alternative i over all alternatives j in choice card C_t, noted as alternative A_{int}, is:

$$P(A_{int}|\beta_n) = \frac{exp(X'_{int}\beta_n)}{\sum_{j \in C_t} exp(X'_{jnt}\beta_n)} \quad (5)$$

And the probability of observing the sequence of T choices by individual n is:

$$P(A_{in1}, \ldots, A_{inT}) = \int \prod_{t=1}^{T} \frac{exp(X'_{int}\beta)}{\sum_{j \in C_t} exp(X'_{jnt}\beta)} f(\beta) d\beta \quad (6)$$

where $f(\beta)$ can be specified to be normal or log-normal: $\beta \sim N(\mu, \sigma)$ for all attributes and $ln(\beta_{pay}) \sim N(\mu, \sigma)$ for the payment attribute. The parameters μ and σ are respectively the mean and the standard deviation of these distributions and are to be estimated by simulation (Train, 2009).

In order to account for the potential correlations in preferences for practice-based and result-based attributes in hybrid schemes, we run an additional specification of the mixed logit model in which correlations are allowed between practice and results attributes and we implement a likelihood ratio test to select the model that best fits our data.

Finally, in order to obtain values of farmers' Willingness to Accept (WTA) to join alternative scheme designs and to be able to measure their relative cost-effectiveness we also run a mixed logit model in Willingness to Pay (WTP) space (Train and Weeks, 2005). In WTP space, the utility is rewritten as:

$$U_{nit} = -\alpha X_{nit}^{pay} + (\beta_n'/-\alpha)X_{nit}^{NonPay} + \varepsilon_{nit} = -\alpha X_{nit}^{pay} + \omega_n' X_{nit}^{NonPay} + \varepsilon_{nit} \tag{7}$$

with X_{nit}^{pay} the payment attribute, X_{nit}^{NonPay} a vector of non-payment attributes, and ω_n is a vector of coefficients representing farmers' WTP for the non-payment attributes.

All model estimations were made using the Apollo Software on R (Hess and Palma, 2019, 2022), while the data preparation and formatting was implemented using Stata 15.

5 Results

The option not to participate was chosen on 36.1% of the choice cards, the practice-based alternative is the most commonly chosen alternative, chosen in 26.9% of the choice cards, followed by hybrid schemes (chosen in 20.6% of choices) and result-based schemes alternatives (16.4% of choices).

5.1 Marginal preferences and WTA for schemes' characteristics

We estimated 4 different specifications of the Mixed Logit Model (Table 6). The first 2 models (MXL1 and MXL2) are estimated in preference space, with MXL2 allowing for correlations between the parameters associated with the practice and the result-based attributes in the utility function for the hybrid scheme, while MXL1 does not allow for such correlations. The last 2 models (MXL3 and MXL4) are estimated in Willingness-to-Pay (WTP) space. Similarly to the estimations made in preference space, MXL3 does not allow for correlations between attributes' random parameters, while MXL4 does account for correlations between the practice and the result attributes' parameters in the hybrid schemes' utility function.

Table 6 shows that under all 4 specifications, all attributes and ASCs have a significant effect on farmers' choices, with the exception of the biodiversity result-based attribute which has inconsistent effects depending on the specification used. Looking at the goodness of fit of the models, the AIC and LL indicate that the models accounting for correlations between parameters associ-

Table 6: Results from the Mixed Logit Models in preference and WTP space

Estimates (Robust St. Err.)	Preference Space MXL1 Mean	MXL1 St. Dev.	MXL2 Mean	MXL2 St. Dev.	WTP Space MXL3 Mean	MXL3 St. Dev.	MXL4 Mean	MXL4 St. Dev.
ASC practice based	-2.525***	3.585***	-2.690***	3.881***	-188.12***	254.97***	-175.63***	256.77***
	(0.238)	(0.245)	(0.269)	(0.298)	(15.24)	(15.87)	(13.48)	(17.48)
ASC hybrid	-2.700***	-5.453***	-1.990***	-4.727***	-210.50***	-346.69***	-134.17***	-264.41***
	(0.422)	(0.464)	(0.450)	(4.117***)	(24.71)	(26.88)	(23.96)	(25.21)
ASC result based	-4.117***	3.966***	-3.977***	-0.814***	-272.90***	255.70***	-212.94***	205.60***
	(0.396)	(0.353)	(0.459)	(0.400)	(18.27)	(17.98)	(17.59)	(15.24)
Practices 2 (ref 1)	-0.820***	-0.416	-0.880***	-0.814***	-39.85***	40.73**	-42.36***	-53.72***
	(0.159)	(0.333)	(0.169)	(0.274)	(8.92)	(17.98)	(9.69)	(13.30)
Practices 3 (ref 1)	-1.188***	-1.421***	-1.379***	-1.795	-54.48***	-83.83***	-68.46***	-108.38***
	(0.190)	(0.245)	(0.203)	(0.244)	(10.84)	(15.59)	(11.29)	(13.64)
Water 1 (ref 0)	-0.970***	1.404***	-1.535***	-1.161***	-53.27***	-28.73	-108.56***	68.13*
	(0.260)	(0.311)	(0.334)	(0.341)	(15.39)	(26.19)	(21.00)	(40.55)
Water 2 (ref 0)	-1.036***	1.492***	-1.369***	1.364***	-59.33***	88.32***	-87.26***	-87.02***
	(0.202)	(0.333)	(0.234)	(0.351)	(11.43)	(19.06)	(12.31)	(17.95)
CC 1 (ref 0)	-0.639***	0.636*	-1.035***	0.398	-27.18***	-28.73	-60.77***	34.00
	(0.188)	(0.382)	(0.252)	(0.409)	(9.49)	(24.23)	(11.14)	(24.78)
CC2 (ref 0)	-1.254***	2.281***	-1.888***	1.828***	-63.66***	-126.67***	-105.39***	-98.04***
	0.229)	(0.273)	(0.297)	(0.293)	(13.05)	(16.89)	(15.14)	(24.91)
Biodiversity 1 (ref 0)	-0.260	-0.691***	-0.487**	-1.184***	0.456	45.53**	-28.25**	41.54*
	(0.172)	(0.302)	(0.207)	(0.245)	(9.689)	(22.19)	(11.07)	(25.06)
Biodiversity 2 (ref 0)	-0.705***	1.069***	-0.888***	1.222***	-6.371	-103.95***	-36.87***	-69.74**
	(0.200)	(0.303)	(0.288)	(0.403)	(11.151)	(14.06)	(12.85)	(35.17)
Share conditioned on result (%)	-0.019***	0.024***	-0.022***	0.035***	-0.763***	1.499**	-0.884***	1.780***
	(0.004)	(0.009)	(0.005)	(0.006)	(0.277)	(0.657)	(0.303)	(0.511)
Payment	0.027***	0.054***	0.027***	0.049***	0.015***		0.015***	
	(0.003)	(0.009)	(0.003)	(0.012)	(0.001)		(0.001)	
Correlations between practice and result-based attributes' coefficients included (hybrid schemes only)	No		Yes		No		Yes	
Number of respondents	731		731		731		731	
Number of observations	1486		1486		1486		1486	
AIC	7834.04		7776.68		8204.96		8063.01	
BIC	8000.08		8019.35		8364.61		8299.29	
LL	-3891.02		-3850.34		-4077.48		-3994.5	

Notes: We used Sobol draws as recommended in Czajkowski and Budziński (2019). We used 3000 draws for each model. We introduced correlation parameters between practices attributes and results attributes in MXL2 and MXL4, which are reported in the bottom half of the table. All parameters are assumed to be normally distributed, but the parameter associated with the price attribute is assumed to be log-normally distributed in the preference space model and is defined as non-random in the WTP space models. In MXL1 and MXL2, mean and St. Dev. of the lognormal distribution are reported for the payment attribute. *: robust p-value < 0.10; **: robust p-value < 0.05, ***: robust p-value < 0.01.

ated with the practice and result-based attributes (MXL2 and MXL4) fit the data better, which is confirmed by Likelihood ratio tests (p-value < 0.01). Only the BIC indicates a slightly better fit of MXL1 in preference space, against other indicators. We therefore base our analysis on MXL2 and MXL4.

We first look at the constants of the models (ASCs). All constants are negative, indicating a baseline cost of participating in an AES rather than maintaining current practices. The least negative constant is the one associated with participation in a hybrid scheme (ASC hybrid), which would require farmers to adopt the first two practices of the menu of practices (reference level for this attribute, which include a 20% reduction of nitrogen fertiliser application and the establishment of 3-meter-wide buffer strips along water courses) but would not entail any requirements in terms of environmental results to be achieved. The second least negative constant is that associated with the practice-based alternatives (ASC practice based) which would also require the adoption of the first two practices from the menu of practices. Finally the alternative that seems to be the least preferred, and that is associated with the most negative ASC, is the result-based alternative. We note that the order of preferences between practice-based and hybrid schemes is reversed when not accounting for the correlation between practice-based and result-based attributes in the hybrid alternatives, but that result-based scheme consistently appear as the most disliked alternative, even though the constant for these alternatives does not entail any requirement in terms of achieving environmental results.

We then look at farmers' preferences for the characteristics of and requirements associated with these 3 alternative scheme designs. We see that for practice-based and hybrid schemes, farmers would require higher payments to adopt more practices, or said otherwise, they would be less likely to join a scheme which requires to adopt more practices for a given payment. On average, the WTA estimates (MXL4) shows that farmers would require to be paid an extra €42.36 per hectare to establish cover crops on 10% of arable and to reduce their use of pesticides by 20%. This would be added to the €175.63 per hectare required to join a practice-based scheme and adopt the first 2 practices of the menu in practice-based schemes (ASC practice) and to the €134.17 per hectare required on average by farmers to join a hybrid scheme (ASC hybrid). If farmers were required to adopt all 6 practices of the menu of option, they would require on average to be paid

€68.46 per hectare in addition to the value of the constants (ASCs). For arable farmers this means, in addition to the 4 previously mentioned practices, establishing green fallows on 10% arable farm acreage, and the establishment and management of enlarged (2-meter-wide) field edges, while for mixed farmers, these two additional practices are the application of manure by injection and the management of permanent grassland at specified stocking rates to favour biodiversity.

For hybrid and result-based schemes, the results show that higher requirements in terms of reduction of greenhouse gases emissions (CC1 and CC2) or increased biodiversity (biodiversity 1 and 2) are associated higher levels of WTA from farmers. However, surprisingly, the WTA of farmers to achieve higher levels of runoff reduction (Water 2, which is a reduction of runoff by 50%) is lower than their WTA to participate in a scheme with relatively lower requirements in terms of reduction of runoff (Water 1, a reduction of runoff by 25%) [8]. In terms of relative preferences between environmental objectives, we note that objectives to increase biodiversity are not as disliked as objectives to reduce runoff to improve water quality or to reduce greenhouse gases net emissions, which are both associated with much higher payments requirements.

Finally, it is interesting to note that, in hybrid schemes, farmers prefer schemes with a lower share of payment conditioned on achieving environmental results, with a required extra €0.88 per hectare for each additional percentage point of payment conditioned on achieving results. This is true for share values between 10 and 90%, and can be interpreted as being the consequence of the increased risks, and contribute to the risk premium associated with payments conditioned on achieving environmental results, relatively to payments conditioned upon implementing specific practices, in line with (Niskanen et al., 2021; Tanaka et al., 2022)

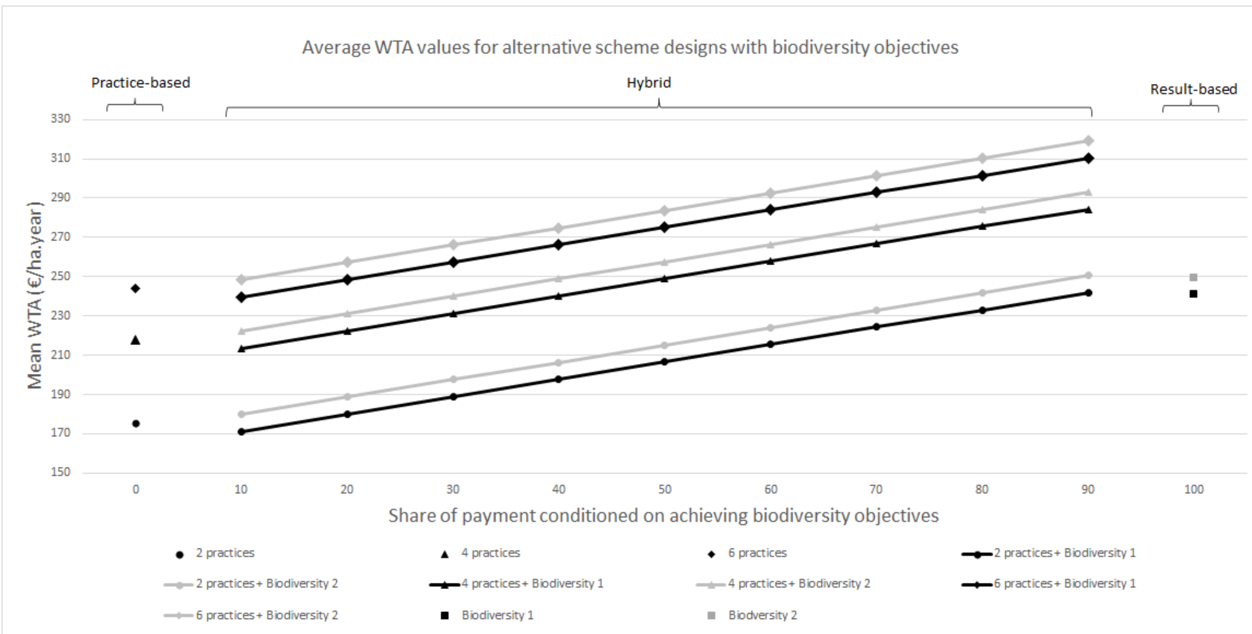
The standard deviation coefficients are all significant, providing evidence that there is heterogeneity amongst farmers in their preferences for practice-based, result-based and hybrid schemes characteristics.

[8] A Likelihood ratio test between MXL4 and a model using the same specification but with the water attributes coded as taking the value 1 for both a reduction by 25 and 50% in runoff and 0 for no runoff reduction requirement, shows that this difference is significant, p-value < 0.01

5.2 Preferences and WTA for alternative scheme designs

In order to compare the relative preferences of farmers to join alternative scheme designs, we now look at the WTA value for the participation in AESs combining the attributes described above. We start by comparing practice-based schemes with schemes aiming for biodiversity improvements, as these are the ones with the lowest associated average WTA values (Figure 2).

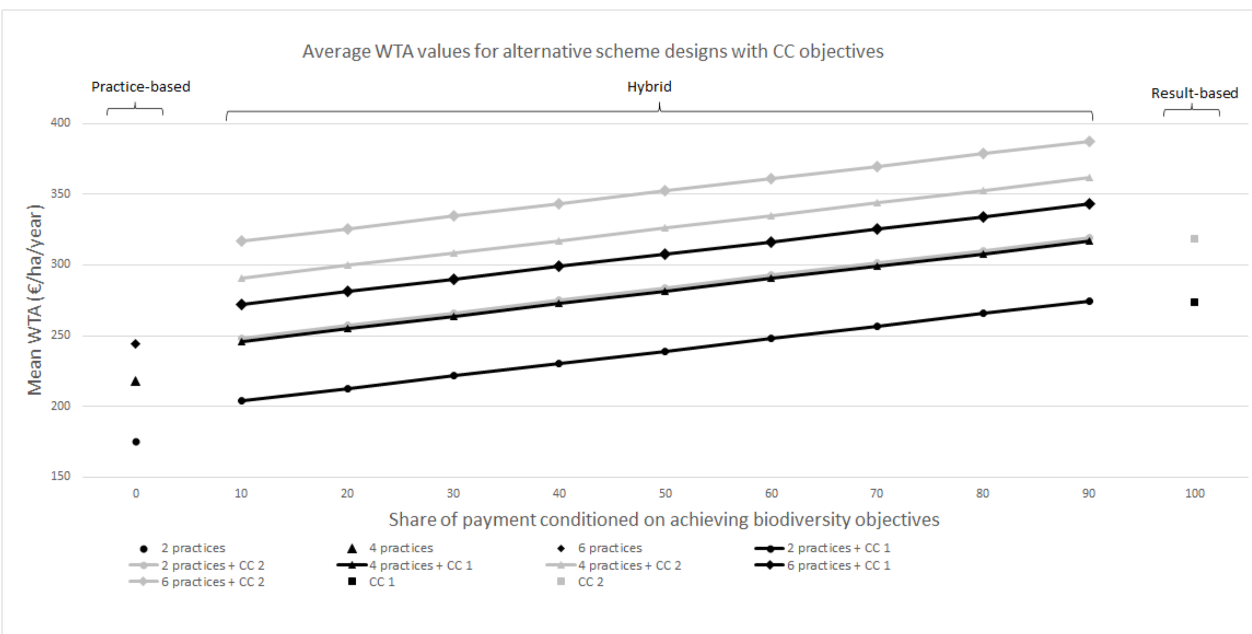
Figure 2: Comparison of WTA for alternative biodiversity schemes



The practice-based scheme associated with the lowest mean WTA value, hence the preferred practice-based scheme on average, is a scheme requiring farmers to reduce their nitrogen fertilisers application by 20% and to establish 3-meter-wide buffer strips along water courses. The minimum payment farmers would require to join such a scheme is, on average, €175/ha/year. The hybrid scheme associated with the lowest mean WTA is that requiring the adoption of the 2 same practices, and the achievement of the biodiversity objective of 5 flowering plant species present on 10% of the farm acreage, with 10% of the payment conditioned on achieving the biodiversity objective, while the rest of the payment is paid upon adoption of the practices. The WTA of farmers for this hybrid scheme is, on average, of €171.26/ha/year, which is marginally lower than the practice-based payment scheme requiring the adoption of the same two practices.

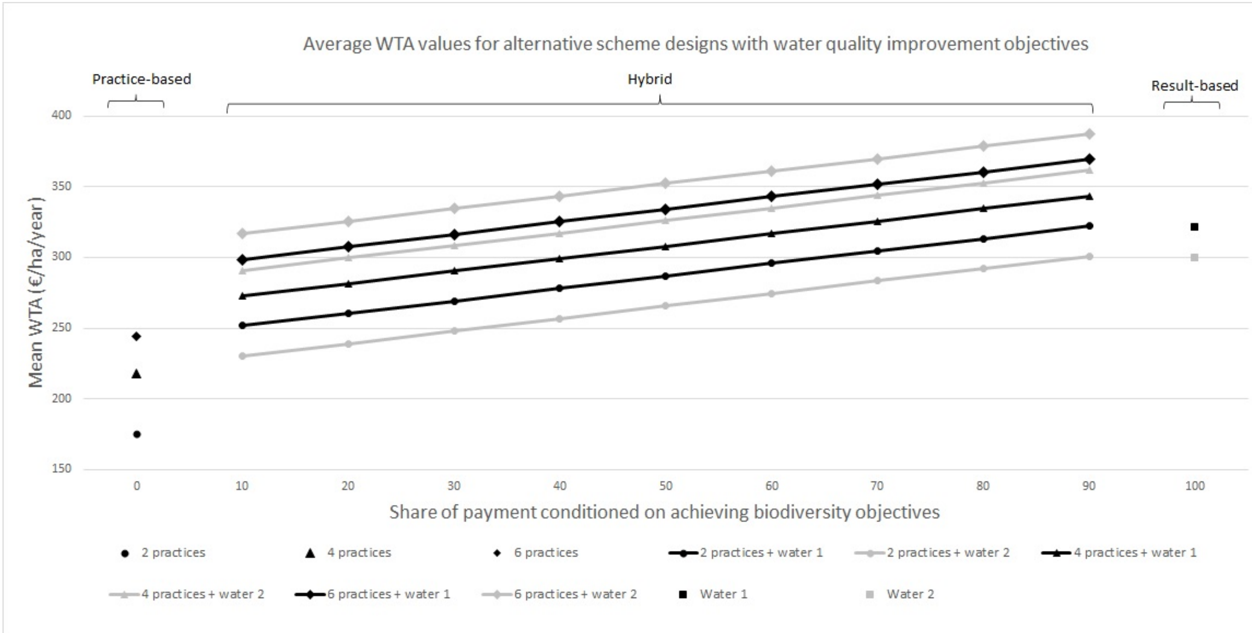
This indicates a slight preference of farmers for hybrid schemes over practice-based schemes for low levels of biodiversity objectives, and 10% of the payment conditioned upon achieving these biodiversity objectives. However, as soon as higher environmental objectives are included in hybrid schemes, or the share of payment conditioned on results increases, practice-based schemes seem to be preferred over hybrid schemes with the same practice requirements. The result-based payment scheme associated with the lowest mean WTA value is the one conditioning payment to the presence of 5 flowering plant species on 10% of the farm acreage, for which the average WTA is of €241.19/ha/year. This value is higher that the hybrid scheme including the same biodiversity objective (€171.26/ha/year) when 10% of payment is conditioned on results) and 2 practices need to be adopted, and similar to the WTA of farmers for an equivalent hybrid scheme with 90% of the payment conditioned on results (€241.95/ha/year). However, when only including biodiversity objectives, the preference between result-based schemes and hybrid schemes that include the requirement to adopt 4 practices or more depend on the hybrid scheme's share of payment conditioned on result, as shown on Figure 2.

Figure 3: Comparison of WTA for alternative climate change mitigation schemes



The relative preferences between practice-based schemes and the 2 other alternative designs are quite different when the latest aim at climate change mitigation or water quality improvements, due to the higher WTA values associated with the greenhouse gases net emissions objectives attribute and the reduction in runoff attribute, respectively. Figure 3 and 4 show that practice-based schemes are always preferred over hybrid or result-based schemes that include objectives to reduce greenhouse gases net emissions or reduction in runoff and the same level of practice-based requirements. The relative preferences between result-based and hybrid schemes remain the same as in the case of schemes with biodiversity objectives, and depends largely on the number of practices required in hybrid schemes and the share of payment conditioned on achieving environmental results.

Figure 4: Comparison of WTA for alternative water quality improvement schemes



When hybrid and result-based schemes include several environmental objectives, farmers' preference for practice-based schemes over these designs becomes even stronger as the marginal WTA values for the result attributes add up while the WTA for practice-based requirements remain the same. The higher WTA for result-based schemes is likely driven by higher uncertainty of achieving the results, and of receiving the associated payment. Result-based payments therefore necessitate a risk premium, and the required premium is higher in cases where environmental outcomes are strongly influenced by external factors, such as weather events affecting nutrient runoff, that are beyond the farmer's control.

6 Cost-benefit analysis of alternative scheme designs

We ask next whether the social benefits from alternative payment designs exceed the social costs, or not. Indeed, higher payments to farmers, to match higher WTA values, may still be acceptable from a policy perspective if scheme designs associated with higher WTA values are also associated with higher environmental benefits. A Cost-Benefit Analysis comparing practice-based, result-based and hybrid designs would allow identifying the most cost-effective scheme design. We use existing values of benefits associated the environmental outcomes targeted by the schemes to illustrate the relative performance of the three alternative scheme designs.

As a first stage we estimate the environmental effect of the alternative schemes studied in the discrete choice experiment. In order to be able to compare the environmental effects of practice-based schemes with those of result-based schemes, micro-economic simulation model developed in OECD (2022) are employed for the assessment of the nitrogen runoff and GHG emission reductions associated with the adoption of the practices in the menu of practices in Finland, the Netherlands, and Sweden. In the case of hybrid scheme, we use the maximum of the simulated outcome of the adoption of the practices and the result-based objectives included in the scheme as farmers would have to comply with both the adoption of practices and the achievement of environmental results to receive the full payment. However, these models do not allow the simulation of biodiversity impacts of the adopted practices so our discussion will focus on nitrogen runoff reduction and reduction of net GHG emissions. We next proceed to the valuation of the costs and benefits.

As regards to social costs of nitrogen runoff reduction (water quality) and GHG emissions (climate change) we use farmers' WTA for each payment design as a primary measure of social costs of nitrogen runoff and GHG emissions reduction (see Boardman et al. (2011), 99-110 for discussion). The social benefits are given by the reduced nitrogen runoff and GHG emission damages. Reductions in nitrogen runoff are assumed to contribute to reduced nutrient runoff damages in the Baltic Sea[9]. We employ both lower bound and upper bound estimate of the unit damage of nitrogen runoff. The lower bound estimate is of € 9 /kg of nitrogen runoff and is based on an estimate by Gren and Folmer (2003) concerning the marginal willingness to pay for reduced nitrogen runoff in the Baltic Sea region. The upper bound estimate for the marginal willingness to pay is € 52 /kg of nitrogen runoff and is based on Ahtiainen (2014) in which a contingent valuation study was conducted in nine coastal states around the Baltic Sea concerning the benefits of reducing marine eutrophication in the Baltic Sea.These two estimates provide social value of reductions in nitrogen runoff. As regards the social value of reduced GHG emissions we employ

[9]We employ nitrogen runoff reduction valuation estimates in the context of the Baltic Sea because for both Finland and Sweden agriculture is very large contributor of the anthropogenic load of nitrogen to the Baltic Sea.

both lower and upper bound estimates. Lower bound estimate of a marginal social damage of GHG emissions is € 50/ton of CO2-eq emissions based on Tol (2011). Upper bound estimate is € 160/ton of CO2-eq emissions based on Rennert (2022).

We report also a more developed social net benefit estimate by including the policy related transaction costs (PRTCs) and so-called marginal cost of taxation (MCT) to the social costs of alternative payment designs. Our estimate of policy related transaction costs of alternative payment designs is based on Ollikainen et al. (2008). MCT is a measure of economic welfare losses due to raising government revenue with distortionary taxes (such as labor taxes). We employ 10% of the total payment transfer as our estimate of marginal cost of taxation.

Table A3 provides the key results regarding the social costs and benefits of alternative payment designs.

As seen in the previous section, practice-based payment have the lowest social cost, as given by farmers' WTA that indicates a required amount of government budgetary transfer for farmers' participation in the given type of payment scheme. Result-based payments have clearly higher WTA estimates and thus imply much higher social costs.

Benefit-cost ratios for all payment designs are below one when lower bound social benefit estimates of nitrogen runoff and GHG emission reductions are adopted. Hence, none of the payment designs proves to be socially beneficial if lower bound social valuation estimates are employed.

With upper bound social valuation estimates, all practice-based schemes are socially beneficial (benefit-cost ratio over one) and their social net-benefits (social benefit with given social valuation minus social cost) increase with the increase in the number of required practices, so that the net-social benefits are highest for the scheme that includes all six practices. In this case, the social benefits of additional practices increase at a higher rate than their social costs (farmers' WTA). Single objective result-based payments remain socially unprofitable except in the case of those targeting a 50% reduction of nitrogen runoff. This payment design has the fourth largest net-social benefits of all alternative payment designs analysed. Among the result-based payments, it has the second lowest social costs and third largest social benefits. Only two of the multiple objective result-based payments are socially profitable with higher bound social valuation estimates

(N-runoff 50% and GHG 25%; and N-runoff 50% and GHG 50%). The social benefits of increased result requirements tend to increase more than their social costs, which is clearly shown, for example, by comparing the payment scheme that has 25% reduction of both nitrogen runoff and GHG emissions with the payment scheme that has 50% reduction of both nitrogen runoff and GHG emissions. Here social costs increase only by € 24 whereas social benefits increase by € 350. Two of the hybrid payments are socially profitable with higher bound social valuation estimates. The first of these is a hybrid payment scheme consisting of two practices and GHG emissions reduction by 25% in which 10% of payment is paid for the results, and the second is the scheme consisting of adopting six practices and reducing N-runoff by 25% and GHG emissions by 50% in which 90% of payment is paid for the results. These two hybrid payments represent lower and higher bound WTAs for hybrid payments. Although the second scheme is clearly more environmentally effective it is also significantly more costly scheme, and thus the social net-benefits are slightly higher for the first hybrid payment scheme. Incorporation of PRTCs and MCT does not affect relative ranking of alternative payment designs but decreases the social net-benefits of all payment designs and thus worsen their benefit-cost ratio. Even with these increased social costs some of the payment designs remain socially profitable. This is the case for practice-based payment with all six practices, single objective result-based payment for 50% reduction of nitrogen runoff, and multiple objective result-based payments for 50% reduction of both nitrogen runoff and GHG emissions. Overall, these results imply that for most of the analysed payment designs with higher environmental requirements, whether through requiring more practices to be adopted or setting higher result requirements, tend to increase the net-social benefits of the payment designs, since the social benefits of environmental improvements increase more than the social costs for environmentally more demanding payment schemes.

It should be noted however that the CBAs discussed here only account for nutrient run-off and GHG emissions reduction and not for biodiversity or other environmental benefits, since the data and models necessary to estimate the biodiversity improvements related to the practices described in the survey are not available. This means that the actual (monetary) benefits of AESs are likely to be higher than those shown in our analysis, and thus AESs are likely to be more socially beneficial than what is reflected in Table A3. It should also be noted that the simulations models do not account for the uncertainty of the effect of practices-adoption on environmental improvements. This CBA is therefore included here for illustrative purposes, showing the importance of including both the differences in the costs and in the benefits associated with different scheme design to inform the choice of AES design.

7 Conclusion

We find that practice-based schemes are always preferred for water quality or CC mitigation objectives over hybrid schemes. The relative preferences of farmers between hybrid schemes and result-based scheme depend on the share of payment conditioned on results and the number of practices to be applied in hybrid schemes, with hybrid schemes preferred over result-based schemes when the share of payment conditioned on result and practice-based requirements are low. Only when targeting biodiversity are result-based schemes and hybrid schemes preferred over (or similarly liked as) practice-based schemes under certain scheme designs. Biodiversity objectives are the most common environmental objectives in result-based payment schemes and most of the literature supporting the use of result-based schemes over practice-based schemes for their increased cost-effectiveness is based on schemes targeting biodiversity objectives (Herzon et al., 2018). While Šumrada et al. (2022) find a preference for result-based schemes over practice-based schemes for managing dry grassland biodiversity in Slovenia, our choice experiment suggests that this result may not extend to other environmental domains such as water quality improvement or climate change mitigation, and result-based schemes targeting water quality improvements or climate change mitigation would require higher payments to farmers to achieve similar uptake rates as for practice-based schemes. This could be explained by the fact that, in the hypothetical schemes presented to farmers in the DCE, the GHG net emissions and runoff objectives were set as an improvement over one's own performance over the past 3 years, ensuring additionality, while the biodiversity objectives were set as objectives in absolute values of numbers of flowering plant species, leaving room for self-selection of farmers who already comply with the objective. This relative preference may be due to the increased complexity of indicators for and lack of observability of nutrient run-off and greenhouse gases net emissions

(O'Rourke and Finn, 2020), in comparison with biodiversity objectives. This result aligns with findings from Niskanen et al. (2021), who find that Finnish farmers generally prefer a practice-based to a result-based approach for agri-environmental schemes. Our Cost-Benefits Analysis also to support this result, however they must be taken with caution as they are based on strong hypotheses. There has been increased policy interest in result-based schemes in order to improve environmental effectiveness and budgetary cost-effectiveness of AE schemes in the EU. In light of the fact that result-based payments were the least preferred among the farmers in this study, policymakers should exercise caution in introducing such features AE schemes. One potentially fruitful option would be to introduce them gradually, for example, starting with hybrid schemes with relatively low payment share linked to environmental results, and then gradually increasing this share when both policymakers and farmers have more experience of results-based features in payment design and implementation.

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Appendix A Additional Tables

Table A1: Power analysis

Sample size	Significance level	Power
402	95%	80%
306	95%	70%
240	95%	60%
174	95%	50%
294	90%	80%
210	90%	70%
150	90%	60%

Table A2: Distribution of responses in Sweden sample by region and farming type

	Mixed farming				Crop farming			
	Sample N	Sample Share	Response N	Response Share	Sample N	Sample Share	Response N	Response Share
Blekinge län	17	2.36	3	1.95	35	1.8	1	1.47
Dalarna	25	3.47	7	4.55	64	3.29	4	5.88
Gotland	19	2.64	7	4.55	42	2.16	1	1.47
Gävleborg	29	4.03	3	1.95	63	3.24	0	0
Halland	29	4.03	4	2.6	89	4.57	4	5.88
Jämtland	24	3.33	6	3.9	39	2	1	1.47
Jönköping	66	9.17	19	12.34	73	3.75	0	0
Kalmar län	41	5.69	10	6.49	80	4.11	3	4.41
Kronoberg	35	4.86	6	3.9	54	2.77	0	0
Norrbotten	9	1.25	6	3.9	62	3.19	0	0
Nötkreatursstöd	4	0.56	0	0	0	0	0	0
Skåne län	74	10.28	17	11.04	240	12.33	24	35.29
Stockholm	15	2.08	8	5.19	73	3.75	1	1.47
Södermanland	21	2.92	6	3.9	69	3.55	3	4.41
Uppsala län	21	2.92	5	3.25	78	4.01	7	10.29
Värmland	28	3.89	10	6.49	87	4.47	1	1.47
Västerbotten	24	3.33	7	4.55	81	4.16	1	1.47
Västernorrland	24	3.33	6	3.9	60	3.08	0	0
Västmanland	15	2.08	2	1.3	81	4.16	3	4.41
Västra Götaland	130	18.06	17	11.04	370	19.01	14	20.59
Örebro län	23	3.19	2	1.3	85	4.37	0	0
Östergötland	47	6.53	3	1.95	121	6.22	0	0
Total	720	100	154	100	1,946	100	68	100

Table A3: Social costs and benefits of alternative payment designs

	Emission reductions (%)		Social cost (€/ha)	Social benefit (€/ha)		Benefit-cost ratio		BC ratio with PRTCs and MCT	
Payment designs	N-runoff	GHGs	WTA	Lower bound	Upper bound	Lower bound	Upper bound	Lower bound	Upper bound
Practice-based payment									
2 practices	21	15	176	29	211	0.17	1.2	0.14	0.99
4 practices	26	21	218	35	266	0.16	1.22	0.13	0.95
All 6 practices	50	45	244	68	522	0.28	2.14	0.21	1.65
Single objective result-based payment									
N-runoff reduction 25%	25	na	321	34	196	0.11	0.61	0.08	0.48
N-runoff reduction 50%	50	na	300	68	392	0.23	1.3	0.18	1.02
GHG reduction 25%	na	25	274	23	72	0.08	0.26	0.06	0.21
GHG reduction 50%	na	50	318	45	145	0.14	0.45	0.11	0.36
Multiple objective result-based payment									
N-runoff and GHG reduction 25%	25	25	382	57	268	0.15	0.7	0.11	0.54
N-runoff 25% and GHG 50%	25	50	427	79	341	0.19	0.8	0.14	0.61
N-runoff 50% and GHG 25%	50	25	361	90	464	0.25	1.29	0.19	0.99
N-runoff 50% and GHG 50%	50	50	406	113	537	0.28	1.32	0.21	1.02
Hybrid payment									
2 practices and GHG 25% (10% share of result-based)	21	25	204	52	241	0.25	1.18	0.19	0.9
6 practices, N-runoff 25% and GHG 50% (90% share of result-based)	50	50	496	113	537	0.23	1.08	0.17	0.83
2 practices, N-runoff 25% and GHG 25% (10% share of result-based)	25	25	312	57	268	0.18	0.86	0.14	0.66

Notes: Baseline: N-runoff 15.1 kg/ha and GHG emissions 1815 kg/ha