Making Agri-Environmental Payments More Cost Effective

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Foreword

Agri-environmental payment schemes, defined as voluntary programmes paying farmers to achieve certain environmental criteria, have gained increasing interest and popularity amongst policy makers and farmers. They are also an important part of the policy toolkit governments can use to abate greenhouse gas emissions from agriculture and contribute to Paris Agreement objectives.

Building on past OECD work, this report identifies "best practice" design principles for cost-effective agri-environmental payment schemes that take into account both governmental budgetary constraints and the need for schemes to attract sufficient farmer participation to be environmentally effective.

To this end, the report reviews the literature, develops a Policy Spectrum Framework that classifies payment types based on key design features for achieving cost-effective outcomes. It then presents policy simulations undertaken to assess the cost-effectiveness of different payment designs and a multi-country choice experiment conducted with farmers to explore their preferences for different types of payments, ranging from practice-based to results-based payments.

This report is a collaborative effort between the OECD Trade and Agriculture Directorate and experts participating in the external Expert Steering Group. Jussi Lankoski and Santiago Guerrero ensured its overall co-ordination. Jussi Lankoski is the principal author of Chapters 1, 2, and 3. Jared Gars, Santiago Guerrero, Laure Kuhfuss and Jussi Lankoski are the authors of Chapter 4. Laure Kuhfuss co-ordinated the design and econometric analysis of choice experiments.

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Executive summary

Tackling the environmental challenges facing agriculture will require improvements to the current set of instruments available to policy makers. One such set of instruments is government agricultural support through agri-environmental payment schemes – voluntary programmes that typically pay farmers for achieving certain environmental objectives.

Despite their increased popularity among policy makers, there is mounting evidence that a large majority of such schemes underperform in achieving environmental objectives due to weakness in design. These include imperfections in the targeting of beneficiaries and linking payments to the right mix of practices or results. This report identifies and discusses “best practice” design principles for agri-environmental payment schemes. It develops a policy spectrum framework that classifies payment scheme types based on key design features for achieving cost-effective outcomes. It performs policy simulations on those design features to assess their cost effectiveness and conducts a multi-country choice experiment with farmers to explore their preferences for contracts based on the adoption of practices, the achievement of environmental results (based on either measured or modelled results) or hybrid mechanisms that offer a payment in exchange for adopting practices and achieving results.

The Policy Spectrum framework, based on the literature review, policy simulations and choice experiment with farmers, identifies seven dimensions of payment design that are important for achieving cost-effectiveness. These key dimensions are:

- Clear, and preferably quantifiable, policy objectives.
- Targeted payment designs that allow consideration of spatial variation of compliance costs and environmental benefits.
- Tailored payment rates that do not overcompensate but cover income forgone from practice adoption (opportunity costs) and farmers’ private transaction costs associated with participation in the payment scheme.
- Adjusted eligibility criteria —such as determination of beneficiaries and decisions whether to pay to individual versus groups of individuals or collectives— depending on the environmental issue in question and whether environmental results are sought at field-parcel or landscape level.
- Acknowledgement and consideration of behavioural responses in payment design, such as farmers’ environmental preferences and risk profiles, to increase participation and render payment schemes more effective.
- Assurance of strong additionality that contributes to budgetary cost-effectiveness by limiting budgetary outlays that do not directly deliver environmental benefits.
- Monitoring and enforcement, assuring that the payments are made for actual environmental improvements, or actions leading to those improvements.

Farm-level policy simulations based on a micro-economic modelling framework and focusing on reducing nitrogen runoff show that results-based schemes are the most cost-effective despite their higher policy-related transaction costs. More specifically:

- The results-based payment, which provides direct incentives to reduce nitrogen runoff is the most cost-effective, as nitrogen runoff reduction is allocated to those production units with relatively high abatement potential.
- Hybrid payments, in which payments are based on both practice adoption and abated nitrogen runoff, are the second most cost-effective payment type.
- The practice-based component of the hybrid payment design is less cost-effective relative to results-based payment, since it provides incentives for stronger practice adoption in the least productive production units that have smaller opportunity costs but also less nitrogen runoff abatement potential. Practice-based payments, where payment is conditional on the stringency of the adopted practice, have a lower cost-effectiveness than hybrid mechanisms, but still grant farmers some degree of flexibility, since farmers can optimise practices based on their opportunity costs and payment levels for each practice adoption.
- Uniform payments for a given selection of practices eliminate that flexibility and are the least cost-effective option. These budgetary cost-effectiveness ranking results hold for both risk-neutral and risk-averse farmers, and with the inclusion of public transaction costs associated with administration of the schemes.

Results from policy simulations differ with those of the choice experiment conducted in Finland, the Netherlands and Sweden. This choice experiment provides insights into the willingness of farmers to enter into AES contracts considering water quality, climate change mitigation, and biodiversity objectives. In contrast to results from the policy simulations, the choice experiment shows that farmers (arable and mixed livestock and arable farmers) in the three countries tend to prefer practice-based and hybrid schemes more than results-based schemes. These preferences are stable across farm types (arable and mixed). Hybrid schemes are preferred over practice-based schemes only in the case of payments for biodiversity requiring the lowest level of environmental practice and result requirements. Practice-based schemes were the most preferred option for higher level environmental requirements, and for considering water quality and greenhouse gas mitigation in addition to biodiversity.

The average willingness to accept (WTA) contracts – that is, the average payment level required by farmers to participate in AES contracts – for achieving water quality, climate change mitigation, and biodiversity objectives with low level of environmental requirements for practice-based schemes (i.e. adopting two practices) is EUR 182/ha/year. The average WTA for adopting a hybrid scheme with the lowest environmental requirements (adopting two practices and achieving biodiversity objectives) varies between EUR 147/ha/year and EUR 179/ha/year, if 10% and 90% of the payment is conditioned upon results being achieved, respectively. For results-based schemes, farmers would require an average of EUR 246/ha/year to adopt a contract with the lowest environmental requirements (i.e. biodiversity objectives only). These estimates increase with the level of environmental requirements and, for hybrid contracts, with the share of payment conditioned on achieving results. Arable farmers tend to display higher WTA levels to participate in AES contracts than mixed farmers

In conclusion, hybrid agri-environmental payment schemes appear to offer the best payment option to take into account of both budgetary constraints and the need for schemes to attract sufficient farmer participation to be environmentally effective. These payments offer policy makers an opportunity to partially test and implement results-based schemes and offer farmers a lower financial risk opportunity to test results-based features of the payments.

Part I Literature review and spectrum framework

1 Introduction

Agri-environmental payment schemes are increasingly popular amongst policy makers. However, their environmental and cost effectiveness depends largely on payment design, including whether participating farmers are paid to adopt environmental practices, to achieve environmental results, or for both. This chapter introduces the key research and policy questions that are covered in this report.

Tackling the environmental challenges facing agriculture will require improvements to the current set of policy instruments available to policy makers. Agri-environmental payment schemes that are voluntary programmes which pay farmers for achieving certain environmental criteria have gained increased interest and popularity among policy makers and farmers. However, there is growing evidence that a large majority of implemented schemes have had relatively low environmental effectiveness. The focus of this paper is on agri-environmental payment mechanisms and thus excluding other kinds of agri-environmental policies, such as regulatory instruments and taxes. This paper does not assess whether payment schemes are better than or preferred policy instruments over the spectrum of alternatives including regulatory, offsets, and cap and trade type of mechanisms. Within the agri-environmental payment mechanisms there are many different options policy makers can consider, and the recommendations from the existing literature on what constitutes "best practice" in policy design are diverse and often limited to specific aspects of policy design or implementation (DeBoe, 2020[1]).

Moreover, there are a number of newer policy options described in the literature, for which there is not a lot of empirical evidence and policy experience. In particular, many economists are recommending that policy makers shift policies to becoming more 'performance-based' or "results-based" rather than 'practice-based', on the basis that such policies are more cost-effective in delivering environmental improvements (Savage and Ribaudo, 2016[2]; Shortle et al., 2012[3]; Lankoski, 2016[4]; Batáry et al., 2015[5]; Burton and Schwarz, 2013[6]; Engel, 2016[7]). Some authors have argued that viewing these policies in binary terms, 'practice-based' versus 'results-based', limits the analysis of exactly how and why practice-based policies are flawed, which in turn may limit analysis of options to improve existing policies (Moxey and White, 2014[8]). For example, Hardelin and Lankoski (2018[9]) and Lankoski (2016[4]) show that incorporating environmental targeting to regions where highest environmental benefits can be achieved greatly improves the budgetary cost-effectiveness of practice-based policies.

A more flexible policy classification is needed, based on a spectrum of uniform practice-based policies at one end and policies based on measured environmental results at the other. Using the policy spectrum framework allows a deeper analysis of factors that contribute towards a policy's success, and allows for the possibility that, rather than simply recommending a shift from practice-based to results-based policies, different policy types could perform well in different contexts and for different environmental effects.

While results-based schemes could be theoretically defined as schemes that are based on actual measurement of environmental results through monitoring, measurement of environmental results are not always feasible at field parcel level. Many important agri-environmental issues, such as nitrogen leaching and runoff, particulate and dissolved phosphorus runoff, sediment runoff, pesticide runoff, and greenhouse gas (GHG) emissions from field parcels, which are considered "non-point source pollution", are extremely difficult and costly to measure at field parcel level, rendering direct environmental results measurement infeasible (or even impossible). Alternative payment design options are thus required to keep these environmental issues within the scope of results payments schemes. These options should as closely as possible resemble payments based on measured environmental results. One option is to base payments on modelled environmental results when the modelling is sophisticated and considers site-specific agronomic, ecological and biophysical features of a given field parcel, such as field slope, soil type, hydrology, or crop rotation to predict the effects of selected practices on environmental results.

Given that in this report both the policy simulations and the choice experiment focus on three environmental issues; nutrient runoff, GHG emissions, and biodiversity, of which two represent non-point source pollution, the payments based on modelled environmental results are considered as one type of results-based payments.[1]

To achieve its objectives, the report:

- synthesises the existing available evidence to provide "best practice" design principles for agri-environmental payment schemes, building on past OECD work

- identifies “new” design elements for which the current evidence is insufficient, and advances the evidence base for promising new design elements
- acknowledges the limits of the work and identifies promising pathways for new kinds of policy design options.

This is undertaken by completing the following components:

- *Literature review and policy spectrum framework*: The review aims to extract design and implementation principles for which there is a well-established evidence base and to identify key policy design elements to be tested in the simulation and experiment components. On the basis of the literature review, a policy spectrum framework classifying different types of mechanisms is developed.
- *Policy simulations*: On the basis of the policy spectrum framework, policy simulations are developed to assess cost-effectiveness (including environmental effectiveness and policy-related transaction costs) of policies ranging from practice-based to results-based payment mechanisms.[2]
- *In-country economic choice experiments with farmers*. To complement the policy simulations, a choice experiment is being developed to elicit farmers’ preferences for different attributes of agri-environmental payments, including practice-based and results-based payment mechanisms.

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Notes

[1] The major differences between payments based on modelled environmental results and payments based on measured environmental results are that monitoring costs are lower for the former and there is no payment uncertainty due to external factors in the case of modelled results.

[2] The aim of the policy simulations is to assess the cost-effectiveness of alternative policy designs, taking into account policy-related transaction costs and a range of different design features and a range of context-specific factors. The micro-economic modelling framework constructed in Lankoski (2016[4]) will form the basis for the policy simulations.

2 Literature review and policy spectrum framework

This chapter seeks to identify and discuss “best practice” design principles for agri-environmental payment schemes. On the basis of a literature review, a Policy Spectrum Framework is developed to classify payment schemes based on key design features that are conducive to achieving cost-effective outcomes. Based on this Framework, an assessment of payment design options is developed based on their advantages and disadvantages.

2.1. Literature review

The literature review has been split into two parts.

- *General literature review to identify evidence on "best practice" design principles for agri-environmental payment mechanisms*: this review is used to inform the Policy Spectrum Framework (Section 2.2). Three hundred and seventy relevant papers have been identified to date. Key papers (meta-analyses or literature syntheses, plus papers containing strong theoretical discussions about desirable properties of agri-environmental measure or discussing criteria for evaluating agri-environmental policies) were identified based on an abstract search and Secretariat expert knowledge.
- *Detailed literature review of choice experiment (CE) studies* ("CE literature review") examining farmer or landholder preferences for agri-environmental policy design elements: a detailed review of 55 choice experiment studies has been completed and is informing the design of the choice experiment component (a summary of key features of reviewed choice experiment studies is provided in Annex F).

2.2. Policy Spectrum Framework

Policy spectrum

Agri-environmental payment mechanism design is a broad field covering many different policy elements. A significant body of past OECD work (OECD, 2010[1]; OECD, 2010[2]; OECD, 2012[3]; Lankoski and Ollikainen, 2003[4]; Lankoski, 2016[5]; Hardelin and Lankoski, 2018[6]) has provided guidance on various elements of policy design. This work builds on these past efforts, and acknowledges that a key 'frontier' for agri-environmental policy design is the question of how and when policies should provide incentives for farmers based on:

- The implementation of agri-environmental *practices or actions*: The basis for a payment is a defined farming practice or action including:
  - farm management actions (e.g. reduced fertiliser application, use of cover crops, conservation tillage, organic farming as per agreed requirements)
  - installation and maintenance of on-farm infrastructure for preventing and mitigating environmental damage or providing environmental goods (e.g. livestock fencing, buffer strips, constructed wetlands).
- Achieving a specified level of *on-farm environmental results or landscape-level aggregate environmental results*: The basis for a payment is defined in terms of environmental results (whether measured or modelled) achieved by the payment beneficiary (whether an individual in case of on-farm results or group of landholders in case of landscape-level results). The payment can be based on achieving specific environmental result thresholds (either measured or modelled), for example, nitrogen runoff below 10 kg/ha or GHG emissions reduction by 20% relative to the baseline. Payment can also be based on abatement of GHG emissions or reduction of nitrogen runoff, for example, EUR 5/kg of nitrogen runoff reduction or EUR 30/tonne of CO_2 equivalent emissions reduction.
- Achieving a specified level of agri-environmental *performance*: Payment is defined in terms of achieving environmental performance measured by *indicators* or *proxies* for the potential environmental results, for example nutrient (N and P) balance kg/ha or environmental benefit index value. The payment can be based on achieving a certain performance threshold (e.g. N-balance below 50 kg/ha) or be based on continuous performance improvements (e.g. EUR/kg of reduced N-balance). Hence, the main difference between the results-based payment and the performance-

based payment is that the former is based on the specific environmental result measured directly (reduction of nitrogen runoff or GHG emissions) whereas the latter is based on proxies for the potential environmental results (for example, nitrogen surplus indicating potential nitrogen runoff or nitrous oxide emissions). Moreover, in many cases these performance indicators or proxies reflect several environmental effects (for example, high N-balance has implications to water quality, air quality and GHG emissions).

- *A combination of practices adoption and achieving a specified level of environmental performance or results (hybrid policy)*: Basis for a payment is defined based on a combination of practice adoption and performance or results achievement. For example, a mechanism which includes a 'base payment' based on practices and a 'bonus payment' based on results.

The question of whether, and how, policies should provide incentives for farms to adopt specific practices, or achieve a specified agri-environmental performance or result is important for at least two reasons. First, an increasingly large literature assessing the performance of existing agri-environmental payment mechanisms – the vast majority of which are practice-based – shows that there is significant 'room for improvement'. Generally *ex post* evaluations have shown that such policies typically have limited environmental effectiveness and do not provide strong value-for-money (budgetary cost-effectiveness) (Batáry et al., 2015[7]; Coderoni and Esposti, 2018[8]; Dal Ferro et al., 2018[9]; Hardelin and Lankoski, 2018[6]; Lankoski, 2016[5]; Shortle et al., 2012[10]; Engel, 2016[11]). These evaluations often conclude that incentivising *practice implementation*, which may have tenuous connection with actual environmental performance or results, is an important reason for the limited environmental- and cost-effectiveness. In light of these findings, policy makers have in recent years become more receptive to considering alternatives to practice-based policies.

Second, advances in digital tools relevant for implementing alternatives (including targeted practice-based policies, as well as performance- and results-based policies) are reducing the costs and practical difficulties of implementing them (OECD, 2019[12]). Thus, policy options which even a few years ago may have been considered 'infeasible' due to high data needs or transaction costs may be more feasible now or in the future. Thus, policy makers have the opportunity to reconsider the feasible policy set. Table 2.1 sets out a spectrum describing the key options policy makers can choose from in this respect.

Table 2.1. Policy spectrum: From actions to outcomes

Uniform action or practice-based	Targeted action- or practice-based	Performance-based	Field- or farm-level results-based	Aggregate or landscape-level results-based
Hybrid policies incorporating practice-based elements with performance- or results-based elements				
Payment is conditional on implementing specified practice(s) Payment is not differentiated across individuals, or spatially Payment generally made to an individual, but could use features such as agglomeration bonuses[a] or zonal-based eligibility rules to incentivise co-ordination	Payment is conditional on implementing specified practice(s) Payment is differentiated (various options for differentiation based on different types of targeting[b]) Payment generally made to an individual, but could use features such as agglomeration bonuses or zonal-based eligibility rules to incentivise co-ordination	Payment is conditional on estimated or measured improvements in farm-level environmental performance (may take into account a limited number of on-farm exogenous factors) Can be differentiated based on different levels of performance, or uniform payment conditional on achieving a specified performance threshold Payment generally made to an individual Could use features such as agglomeration	Payment is conditional on estimated or measured field- or farm-level environmental results (if estimated, taking into account both endogenous and exogenous factors) Can be differentiated based on different levels of results, or uniform payment conditional on achieving a specified results threshold Payment generally made to an individual Could use features such as agglomeration bonusesa or zonal-based	Payment is conditional on estimated or measured aggregate or landscape - level environmental results (if estimated, taking into account both endogenous and exogenous factors) Can be differentiated based on different levels of results, or could be uniform payment conditional on achieving a specified results threshold Payment could be made to a group or individual

Uniform action or practice-based	Targeted action- or practice-based	Performance-based	Field- or farm-level results-based	Aggregate or landscape-level results-based
Hybrid policies incorporating practice-based elements with performance- or results-based elements				
		bonuses[a] or zonal-based eligibility rules to incentivise co-ordination	eligibility rules to incentivise co-ordination (if not differentiating payment based on level of results)	

Notes:

a. An "agglomeration bonus" is an incentive paid if a desired spatial configuration of practice adoption in a given region is achieved (e.g. buffer strips adopted in all field parcels adjacent of given water course). Other types of spatial incentives are also possible: for example, an agglomeration malus instead rewards landscape diversity (i.e. penalises agri-environmental actions taken in adjacent units).

b The concept of "targeting" can be implemented via several different policy dimensions, e.g. one policy may target by restricting eligibility to producers in a certain area or who meet certain key criteria, but pay uniformly to all eligible participants; another may have open eligibility but may encourage targeting via self-selection by differentiating payments by paying more in areas where environmental benefits (or cost-benefit ratios) are higher

Framework for providing "best-practice guidance" on where to situate along the policy spectrum

The policy-spectrum shows that even within this particular 'frontier' of policy design, there are many different options available for policy makers. Therefore, the question naturally arises as to where policy makers should choose to situate along the spectrum, given their specific context. This section provides the first steps towards developing a framework for providing guidance on this question.

This report uses *cost-effectiveness* as the key criterion for providing guidance on 'best practice' agri-environmental payment mechanism design. Cost-effectiveness is a holistic concept that takes into account environmental effectiveness, different kinds of costs (e.g. compliance costs and policy-related transactions costs), and can incorporate dynamic considerations (e.g. policy impacts on innovation). OECD (2010, p. 17[1]) characterises cost-effectiveness of agri-environmental policies as follows: "minimising the costs, prior to remuneration for profit losses if any, of achieving the environmental goal…the cost-efficient policy instrument is the one that minimises compliance costs while achieving the environmental target."

It is acknowledged that additional criteria beyond cost-effectiveness are also relevant for policy evaluation and guidance. For example, equity and distributional impacts may warrant attention in their own right, not least because the distributional consequences of a policy may affect its cost-effectiveness in the long term (Engel, 2016[11]). More broadly, behavioural and social impacts of alternative policy options may also be of interest, again because of their long-term impact on policy cost-effectiveness, or in their own right (Dessart, Barreiro-Hurlé and van Bavel, 2019[13]; OECD, 2012[14]; Engel, 2016[11]). Another potential consideration is ancillary benefits and costs, which are impacts caused by agri-environmental policy mechanisms, but which are not encompassed by the explicit policy objective (OECD, 2010[1]). Where relevant, this paper considers how different policy design options perform against such other criteria; it should however be noted that, compared to providing quantitative measures of cost-effectiveness, in general it is relatively difficult to quantify performance against these criteria or to provide qualitative assessments that are generalizable or comparable across contexts.

To date, seven key dimensions for assisting policy makers to decide on where to locate along the draft Policy Spectrum have been identified. Each dimension constitutes a desirable property of agri-environmental policies that is considered important for achieving cost-effectiveness, based on Secretariat expert judgement and the literature review, and also taking into account recently developed taxonomy to characterise agri-environmental schemes with special focus on those policy design features that are conducive to their cost-effectiveness (Guerrero, 2021[15]). An overview of the dimensions is provided in Table 2.2, and the seven dimensions are discussed below.

Table 2.2. Dimensions of cost-effective agri-environmental payment mechanisms

Policy feature	Specification	Key design options
Setting clear policy objectives	How many objectives?	Single objective Multiple objectives
	Can the objectives be quantified?	Objectives are easy to monitor and quantify Objectives are difficult or costly to monitor and quantify
Targeting	Spatial targeting	Zonal targeting based on environmental sensitivity (e.g. proximity to watersheds, areas with soil degradation)
	Cost-targeting	Compliance cost thresholds in enrolment screens
	Benefit-cost targeting	Environmental benefit based Environmental Benefit Indices (EBIs) Ratio of environmental benefits to compliance cost
Eligibility	Beneficiaries	Individual Groups of individuals or collectives
	Farm type	Intensive farming systems Extensive farming systems Farm size
	Other eligibility criteria	Income Age
Behavioural aspects	Dispositional factors	Resistance to change Flexibility Risk attitude Environmental concern
	Social factors	Group behaviour, influence of neighbours
	Cognitive factors	Perception of costs, benefits and risks
Additionality	Definition of baselines	Historic baselines Current environmental performance as baseline Analytical baselines Dynamic baselines Baseline practice or performance requirements
Tailoring	Calculation of payment rate	Based on compliance costs Based on value of environmental benefits Based on environmental performance or results Bid-based (conservation auctions)
	Uniform payments	Based on estimated average compliance costs
	Differentiated payments	Based on estimated differential compliance costs or environmental benefits Bid-based, auction mechanisms
	Advisory systems	Training and education Communication platforms and information sharing Consulting
	Contract design	Contract length Flexibility
	Hybrid schemes	Mix of action and performance- or result-based payments Fixed payment elements Bonus payments
Conditionality and Enforcement	Monitoring	In situ inspections Digital Technologies Self-monitoring Group monitoring
	Sanctions	Expiration of future payments Reimbursement of past payments

Notes:
a. Note that design options may not be mutually exclusive: hybrid policies containing elements of more than one option are possible.
b. Note that information-oriented policies (e.g. provision of extension and technical assistance, government-developed digital tools to assist farmers' participation in policy mechanisms etc.) are considered as part of the overall policy mix, either as an intrinsic part of the agri-environmental payment mechanism or as a complementary policy.

Setting clear policy objectives

The exact policy objectives have an influence on where to situate the policy measure along the above spectrum, as the possibility of linking specific farm actions or practices to broader environmental policy objectives differs across objectives.

An important consideration is whether policies should focus on a single objective or on several. Noting that there are many linkages between on-farm management actions and various environmental outcomes, setting multiple objectives may allow a policy to take advantage of synergies between objectives (Engel, 2016[11]). However, given that actions to achieve each single objective are unlikely to be perfectly correlated, there may be both synergies and trade-offs to consider. Also, setting multiple objectives increases policy complexity and may result in increased implementation challenges and transaction costs, which may hamper cost-effectiveness. Studies in favour of either approach are identifiable in the literature: for example, Meyer et al. (2015[16]) recommend agri-environmental policies focus on a single environmental objective, whereas others recommend setting objectives which take advantage of synergies between related environmental outcomes.

Whether single or multiple, for any cost-effective policy it is important that objectives are clearly defined and measurable. Often this is not the case in practice (Uthes and Matzdorf, 2013[17]; Wunder, Engel and Pagiola, 2008[18]). Objectives should be quantifiable to allow measuring whether policy goals have been achieved cost-effectively (Lankoski, 2016[5]). Biodiversity indicators or the definition of water quality levels could serve this purpose.

If suitable indicators can be identified, performance-based and result-based schemes tend to be advantageous and to deliver more cost-effective results (Börner et al., 2017[19]; Engel, 2016[11]; Allen et al., 2014[20]). Hitherto, result-based schemes have been used predominantly for biodiversity objectives and are claimed to be well suited, especially for the maintenance of existing environmental conditions (Herzon et al., 2018[21]; Schwarz et al., 2008[22]; Allen et al., 2014[20]; Bertke, Klimek and Wittig, 2008[23]). When targeting specific species, results-based schemes can also be advantageous (Matzdorf, Kaiser and Rohner, 2008[24]); paying Dutch farmers by clutch of meadow birds, for instance, proved to be more cost-effective than remunerating them for specific mowing restrictions (Verhulst, Kleijn and Berendse, 2007[25]; Musters et al., 2001[26]). Practice-based payments often do not effectively protect biodiversity, since correlation between the prescribed practices and the desired outcome is not guaranteed (Kleijn et al., 2001[27]; Kleijn et al., 2004[28]; Zechmeister et al., 2003[29]).

Due to its complexity, however, biodiversity is difficult to measure. While some authors therefore express caveats for result-based schemes, others point out that suitable indicator approaches, especially for grassland, have already been successfully identified and implemented (Peerlings and Polman, 2009[30]; Wittig, Kemmermann and Zacharias, 2006[31]; Bertke, Klimek and Wittig, 2008[23]; White and Sadler, 2012[32]; Moxey and White, 2014[33]; Diekmann, 2003[34]). Further research and development of digital tools may facilitate quantification, which should render result-based schemes more cost-effective in the future. Yet, for objectives with outcomes impossible or too costly to monitor, or which largely depend on external factors such as weather conditions, practice-based approaches may remain the more appropriate option (Engel, 2016[11]; Börner et al., 2017[19]; Hanley and White, 2013[35]).

O'Rourke (2020[36]) summarises some desirable characteristics of indicators for results-based policies:

- They should represent the environmental issue that the scheme proposes to address and be directly linked to the environmental objective of the programme and the payment basis.
- They should be mostly achieved by management practices and, to the extent possible, not be influenced by exogenous factors such as weather conditions.
- They should be easy to measure, quantify, and observe by the farmer.
- There needs to be a clear understanding on how farmers' decisions affect the indicator.

Table 2.3 shows examples of indicators used in results-based schemes in OECD countries.

Table 2.3. Examples of indicators used in results-based agri-environmental schemes

Country	Name of scheme	Indicators	Payment basis
Australia	Box gum grassy woodland project (https://www.lls.nsw.gov.au/regions/south-east/grants-and-funding/thinking-inside-the-box-gum-grassy-woodland)	Conservation value score of box gum grassy woodland	Bid-based
Australia	Reef Trust Tender—Burdekin (https://www.nqdrytropics.com.au/reef-trust-tender2/)	Reduction of nitrogen application (kg)	Bid-based
Austria	Humus-Program of the Ökoregion Kaindorf	Humus content in soil	Ton of CO2 sequestered in humus
Germany	Harrier nest protection in arable fields (Weihenschutz) - Nordrhein-Westfalen	Number of nests of certain bird species	Forgone income from protecting nests/Per nest
Germany	Coordinated grassland bird protection (Gemeinschaftlicher Wiesenvogelschutz) - Schleswig-Holstein	Presence of specific grassland-breeding birds species	Per hectare in those areas where birds have bred. The payment rate increases with the number of nests
Germany	Species-rich grassland (Artenreiches Dauergrünland) - Baden-Württemberg	Presence of minimum 4 or 6 flower species	Per hectare in those areas where species are found. The payment rate increases with the number of species
Germany	Species-rich grassland (Artenreiches Grünland – Kennarten) - Rheinland-Pfalz	Presence of minimum 4 or 8 grassland plant species	Per hectare in those areas where species are found. The payment rate increases with the number of species
Ireland	Sustainable agricultural plan for the Macgillycuddy reeks	Peatland scorecard	Based on habitat management costs and the peatland score
Ireland	Managing the habitats of the Aran islands	Habitat condition based on presence and abundance of specific species and management practices	Based on management costs
Ireland	Protecting farmland pollinators	Score obtained from the abundance and diversity of plants and pollinators, farm features and physical structures	Based on the score and quality of habitat
Ireland	The Burren programme	Score obtained from management practices and landscape characteristics	Based on cost incurred and income forgone. The payment rate increases with the score
Spain	Biodiversity in grasslands and improved hedges	Number of grassland species and hedges (characteristics and location)	Based on willingness to accept methods for participating into the programme

Source: Result based payments network (https://www.rbpnetwork.eu/).

Targeting

Heterogeneity is a natural feature of agriculture and environment linkages. There is a large spatial variation across landscapes with respect to productivity (and thus profitability of production) and environmental sensitivity. Numerous authors recommend a targeted policy design, which considers spatial variation of compliance costs and environmental benefits, to enhance environmental effectiveness and cost-effectiveness of policy (Espinosa-Goded, Barreiro-Hurlé and Ruto, 2010[37]; Broch et al., 2013[38]; Berry et al., 2005[39]; Matzdorf, Kaiser and Rohner, 2008[24]; Bartkowski et al., 2018[40]; Uthes and Matzdorf, 2013[17]; Wünscher, Engel and Wunder, 2008[41]).

Effectively addressing spatial variation of costs and benefits in policy implementation requires good data on the farmers' compliance costs and environmental sensitivity. In turn, this leads to greater administration efforts and increased implementation costs (policy-related transaction costs). (Balana, Vinten and Slee, 2011[42]; Engel, 2016[11]; Falconer, 2000[43]; Uthes and Matzdorf, 2013[17]). However, some studies have shown that the efficiency gains from targeting can outweigh the implementation costs (Armsworth et al., 2012[44]; Lankoski, 2016[5]). For example, Lankoski (2016[5]) employs the 'targeting gains ratio" to identify the budgetary cost-effectiveness gains from environmental targeting relative to the increase in transaction costs when more targeted payments are implemented. Targeting gains ratio varies across different payment designs, but is found to be as high as 28 in the best case, meaning that EUR 1 spent on public transaction costs for improved environmental targeting pays back EUR 28 through budgetary cost-effectiveness gains. Plausibly the gains from targeting are larger the greater the heterogeneity in costs and benefits (Wünscher, Engel and Wunder, 2008[41]; Armsworth et al., 2012[44]; Engel, 2016[11]).

A relatively inexpensive form of targeting is area-based targeting using geographical criteria, such as location near protected areas or proximity to watersheds, compared to data-intensive targeting at an individual farm-level (FAO, 2007[45]; Engel, 2016[11]). However, if environmental characteristics vary significantly within the area, site-specific environmental scores are a more suitable option. If farmers differ in their compliance costs, it may be useful to target low-costs sites and hence achieve a higher environmental performance with a given budget. Cost-targeting is often accompanied by payment differentiation (e.g. using discriminatory price auctions), remunerating the farmers by their compliance costs (Engel, 2016[11]). Wünscher et al. (2008[41]) propose that cost-targeting with payment differentiation may contribute the largest part of the increase in cost-effectiveness from improved targeting.

Cost-targeting is beneficial only when environmental benefits within region or across farms and field parcels are relatively homogeneous (Claassen, Cattaneo and Johansson, 2008[46]). With heterogeneity in both environmental benefits and compliance costs between farms, the two approaches should be combined to benefit-cost targeting. Specific performance scoring systems, such as the environmental benefit indices, allows policy makers to target the farms that achieve the highest environmental gains relative to costs (i.e. the agri-environmental payment) and thus improves budgetary cost-effectiveness. Numerous studies have identified efficiency gains from benefit-cost targeting (Claassen, Cattaneo and Johansson, 2008[46]; Uthes and Matzdorf, 2013[17]; Arbuckle, 2013[47]; Barton et al., 2003[48]; Wünscher, Engel and Wunder, 2008[41]; Lankoski, 2016[5]; Hardelin and Lankoski, 2018[6]).

Eligibility

Agricultural and agri-environmental policies mostly target farmers or landholders. They can address either individual farmers or groups of farmers or collectives. Furthermore, they can be restricted to certain characteristics, such as farm type or size, farmers' income, education level or age (OECD, 2007[49]).

Agri-environmental payments are most often directed to individual farmers for their conservation efforts, but could alternatively be allocated to groups of farmers to receive remuneration for collective actions or environmental results at the landscape level. The preferred approach depends, for example, on the environmental issue in question. When a specific spatial pattern of measures is needed to achieve an environmental objective, such as broader biodiversity conservation, or protection of species with large habitats, cooperation between land-managers can be beneficial (Franks, 2011[50]; Engel, 2016[11]; Mills et al., 2012[51]). Several authors claim that coordinated action or community commitment improves environmental performance or efficiency of a scheme (Brouwer, Tesfaye and Pauw, 2011[52]; Le Coent and Thoyer, 2014[53]; Prager, Reed and Scott, 2012[54]; Uthes and Matzdorf, 2013[17]; Burton and Schwarz, 2013[55]; Franks, 2011[50]). It can also reduce the risk of leakage by preventing relocation of harmful activities to adjacent sites (Engel, 2016[11]).

Another benefit of co-ordinated action is the possibility of mutual learning and the creation of social capital (Lastra-Bravo et al., 2015[56]; Mettepenningen et al., 2013[57]). By exchanging knowledge, farmers can not only share best practices and foster innovation, but can also decrease compliance costs, for instance by sharing machinery costs (Polman, 2002[58]; Franks, 2011[50]; Mettepenningen et al., 2013[57]). On the other hand, the requirement of large capital expenditures, conflicts related to timing of machinery usage, monitoring of depreciation and variable costs might make potential payment recipients reluctant to be involved in a group scheme. Effects of group payments on transaction costs are ambiguous. Farmers within a target area may differ in risk preferences, environmental attitudes, cost of capital, and discount rates in a way that may increase the transaction costs of group action. Some authors have stated that by grouping beneficiaries, transaction costs are relatively lower (Goldman, Thompson and Daily, 2007[59]; Jones et al., 2009[60]), while others predict an increase of transaction costs owing to higher coordination efforts (Franks, 2011[50]; Mills et al., 2012[51]).

Collective contracts can have positive impacts on compliance and enforcement, since it can activate normative behaviour and peer monitoring (Brouwer, Tesfaye and Pauw, 2011[52]; Mills et al., 2008[61]; Cranford, 2014[62]; Hanley and White, 2013[35]; Sommerville, Jones and Milner-Gulland, 2009[63]), which might lower administrative costs (Dietz, Ostrom and Stern, 2003[64]; Dobbs and Pretty, 2008[65]; Mills et al., 2012[51]). On the other hand, many authors stress the importance of advisory systems or intermediary agencies to assist coordinated action, raising transaction costs for the implementing agency (Burton and Paragahawewa, 2011[66]; Moxey and White, 2014[33]; Riley et al., 2018[67]; Mills et al., 2012[51]; Franks, 2011[50]).

Another eligibility criterion can be the farm type, which has ramifications for participation rates and efficient attainment of environmental outcomes. Because of higher conservation benefits, several authors advocate for explicitly targeting extensive agricultural landscapes (Dahms et al., 2010[68]; Aviron et al., 2005[69]). Additionally, intensive farms request higher compensation payments than less intensive ones, increasing the cost of the policy (Breustedt, Schulz and Latacz-Lohmann, 2013[70]; Danne and Musshoff, 2017[71]). However, engaging with larger farms would allow benefiting from economies of scale, which contributes positively to the cost-effectiveness of the policy (Adams, Pressey and Stoeckl, 2014[72]; Espinosa-Goded, Barreiro-Hurlé and Dupraz, 2013[73]).

Behavioural aspects

The voluntary character of agri-environmental payments necessitates that policy design and implementation are attractive for farmers to ensure their participation. However, it is insufficient if payments are solely economically beneficial for farmers and neglect the fact that other factors might influence farmers' decision-making. Thus, insights from behavioural economics can improve agri-environmental policy design in this respect. Dessart, Barreiro-Hurlé and van Bavel (2019[13]) identify three different types of factors, which play into farmers' considerations, additional to purely economic reasoning:

- *Dispositional factors* which encompass the farmers' personality, their risk attitudes and environmental concerns;
- *Social factors* such as preferences for interactions with other individuals, social norms and expectations;
- *Cognitive factors* which describe the ability of farmers to understand the benefits and costs that they are facing, their belief on outcomes and their own abilities to reach certain goals.

Acknowledging behavioural factors and addressing them through adequate policy design can increase participation and render agri-environmental programmes more effective (OECD, 2012[14]; Dessart, Barreiro-Hurlé and van Bavel, 2019[13]).

The most important *dispositional factors* are personal preferences on flexibility and inherent resistance to change, risk preferences and environmental concerns. Several studies have shown that farmers are resistant to change (Burton, Kuczera and Schwarz, 2008[74]; Sheeder and Lynne, 2011[75]). In Hermann, Mußhoff and Agethen's study (2016[76]), for example, resistance to change was the reason for deterring conventional hog farmers from converting to organic practices. Relatively easy entry conditions with incremental increases towards more sustainable practices could be an effective solution (Öhlmér, Olson and Brehmer, 1998[77]; Schroeder et al., 2013[78]). Furthermore, specifically targeting farmers with positive or less reluctant attitudes towards change and sustainable land management can be beneficial. Both Dessart, Barreiro-Hurlé and van Bavel (2019[13]) and Falconer (2000[43]) recommend to segment sub-populations of farmers with similar attitudes, which is especially relevant for group payments.

Besides change, rigid management prescriptions may discourage farmers from enrolling in agri-environmental schemes. More flexibility and less stringent restrictions are preferred by farmers and can increase participation (Engel, 2016[11]; Darnhofer et al., 2017[79]; Wittig, Kemmermann and Zacharias, 2006[31]; Klimek et al., 2008[80]; Ruto and Garrod, 2009[81]; Wilson and Hart, 2001[82]; Dessart, Barreiro-Hurlé and van Bavel, 2019[13]).

Result-based payments are an effective way to provide flexibility for selection of environmental practices (Matzdorf, 2004[83]; Bräuer, Müssner and Marsden, 2006[84]; Musters et al., 2001[26]; Gorddard, Whitten and Reeson, 2008[85]; Andeltová, 2018[86]; Burton and Schwarz, 2013[55]), since farmers are free to achieve environmental results with the measures they consider the most appropriate. This allows greater cost-effectiveness (Casey and Boody, 2007[87]; Ferraro and Simpson, 2002[88]; Wunder, 2005[89]; Wätzold and Drechsler, 2005[90]; Casey and Boody, 2007[87]) because farmers may have better knowledge on local conditions and environmental interrelations (Andeltová, 2018[86]; Zabel and Roe, 2009[91]).

Farmers' *attitude towards risk* is another relevant dispositional factor. Many authors state that risk preferences play a role in adoption of conservation contracts (Claassen, Cattaneo and Johansson, 2008[46]; Chèze, David and Martinet, 2017[92]; Kuminoff and Wossink, 2010[93]) and higher risks could possibly decrease scheme uptake (Loisel and Elyakime, 2006[94]). Others have claimed that "risk does not have a clear negative impact on the willingness to participate" (Matzdorf and Lorenz, 2010, p. 542[95]), also in (Trujillo-Barrera, Pennings and Hofenk, 2016[96]; Brouwer, Tesfaye and Pauw, 2011[52]).

Results-based schemes expose farmers to a higher uncertainty of the amount of payment and therefore necessitate a risk premium (Schwarz et al., 2008[22]; Andeltová, 2018[86]; Zabel and Roe, 2009[91]). The required premium is higher in cases where environmental outcomes are strongly influenced by external factors such as weather events or pests and hence beyond the farmer's control (Schwarz et al., 2008[22]). In some cases these risks may decline over time when farmers gather experience and knowledge on effective management practices (Baumgärtner and Hartmann, 2001[97]; Burton and Schwarz, 2013[55]). This makes easy entry conditions and higher risk premiums possible policy solutions which are particularly relevant at initial stages of the scheme (Schroeder et al., 2013[78]).

Environmental concern is often mentioned to positively affect enrolment in agri-environmental schemes (Toma and Mathijs, 2007[98]; Best, 2010[99]; Läpple and Van Rensburg, 2011[100]). This calls for social marketing programs, such as media campaigns or agricultural education services aiming at raising environmental awareness (Cullen et al., 2018[101]; Dessart, Barreiro-Hurlé and van Bavel, 2019[13]). Relative to practice-based payments, result-based payments tend to increase social networking, knowledge sharing and intrinsic motivation for environmental conservation (Matzdorf, 2004[83]; Matzdorf, Kaiser and Rohner, 2008[24]; Andeltová, 2018[86]; Burton and Schwarz, 2013[55]).

Besides dispositional factors, social considerations are a crucial element in farmers' decision making. It has been shown that behaviour of neighbouring farmers influences participation decisions (Damianos and Giannakopoulos, 2002[102]; Defrancesco et al., 2008[103]). Scheme adoption of neighbouring farmers positively affects contract uptake (D'Emden, Llewellyn and Burton, 2008[104]; Gillich et al., 2019[105]). Furthermore, there is evidence that peer pressure and social norms have ramifications on farmers' decision to participate (Burton and Paragahawewa, 2011[66]; Emery and Franks, 2012[106]; Chen et al., 2009[107]) and fear of judgment by peers may increase the probability of scheme uptake (Emery and Franks, 2012[106]). Although Sattler and Nagel (2010[108]) downplay the relevance of judgment of others in adoption decisions, numerous authors stress that social networks can catalyse farmers' behaviour (Polman and Slangen, 2008[109]; Mathijs, 2003[110]; Capitanio, Adinolfi and Malorgio, 2011[111]; Beckmann, Eggers and Mettepenningen, 2009[112]; Peerlings and Polman, 2009[30]). Peer effects can also help proliferate new practices. If learning is a primary barrier to the adoption of a practice or set of practices that achieve the desired performance or results, non-program participants may learn or be encouraged by their participating neighbors, and in turn later adopt practices, even without payment. If spillovers do occur, this increases the benefit-cost ratio of individual payment schemes as opposed to group payment schemes.

Cognitive factors play an important role in farmers' decision-making. Here, it is important that the farmer fully understands the costs, benefits and risks and perceives them realistically. It has been shown that farmers' perception of costs, benefits and risks may be distorted and does not always reflect the real measures (Michel-Guillou and Moser, 2006[113]; Doyle, 2012[114]; Bocquého, Jacquet and Reynaud, 2014[115]; Hardaker and Lien, 2010[116]; Kahneman and Tversky, 1979[117]). Immediate benefits weigh disproportionally more in farmers' calculations than those in the future, and risks of high impact and low-probability extreme events, such as hail, tend to be overestimated (Doyle, 2012[114]; Bocquého, Jacquet and Reynaud, 2014[115]).

These knowledge issues can be tackled through adequate policy design by raising farmers' awareness, education and training (Trujillo-Barrera, Pennings and Hofenk, 2016[96]). Access to relevant and reliable information is crucial for a farmer's decision to participate in a scheme (Llewellyn, 2007[118]; Kallas, Serra and Gil, 2010[119]; Balderas Torres et al., 2013[120]). Precise information channelling and the provision of advisory systems are valuable policy elements (D'Emden, Llewellyn and Burton, 2008[104]; Dessart, Barreiro-Hurlé and van Bavel, 2019[13]), and can contribute to a reduction of communication costs and hence improve the efficiency of the policy (Defrancesco et al., 2008[103]).[1] In order to tackle farmers' tendency to value immediate costs more than long-term benefits, higher payments should be made at initial stages of the contract when farmers face high fixed costs (Duquette, Higgins and Horowitz, 2012[121]; Grolleau, Mzoughi and Thoyer, 2015[122]; Colen et al., 2016[123]; Dessart, Barreiro-Hurlé and van Bavel, 2019[13]).

Additionality

OECD (2012, p. 11[3]) defines additionality as "the extent to which the policy was a necessary condition for obtaining the targeted result". Chabé-Ferret and Subervie (2013[124]) then define "windfall effects" as payments (or "windfall" gains) made in respect of actions which are not additional. For example, (Claassen, Duquette and Smith, 2018[125])show that additionality vary across practices for practice-based schemes in US agricultural conservation programs. Weak additionality means that a significant portion of payments are received by participants for implementing practices or management actions that would have taken place even in the absence of the payment. Achieving strong additionality contributes towards cost-effectiveness in that it limits budgetary outlays that do not directly deliver environmental benefits.

Assuring additionality necessitates clearly defined baselines and reference levels, which in practice are often lacking (Engel, 2016[11]; Wunder, Engel and Pagiola, 2008[18]; Ferraro and Pattanayak, 2006[126]; Casey and Boody, 2007[87]; Porras et al., 2011[127]). A baseline should consider the environmental condition at the beginning of the contract and incorporate the expected changes in external factors and land use that would have taken place in absence of the program (Naeem et al., 2015[128]; Claassen, Cattaneo and Johansson, 2008[46]).

However, a common practice is to use *historic baselines* (Angelsen and Wertz-Kanounnikoff, 2008[129]), which do not reflect likely future changes. While historic baselines can be computed relatively easily, they might punish farmers who have taken pro-environmental actions before the programme (Alpizar et al., 2013[130]).

Reference levels based on *current environmental performance* can mitigate aforementioned problem with historic baselines. By computing a farm-specific baseline, such as an environmental benefit index,[2] the actual improvement can be measured and remunerated. Weinberg and Claassen (2006[131]) show an increase of environmental effectiveness by a factor of five when shifting from payments for "good performance" to payments for "improved performance". Similar results have been found by Casasola et al. (2009[132]).

Result-based schemes directly link payments to environmental results (Matzdorf and Lorenz, 2010[95]) and hence have the potential to achieve high additionality (Burton and Schwarz, 2013[55]). Furthermore, result-based schemes provide incentives to enroll the best-suited land for provision of environmental results and thus enhance environmental effectiveness and prevent adverse selection (Matzdorf, Kaiser and Rohner, 2008[24]; Quillérou and Fraser, 2010[133]; Börner et al., 2017[19]; Burton and Schwarz, 2013[55]; Engel, 2016[11]). On the other hand, they also attract farms where the required results are already achieved or close to achievement (Uthes and Matzdorf, 2013[17]), which impedes additionality.

An effective definition of baselines is critical for additionality and cost-effectiveness (Bosch et al., 2013[134]; Porras et al., 2011[127]; Berkhout, Doorn and Schrijver, 2018[135]), and particularly important for result-based schemes (Burton and Schwarz, 2013[55]; Schwarz et al., 2008[22]). Setting the baselines right is a difficult exercise, requiring the availability of data and models on the landscape or even farm level (Claassen, Cattaneo and Johansson, 2008[46]; Wunder, Engel and Pagiola, 2008[18]). This is time-consuming and entails high transaction costs (Wunder, Engel and Pagiola, 2008[18]; Naeem et al., 2015[128]; Bosch et al., 2013[134]). The feasibility of baseline-setting affects whether practice-based or result-based payments are more suited (Berkhout, Doorn and Schrijver, 2018[135]). If administrative capacities are high and data is available at reasonable cost, allowing for the definition of effective baselines, result-based payments can lead to more effective environmental protection (Bosch et al., 2013[134]; Burton and Schwarz, 2013[55]). If this not the case, practice-based payments are a better alternative, since they do not require reliable monitoring of environmental improvements (Herzon et al., 2018[21]; Colombo and Rocamora-Montiel, 2018[136]). Moreover, for practice-based payments, additionality can sometimes be roughly inferred by whether the participant had undertaken practice in the past.

Tailoring

The payment rate has important implications for budgetary cost-effectiveness of the scheme. Any rate above the minimum payment necessary to guarantee participation will overcompensate farmers for income forgone and extra costs incurred, thus reducing the number of participants possible under a fixed budget, and hence reducing both environmental effectiveness and budgetary cost-effectiveness (Brouwer, Tesfaye and Pauw, 2011[52]; Börner et al., 2017[19]; Ferraro, 2008[137]; Lankoski, 2016[5]) (Balderas Torres et al., 2013[120]; Bastian et al., 2017[138]; Dickinson et al., 2012[139]; Miller et al., 2011[140]; Farmer et al., 2011[141]; Farmer, Chancellor and Fischer, 2011[142]).

A minimum payment covers the farmers' compliance costs with the scheme. These are comprised of the income forgone from practice adoption (opportunity costs) and the farmers' private transaction costs (Wunder, Engel and Pagiola, 2008[18]; Falconer, 2000[43]; Berkhout, Doorn and Schrijver, 2018[135]; Engel, Pagiola and Wunder, 2008[143]; Mettepenningen et al., 2013[57]). Several authors point out that payments solely based on opportunity costs without transaction costs are insufficient (Wünscher and Engel, 2012[144]; Wünscher, Engel and Wunder, 2008[41]; Falconer, 2000[43]). Likewise, payments should account for possible shifts in opportunity costs or market prices over time (Herzon et al., 2018[21]; Niens and Marggraf, 2010[145]; Russi et al., 2016[146]).

The alternative remuneration method is to link payments to the social value of the environmental benefit that has been created (Berkhout, Doorn and Schrijver, 2018[135]; Hanley and White, 2013[35]; Engel, 2016[11]). Payment based on the value of environmental benefits is particularly relevant for the result-based payment schemes, where the achievement of environmental results provides the basis for payments. However, monetary valuation (social valuation) of environmental results is challenging and even for result-based schemes in which the payment is linked to the quantity or quality of the environmental result, the payment calculation may still be based on income foregone and extra costs incurred (Herzon et al., 2018[21]; Schwarz et al., 2008[22]; Lankoski, 2016[5]).

Many studies show that farmers request higher payments for accepting restrictive contracts and reduced flexibility. Ruto and Garrod (2009[81]) stated that farmers request greater financial incentives for lower flexibility. Espinosa-Goded, Barreiro-Hurlé and Ruto (2010[37]) showed that higher payments increased farmers' willingness to participate in schemes that required a change in farm management practices. Multiple studies confirm that lower payments were needed for less rigid contracts in terms of management prescriptions, contract length and paperwork involved (Espinosa-Goded, Barreiro-Hurlé and Ruto, 2010[37]; Ruto and Garrod, 2009[81]; Christensen et al., 2011[147]; Lastra-Bravo et al., 2015[56]; Breustedt, Schulz and Latacz-Lohmann, 2013[70]).

Allowing for more flexibility in management practices lowers the remuneration needed as farmers can select the least-cost practices for themselves and therefore increased flexibility can decrease overall budgetary costs. Result-based payments provide more flexibility in this regard as farmers can more freely choose the practices to attain the desired environmental result (Schwarz et al., 2008[22]; Matzdorf and Lorenz, 2010[95]; Zabel and Roe, 2009[91]; Schilizzi, Breustedt and Latacz-Lohmann, 2011[148]; Matzdorf, 2004[83]; Schilizzi and Latacz-Lohmann, 2016[149]; Lankoski, 2016[5]). Furthermore, higher flexibility can reduce farmers' compliance costs providing an incentive to identify the most efficient options (Matzdorf and Lorenz, 2010[95]; Weinberg and Claassen, 2006[131]; Wätzold and Schwerdtner, 2005[150]; Burton and Schwarz, 2013[55]).

On the other hand, result-based schemes expose farmers to higher uncertainty of payments and therefore may necessitate risk premiums.[3] If these risk premiums are higher than the compensation needed for reduced flexibility, a practice-based scheme might reduce the needed payment level (Schilizzi, Breustedt and Latacz-Lohmann, 2011[148]; Schilizzi and Latacz-Lohmann, 2016[149]).

Short-term contracts are the preferred option by farmers giving them flexibility on their farm management in the future (Engel, 2016[11]; Balderas Torres et al., 2013[120]; Berkhout, Doorn and Schrijver, 2018[135]; Miller et al., 2011[140]). This is especially relevant for practice-based schemes, where farmers value the option to change management practices when the contracts expire (Ruto and Garrod, 2009[81]; Lütz and Bastian, 2002[151]; Pasquini et al., 2009[152]). Shorter commitments allow farmers to stay responsive to changes in future market conditions, which might affect their opportunity costs (Engel, 2016[11]; Niens and Marggraf, 2010[145]; Russi et al., 2016[146]). Furthermore, short contracts allow trying out the policy for both the farmer and the implementing agency, if the scheme is in its initial stages (Engel, 2016[11]; Christensen et al., 2011[147]).

Some environmental objectives might require long-term commitments, calling for longer contracts, such as biodiversity conservation (Ruto and Garrod, 2009[81]; Berkhout, Doorn and Schrijver, 2018[135]). Long-term contracts can assure long-term provision of the environmental service and can help to assure conditionality (Engel, 2016[11]). For result-based schemes long-term contracts are beneficial, since the rationale of result-based payments is that farmers build up knowledge and develop new skills and innovation over time (Burton and Schwarz, 2013[55]; Baumgärtner and Hartmann, 2001[97]; Wittig, Kemmermann and Zacharias, 2006[31]). The aforementioned inherent risk of result-based schemes may also decline with increasing experience (Burton and Schwarz, 2013[55]; Casey and Boody, 2007[87]; Wätzold and Drechsler, 2005[90]). Additionally, it might take time until environmental outcomes can be observed (Schwarz et al., 2008[22]; Herzon et al., 2018[21]; Hasund, 2013[153]). Therefore scheme success might be increased with long-term contracts (Mccracken et al., 2015[154]; Sattler and Matzdorf, 2013[155]).

Uniform fixed payment is currently the most commonly used option for agri-environmental schemes (Engel, 2016[11]; Latacz-Lohmann and Schilizzi, 2005[156]; Schwarz et al., 2008[22]; Schilizzi, Breustedt and Latacz-Lohmann, 2011[148]). Its advantage is easier implementation and thus smaller transaction costs due to lower information needs (OECD, 2007[49]). If environmental benefits and compliance costs are relatively homogeneous among farmers and can be reasonably estimated, uniform payments are advisable (Mills et al., 2012[51]; Lankoski, 2016[5]).

Conversely, if compliance costs or environmental benefits differ largely among participants, uniform payments fail to account for this heterogeneity (OECD, 2007[49]; Latacz-Lohmann and Breustedt, 2019[157]; Hasund, 2013[153]; OECD, 2010[1]; Lankoski, 2016[5]), leading to overcompensation of farmers with low compliance costs (Groth, 2005[158]; Berkhout, Doorn and Schrijver, 2018[135]; Armsworth et al., 2012[44]; Schwarz et al., 2008[22]; OECD, 2010[1]), while farmers with high compliance costs, who could potentially deliver large environmental benefits, will not enter into the scheme, since they would be undercompensated (Groth, 2005[158]; Berkhout, Doorn and Schrijver, 2018[135]; Schwarz et al., 2008[22]; Wünscher, Engel and Wunder, 2008[41]).

Under heterogeneous conditions, uniform payments therefore reduce the budgetary cost-effectiveness of the scheme due to high information rents (an overcompensation of a farmer's income forgone and extra costs incurred) for low compliance cost farmers and adverse selection (Armsworth et al., 2012[44]; Wünscher, Engel and Wunder, 2008[41]; Holm-Mueller, Radke and Weis, 2002[159]; OECD, 2010[1]; Lankoski, 2016[5]). The choice between standardised and less costly fixed payments and more complex differentiated payments hence depends on the heterogeneity among farms regarding compliance costs and environmental benefits (OECD, 2007[49]; Börner et al., 2017[19]; Wätzold and Schwerdtner, 2005[150]).

In contexts with high variability among farmers, payments can be differentiated, either on the basis of compliance costs or environmental benefits (Hanley and White, 2013[35]). Numerous authors have confirmed increased environmental effectiveness and cost-effectiveness with differentiated payments (Engel, 2016[11]; Porras et al., 2011[127]; Ezzine-De-Blas et al., 2016[160]; Groth, 2005[158]; Wünscher, Engel and Wunder, 2008[41]; Lankoski, 2016[5]). However, differentiated payments require more information than uniform payments and thus have higher transaction costs that reduce the potential cost-effectiveness gains from payment differentiation. (Engel, 2016[11]; Börner et al., 2017[19]; Börner et al., 2017[19]; Wätzold and Schwerdtner, 2005[150]; OECD, 2010[1]; Lankoski, 2016[5]). Another concern is that differentiated payments might be perceived as unfair by policymakers and farmers (Latacz-Lohmann and Schilizzi, 2005[156]; Wunder, Engel and Pagiola, 2008[18]; Holm-Müller and Hilden, 2004[161]).

Differentiated payments based on compliance costs require information on farmers' compliance costs and farmers might not have incentives to reveal their true costs. This information asymmetry reduces the cost-effectiveness of the agri-environmental schemes (Engel, 2016[11]; Börner et al., 2017[19]; OECD, 2007[49]; Wunder, Engel and Pagiola, 2008[18]; Latacz-Lohmann and Breustedt, 2019[157]; Cooper, Hart and Baldock, 2009[162]; Canton, De Cara and Jayet, 2009[163]). One mechanism to overcome the asymmetric information problem are self-selection contracts. The implementing agency offers different contract types, which farmers choose depending on their own characteristics and hence reveal their preferences and compliance costs (Wu and Babcock, 1996[164]; Ozanne and White, 2007[165]; OECD, 2010[1]). Another mechanism to overcome information asymmetry is bidding mechanisms such as auctions, which have already been used in practice, for example, in the Conservation Reserve Program in the United States (Claassen, Cattaneo and Johansson, 2008[46]) and in the Victorian Bush Tender Trial (Cocklin, Mautner and Dibden, 2007[166]; Stoneham et al., 2003[167]; Vukina, Levy and Marra, 2006[168]; OECD, 2010[1]).

Through competitive bidding for agri-environmental contracts, farmers reveal their compliance costs, which reduces information rents and overcompensation and hence increases budgetary cost-effectiveness (Berkhout, Doorn and Schrijver, 2018[135]; Costedoat et al., 2016[169]; Herzon et al., 2018[21]; Boxall, Perger and Weber, 2013[170]; Stoneham et al., 2003[167]; Schillizzi and Latacz-Lohmann, 2007[171]; Glebe, 2008[172]).

In various studies auctions outperform fixed uniform payments with cost-effectiveness gains between 16% – 315% (without transaction costs) (Latacz-Lohmann and Schilizzi, 2005[156]). The gains in budgetary cost-effectiveness of auctions, however, are highly dependent on the magnitude of additional transaction costs relative to more simple payment designs (Glebe, 2008[172]; OECD, 2010[1]; Lankoski, 2016[5]). Lankoski (2016[5]) incorporates transaction costs of different payments designs (uniform payment, differentiated payments and auctions) for budgetary cost-effectiveness analysis of payments promoting biodiversity enhancement in farmland and finds that auctions and differentiated payments perform better than uniform payment even when transaction costs are accounted for (cost-effectiveness gain is 16% for auction and 5% for differentiated payment).

Following Lankoski (2016[5]) the relative performance of different payment designs, from uniform payments to results-based payments, depends on the extent to which opportunity costs and environmental quality[4] vary across participants as illustrated in Table 2.4. Uniform payment works well when both opportunity costs and environmental quality are homogenous. When opportunity costs vary but environmental quality is homogenous then differentiated payment on the basis of costs would perform better and be fairer than uniform payment. In this case, an auction system would also perform well, but differentiated payment would probably be an easier and more flexible system when opportunity costs are reasonably well known. When environmental quality varies, the added value of auction systems and other targeting mechanisms (results-based or differentiated payments) increases. In these cases, auctions work well when the number of potential participants (bidders) is large, and results-based payment would be best suited for situations where the number of participants is low. When environmental quality varies, efficiency requires that auction and other mechanisms employ an environmental scoring system to address environmental heterogeneity, e.g. use of environmental benefit index. Also, policy-related transaction costs affect the efficiency of alternative payment types and thus auctions may be preferred to results-based schemes when potential pool of participants is large.

Table 2.4. Suitability of different payment types under homogenous and heterogeneous spatial conditions

Environmental quality	Opportunity costs	
	Homogenous	Heterogeneous
Homogenous	Uniform payment (N, n)	Differentiated payment-cc (N, n)
Heterogeneous	Differentiated payment-eb (N,n) Auction-eb (N) Results-based payment-eb (n)	Differentiated payment–cc and eb (N,n) Auction–cc and eb (N) Results-based payment–cc and eb (n)

Note: N = works well with large number of participants; n = suitable for small number of participants; cc = differentiated on the basis of compliance costs; eb = differentiated on the basis of environmental benefits.
Source: Lankoski (2016[5]).

Conditionality and enforcement

Achieving strong conditionality means that farmers participating in an agri-environmental schemes receive remuneration if and only if they actually deliver the agreed action, practice, performance, or result as specified in their contract (Hardelin and Lankoski, 2018[6]; Engel, Pagiola and Wunder, 2008[143]; OECD, 2007[49]; Rojas and Aylward, 2003[173]). This assures that the payments are spent for actual environmental improvements, or actions leading to those improvements, and that the policy is cost-effective. Monitoring and controls are key elements to guarantee conditionality and increase compliance (Engel, Pagiola and Wunder, 2008[143]; OECD, 2007[49]; Porras et al., 2011[127]; Naeem et al., 2015[128]; Grammatikopoulou, 2016[174]).

The feasibility of monitoring and control of the measures may be challenging and comes with considerable costs (Berkhout, Doorn and Schrijver, 2018[135]; Claassen, Cattaneo and Johansson, 2008[46]; Chaplin, 2018[175]; Schwarz et al., 2008[22]). Porras et al. (2011[127]) state that if a practice-based scheme is based on easily observable land-use measures then it probably has lower monitoring costs than results-based schemes.

Monitoring costs depend on the environmental objective and its measurability. Some environmental goals are difficult to quantify and to measure, and thus quantified measurements for environmental performance are lacking (Brouwer, Tesfaye and Pauw, 2011[52]; Moxey and White, 2014[33]; Kaiser et al., 2010[176]; Burton and Schwarz, 2013[55]; White and Sadler, 2012[32]; Matzdorf, Kaiser and Rohner, 2008[24]). When it is impossible to define clear indicators or when monitoring of results is more costly than monitoring of practices, practice-based payments are easier to enforce and can be more appropriate (Herzon et al., 2018[21]; Hanley and White, 2013[35]; Allen et al., 2014[20]; Börner et al., 2017[19]).

Moral hazard is a concern for agri-environmental payments. Farmers might have incentives to cheat, receiving the compensation without implementing the required practices and thus incurring the full compliance costs for their commitment. This is particularly the case for farmers with high compliance costs, since their pay-off for cheating is higher than for other farmers (Latacz-Lohmann and Schilizzi, 2005[156]; OECD, 2010[1]).

Controls and monitoring can only be effective if non-compliance is detected and penalised (OECD, 2007[49]; Wunder, Engel and Pagiola, 2008[18]). Sanctions usually include the cancellation of future payments or sometimes past payments have to be paid back (Brouwer, Tesfaye and Pauw, 2011[52]; Wunder, Engel and Pagiola, 2008[18]; Engel, 2016[11]). While the rationale for fines is to achieve high compliance levels, excessive penalties can actually reduce compliance or participation because farmers might perceive them as demotivating (Engel, 2016[11]; Börner et al., 2017[19]; Falk and Kosfeld, 2006[177]; Vollan, 2008[178]). Herodes (2008[179]) finds that unclear control criteria entail widespread reluctance among farmers for scheme participation. Thus, it is important to have clear control criteria that are linked to farmer-controlled variables to enhance scheme participation.

Successful enforcement requires setting the levels of the following elements appropriately: 1) intensity of monitoring, 2) level of sanctions, 3) stringency of compliance requirements, and 4) level of agri-environmental payments (Latacz-Lohmann, 1998[180]). Several authors have derived optimal monitoring and sanction strategies in the context of agricultural and agri-environmental policies (Choe and Fraser, 1999[181]; Ozanne, Hogan and Colman, 2001[182]; Kampas and White, 2003[183]; Fraser, 2002[184]).

In practice, monitoring rates for agri-environmental payments are relatively low in developed countries and lie between 3% and 5% (Wunder, Engel and Pagiola, 2008[18]; OECD, 2010[1]). Many programmes lack effective enforcement strategies (Hart and Latacz-Lohmann, 2005[185]), which could reduce environmental effectiveness (Ezzine-De-Blas et al., 2016[160]). Yet, enforcement is a crucial element for conditionality and hence an important driver for the cost-effectiveness of the policy.

2.3. Policy Spectrum Framework: Assessment of payment design options according to key dimensions of cost-effectiveness

Table 2.5 provides an assessment of policy design options covered by the Framework. This assessment is based on the literature review and Secretariat’s judgement. It does not aim to identify the single “best” policy design (no “one size fits all” approach), but rather discusses advantages and disadvantages of different options, presenting evidence from literature review, policy simulations and economic experiment on performance of different policy options according to the key criteria (primarily cost-effectiveness, but also other criteria as discussed above, where warranted). In Table 2.5, uniform and targeted practice-based payments are discussed in the same column, since both are practice-based options. Aggregate or landscape-level results-based payment is not separately presented it represents a special case of results-based payment.

Table 2.5. Qualitative assessment of payment design options from a cost-effectiveness viewpoint

Policy design element	Uniform or targeted practice-based payment	Performance-based payment	Result-based payment	Hybrid payment
Quantifiable policy objectives	May be preferred option only when environmental performance or results are very difficult or costly to measure. Works if practices are highly correlated with environmental performance or results and quantitative targets are set e.g. for acreage or number of participants.	Improves cost-effectiveness if suitable environmental performance proxies are available, such as environmental benefit indices and nutrient balances. Suitable option if direct environmental results cannot be measured.	Improves cost-effectiveness if environmental results can be reliably measured or suitable indicator approaches are available, for example, in the context of biodiversity.	Improves cost-effectiveness relative to pure practice-based approach.
Targeting	Uniform practice-based payment has poor cost-effectiveness when there is spatial heterogeneity in compliance costs and/or environmental benefits. Targeted (whether cost-targeting or benefit targeting or benefit-cost targeting) practice-based payment improves cost-effectiveness relative to uniform payment.	Improves cost-effectiveness by allowing spatial targeting based on environmental proxies (e.g. nutrient surplus or environmental benefit index value).	Improves cost-effectiveness by allowing spatial targeting based on environmental benefits or benefit-cost ratios.	Improves cost-effectiveness by allowing spatial targeting based on environmental benefits or benefit-cost ratios.
Tailoring	Uniform payment rate works only when compliance costs are homogeneous among farmers, which is rarely the case. Poor cost-effectiveness due to overcompensation of compliance costs to low-cost farmers (information rent). High-cost farmers with potentially high environmental benefits do not participate (adverse selection).	Payment rate can be tailored, for example, by providing differentiated payment rate on the basis of environmental performance. Combination of competitive bidding (auctions) and environmental benefit index would allow benefit-cost targeting that highly improves cost-effectiveness as auction mechanism reduces information rent and environmental benefit index targets high benefit sites.	Improves cost-effectiveness as payment rate can be tailored to reflect environmental results achieved. The uncertainties associated with the achievement of the results may require a risk premium for risk-averse farmers, which reduces budgetary cost-effectiveness.	Payment rate can be tailored according to compliance costs of adopting the practices and environmental results achieved. Reduces the financial risk for farmers as compliance costs are covered for practice adoption.
Additionality	Option only when environmental performance or results are very difficult or costly to measure. Can provide additionality, if practices are highly correlated with environmental performance or results, and practices would not	Enables payment for the environmental performance improvement and thus increases environmental effectiveness, additionality and budgetary cost-effectiveness.	Result-based payment directly linked payment to environmental results and hence has the potential to achieve high additionality, environmental effectiveness and budgetary cost-effectiveness. However, if payment is linked to	Bonus payment (result-based payment) is directly linked to environmental results so there is high potential for additionality.

Policy design element	Uniform or targeted practice-based payment	Performance-based payment	Result-based payment	Hybrid payment
	have been adopted without payment.		maintaining already achieved results then additionality is low.	
Enforcement	Monitoring and enforcement should be relatively easy for observable measures, such as land use and land cover based measures. But, is more difficult for unobservable measures, such as chemical fertiliser, pesticide and manure application intensity. May be preferred option If practices can be monitored and enforced more easily and with much lower transaction costs than performance-based or results-based payments.	If environmental performance improvements can be clearly defined and monitored then performance-based payments can be beneficial. However, this requires suitable environmental performance indicators that may be lacking for some environmental objectives. When it is impossible to define clear performance indicators or when monitoring of performance is more costly than monitoring of practices, practice-based payments may be easier to enforce and can be more appropriate	If results can be clearly defined and monitored then result-based payments can be beneficial. However, this requires suitable and reliable indicator approaches that may be lacking for some environmental objectives. When it is impossible to define clear indicators for results or when monitoring of results is more costly than monitoring of practices, practice-based payments may be easier to enforce and can be more appropriate	May be beneficial if practices are easily observed, monitored and enforced.
Transaction costs	Transaction costs (both public and private) should be relatively low for uniform practice-based payment and this is especially the case when practices are relatively easy to observe, monitor and enforce (e.g. land use based measures). Targeted uniform payments will increase transaction costs somewhat as information is required, for example, on spatial variation of potential environmental benefits of practice adoption.	Differentiated payments and bidding mechanisms have higher transaction costs than uniform payments due to higher information needs, including information related to spatial variation of environmental benefits and/or compliance costs. Also the development of suitable environmental performance indicators that can be tailored to local circumstances adds complexity and transaction costs.	Transaction costs can be reduced if reliable result indicators based on up-to-date data are readily available and if these are relatively easy to understand and measure by farmers, which allows self-monitoring by farmers.	Transaction costs may be high as both practices and results need to monitored and enforced.
Behavioural factors	Provides rigid management proscriptions without farm-specific flexibility that are not necessarily the least-cost ways to achieve environmental objectives. Does not provide incentives for innovation. Financial risk lower than with the performance-based and the results-based	Increases flexibility and fosters innovation, which promotes the least cost achievement of the environmental performance targets. If environmental performance scores are dependent on factors outside of farmers' control then may increase financial risk relative to the practice-	Increases flexibility and foster innovation, which promotes the least cost achievement of the environmental results. Relative to the practice-based payments the result-based payments tend to increase social networking, knowledge sharing and intrinsic motivation for environmental	Relative to the pure results-based payment decreases flexibility and innovation and thus potentially cost-effectiveness. On the other hand is less risky option to risk-averse farmers which may increase acceptance and participation.

Policy design element	Uniform or targeted practice-based payment	Performance-based payment	Result-based payment	Hybrid payment
	payments, especially when environmental performance and results are dependent on external factors (e.g. weather) outside of the farmers' control.	based payment.	conservation. However, relative to practice-based payments the results-based payments may increase financial risk for farmers and thus may increase a risk premium required by risk-averse farmers.	

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Annex 2.A. Economic experiment component: Summary of findings from choice experiment literature review

Annex Table 2.A.1. Choice experiment design features: Selected results from the literature

Source	Country and region	Time period	Choice variables	Sample size	No. choice sets	Survey delivery method	Payments for	Estimation method
Adams et al (2014[72]), Adams et al (2012[186])	AUS	May to September 2009	Three labelled attributes [Conservation covenant; Conservation management agreement; Sell] - Payment (as a % of stewardship costs): (0%; 50%: 100%: 150% for 2 attributes, Market value for Sell attribute) - Configuration: (From no land set aside to one small patch; From no land set aside to several patches; From no land set aside to one continuous area; From one small patch set aside to several patches; From several patches set aside to one continuous area)	92	80: 8 blocks of 10 choice sets (no opt-out)	Face-to-face and mail	Stewardship Program	Conditional mixed-effects logit
Alló et al (2015[187])	SPA	summer 2012	- Payment (EUR, per ha): (30; 60; 90; 120) - Flexibility (how much of the total area enrolled in the contract can be excluded without penalty each year): (0%; 40%) - Fine in addition to the return of the payment (EUR, per ha): (0; 200) - Cover crop area: (0%; 20%) - Restriction on land use: (No restrictions; April 1–August 1)	359	8: 2 blocks of 4 choice sets	face-to-face	AES for bird protection	Ordered logit model
Bastian et al (2017[138])	US	?	- Easement length: (Perpetuity; 20-25 years) - Public access: (Y/N) - Inclusion of wildlife habitat: (Y/N) - Restricted managerial control: (Y/N) - Financial benefit (% of the average land market value): Income and estate tax benefit plus (0; 25; 50; 45; 100)% of average market value of land	Landowner 2101 / Land trust 291	24: (Landowners: 12 blocks of 2 choice sets), (Land trusts: 6 blocks of 4 choice sets)	Mail	conservation easements	RPLM
Beharry-Borg et al (2013[188])	GBR	January and June 2009	- Inorganic fertiliser application per acre: (current level; 25% less; 50 % less) - Farmyard manure application per acre: (current level; 25% less; 50 % less) - Blocking of drainage 'grips': (All; Block 50% of existing grips; Block 100% of existing grips) - Contract length (years): (3; 5; 10) - Compensation payment (GBP per ha per year): (2; 4; 10; 16; 22; 28)	97 (6 protest respondents are included)	18: 3 blocks of 6 choice sets	face-to-face	water quality protection	CLM and LCM

Source	Country and region	Time period	Choice variables	Sample size	No. choice sets	Survey delivery method	Payments for	Estimation method
Bennett et al. (2018[189])	CHN	2012	- Contract length (year): (1; 5; 10) - Release option: (Cannot leave the programme; Can leave the programme without a penalty) - Land area enrolled (% of household land area): (20; 50; 100) - Annual pesticide use reduction (% in comparison to 2011): (5; 10; 20; 30) - Annual cash subsidy (CNY, per mu=1/15ha): (10; 50; 80; 120)	288	72: 9 blocks of 8 choice sets	face-to-face (Not mentioned clearly)	Coastal Wetlands Protection	CLM
Breustedt et al. (2013[190]) (in German)	GER	Summer 2010	3 labelled attributes [Grassland area enrolled (minimum %): (5; 10; 20)] - Fertilization: (Allowed organic and mineral fertilizers; Allowed organic fertilizer; No fertilizer allowed) - First mowing not before ...: (June 1st; June 22nd) - Maximum number of grazing animals (1 animal = 1 cow or 3 sheep, per ha): (2; 3; 4) - Duration of the contract (year): (1; 5; 10) - Annual compensation (EUR/ha): (250; 350; 450)	68	63: 8 blocks of 8 choice sets (- 1 for a dominant choice)	face-to-face	AES for grassland	CLM
Broch et al. (2013[38]) and Broch and Vedel (2011)	DEN	Jan-Feb 2009	- purpose of afforestation (groundwater; recreation; biodiversity) - option of cancelling the contract (within 5 years; within 10 years; binding) - monitoring (visit) by authorities (0%, 1%, 10%, 25%OTSC) - compensation level (one-time compensation per hectare: EUR0; EUR3600-5600 in EUR400 steps)	842	36: 6 blocks of 6	Web-survey	afforestation	RPLM - Error Component Specification
Brouwer et al (2015[191])	GER	May-September 2012	- Area size (% of the farmer's total area of cultivated land): (10; 25; 50) - Forest type: (Commercial production forest; Non-commercial natural forest) - Availability of technical advice: (Y/N) - Public recreational access: (Y/N) - Return to farmland end of the contract: (Y/N) - Contract duration (years): (10; 25; 50) - Compensation (EUR/ha/year): (250; 500; 750; 1000; 1500; 2000)	Netherlands: 273, Germany: 206	120: 20 blocks of 6 choice sets	face-to-face	Afforestation agreement	RPLM and Latent class (LC) models
Chen et al. (2009[107])	CHN	May-August 2006	- Conservation payment (100 to 300 yuan/mu with an intermediate value of 200) ***after the first quarter of the survey, the high payment level was adjusted to 250 yuan/mu*** - Programme duration (3; 6; 10 years) - Neighbours' behaviours (25%, 50%, or 75% of households in the same group would reconvert part or all of their enrolled land plots)	304	9: 3 blocks of 3 choice sets	Face-to-face	maintaining forest on their (GTGP) land plots (although experiment related to maintaining forest after programme ends)	PM

Source	Country and region	Time period	Choice variables	Sample size	No. choice sets	Survey delivery method	Payments for	Estimation method
Chèze, David and Martinet (2017[92])	FRA	June 2016 to February 2017	- Profit variation: variation in average annual gross margin per hectare (-EUR50; 0; +EUR50; +EUR100) - Harvest risk: variation in no. years with poor harvest out of ten (0; +1 year; +2 years) - Additional commitments compared to SQ: (none; join AES; joining a Charter (flexible commitment); green certification) - Reduction in health / environmental exposure cf SQ: (0%; -20%; -50%; -80%)	83	16, blocked into 2 groups = 8 choice sets per respondent	Face-to-face and web-survey	Reduced use of pesticides	CLMand RPLM
Christensen et al. (2011[147])	DEN	December 2009-January 2010	- management flexibility: buffer zone width (6m; 6-24m) - management flexibility: use of artificial fertiliser and pesticides in buffer zone (fertiliser can be used; no pesticides or artificial fertiliser) - assistance with contract application (free assistance from extension service, common application form) - contract length (1 year; 5 years) - option to be released from a contract before it expires (no; released without costs once per year) - compensation level (per ha per year: EUR134; EUR 228; EUR 336, EUR510)	444	8	Web-survey	pesticide-free buffer zones	RPLM
Costedoat et al. (2016[169])	MEX	November through December 2014	- Forest parcels: (Individual decision; Negotiated by the community assembly; All forests of the ejido) - Technical intermediary: (External service provider; Community technician; CONAFOR) - Payment (MXN, per ha per year): (250; 500; 1000; 2000) - Use of payment: (100% cash; 50% cash + 50% collective agricultural productive project (tractors); 50% cash + 50% social project (community public good))	82	18: 3 blocks of 6 choice sets	face-to-face	PES for biodiversity-related ecosystem services	CLM and Latent class (LC) models
Danne and Musshoff (2017[71])	GER	January to March 2016	- Programme Financing: (Dairy company scheme; Governmental scheme; Food industry scheme) - Annual grazing period (days per year): (120; 150; 180) - Daily grazing period (hours per day): (6; 8; 16) - Feeding standards: (Staple feed consisting only of green fodder; Concentrated feed reduced by 20%; Amount of maize silage reduced by 30%) - Price Premium (eurocents per kg raw milk): (1; 3; 5)	293	12	Web-survey	Pasture grazing programmes	RPLM
Dhingra et al. (2015[192])	US	spring, summer and fall of 2014	- Maximum payment (% of NRCS local county rental rates: 80%; 100%; 120%) - Terms of contract payment (fixed at start; re-adjusted every 5 years) - Contract length (10 years; 15 years) - Establishment cost sharing (50%; 100% government cost share) - Land use restrictions (Idle; graze/hay every other year)	76	23	Face-to-face	Participation in US Conservation Reserve Programme (land retirement)	Exploded logit model with no ties in ranking

Source	Country and region	Time period	Choice variables	Sample size	No. choice sets	Survey delivery method	Payments for	Estimation method
El Mokaddem et al. (2016[193]) (in French)	Morocco	?	- Collective development of land for anti-erosion (ha): (0; 1000; 3000; 5000) - Area with a specific pasture for sheep grazing (in proportion to the collective pasture area): (0; 1/4; 1/3; 1/2) - Planting fruit trees (in total number of trees planted): (10; 20; 50; 100) - Payment (MAD (1EUR=11,047MAD), per household per year): (200; 400; 500; 600) - Technical assistance (7 days/year): (None, Plant Production, Animal Production, Mixed)	144	16: 2 blocks of 8 choice sets	face-to-face	Common-pool pastures conservation	CLM
Espinosa-Goded and Barreiro-Hurlé (2010[194]) (in Spanish)	SPA	?	- Flexibility on the area under AES: (Free; 50% eligible area) - Flexibility over grazing/harvesting (Free; Prohibited between August and September) - Presence of a mandatory and free technical assistance service: (Y/N) - Fixed payment of EUR1,000 per contract regardless of the area (to cover adoption costs of AES): (Y/N) - Premium level (EUR, per year per ha): (60; 80; 100; 120)	200	96: 16 blocks of 6 choice sets	face-to-face	AES for Nitrogen Fixing Crops in rain-fed areas	RPLM - Error Component Specification
Espinosa-Goded, Barreiro-Hurlé and Ruto, (2010[37])	SPA	June–August 2008	- a compulsory enrolment of 50% of eligible area (free; 50% of eligible surface) - flexibility over grazing in the land under the AES (Free; limited, taking into account RDP specifications for specific regions) - fixed one-off payment of EUR1000 as part of the contract (yes; no) - availability of a compulsory and free of charge technical training and advisory service (yes; no) - per ha premium level (per year) (EU/ha: 60; 80; 100; 120)	300	96: 16 blocks of six choice sets	Face-to-face	introduction of nitrogen fixing crops in dry land areas	RPLM - Error Component Specification
Franzén et al. (2016[195])	SWE	?	- Annual subsidy (SEK, per ha): (Arable land 3000 (Other land use 1500); Arable land 4000 (Other land use 2250)) - Time frame for subsidy and commitment (year): (Min commitment 5 (Max extension 20); Min commitment 10 (Max extension 30)) - Practical support: (No practical assistance for projecting and design of wetland; A collaboration forum, and practical assistance with projecting and designing a wetland) - Economic compensation for construction (% of cost within ceiling): (50–90; 100) - Cost ceiling for compensation (SEK): (100,000; 200,000)	29	8: 2 blocks of 4 choice sets	Mail	Wetland creation	generalized linear mixed model
Greiner (2015[196]) and Greiner et al. (2014[197])	AUS	April–July 2013	- Conservation requirement (short spelling; long spelling; total exclusion) - Compensation level (per ha per year: AUD1; 2; 4; 8; 16; 32) - Contract length (5 years; 10 years; 20 years; 40 years) - Flexibility (yes, no) - Monitoring (self-monitoring w 25% random spot checks; external monitoring)	104	24: 4 blocks of 6 choice sets	Face-to-face and mail	Conservation of (extensive) cattle grazing lands	RPLM and Latent class (LC) models

Source	Country and region	Time period	Choice variables	Sample size	No. choice sets	Survey delivery method	Payments for	Estimation method
Hope et al. (2008[198])	India	?	- Land commitment to organic farming (acres): (25%; 50%; 75%; 100%) - Organic crop price increase (per 100 Rupees): (5; 7; 9; 11; 13; 15) - Cost of certification (Rupees, per acre): (1,000 as a group; 3,000 as a group; 3,000 as an individual) - Compost price (Rupees,per trolley): (600; 900; 1,200; 1,500) - Labour days to compost one trolley: (4; 8; 12; 16)	640	64: 8 blocks of 8 choice sets	face-to-face	Wetland conservation	CLM and LCM
Hoyos et al. (2012[199]), Etxano et al. (2015[200])	FRA / SPA (Basque Country)	? WTP is based on 2008 value	- Native forest (% of land converted by cork oak woodland): (2 (status quo); 10; 20; 30) - Biodiversity (Number of endangered species of flora and fauna): (25 (status quo); 15; 10; 5) - Recreation (Conservation status of walking pathways): (Low (status quo); Medium; High; Very high) - Exotic tree plantations (% of land area covered by pine forest): (40 (status quo); 30; 25; 15) - Vineyard (% of land covered by vineyards): (40 (status quo); 30; 20; 10) - Cost (EUR, per year): (0 (status quo); 5; 10; 30; 50; 100)	221	120: 20 blocks of 6 choice sets	face-to-face	Land use	CLM and RPLM
Hudson and Lusk (2004[201])	US	?	- Expected Income USD (135000; 150000; 165000) - Price Risk Shifted (None; Semi-Fixed; Fixed) - Autonomy (None; Some; Same) - Asset Specificity (10%; 30%; 50%) - Provision of Inputs (0%; 50%; 100%) - Length of Contract (1; 3; 5)	49	73: 4 blocks of 16 choice sets and 1 block of 9	Face-to-face	Undefined generic kind of contract	CLM and RPLM
Jaeck et al. (2014[202])	FRA	?	- Weed control technology: (Intensive chemical weeding (3 applications or more); Chemical weeding with 1 or 2 applications; Mechanical weeding; Manual weed removal) - Varietal choice: (Short cycle (140–150 days); Medium cycle (150–160 days); Long cycle (>160 days)) - Crop rotation: (Long rotation (1 year of rice every 5 years); 'Cereal' rotation (2 years of rice every 5 years); 'Intensive cereal' rotation (2 or 3 consecutive years of rice)) - Yield (tons, per ha): (yield< 2; 2<yield< 5; 5<yield<7; Yield<7) - Risk (Year): (0; 1; 3) - Single payment scheme (EUR, per ha): (0; 400; 700; 1000)	104	22: 2 blocks of 11 choice sets	face-to-face	CAP for rice cropping technologies	RPLM and LCM

Source	Country and region	Time period	Choice variables	Sample size	No. choice sets	Survey delivery method	Payments for	Estimation method
Kaczan et al. (2013[203])	Tanzania	September and November, 2010	- Individual payment for maintenance of agroforest (Approximate USD, per acre per year): (0; 21; 50; 176) - Collective payment provided to a dedicated village development fund (Approximate USD, per acre per year): (0; 21; 50; 176) - Upfront fertilizer payment (Approximate USD, per acre, one-time): (0; 140 (binary variable)) - Conditionality low (No inspections—farmers are required to keep a log book documenting farm activities which may be audited): (Y/N) - Conditionality moderate (Inspecting farmers' farms once per year): (Y/N) - Conditionality high (Inspecting farmers' farms twice per year. Also will ensuring trees are indigenous species.): (Y/N)	220	32: 4 blocks of 8 choice sets	face-to-face	PES for avoiding deforestation	CLM and LCM
Kreye et al. (2017[204])	US	2014	- Incentive type (USD, per acre): (Annual payments; Reduction in the estate tax; Annual depredation payment; Safe harbor agreement) - Technical assistance: (Advice about stewardship practices; Advice about securing water resources; Advice about improving game populations; Help identifying other incentive programmes) - Acres enrolled: (25% of eligible acres; 50% of eligible acres; 75% of eligible acres; 100% of eligible acres) - Contract duration (year): (5 years; 10 years; 20 yearsl; 30 years) - Monitoring agency: (US Fish and Wildlife Service; Florida Fish and Wildlife Conservation Commission; US Department of Agriculture; Independent environmental consultant)	187	16: 2 blocks of 8 choice sets	Mail	Panther conservation	RPLM

Source	Country and region	Time period	Choice variables	Sample size	No. choice sets	Survey delivery method	Payments for	Estimation method
Kreye et al. (2018[205])	US	December 2015 and February 2016	Management choices - BMP1: Implement 100% of applicable silvicultural BMPs. - BMP2: Implement at least 85% of applicable silvicultural BMPs. - WLD1: Locate concentrated heavy equipment away from active burrows or nests. - WLD2 Heavy equipment use must be minimized around nests during hatching season. - ADD1: Manage stands to have two age classes. - ADD2: Prescribed fire is applied every 3–5 years in stands over 10 years in age. Landowner empowering policy tools - TA1: Technical assistance is provided to help meet programme requirements. - TA2: NO technical assistance. - FA1: 50% cost-share is provided to help meet programme requirements. - FA2: NO cost-share assistance. - EXP1: Participating landowner is exempted from permitting for the incidental take of State Imperilled Species on their forestland. - EXP2: Participating landowner is NOT exempted from permitting for the incidental take of State Imperilled Species on their forestland.	200	12	Mail and web-survey	Wildlife Best Management Practices	RPLM
Kuhfuss et al. (2016[206]) and Kuhfuss, Préget and Thoyer (2014)	FRA	Summer 2012	- reduction of herbicide (-30%; -60%; -100%) - localised use of herbicide (yes, no) - final collective bonus of EUR 150/ha (yes, no) - free administrative and technical assistance (yes, no) - compensation level/ha (EUR 90; 170; 250; 330; 410; 500) Two-step experiment: - choice of contract - choice of acreage	290	18: 3 blocks of 6 choice sets	Web-survey	innovative herbicide-reduction contracts	Kuhfuss et al (2016): CLM and RPLM, FE and 2-stage Heckman model); Kuhfuss, Préget and Thoyer (2014): LCM
Latacz-Lohmann and Breustedt (2019[157])	GER	?	- Fertilisation (organic and mineral allowed; organic permitted; no fertilisation allowed) - First mowing not before (1 June; 22 June) - Maximum grazing with (2; 3; 4) animals per ha (1 animal = 1 cattle or 3 sheep) - Contract period (1; 5; 10 years) - Annual compensation EUR per ha (250; 350; 450)	68	63: 8 blocks of 8 choice sets (- 1 for a dominant choice)	Face-to-face	Protection for breeding birds on permanent pasture	CLM (For enrolled land area, OLS and multinomial Heckman model)

Source	Country and region	Time period	Choice variables	Sample size	No. choice sets	Survey delivery method	Payments for	Estimation method
Layton and Siikamäki (2009[207])	FIN	?	Two-steps: - choice of contract - choice of acreage - Payment (ERU): (ranged between about 85 and 11,770) - Contract length: (ranged between 10 and 50 years, in 5-year increments)	1129	3 choice sets	Mail	habitat preservation on private lands	Beta-binomial model and multivariate censored regression
Leinhoop and Brouwer (2015[208])	GER	May and September 2012	- Forest size (%) (5; 10; 25; 50) - Forest type (commercial; non-commercial) - Technical advice (yes, no) - Recreational access (yes, no) - Return to agriculture at end of contract (yes, no) - Contract length (10 years, 25 years, 50 years) - Compensation level (EUR per ha per year: 500; 750; 1000; 1500; 2000; 3000)	208	120: 20 blocks of 6 choice sets	Face-to-face	Afforestation	RPLM
Lizin, van Passel and Schreurs (2015[209])	BEL	December 2012–February 2013	- Lot size (ha): (0.5; 1.5; 2.5; 3.5) - Soil productivity: (Low; Rather low; Rather high; High) - Driving time to home (min): (5; 10; 15; 20) - Distance to other land (km): (0; 0.750; 1.500; 2.250) - Land use restrictions: (None; Crop restriction; Fertilizer restriction; Usage restriction) - Price (EUR per ha): (15,000; 25,000; 35,000; 45,000)	188	16: 2 blocks of 8 choice sets	face-to-face	Land use restrictions	RPLM and error component logit
Ma et al. (2012[210])	US	2008	Two-steps: - choice of contract - choice of acreage - annual payment for a period of 5 years (USD per acre, A specific range for each of 4 cropping systems): (A: 4-17; B: 10-36; C: 15-55; D: 20-75) - payment provider: (federal government; non-governmental organisation) - sequence of cropping practices (increasing or decreasing in complexity and expected environmental benefits)	1,688	16	Mail	PES in agriculture	Double hurdle model (comprised of a Probit for willingness to consider and a Tobit for acreage enrolment)
Pan et al. (2016[211])	CHN	between July and August 2014	- Technical support: (No technical support (baseline); Medium technical support; High technical support) - Pollution fees (Yuan, per head per month): (0 (baseline); 2.8; 5; 10) - Technical standards: (Y/N (baseline)) - Biogas subsidies (Yuan, per household): (0 (baseline); 1000; 1500; 2000) - Manure market (Yuan, ton): (0 (baseline); 100; 150) - Manure handling rate: (Increase 0% (baseline); Decrease 5%; Increase 15%)	754	12: 3 blocks of 4 choice sets	face-to-face	livestock pollution control policy	RPLM

Source	Country and region	Time period	Choice variables	Sample size	No. choice sets	Survey delivery method	Payments for	Estimation method
Peterson et al (2007[212]); (2012[213]); (2014[214])	US	August 2006-January 2007	- Application time (hours): (4; 16; 24; 40) - Monitoring: (Annual verification; spot check) - Penalty USD/acre enrolled: (50; 100; 250; 500) - Trading revenue USD/acre enrolled: (3; 7; 15; 25) - Type of practice required: (Filter strip; No-till) - Haying/grazing allowed on filter strip (Yes/No) - Rotational no-till allowed (Yes/No)	135	32: 2 blocks of 16	Face-to-face	Water quality trading	RPLM
Pröbstl-Haider et al. (2016[215])	AUT	January and September 2012	- Type of management: (Cash crop cultivation; Short-rotation cultivation; Grassland cultivation) - Gross margin (EUR, per ha per year): (Cash crop cultivation: 300; 450; 750; 1200; 1650, Short-rotation cultivation: 150; 375; 550; 725, Grassland cultivation: 75; 150; 250) - Environmental premium (EUR, per ha per year): (Cash crop cultivation: None; Greening premium 50; Greening premium 150, Short-rotation cultivation: None; Climate premium 50; Climate premium 100; Climate premium 150, Grassland cultivation: Austrian AES-funding 300; Austrian AES-funding 600; Austrian AES-funding 900; Austrian AES-funding 1200) - Duration (year): (Cash crop cultivation [rotation period]: 1, Short-rotation cultivation [rotation period]: 15; 20; 25, Grassland cultivation [contract period]: 7) - Potential price fluctuations: (Cash crop cultivation: Low; Medium; High; Very high, Short-rotation cultivation: Low; Medium; High, Grassland cultivation: Low) - Likelihood of complete crop failure: (Cash crop cultivation: Every 2 years; Every 3 years, Short-rotation cultivation: Every 10 years; Every 25 years, Grassland cultivation: Every 5 years; Every 10 years; Every 15 years)	148	48	face-to-face	Land use under climate change (cash crop cultivation, short-rotation forestry, grassland cultivation)	CLM
Rabotyagov and Lin (2013[216])	US	February 2009.	- Payment (USD, per acre per year): (25; 50; 100; 200) - Contract length (years): (10; 30; 50; In perpetuity) - Extent of participation (share of forest stand): (More than 0, but less than 1/3; More than 1/3, but less than 2/3; More than 2/3, but less than entire stand; Entire stand) - "Biodiversity pathway" management: (Y/N)	678	32: 4 blocks of 8 choice sets	Mail	working forest conservation contracts (WFCC)	RPLM - Error Component Specification
Rocchi et al. (2017[217])	ITA	?	- Nature: (No surface; 1/3 surface; 1/2 surface) - Biodiversity: (Do not make it; Creation of hedges) - Landscape: (Do not make it; Creation of fences) - Seeds: (No surface; 1/2 surface; All the surface) - Lisciviation: (No surface; 1/2 surface; All the surface) - Money (EUR/ha per year): (50; 100; 150; 200)	244	16: 4 blocks of 4 choice sets	face-to-face	AES in buffer areas	LCM

Source	Country and region	Time period	Choice variables	Sample size	No. choice sets	Survey delivery method	Payments for	Estimation method
Rossi et al. (2011[218])	US	?	- Replant with SPB resistant Pine: (Required; Not required) - Pre-commercial Thinning: (Required; Not required) - Commercial Thinning: (Required; Not required) - Prescribed Burning: Required (1 time; 2 times;3 times; Not required) - Local Landowner Participation Rate: (5%; 50%) - Incentive Payment (USD per acre): (30; 80; 120; 160; 200; 250)	173	48: 4 blocks of 6 choice sets (24 profiles as the basic foundation, shifting to an additional 24 profiles)	Mail	forest management practices (Southern Pine Beetle Risk Reduction Cost-Share Program)	Heteroskedastic Extreme Value (HEV) models
Ruto and Garrod (2009[81]), Arnaud et al. (2007[219])	Various [a]	May-December 2005	- Contract length (5, 10, and 20 years) - flexibility in terms of what areas of the farm are entered into the scheme (yes, no) - flexibility in undertaking some of the measures required under the scheme (yes, no) - average time spent on paperwork/administration (less than 2 h/week, 2–5 h/week, or more than 5 h/week). - compensation level (per ha: 5%; 10%; 20%)	2262	24: 6 blocks of 4 choice sets	Face-to-face	EU CAP AES (various)	RPLM and Latent class (LC) models
Saïd and Thoyer (2007[220])	FRA	August 2006.	- Level of financial needs - Level of compliance costs with AES - Level of environmental benefits - Level of compensation payment	32	9: 3 blocks of 3 choice sets	Face-to-face	Contracting for the grass premium	BLM
Santos et al. (2015[221])	POR	October and December 2013	- Area size (% of eligible farm land area): (25; 50; 75) - Cattle density (Livestock units per ha of forage area): (0.2; 0.5; 0.7) - Tree density (Number of trees per ha): (20; 30; 40) - Contract duration (Years): (5; 10; 20) - Compensation (EUR/ha/year): (100; 250; 450)	111	64: 8 blocks of 8 choice sets	face-to-face	AES for agro-forestry ecosystem	RPLM
Schulz et al. (2014[222])	GER	Summer of 2012	- Ecological Focus Area (EFA): (5%; 7%; 10% of a farm's arable land) - Arable crop diversity: At least 3 crops (in excess of EFA), each covering no less than (5%; 15%; 25%) of arable land - Land creditable against EFA: (None; Land enrolled in AES; Landscape features (hedges, ponds, stone walls, etc.); Land in AES and landscape features) - Permissible use of EFA: (Leguminous crops; Leguminous crops, but they must be grown on twice the EFA; No productive use (EFA must be set aside)) - Choice of EFA location: (Location of EFA can be freely chosen each year; EFA location fixed for 3 years) - Reduction of single payment in case of opt-out (EUR per ha per year): (35; 70; 105; 140; 175)	128	25: 8 choice sets	Web-survey	"greening" of the CAP	BLM and LCM

Source	Country and region	Time period	Choice variables	Sample size	No. choice sets	Survey delivery method	Payments for	Estimation method
Sorice et al. (2013[223])	US	?	- Conservation easement type: (no easement; permanent donated easement; permanent sold easement) - Contract length (years): (10; 40; 70; 100) - Credit profit margin (USD per credit): (100; 200; 400; 600; 1600) - Payment structure: (25% year 1, 75% year 5; 50% year 1, 50% year 5; 75% year 1, 25% year 5; 100% year 1) - Decision-making: (programme staff make all land management decisions; landowner and staff share decision-making; landowner makes all decisions) - Obligation once conservation agreement ends (if gopher listed as endangered species): (none; baseline; full) - Result (effectiveness, increase in no. gopher tortoises in country as a result of landowners opting in): (0%; 5%; 10%; 15%)	251	48: 8 blocks of 6 choice sets	Mail	Maintaining and managing habitat for an at-risk species, the gopher tortoise (Gopherus polyphemus)	RPLM
Star et al. (2019[224])	AUS	February to April 2018	- Days of paid work: (0; 5; 10; 25) - Payment (AUD, per day): (0;100; 200; 500;1000) - Extra unpaid days will be required (50:50 risk): (0; 5; 10; 25) - Risk that the project will not fix the problem: (0; 10; 25; 50)	75	32: 8 blocks of 4 choice sets	face-to-face	projects to reduce gully erosion and subsequent sediment run-off	RPLM
Tesfaye and Brouwer (2012[225])	Ethiopia	July 2009.	- Principal (contract provider): (Regional Agricultural Bureau; Local Peasant Association) - Contract length (year): (1; 2; 3; 5; 10) - Payment (Birrr (USD 1=12.56 Birr in 2009), per month): (50; 100; 150; 200; 250; 300) - Land use certificate guarantee: (Y/N) - Soil conservation measure: (Stone bund; Soil bund; Fanya juu) - Number of times for additional extension service including monitoring (year): (1; 2; 4; 6)	750	162: 18 blocks of 9 choice sets	face-to-face	soil conservation	RPLM - Error Component Specification
Vaissière et al. (2018[226])	FRA	May-June 2016	- Management plan: (4 levels of increasingly restrictive (more environmentally friendly) management; opt-out) - Contract length: (9; 18; 25; 40 years; opt-out) - Conditional bonus EUR200/ha/year for additional ecological conditions in management plan (yes; no; opt-out) - Compensation level (base)/ha/year: (EUR800, EUR1100, EUR1500, EUR2000; opt-out)	144	16: 0 block of 8 choice sets	Web-survey	biodiversity offsets	RPLM
Vedel et al. (2015[227])	DEN	January and February 2009	- Purpose of afforestation: (Biodiversity; Ground water protection; Recreation) - Option of cancelling the contract: (Option of cancelling within 10 years; within 5 years; Binding contract) - Monitoring: (1%; 10%; 25%) will be monitored - Compensation (USD, one-time per ha): (3620–5525 in steps of EUR 400)	853	36: 6 blocks of 6 choice sets	Web-survey	afforestation	CLM and Latent class (LC) models

Source	Country and region	Time period	Choice variables	Sample size	No. choice sets	Survey delivery method	Payments for	Estimation method
Villamayor-Tomas et al. (2019[228])	GER, SWITZ, SPA	?	- Location of trees: (Coordinated; Not Coordinated) - Share of farm: (1%;5%;10%) - Recommendation (endorsement of the programme): (by farmers; by scientists; no particular recommendation) - Payment for action (ERU, per year per ha): (50;100;150;200)	195	12 choice sets	Mail, Web-survey, face-to-face	a tree planting measure	CLM
Villanueva et al. (2015[229])		October 2013 to January 2014	- Cover crops area: (25%; 50%) - Cover crops management: (Free; restrictive management) - Ecological focus areas (EFA): (0%; 2%) - Collective participation: (Individual; collective participation) - Monitoring each year: (5%; 20%) - Payment (USD, per year per ha for a 5-year AES contract): (100; 200; 300; 400)	295	192: 24 blocks of 8 choice sets	face-to-face	AES permanent cropping	LCM
Villanueva et al. (2017[230])) (in Spanish)	La Sierra and Los Pedroches (Córdoba), and Sierra Norte (Sevilla), Spain	October-December 2016	- Plant cover surface: (10% (reference level); 30%; 50%; 100%) - Plant cover management: (Free (reference level); Limited; Brushcutter and/or Shredder blade disc; No practice) - Insecticide treatment: (Free (reference level); Limited; Ecological; No treatment) - Premium for results (EUR/ha): (Non-inclusion of the premium (reference level); Inclusion of a premium for results of EUR 400/ha to be received in the 5th year of the programme) - Annual payment (EUR/ha/year, during the 5 years of AEP): (50; 150; 250; 350)	254	24: 4 blocks of 6 choice sets	face-to-face	AES for mountain olive groves	RPLM - Error Component Specification
Vorlaufer et al. (2017[231])	Zambia	May and September 2015	- Payment vehicle: (Annual cash payment; Monthly cash payments; Voucher payments; Input payments) - Payment levels (ZMW, per year per acre): (60 (8.2USD); 120 (16.4USD); 240 (32.9USD); 480 (65.8USD)) - Contract duration (year); (10; 20) - Implementing organization: (Government of Zambia; NGO) - Forest co-benefits: (No extraction; Firewood extraction; Subsistence extraction; Commercial extraction)	320	16: 4 blocks of 4 choice sets	face-to-face	PES for deforestation	CLM and LCM
Wachenheim et al. (2019[232])	US	2017	- Rental payment (% of local land rental rates reported by NASS): (70; 85; 100; 110%) - Mid-contract adjustment: (payment fixed at the start of the contract; readjusted up or down at mid-contract to reflect changes in local rental rates) - Length of contract (year): (5; 10; 15) - Managed burning: (allowed; not allowed) - Conservation practice: (required; not required)	672	30: 2 blocks of 15 choice sets	Mail	working wetlands conservation programme	Mixed rank ordered logit

Source	Country and region	Time period	Choice variables	Sample size	No. choice sets	Survey delivery method	Payments for	Estimation method
Ward et al. (2016[233])	Malawi	Jun-14	- Intercropping required: (Y/N) - Zero tillage required: (Y/N) - Percentage of crop residues mulched: (0; 25; 50; 75; 100) - Programme implementer: (DLRC; NASFAM; TLC; World Vision) - Subsidy level (USD, per acre per year): (0;10; 20;30; 40)	1791	20: 2 blocks of 10 choice sets	face-to-face	Conservation Agriculture for soil quality and crop diversification	RPLM
Yeboah et al. (2015[234])	US	Summer 2016	- Contract length: (10-20 years) - Signing bonus (USD): (0-200) - % of cost share assistance for practice installation: (0-140%) - annual soil rental payment (USD/acre enrolled): (50-275)	1106	108: 36 blocks of 3 choice sets	Mail and web-survey	Filter strip programme for watershed protection	CLM
Yu and Belcher (2011[235])	CAN	Jul-07	- Compensation level: (CAN per acre: 10 - 55 in USD 5 increments)	212	Randomly assigned compensation level varying between CAN10-CAN55/acre	Mail	Conserving riparian areas	Binary PM and CLM

Notes: a BLM = binomial logit model, CLM = conditional logit model, FEM = fixed effects model, LCM = latent class model, OLS = ordinary least squares, PM = Probit model, RPLM = random parameter logit model. GTGP = Grain-to-Green Program.

Notes

[1] In the case of results-based schemes there are operational challenges in terms of having the necessary and appropriate agroecological expertise to deliver at farmer, advisor and controls level of paying agencies, since results-based schemes have a higher knowledge need and it will take time to scale up appropriate expertise.

[2] Note that environmental benefit index (EBI) is used in this document as a general term and it does not refer to the Environmental Benefit Index (EBI) employed to rank and select land parcels to the Conservation Reserve Program (CRP) established by the Food Security Act of 1985 and administered by the US Department of Agriculture (USDA).

[3] It is important to note that the risk premium will have to be borne by the society in any case. In the case of result-based payments, it is an explicit component of the payment rate paid for by the tax-payer. For practice-based payments, the risk (of not obtaining the desired environmental outcomes) is borne by the society and hence implicitly paid for by the citizen.

[4] Environmental quality refers here mainly to the inherent environmental quality of the field parcel. It could also include the environmental benefits of a particular environmental pratice adoption of a chosen agri-environmental contract in given field parcel.

Part II Policy simulations and multi-country choice experiments with farmers

3 Cost-effectiveness of alternative payment designs

On the basis of the Policy Spectrum Framework presented in Chapter 2, farm-level policy simulations based on a micro-economic modelling framework assess how different types of payment designs (ranging from practice-based to results-based payments) perform in different contexts with regard to their environmental effectiveness (reduction of nitrogen runoff and nitrous oxide emissions, and enhancement of biodiversity), policy-related transaction costs, and budgetary cost-effectiveness (government payment and public transaction costs / environmental benefits).

3.1. Focus of policy simulations

On the basis of the general literature review and the policy spectrum framework policy simulations are being developed to assess cost-effectiveness (including environmental effectiveness and policy-related transaction costs) of payment designs ranging from practice-based to results-based payment mechanisms, taking into account a range of different design features and a range of context-specific factors. A secondary aim is to identify which factors appear to be most influential in causing changes in the relative cost-effectiveness of different payment options.

To undertake the policy simulations, a micro-economic modelling framework has been developed (see Annex 3.A for a technical description of the theoretical framework and empirical specification of the model). This framework analyses representative production units (field parcels with uniform size of one hectare) and captures spatial heterogeneity with respect to productivity and profitability of agricultural production as well as heterogeneous environmental sensitivity of different production units. The model captures three types of environmental effects: nitrogen runoff (water quality), nitrous oxide emissions (greenhouse gas emissions), and quality of semi-natural habitats (biodiversity). Policy simulations assume that farmers are risk-neutral. Farmers' risk aversion will be considered in Section 3.5.4.

3.2. Data

Data sources consist of regional data from Manitoba and Saskatchewan provinces of Canada, country specific data from Sweden and NUTS2 level regional data for 11 other EU countries drawn from CAPRI database.[1] Altogether 38 differential production units are developed on the basis of these data.

Key data used as input for the analysis include N-fertiliser use, crop yields, production costs, and data on N-runoff and N_2O emissions. Crop yield functions and environmental process functions are calibrated so that crop yield, N-runoff and N_2O emissions correspond to their observed levels given the observed level of N-fertiliser use and soil type.

The environmental benefit index (EBI) is employed in simulations (see more detailed description in Annex 3.A). This index is a multi-objective index taking into account the impact on N-runoff, N_2O emissions and quality of wildlife habitat. This index is a relative environmental gain index, which describes each production unit's relative impact (across all 38 production units) on the three environmental effects at the edge of field. Thus, EBI index value is high for a given production unit, when it has relatively high N-runoff and N_2O emissions or high quality of wildlife habitat. The higher is the EBI index value for a given production unit the higher are the environmental benefits if production unit participates in the agri-environmental payment scheme. All three environmental effects have the same weight in the EBI.

3.3. Baseline

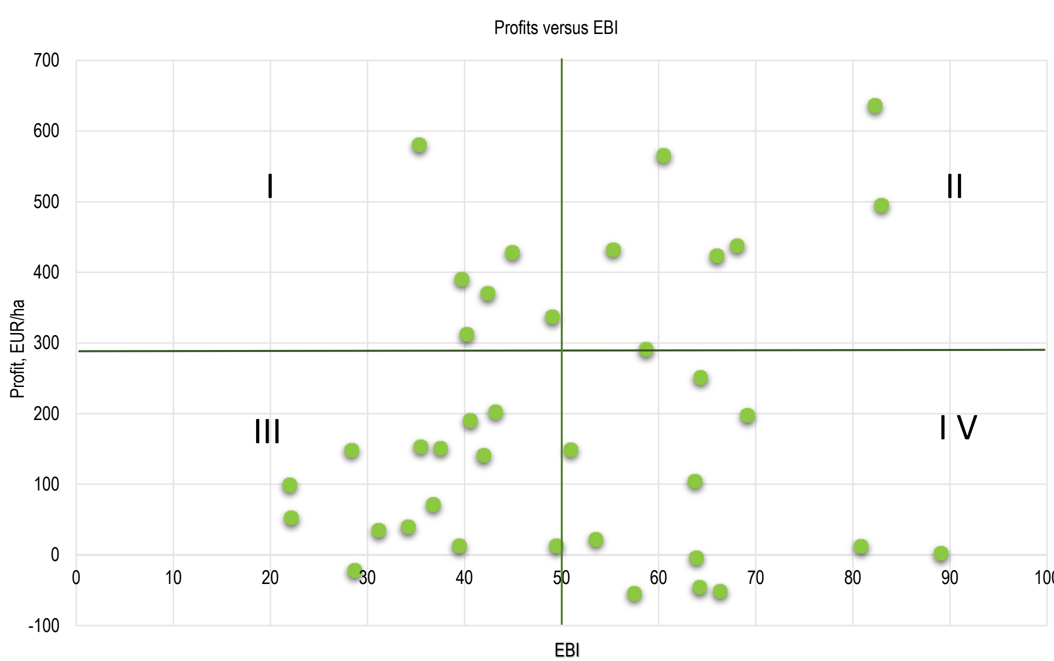
Table 3.1 provides a summary of the Baseline situation without agri-environmental payments regarding nitrogen fertiliser application, wheat yield, profits from production, nitrogen runoff, N_2O emissions in carbon dioxide equivalent emissions (CO_2-eq) and EBI. As these results indicate, there is a large variation with respect to nitrogen application intensity, crop yield and profitability of production. Similarly, there is also large variation as regards environmental effects. This large variation provides a good basis for policy analysis as it shows how well different payment designs perform under heterogeneous contexts with respect to profitability of production and environmental sensitivity.

Table 3.1. Baseline situation without A-E payment

	Nitrogen application, kg/ha	Wheat yield, kg/ha	Profits, EUR/ha	N-runoff, kg/ha	CO_2-eq emissions, kg/ha	EBI
Minimum	29	898	-54	4	55	22
Mean	142	5656	200	16	649	51
Maximum	196	9081	637	32	1384	89
Standard.dev.	39	2206	198	7	346	17

Figure 3.1 illustrates the baseline situation of profitability of production versus EBI for each modelled production unit. It illustrates the relevance of each production unit with respect to potential participation in the agri-environmental payment scheme. From a policy planner's viewpoint, production units located in the first quadrant provide a poor benefit-cost ratio if selected to the agri-environmental payment scheme. This is because they provide low environmental benefits (due to low EBI index value) and high opportunity costs of participation (due to high profitability of production). Conversely, the most suitable production units for agri-environmental scheme are those located in the fourth quadrant that have relatively low profits and high environmental benefits. Whether production units located in quadrants two and three are suitable for agri-environmental scheme depends on the budget situation and their individual environmental characteristics (relevant for quadrant two with relatively high environmental benefits).

Figure 3.1. Profitability of production versus EBI



3.4. Policy simulations

The policy simulations are illustrative in nature and the aim is to assess how different types of payment designs (e.g. pay-for-practice vs. pay-for-result vs. pay-for-group performance) perform in different landscape contexts with regard to their environmental effectiveness, policy-related transaction costs, and budgetary cost-effectiveness. To this end, policy simulations are conducted in the context of two different fictitious landscapes. First it is assumed that there is no specific spatial structure for the landscape and that the environmental effects of heterogeneous production units do not depend on their exact location in the landscape (Fictitious landscape I). In the second case (Fictitious landscape II) the focus is on nitrogen runoff from field parcels and an artificial landscape is created in which a location of different production units is randomised to border either a watercourse (river or lake), open main ditch or other field parcels. The location of the field parcel relative to a watercourse affects the retention of nitrogen runoff before the runoff enters the watercourse and thus the actual nitrogen loading from a given field parcel to the watercourse. For parcels bordering receiving surface waters (rivers and lakes), retention is assumed to be zero; 10% retention for those bordering a main ditch; and 40% for those parcels bordering other field parcels.

Policy simulations in this section assume that farmers are risk-neutral and cost-effectiveness ranking does not consider policy-related transaction costs. Impact of policy-related transaction costs on budgetary cost-effectiveness of alternative payment designs are analysed in Section 3.4.6.

The payment designs to be assessed in the context of two different landscapes (exact location of the production unit does not affect the environmental outcome in the case of Fictitious landscape I, while it matters in the case of Fictitious landscape II) are presented in Table 3.2 and described in more detail below.

Table 3.2. Analysed payment designs for two fictitious landscapes

Fictitious landscape I	Fictitious landscape II
Uniform payment (P1)	Uniform payment (P7)
Uniform payment with EBI (P2)	Agglomeration payment (P8)
Environmentally differentiated payment with EBI (P3)	Practice-based payment (P9)
Compliance cost differentiated payment with EBI (P4)	Results-based payment (P10)
One-dimensional auction (CC) with EBI (P5)	Hybrid payment (P11)
Two-dimensional auction (CC/EBI) with EBI (P6)	

3.4.1. Payment designs for fictitious landscape I

The total budget for the agri-environmental programme is fixed at EUR 1 000. Participating farmers are expected to comply with two compliance requirements: i) reduction of nitrogen fertiliser application by 30% and ii) establishing a five-meter wide buffer strip. The level of the uniform payment is set at EUR 53/ha, reflecting the median of income forgone for complying with two compliance criteria. The following payment designs are analysed:

- *Uniform payment* (P1) without environmental targeting: all farmers for whom the sum of the income forgone, the practice adoption (e.g. buffer strip establishment) and management costs is less than the uniform payment level are assumed to participate in the payment programme. From this subpopulation of farmers the programme participants are selected as a random draw up to the given budget limit.
- *Uniform payment with Environmental Benefit Index (EBI) targeting (P2):*[2] All farmers for whom the sum of the income forgone and the practice adoption and management costs is less than the uniform payment level are assumed to participate in the payment programme. From this

subpopulation of farmers the programme participants are selected from the highest to lowest EBI index value (as the payment is the same for all participants) until the budget limit is reached.

- *Environmentally differentiated payment policy with EBI targeting (P3)*: The payment level is differentiated on the basis of EBI to reflect differential environmental benefits provided by programme participants. Three different payment levels are offered: (i) EUR 70/ha for field parcels having EBI scores 70 and above; (ii) EUR 53/ha for EBI scores 37-69; and (iii) EUR 35/ha for EBI scores 36 and below. All farmers for whom the sum of the income forgone and the practice adoption and management costs is less than the differentiated payment level for a given field parcel EBI score are assumed to participate in the payment programme. From this subpopulation of farmers the programme participants are selected from the highest to lowest ratio of EBI/payment until the budget limit is reached.
- *Differentiated payment policy on the basis of compliance costs with EBI targeting (P4)*: Payment level is differentiated between production units to reflect differential income forgone of adopting the given practices. Three different payment levels are offered to reflect differential compliance costs: (i) EUR 63/ha; (ii) EUR 53/ha; and (iii) EUR 43/ha. All farmers for whom the sum of the income forgone and the adoption and management costs of practice is less than differentiated payment level for a given production unit are assumed to participate in the programme. From this subpopulation of farmers the programme participants are selected from highest to lowest ratio of EBI/payment until budget limit is reached.
- *One-dimensional bid-scoring index auction (P5)*: Farmers' expectations regarding the bid cap are formed on the basis of compliance costs of adopting the practices and it is assumed that farmers have identical beliefs regarding variation in compliance costs (with assumed variation by 20% around the mean).
- *Two-dimensional bid-scoring index auction (P6)*: Farmers' expectations regarding the bid cap are formed on the basis of the ratio of bid to EBI (with assumed variation by 20% around the mean).

3.4.2. Payment designs for fictitious landscape II

The total budget for the agri-environmental programme is fixed at EUR 1 000 for all payment designs. All payment designs consider the retention of nitrogen runoff, that is, the actual impact of edge-of-field nitrogen runoff on receiving watercourse. Payment levels across different payment designs are set to correspond, on average, to that of the uniform payment of EUR 53/ha.

- *Uniform payment (P7)* without environmental targeting: Participating farmers are expected to comply with two compliance requirements: i) reduction of nitrogen fertiliser application by 30%; and ii) establishing a 5-meter wide field margin covered by perennial grasses (in essence this will be a buffer strip for those production units bordering watercourse or main ditch and an ecological compensation area for production units bordering other field parcels). The level of uniform payment is set at EUR 53/ha, reflecting the median of income forgone for complying with the two compliance criteria. All farmers for whom the sum of the income forgone and the practice adoption and management costs is less than the uniform payment level are assumed to participate in the payment programme. From this subpopulation of farmers the programme participants are selected as a random draw up to the given budget limit.
- *Agglomeration payment (P8)*:[3] Participating farmers are expected to comply with two compliance requirements: i) reduction of nitrogen fertiliser application by 30% and ii) establishing a 5-meter wide field margin covered by perennial vegetation (this will be a buffer strip for those production units bordering watercourse or main ditch and an ecological compensation area for production units bordering other field parcels). The level of uniform payment is set at EUR 53/ha, reflecting the median of income forgone for complying with the two compliance criteria. Payment is offered to all production units only when production units bordering watercourse or main ditch also comply

with practice adoption. It is assumed that farmers owning the production units know each other and each other's compliance costs, and cooperate to maximise the aggregated profit from participation of all production units. If the income forgone of practice adoption for a given production unit bordering watercourse is higher than the level of uniform payment then side-payments are offered by other production units. That is, each production unit either receives or offers side-payments depending on income forgone for practice adoption relative to the uniform payment level.

- *Practice-based payment (P9)*: The participating farmer is paid on the basis of the nitrogen application reduction and the field margin establishment and management. The payment level is EUR 1.0/kg of N fertiliser reduction relative to the baseline (farmer's private optimum without agri-environmental payment programme) and EUR 35 per meter of field margin width. The participating farmer chooses the nitrogen application reduction and field margin width to maximise profit from participation.
- *Results-based payment (P10)*: the participating farmer is paid for abated nitrogen runoff. The payment level is EUR 6.4/kg of abated nitrogen runoff relative to the baseline without the agri-environmental payment programme.
- *Hybrid payment (P11):* the participating farmer is paid on the basis of both practice adoption and abated nitrogen runoff. In order to respect the same average payment level across different payment designs the payment levels of practice-based payment and the results-based payment are halved from those provided in their respective payment designs. Thus, for the practice adoption the payment level is EUR 0.5/kg of N fertiliser reduction relative to the baseline and EUR 17.5/meter of field margin width. For the abated nitrogen runoff the payment level is EUR 3.2/kg of abated nitrogen runoff relative to the baseline. The participating farmer chooses the nitrogen application reduction and field margin width to maximise profit from practice adoption and nitrogen runoff reduction.

3.5. Results

3.5.1. Budgetary cost-effectiveness of different payment designs

The results are first presented for the case of Fictitious Landscape I. Table 3.3 provides key results for the first six payment designs (P1-P6). The last column of the table reports information rent as a share of payment. Information rent is overcompensation of income forgone and extra costs incurred. With uniform payments it is highest for production units that have lowest compliance costs for adopting the given practices.

Table 3.3. Fictitious Landscape I: Results for different payment designs

Payment type	Budget, EUR	Total EBI points	Cost-effectiveness, EUR/EBI point	Information rent, EUR/ha	Information rent, % of payment
Uniform payment (P1)	954	808	1.18	35.2	66
Uniform payment with EBI (P2)	954	1 085	0.88	21.9	41
Environmentally differentiated payment with EBI (P3)	950	1 077	0.88	24.5	41
Compliance cost differentiated payment with EBI (P4)	964	1 148	0.84	17.3	32
One-dimensional auction (CC) with EBI (P5)	954	1 249	0.76	15.8	31
Two-dimensional auction (CC/EBI) with EBI (P6)	990	1 369	0.72	17.3	45

As shown by earlier studies identified in the literature, the uniform payment policy (which does not employ systematic selection of participants on the basis of the cost-effectiveness) performs less efficiently than other payment types. This is indicated by its low level of environmental benefits (total EBI points), high information rent (66% overcompensation of income forgone for the adoption of the practices), and thus high cost per EBI point relative to other payment designs.

Using EBI targeting as part of a uniform payment policy greatly improves the environmental effectiveness and consequently budgetary cost-effectiveness of uniform payment. Also, the information rent is reduced, since production units with higher environmental benefits but also with higher compliance costs are selected to the agri-environmental payment programme. Overall, environmental targeting increases budgetary cost-effectiveness by 34%, that is, 34% more environmental benefits are achieved with the same government budget expenditure.

The environmentally differentiated payment with EBI targeting has the same budgetary cost-effectiveness as the uniform payment with EBI targeting but it results in slightly higher information rent per ha, as some production units that have high environmental benefits are overcompensated even more with a differential payment level. A differentiated payment based on compliance costs and with EBI targeting increases the cost-effectiveness because it reduces overcompensation to those production units that have low compliance costs and relatively low environmental benefits. Relative information rent is the second lowest among the analysed payment designs.

The one-dimensional bid scoring auction (Compliance Cost (CC) auction with EBI) performs much better than the uniform payment as farmers are selected on the basis of their benefit/cost ratio. The two-dimensional bid scoring auction performs even better with respect to cost-effectiveness. It results in the highest total EBI points, but it also somewhat increases farmers' information rents (overcompensation of income forgone) relative to one-dimensional bid-scoring auction. The reason for higher information rents under the two-dimensional bid-scoring auction are shown by the theoretical framework presented in Annex 3.A. It shows that when farmers have access to EBI information, a higher EBI increases bids and thus the information rent for those farmers who are selected. This is confirmed in the last column of Table 3.3. The increase in information rents thus somewhat decreases the performance of the two-dimensional bid scoring auction although it is still the most cost-effective of the analysed payment designs.

Overall, these results confirm the conclusions from the literature review that the cost-effectiveness gains from environmental targeting and tailoring of the payment level are potentially very large.

Results for the Fictitious Landscape II are presented in Table 3.4. It provides key results for payment designs P7-P11. These policy simulations focus on nitrogen runoff reduction in a situation where a location of the production unit relative to watercourse matters for actual environmental outcome due to nutrient (nitrogen) retention.

Table 3.4. Fictitious Landscape II: Results for different payment designs

Payment type	N-application, kg/ha	Field margin, %	N-runoff reduction, kg	Budget, EUR	Cost-effectiveness, EUR/kg
Uniform payment (P7)	99.6	5.0	96	954	10.0
Agglomeration payment (P8)	99.6	5.0	121	974	8.1
Practice-based payment (P9)	95.7	23.0	101	975	9.6
Results-based payment (P10)	131.4	12.0	150	963	6.4
Hybrid payment (P11)	113.2	17.0	129	939	7.3

Note: N-application (kg/ha) and field margin (%) are averages across production units.

As in the previous case the uniform payment without environmental targeting (P7) is the least cost-effective payment option. The cost-effectiveness of practice-based payment (P9) is also relatively low, although it provides a more flexible payment design for farmers, since farmers can optimise field margin size and N-application reduction based on their opportunity costs and payment levels for each practice adoption unlike in the case of the uniform payment. Due to incentives provided by the practice-based payment, both N-application reduction and field margin size are largest among the analysed payment designs. However, it still results in the second lowest N-runoff reduction relative to the baseline. This is because production units with the lowest opportunity costs have the strongest incentives to establish these practices, but they may at the same time have the lowest abatement potential due to their location and thus nutrient runoff retention.

Although the agglomeration payment requires the same fixed practice adoption as the uniform payment it is much more effective in N-runoff reduction, since production units with high abatement potential also participate in the payment programme. Also its budgetary cost-effectiveness is much higher than that of the uniform payment and the practice-based payment.

The most cost-effective payment design is the results-based payment, which provides direct incentives to reduce N-runoff while considering the location of the production unit and thus nutrient retention (P10). Thus, under the results-based payment N-runoff reduction is allocated to those production units with relatively high abatement potential. The results-based payment attains the largest N-runoff reduction although the average N-application level is highest and the average field margin size only the third largest among payment design options.

Hybrid payment combines features from the practice-based and the results-based payment designs. It is the second most environmentally effective and cost-effective payment type of those analysed. Practice-based features of this design reduce its cost-effectiveness relative to pure results-based payment, since it provides incentives to stronger practice adoption in the least productive production units that have smaller opportunity costs but also less abatement potential.

Overall, these results show that the results-based payment, which optimises both opportunity cost (income forgone for adopting practices) and N-runoff reduction potential, is clearly more cost-effective than other payment designs that either neglect heterogeneous opportunity costs or abatement potential or both.

3.5.2. Economic efficiency versus coverage and distributional impacts

Targeting and tailoring of agri-environmental payments may create tradeoffs between economic efficiency and distributional issues. In this section, economic efficiency and distributional impacts are analysed for the selected payment designs in the case of Fictitious landscape II.

Economic efficiency is measured here by the environmental benefits for a given budget expenditure, that is, programme expenditure EUR per kg of N-runoff reduction. Following (Wu and Yu, 2017[1]), two measures of distributional impacts are adopted: (i) coverage and (ii) distribution of outcome. Coverage is measured as the share of successful programme applicants, that is, the share of selected programme participants of all potential applicants (potential applicants are all farmers whose profit from participation is positive for a given payment design). Thus, a larger share of selected farmers is considered more equitable. Distribution of outcome is measured by income (profit) gain from programme participation for selected participants, that is, how income gain from participation is distributed among selected participants.

Following Wu and Yu (2017[1]), the measures of equity (coverage and distribution of outcome) are constructed as the aggregate scores using *Gini* coefficients, so that aggregate score for coverage (C) and distribution of outcome (DO) is given by $C = 1 - Gini_C$ and $DO = 1 - Gini_{DO}$, respectively.[4] Hence, the value of Gini in each formula is different. Both C and DO range from zero to one. For example, it is close to zero if most of the income gains from programme participation accrue to very few farmers, while it is one if income gains are equalised among all participating farmers.

Table 3.5. Economic efficiency, coverage and distribution of outcome of selected payment designs

Payment type	Economic efficiency	Coverage	Distribution of outcome
Uniform payment (P7)	0.64	0.62	0.87
Practice-based payment (P9)	0.67	0.45	0.88
Results-based payment (P10)	1.00	0.74	0.70
Hybrid payment (P11)	0.88	0.55	0.84

Note: Economic efficiency is scaled so that the most cost-effective payment design, that is, results-based payment, is scaled to one and others are scaled relative to it. For economic efficiency, coverage and distribution of outcome measures the higher the value, the greater the efficiency or equality.

The results-based payment scores highest in terms of both economic efficiency and coverage, while it is the weakest instrument as regards distribution of outcome. It promotes economic efficiency through providing direct incentives for N-runoff reduction and allocating abatement to those production units with relatively high abatement potential. It also promotes coverage, since the lowest budget expenditure per unit N-runoff reduction stretches the budget and more applicants can be selected to the programme. Its low score with regard to distribution of outcome is due to allocating most of the abatement to the production units with highest potential, and thus the income gain from this payment design varies considerably, although the payment per unit reduction is same for all participants.

The uniform payment scores poorly with respect to economic efficiency, but it performs relatively well in terms of both coverage and distribution of outcome. As regards coverage, it scores relatively well as there is no screening or targeting of applicants (e.g. based on EBI), and thus 18 production units out of 29 applicants are selected to the programme. It scores relatively well also with respect to distribution of outcome, since the median income gain for selected participants from uniform payment (EUR 53/ha) is EUR 34.6/ha with a standard deviation of 8.2.

The economic efficiency of the practice-based payment is relatively low because production units with the lowest opportunity costs have the strongest incentives to establish these practices, while their abatement potential may be low due to their location and thus nutrient runoff retention potential. The practice-based payment has a low score with respect to coverage because only 17 production units out of 38 applicants are selected to the programme. Its high score as regards distribution of outcome is due to the relatively small variation of income gain for the selected participants (median income gain EUR 19.7/ha with a standard deviation of 6.4).

The hybrid payment combines features of both the practice-based and the results-based payment and its scores for different efficiency, coverage and distribution of outcome measures reflect this. Thus, it performs better than the practice-based payment with respect to economic efficiency and coverage, while it has a slightly lower score for the distribution of outcome measure.

Overall, these measures show that there are tradeoffs between economic efficiency and distributional impacts and none of the payment designs performs best in terms of all measures. However, the results-based payment seems to perform best and the practice-based payment worst, on average.

Tradeoffs between economic efficiency and distributional impacts have implications for the political acceptability of different payment designs. Political acceptability is important for the success of the voluntary payment approach and different stakeholders weigh certain criteria over the others. For example, environmental lobbies tend to favour environmentally effective payment designs (e.g. environmental performance-based or results-based payments) that usually require detailed spatial targeting and tailoring of payments. Due to spatial targeting and tailoring of payment levels, these types of payment designs may score relatively low with respect to coverage and distribution, although their cost-effectiveness can help to stretch limited resources to cover a larger area or more farmers. In contrast, farmers and farm lobbies put relatively more weight on distributional impacts and transaction costs (especially private transaction costs) of payment designs and may thus favor designs that are not necessarily the most environmentally effective or cost-effective. For example, uniform payment approaches may be preferred by these stakeholders because they provide the same monetary compensation for all farmers, notwithstanding the fact that foregone income and extra costs may vary considerably among farmers.

3.5.3. Budgetary cost-effectiveness gains from targeting and tailoring versus policy-related transaction costs

The budgetary cost-effectiveness ranking of alternative payment designs can be affected by the required management capacities of public agencies, and the associated public sector transaction costs for design, implementation, monitoring and enforcement.

Spatial targeting and tailoring of payments imply a potential trade-off between improving the precision of payments and increasing policy-related transaction costs (PRTCs). Therefore, a good grasp of PRTCs is required to find a payment design that offers a good balance between improved precision and increased transaction costs.

Empirical literature shows that there is huge variation in policy-related transaction costs between different types of agri-environmental policy instruments (for overview of estimates see e.g. Lankoski (2016[2])). The common way to define PRTCs in the empirical literature has been to express them as a percentage of transfers. Studies demonstrate that policy instruments applied to existing commodity market transactions, such as pesticide and fertiliser taxes, imply low PRTCs on the range of 0.1-1.1% of tax revenue. On the other hand, individually tailored agri-environmental contracts have the highest PRTCs, on the range of 25-66% of payment transfer, because of their high asset specificity and the low frequency of transactions, that is, the number of contracts. Most of the payment designs have PRTCs that are on the range of 5%-15% of payment transfer. For example, Ollikainen, Lankoski and Nuutinen (2008[3]) assessed PRTCs of agri-environmental payments in Finland and found that transaction costs increase with more targeted and differentiated agri-environmental measures. For the basic mandatory measures, PRTCs are 2% of payment transfer and comparable to those of the area-based income support measures, while for more targeted measures, such as tailored fertiliser application limits and spatially targeted reduced tillage, PRTCs are on the range of 8-10% of payment transfer. Connor et al. (2008[4]) assessed the cost-effectiveness of land conservation auctions and payment policies in Australia and estimated that PRTCs are 11% and 9% for auctions and differentiated payments, respectively.

Since the focus of the analysis is budgetary cost-effectiveness (maximum environmental benefits for a given budget/payment transfer) only public administration PRTCs (policy design, implementation, monitoring and enforcement) are considered in the following analysis and ranking of payment designs.

It should be noted that farmers' private transaction costs affect their willingness to participate in voluntary payment programmes and thus the political acceptability and ultimately, the success of the programme. While most of the existing literature focuses on public administration PRTCs, a few studies have estimated the private transaction costs for farmers of participating in agri-environmental programmes. For example, Rorstad, Vatn and Kvakkestad (2007[5]) find that these private transaction costs can range from 2.3% (payment for reduced tillage) to 9.1% (payment for preserving cattle breeds) of the compensation payment in the case of Norway. Mettepenningen, Verspecht and van Huylenbroeck (2009[6])explore farmers' transaction costs in the context of European agri-environmental schemes and find that total private transaction costs are, on average, EUR 40.2 per ha. This is the equivalent of 14.3% of the total cost of the policy for the farmer (other costs include, for example, foregone income and investment annuity) and 25.4% of the overall agri-environmental payment. These results indicate that farmers' private transaction costs can, in some cases, be relatively large and may thus affect farmers' willingness to participate in voluntary payment programmes. Moreover, the farmers' private transaction costs present in group payment schemes, such as Agglomeration Payment scheme (P8), may strongly reduce farmers' willingness to participate in such schemes. Hence, consideration of the transaction costs for farmers of adopting different types of agri-environmental practices and payment designs is crucial for success of the selected payment approach.

Public administration PRTCs are calculated for different payment types on the basis of Finnish studies (Ollikainen, Lankoski and Nuutinen, 2008[3]; Lankoski, Lichtenberg and Ollikainen, 2010[7]). These studies are employed as they provide transaction cost estimates for payments that are linked to fertiliser use reduction and buffer strip establishment and management, which are key abatement measures in the simulation model used in this chapter.

Environmental targeting and tailoring of payment rates imply specific information for payment design, implementation, monitoring and enforcement. Transaction cost elements included in the calculations include: (i) initial outlay for the site survey and soil testing; (ii) buffer strip area and management verification; (iii) nitrogen soil testing to verify nitrogen fertiliser use reduction and to provide input to nitrogen runoff estimations; and (iv) design and implementation of EBI for environmental targeting. Some of these cost elements take place only once per payment programme period ((i) and (iv)) while others are annual. However, enforcement costs would be very high for annual monitoring and inspection of each site and thus random monitoring and inspection (20% probability) is assumed in these calculations, which is relatively high compared to actual agri-environmental payment programmes in developed countries (inspection rate 3%-5%).

The second column of Table 3.6 presents PRTCs as a share of total payment transfers for each payment design. PRTCs increase with increased targeting and tailoring of the payments and is the lowest for uniform payment and the highest for two auction designs. The third and fourth columns show budgetary cost-effectiveness of each payment design without and with PRTCs, respectively. Results show that due to relatively small differences in PRTCs between different payment designs the cost-effectiveness ranking of payment designs is only slightly affected by inclusion or exclusion of PRTCs. The cost-effectiveness rank of the uniform payment with EBI (P2) only switches with that of the environmentally differentiated payment with EBI (P3) when PRTCs are included.

The last column of Table 3.6 shows the targeting gains ratio of different payment designs. The targeting gains ratio represents the budgetary cost-effectiveness gains from environmental targeting and payment rate tailoring relative to the increase in PRTCs. Uniform payment without targeting is a benchmark for calculating this ratio (i.e. the ratio of the difference in the value of EBI points or N-runoff reduction and PRTCs for a given payment type and uniform payment). Targeting gains ratios vary greatly between different payment designs. It is highest for uniform payment with EBI targeting (P2) in which case one EUR spent on PRTCs pays back EUR 23 through cost-effectiveness gains from improved environmental targeting. Also for other targeted and tailored payment designs the gains are significant.

Table 3.6. Fictitious Landscape I: Gains from targeting and tailoring versus PRTCs

Payment type	PRTCs %	Cost-effectiveness without PRTCs	Cost-effectiveness with PRTCs	Targeting gains ratio
Uniform payment (P1)	9%	1.18	1.29	-
Uniform payment with EBI (P2)	11%	0.88	0.97	23
Environmentally differentiated payment with EBI (P3)	13%	0.88	1.00	8
Compliance cost differentiated payment with EBI (P4)	13%	0.84	0.95	10
One-dimensional auction (CC) with EBI (P5)	14%	0.76	0.87	13
Two-dimensional auction (CC/EBI) with EBI (P6)	14%	0.72	0.82	14

Table 3.7 provides corresponding results for Fictitious landscape II with a focus on nitrogen runoff reduction. PRTCs are the highest for the hybrid payment design (P11) which requires monitoring of both practices and results. However, even with the highest PRTCs, it remains the second best option from a cost-effectiveness viewpoint. Under this Fictitious landscape, the cost-effectiveness ranking of payment designs is not affected by inclusion or exclusion of PRTCs. Targeting gains ratio is highest for the results-based payment (P10) and much more modest for the practice-based payment (P9) and the hybrid payment (P11). Practice-based features of these payment designs reduce cost-effectiveness due to incentives provided to stronger practice adoption in the least productive production units that have smaller opportunity costs but also less abatement potential.

Table 3.7. Fictitious Landscape II: Gains from targeting and tailoring versus PRTCs

Payment type	PRTCs %	Cost-effectiveness without PRTCs	Cost-effectiveness with PRTCs	Targeting gains ratio
Uniform payment (P7)	9%	10.0	10.9	-
Agglomeration payment (P8)	12%	8.1	9.0	9
Practice-based payment (P9)	12%	9.6	10.8	2
Results-based payment (P10)	12%	6.4	7.2	19
Hybrid payment (P11)	21%	7.3	8.8	3

Overall, the above results show that due to the relatively small differences in PRTCs between the different payment designs, the cost-effectiveness ranking of the payment designs is only slightly affected by the inclusion or exclusion of PRTCs. The small variation in PRTCs may favour more targeted and tailored payment designs despite their higher PRTCs. In order to test the influence of the variation of PRTCs on the cost-effectiveness ranking of alternative payment designs, a sensitivity analysis is conducted. In this sensitivity analysis, the probability of random monitoring and inspection is increased from 20% to 35%.

Table 3.8 provides the sensitivity analysis results for Fictitious Landscape II with a focus on nitrogen runoff reduction.

Table 3.8. Fictitious Landscape II: Sensitivity analysis of the impact of higher PRTCs on the cost-effectiveness ranking of payment designs

Payment type	PRTCs %	Cost-effectiveness without PRTCs, EUR/kg	Cost-effectiveness with PRTCs, EUR/kg	Targeting gains ratio
Uniform payment (P7)	15%	10.0 (5.)	11.5 (4.)	-
Agglomeration payment (P8)	20%	8.1 (3.)	9.6 (2.)	5.4
Practice-based payment (P9)	20%	9.6 (4.)	11.6 (5.)	1.1
Results-based payment (P10)	20%	6.4 (1.)	7.7 (1.)	11.7
Hybrid payment (P11)	35%	7.3 (2.)	9.9 (3.)	1.8

Note: Ranking of the given payment design is given in parenthesis.

In comparison to the base case of PRTCs presented in Table 3.7, PRTCs as a share of total payment transfer (presented in the second column) have increased clearly for all payment designs. The third and fourth columns show the budgetary cost-effectiveness of each payment design without and with PRTCs, respectively. The results show that with increased PRTCs the cost-effectiveness ranking of the payment designs is now more affected by the inclusion or exclusion of PRTCs. In this case the relative performance of the uniform payment (P7) and the agglomeration payment (P8) improves, while it worsens for the practice-based payment (P9) and the hybrid payment (P11). In the last column of Table 3.8 the targeting gains ratio for all payment designs is clearly lower than the corresponding figures in Table 3.7. With increased PRTCs the targeting gains for the practice-based payment (P9) and the hybrid payment (P11) are relatively small.

3.5.4. Implications of farmers' risk preferences

Farmers' decisions to adopt environmentally friendly practices and their responses to different payment designs are affected by their risk preferences. Thus, it is important to consider farmers' risk preferences and the heterogeneity in their risk aversion in agri-environmental policy design and implementation. Farmers face different types of risks, including crop yield risk, input and output price risk, and government policy risk (risks created by unpredictable changes in policies and regulations). Several types of mechanisms such as crop and revenue insurance have been developed to alleviate these risks.

The focus of this section is on the impact of risk aversion on farmers' responses to the different payment designs in the case of Fictitious landscape II. Risk-neutral and risk-averse farmers are compared in terms of environmental practice adoption and agri-environmental programme participation.

Modeling farmers' decisions under risk aversion is based on the expected utility (EU) framework. An exponential utility function is adopted:

$$EU(\pi) = 1 - e^{-r\left[\mu - \frac{1}{2}r\sigma^2\right]} \quad (1)$$

As regards equation (1) any solution that maximises $\left[\mu - \frac{1}{2}r\sigma^2\right]$ also maximises expected utility from profits, EU(π), and thus maximisation of a linear function of mean (μ) and variance (σ^2) of profit is equivalent to expected utility maximisation. The mean-variance approach (see e.g. (Levy and Markowitz, 1979[8]) adopted here thus implies that if a distribution is defined by its first two moments, the expected utility is a function of the distribution's mean and variance. The constant *r* measures the degree of risk aversion: the larger *r* is, the more risk averse the farmer is. Hence, the utility of the farmer is increasing with the mean of his profits and decreases with the variance of profits. The rate of decrease with the variance is larger the more risk averse the farmer is.

Four payment designs are analysed in this section: the uniform payment (P7), the practice-based payment (P9), the results-based payment (P10) and the hybrid payment (P11). Farmers' heterogeneous risk preferences are mainly based on Iyer et al. (2019[9]), who conducted a systematic review of farmers' risk preferences in Europe.

As regards the variance component of modelling, the uniform payment (P7) and the practice-based payment (P9) modelling uses the variance of crop revenue, while in the cases of the results-based payment (P10) and the hybrid payment (P11), the focus is on the variance of nitrogen runoff. This is because the variance of nitrogen runoff only affects farmers' optimal choice of inputs (nitrogen application and buffer strip establishment) in the latter two types (P10 and P11).

Table 3.9 provides results for both risk-neutral and risk-averse farmers as regards input use, profits and N-runoff and cost-effectiveness.

Table 3.9. Farmers' risk preferences, practice adoption and expected profit of agri-environmental programme participation

	Risk-neutral farmers					Risk-averse farmers				
	N-application, kg/ha	Buffer strip size, ha	Profit, EUR/ha	N-runoff, kg/ha	Cost-effectiveness, EUR/kg	N-application, kg/ha	Buffer strip size, ha	Profit, EUR/ha	N-runoff, kg/ha	Cost-effectiveness, EUR/kg
Baseline	140	-	189	14.9	-	127	-	185	13.5	-
Uniform payment (P7)	94	0.05	213	8.6	11.2	75	0.05	215	8.2	11.7
Practice-based payment (P9)	93	0.23	242	7.5	11.5	79	0.31	229	3.2	13.4
Results-based payment (P10)	130	0.11	226	8.5	6.4	127	0.02	215	10.7	6.4
Hybrid payment (P11)	112	0.16	227	7.5	7.8	118	0.06	205	10.9	10.7

Note: All figures shown are mean of participating farmers under each payment design and risk preference assumption.

These simulations were conducted for 14 cases, which represents one-third of those analysed in the previous sections, and so the total budget for the agri-environmental programme is reduced by two-thirds for all payment designs. All payment designs consider the retention of nitrogen runoff; that is, the actual impact of edge-of-field nitrogen runoff on the recipient watercourse. Payment levels across different payment designs are set to correspond, on average, to the uniform payment of EUR 53/ha.

Baseline results show that optimal nitrogen application intensity for risk-averse farmers is about 9% smaller than that of risk-neutral farmers as nitrogen fertiliser increases cultivation costs for sure while crop output and thus revenue is considered risky. Optimal size of buffer strip is zero in both cases as there are no incentives for the buffer strip establishment in the Baseline. Due to higher nitrogen application intensity, nitrogen runoff is about 10% higher in the case of risk-neutral farmers relative to risk-averse farmers.

If farmers have the option to choose one of these payment designs (or schemes), then the level of profits under each payment design determines which option is preferred by both risk-neutral and risk-averse farmers, since exactly the same agri-environmental budget is provided under each payment design. For both risk-neutral and risk-averse farmers, the highest average profits of selected farmers are obtained under the practice-based payment (P9), and thus this payment scheme would be the most preferred option from a profitability standpoint. However, in terms of distributional impacts (coverage and distribution of outcome), it scores lower than uniform payments since fewer farmers can be included in the programme within the given budget.

The practice-based payment (P9) is also the least cost-effective payment design for both risk-neutral and risk-averse farmers. As discussed earlier in the context of Fictitious landscape II, the practice-based payment reduces budgetary cost-effectiveness due to incentives provided for stronger practice adoption in the least productive production units that have smaller opportunity costs but also less abatement potential. Both risk-neutral and risk-averse farmers strongly adjust nitrogen application intensity and size of buffer strips under the practice-based payment relative to the incentives provided by the results-based payment (P10) and the hybrid payment (P11).

Risk-averse farmers, whose expected utility from profits is strongly affected by variance of crop revenue, adjust input use strongly as the practice-based payment provides a non-stochastic income stream. Since nitrogen application is reduced by 38% and buffer strips cover 31% of cultivated area, the resulting nitrogen runoff is very small (76% reduction relative to the Baseline).

Those risk-averse farmers who would participate in the results-based scheme adjust their input use much less than risk-neutral farmers. This is explained by the variance of nitrogen runoff that makes the results-based payment stochastic for risk-averse farmers. This stochastic feature of the results-based payment also affects how much risk-averse farmers adjust their input use under the hybrid payment scheme. Under the hybrid payment scheme risk-averse farmers' input use is adjusted more than under the pure results-based scheme but clearly less than under the pure practice-based payment.

The most cost-effective payment design is the results-based payment (P10), with the hybrid payment (P11) being the second most cost-effective payment type of those analysed. However, their distributional impacts (coverage and distribution of outcome) are weaker than those of uniform payments, as fewer farmers can be included in the programme within the given budget.

Hence, as in Section 3.5.2 above, these results show that there are tradeoffs between economic efficiency and distributional impacts: none of the payment designs emerges as a top performer in all categories. These tradeoffs need to be minimised, while maintaining to the greatest extent possible the environmental effectiveness and budgetary cost-effectiveness of the selected payment design in order to enhance farmers' participation in voluntary payment programmes. For example, a hybrid payments could include relatively simple practice adoption for the base payment to maximise coverage of the programme, with the environmental effectiveness and budgetary cost-effectiveness of the programme then being maximised by a bonus payment for environmental results.

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Annex 3.A. Policy simulation component: Theoretical framework, model calibration and data

In this annex a simple theoretical framework is developed to illustrate a farmer's decision to participate in a government agri-environmental payment programme as well as analyse government's selection of participants for a programme. This is followed by a description of model calibration and data requirements.

Theoretical framework for working lands AE programme

The starting point of the conceptual framework is a heterogeneous land quality model with different soil types and land productivities. Following Lichtenberg (1989[10]) and Lankoski and Ollikainen (2003[11]), land quality differs over field parcels (j) and it is ranked by a scalar measure, q, with the scale chosen so that minimal quality is zero and maximal quality is one, i.e. $0 \leq q \leq 1$. Crop yield per hectare, y, is a function of land quality q and fertilizer application rate l_j, that is, $y = f^j(l_j; q)$. In the absence of government agri-environmental payment programme farmers' short-run restricted profits are defined as $\pi_0^j = pf^j(l_j; q) - cl_j - K_j$, where p and c represent the respective prices of crop and fertilizer and K_j other cultivation costs per hectare.

In the case of government policy to enhance semi-natural habitat provision, to reduce nitrogen runoff from field parcels to watercourses and to promote soil carbon sequestration let $m_j(q)$ denote the share of field parcel of productivity q allocated to crop production that is retained as a semi-natural habitat (whether buffer strip, field-forest border biodiversity strip or enlarged field margin). Heterogeneous productivity of field parcels implies that the establishment and management of semi-natural habitats, m, results in differential opportunity costs in different field parcels. Also, biodiversity benefits, nitrogen runoff reduction effectiveness, and soil carbon sequestration differ due to differential site-productivity of environmental service provision (owing to differences in soil types, field slopes, etc.). Similarly reduction of nitrogen fertiliser application rate $l_j(q)$ contributes to reduction of nitrogen runoff and nitrous oxide (N_2O) emissions.

Simple uniform payment policy for buffer strip establishment

For the ease of implementation the government can set a fixed width of buffer strip, $\hat{m}$, (e.g. 5 or 10 meters) and uniform payment for biodiversity strip $\hat{b}$. In this case farmers' profits are defined as

$$\pi_1^j = (1 - \hat{m})\{pf^j(l_j) - cl_j - K_j)\} + (\hat{b} - \gamma_j)\hat{m} - \theta_j, \qquad (1)$$

where γ_j denotes the annualised establishment and management costs of buffer strip and θ_j denotes farmer's private transaction costs of participating in agri-environmental programme. A farmer will participate in this programme if his profits under the programme, π_1^j, are higher than his reservation profits, π_0^j.

Differentiated payment for nitrogen fertiliser use reduction and buffer strip establishment

For spatial targeting of agri-environmental measures, here nitrogen fertiliser use reduction and buffer strip establishment, the government can implement differentiated payment levels s_j and b_j. In this case farmers' profits are defined as

$$\pi_1^j = (1 - m_j)\{pf^j(l_j) - cl_j - K_J + s_J(l_j^0 - l_j)\} + (b_j - \gamma_j)m_j - \theta_j. \quad (2)$$

Conservation auctions

In the case of conservation auction farmers competitively bid for a limited amount of agri-environmental contracts. Iho et al. (2014[12]) and Glebe (2013[13]) modified Latacz-Lohmann and van der Hamsvoort (1997[14]) model and included environmental benefit index (EBI) in the bidding. Following Iho et al. (2014[12]) farmers make expectations on bid/EBI ratios when they participate in bidding. EBI values are denoted by e and the upper limit of the bidder's expectation about the maximum expected bid/EBI is denoted by $\bar{\beta} = b''/e''$. By assumption bidders' expectations about this implicit bid cap are uniformly distributed in the range$\left[\underline{\beta},\ \bar{\beta}\right]$, where the lower bar represents the minimum (defined by $\underline{\beta} = b'/e'$) and upper bar the maximum expected bid cap. The probability that the bid is accepted is given by

$$P(\theta \leq \bar{\beta}) = \int_{\theta}^{\bar{\beta}} f(\theta)d\theta = 1 - F(\theta) \quad (3)$$

Where $\theta = \frac{b}{e}$, *f*(θ)is density function and F(θ) distribution function. The expected net payoff of the risk-neutral farmer from bidding is a product of the revenue from winning the bid and the acceptance probability:

$$(\pi_1 + b - \pi_0)(1 - F(\theta)), \quad (4)$$

where π_0 denotes the profit under no participation and π_1 is profit under the secured conservation contract. The farmer chooses the bid, *b*, and thereby the ratio *b*/EBI, according to:

$$b^* = \pi_0 - \pi_1 + \frac{(1-F(\theta))e}{f(\theta)}, \quad (5)$$

where *f(θ)* is the probability density function associated with *F*(*θ*) and *e* is the field parcel's EBI-value.

The difference $\pi_0 - \pi_1$ in equation (5) represents the income forgone for adoption of agri-environmental practices (reduction of nitrogen fertiliser use and the establishment and management costs of buffer strip) and farmer's private transaction costs of participation. The additional term $(1 - F(\theta))e/f(\theta)$ is the information rent.

The optimal bid in the presence of EBI is determined by:

$$b^* = \frac{\pi_0 - \pi_1 + e\overline{\beta}}{2}. \quad (6)$$

Hence, when EBI matters for participation in an auction, the optimal bid depends on the conservation costs and the expected cap multiplied by the bidder's own EBI value ($e\bar{\beta} = e(b''/e'')$).The higher is the EBI of the submitted field parcel, the higher is the bid ($\frac{db}{de} = \frac{\bar{\beta}}{2} > 0$). Glebe (2013[13]) also shows that farmer's optimal bid changes when he receives information about the environmental score of the field parcel and farmer's bid increases (decreases) when informed that his environmental score is greater (smaller) than average score.

When farmers expect similar environmental performances across farmers, the optimal bid is the same as under the auction without EBI, that is, $b^* = \frac{\pi_0 - \pi_1 + b''}{2}$, (see Iho et al., (2014[12]). Hence, in this case farmers' expectations are formed only on the basis of income forgone for adopting environmental practices and not on bid/EBI ratios.

Empirical application of the theoretical framework

The empirical application is built on the key features of the theoretical model.

Crop production

Per hectare crop yield is modelled as a function of nitrogen fertiliser application. A Mitscherlich yield function is applied for wheat to define the optimal fertiliser application and yield level.

$$f(l_i; q_i) = \phi_i(1 - \sigma\, exp(-\rho l_i)) \quad (7)$$

Where l_i is nitrogen application rate in a given micro-unit (field parcel) i (i=1…38) and φ_i, σ and ρ are parameters.

The crop yields depend on soil productivity and soil type and these differences are incorporated through maximum yield parameter, φ_i.

Environmental effects

GHG emissions

GHG emissions include emissions from nitrogen fertiliser application (N_2O). In the next version of the empirical model extensive grasslands, environmental (green) set-aside and buffer strips are considered to provide a net-sequestration of soil carbon (that is, they are carbon sinks).

Nitrogen runoff

The following nitrogen runoff function based on Simmelsgaard (1991[15]) and Simmelsgaard and Djurhuus (1998[16]) is employed,

$$Z_l^i = (1 - m^\eta)\varphi_i\, exp(\gamma_0 + \gamma l_i(1 - m)), \quad (8)$$

where Z_l^i = nitrogen runoff at fertiliser intensity level l_i, kg/ha, φ_i = nitrogen runoff at average nitrogen use, $\boldsymbol{\gamma_0} < \mathbf{0}$ and $\boldsymbol{\gamma} > \mathbf{0}$ are constants and l_i = nitrogen fertilisation in relation to the normal fertiliser intensity for the crop, $0.5 \leq l \leq 1.5$. The first term in (8) describes nitrogen uptake by the buffer strips.

Biodiversity

The quality of arable and semi-natural habitats is measured by employing habitat quality indices based on observed species number of butterflies in different kinds of arable farmland habitats (Kuussaari and Heliölä, 2004[17]). Habitat quality indices show that oilseeds (rape seed) are two and green set-aside 5–6 times more valuable habitat for butterflies than cereal fields, whereas field edges and buffer strips are 7 times more valuable habitats. The highest quality habitat would be a natural meadow, which is 8.1 times more valuable a habitat than cereal fields. These relative weights are used when calculating a biodiversity index value for each representative production unit. Thus, the biodiversity index value of a given production unit depends on the size of field edges and the buffer strip and the chosen land use (habitat quality of the given land use). Naturally buffer strips are not established in those field parcels, which are allocated to green set-aside or extensive grasslands (e.g. a natural meadow).

Environmental benefit index

Environmental benefit index (EBI) is modelled as a relative environmental gain index for a given representative production unit as an edge-of-field relative impact on nitrogen runoff, N_2O emissions, and quality of wildlife habitat (see similar approach in Cattaneo et al. (2005[18]) and Claassen et al. (2004[19])). Relative impact estimates are converted to a 0-1 impact index (EBIje) for each environmental effect:

$$EBI_{je} = \frac{RG_{je} - \min(RG_e)}{\max(RG_e) - \min(RG_e)} \quad (9)$$

Where min(RG_e) and max(RG_e) are the minimum and maximum impact estimates across all production units j for the *e*th environmental effect. EBI_{je} is scaled so that the largest impact unit(s) receives 100 EBI points. Total EBI for each production unit is a weighted sum of its EBI points for three environmental effects analysed (where sum of the weights equals 1).

Farmers' risk preferences

Regarding farmers' risk preferences, the flexible utility function developed by Saha (1997[20]) is employed:

$$U(\pi, \sigma) = \pi^{\theta} - \sigma^{\gamma} \quad (10)$$

where θ > 0 and γ are parameters. The risk attitude measure is given by the marginal utility ratio of the utility function, $U(\pi, \sigma) = (\frac{\gamma}{\theta})\pi^{1-\theta} - \sigma^{\gamma-1}$. Risk aversion corresponds to θ > 0 and risk-neutrality to θ =0. Decreasing absolute risk aversion is presented by θ > 0. Hence, farmers are assumed to be risk-averse and have decreasing absolute risk aversion.

Notes

[1] Nomenclature of territorial units for statistics (NUTS) is a hierarchical system for dividing up the economic territory of the EU and the UK for the purpose of the collection, development and harmonisation of regional statistics. NUTS2 includes 242 regions. The Common Agricultural Policy Regional Impact (CAPRI) model is an agricultural sector model that combines a global partial equilibrium model for agri-food products with non-linear programming models for NUTS2 regions in the European Union and the United Kigngdom (www.capri-model.org/docs/capri_documentation.pdf).

[2] In performance-based screening farmers are paid according to measured environmental performance or benefits generated by using proxies, such as the environmental benefit index (EBI). For example, in the US Conservation Reserve Program (CRP) the combination of performance screening through the EBI and competitive bidding has been used to select CRP participants. This benefit-cost targeting allows policy makers to rank and select participants on the basis of the benefit-cost ratio of their bids (where the EBI represents the benefit and farmer's bid represents cost) (OECD, 2010[21]).

[3] For biodiversity, connected habitats are ecologically more valuable than isolated habitats and improved spatial connectivity of fragmented habitats is needed. Agglomeration payment design provides incentives for farmers to conserve spatially connected habitats. A bonus payment is paid to landowners if managed habitats achieve a desired spatial configuration.

[4] The Gini coefficient is an indicator that describes the level of inequality for a given variable and it varies between 0 (perfect equality) and 1 (extreme inequality). The higher (lower) is the Gini coefficient, the greater is the inequality (equality).

4 Choice experiment survey

To complement the policy simulations, a choice experiment was developed to understand farmers' preferences for different attributes of agri-environmental payments, including practice-based and results-based payment mechanisms. This chapter draws on experiments undertaken in 2021 with farmers across three OECD countries (Finland, Netherlands and Sweden) to understand the role of payment design and farmer characteristics on participation in different agri-environmental payment schemes.

4.1. Eliciting farmers' preferences on agri-environmental payment schemes to increase their participation

Tackling the environmental challenges associated with agriculture requires improvements in the current set of instruments available to policy makers. One such instrument, agri-environmental payment schemes, are voluntary programmes that pay farmers for the adoption of environmental practices. Despite their popularity, there is mounting evidence that many these schemes underperform against their environmental objectives.

Voluntary agri-environmental contracts that offer fixed payment rates suffer from two major problems. First, farmers who face the lowest costs of compliance with environmental requirements are more likely to enter the programme; in cases where the programme pays some farmers for doing nothing differently from what they would have done in the absence of payment, adverse selection may induce large windfall effects (Chabé-Ferret and Subervie (2013[1]). Second, those farmers with the highest costs of compliance are less likely to enter the programme, although they may be precisely those whose engagement would make the greatest contribution to the programme's effectiveness (Kuhfuss et al., 2015[2]). Despite these well-known shortcomings, there is limited evidence on how payment design features could be changed to improve the targeting of beneficiaries and including the best mix of practices or results upon which payments should be conditioned.

Since agri-environmental payment mechanisms rely on the voluntary participation of farmers to achieve their environmental outcomes, it is important to understand how and why farmers choose to participate in these mechanisms. This is particularly the case when considering the introduction of new agri-environmental policy mechanisms. As noted in Part I, policy makers have expressed an interest in exploring the potential of performance-based or results-based payment schemes to improve the cost-effectiveness of agri-environmental payment schemes. Gauging the preference of farmers for specific payment designs can help anticipate their possible adoption and effects.

The purpose of Part II is to offer such evidence, and explore how different types of farmers in selected countries respond to specific agri-environmental payment designs: practice-based schemes, where payments are based on adoption of specific practices; results-based payments,[1] which link payments to measurable results; and hybrid payments, under which payment depends on both implementing specific practices and achieving specific results. The report is based on a choice experiment conducted with farmers, using a survey instrument that can be adapted to other country and policy contexts.

Choice experiments belong to the set of ex ante methods and have been applied to numerous issues in a variety of research fields (Holmes, Adamowicz and Carlsson, 2017[3]).[2] They are stated preferences methods (surveys) that aim to reveal information about individual (in this case, farmers) choices and preferences, and are grounded in consumer and microeconomic theory (Hanley, Mourato and Wright, 2001[4]). Essentially, choice experiments consist of presenting individuals with a range of choices, and asking the individuals to trade-off different levels of attributes of interest.[3]

This method has been increasingly used in research. A review of the literature found 55 choice experiment studies focusing on agriculture (Annex 4.C). Most of the studies tested farmers' willingness to accept contracts that pay for implementing specific practices. The literature is scant on analysis of willingness to accept contracts that pay for achieving results. The literature reviewed for this report found only one pure results-based contract and a few hybrid schemes that usually had no straightforward linkages between payment levels and the performance attribute.

The choice experiment presented in this part of the report studies policy design elements for multiple environmental objectives. While different design features can be tested in policy simulations (as undertaken in the first part of the report), this approach cannot account for certain real-world aspects, including behavioural characteristics of farmers, which are generally difficult to model. The experiment provides valuable evidence which, together with the simulations, yields richer insights into practical design considerations for agri-environmental payment schemes. The proposed choice experiment aimed to determine how farmer and farm characteristics (e.g. gender, age, farm size) and behavioural aspects (e.g. risk aversion, attitudes towards the environment) impacted the choice of different agri-environmental contracts and determine farmer's willingness to accept a given contract.

The choice experiment was implemented in three volunteer countries: Finland, the Netherlands and Sweden, but the survey instrument developed for this project could be adapted and applied to other countries interested in the design of practice-based, hybrid and results-based agri-environmental payments.

In April 2020, Argentina and Finland conducted focus groups to obtain feedback from experts and farmers on the first version of the survey. The Netherlands conducted focus groups in June 2020. In light of this feedback and interactions with country experts, the OECD drafted a pilot version of the survey. The survey was originally drafted in English and was translated by participating countries into Dutch, Finnish, Spanish and Swedish and coded in LimeSurvey by a contracted expert.

In January 2021, the pilot survey was completed in Argentina, Canada, Finland and Sweden. Based on the responses from the pilot survey, the survey was adjusted and implemented in March 2021 in the Netherlands, Sweden and Finland. Each country drew on a representative sample of farmers and used incentives to increase participation in the survey. Canada and Argentina were ultimately unable to participate in the final survey due to logistical complications.

Following standard choice experiment design, the survey has four sections, i) introduction, ii) contextual questions, iii) choice exercise, and iv) behavioural questions. There are two main versions of the survey, one for arable farming (general field cropping of cereals, oilseed and protein crops) and one for 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. [4]

4.2. Introduction to the survey

The introduction explains the purpose of the survey, presents general instructions on how to respond to the survey, and the use of data collected, and also includes a point of contact to clarify questions about the survey and a consent form. The introduction highlights that the answers to the survey will directly contribute to informing the design of agri-environmental payment schemes in the future.

4.2.1. Contextual questions

This section contains questions about the participant, farm characteristics and experience with agri-environmental schemes. Data gained from these questions are primarily used i) to assess the representativeness of the sample, ii) to select the survey type (arable or mixed), and iii) to serve as explanatory variables for explaining variation seen in the choice exercise.

4.2.2. Choice exercise

This section is the core of the survey. It starts with a description of the hypothetical agri-environmental policy schemes, includes instructions on how to complete the choice exercise and contains the choice exercise itself (more detail below). Since the main objective of the choice exercise is to elicit farmers' preferences for practice-based, results-based and hybrid agri-environmental contracts for achieving water quality, climate change mitigation and biodiversity objectives, the hypothetical agri-environmental policy schemes sub-section explains how the different hypothetical contracts work, including how they would be monitored and enforced.

Schemes based on the adoption of specific practices offer an annual payment for five years and pay for the adoption of some or all of the following.

Both arable and mixed

- A reduction of nitrogen fertiliser application (including mineral and manure sources) by 20% on all cultivated fields – compared to average use over the three years preceding enrolment.
- The establishment of three-meter-wide buffer strips along all main ditches and water courses in all cultivated fields.
- The establishment of cover (or catch) crops on 10% of cultivated fields.
- The reduction in pesticide use by 20% in all cultivated fields – compared to average use over three years preceding enrolment

Only arable

- The establishment of green fallow on 10% of arable farm acreage.
- The establishment and management of enlarged (2-meter-wide) field edges (e.g. margins, stone walls or hedged) on at least 30% of cultivated fields.

Only mixed

- The application of all manure by injection instead of broadcasting (whole farm).
- The management of permanent grassland to favour biodiversity, by imposing a stocking rate between xxx (to be defined by countries) and yyy (to be defined by countries) livestock units per hectare and ensuring the removal of all brushwood.

Environmental results-based schemes offer an annual payment for five years if the following results are achieved.

- *Climate change mitigation*. Reduction (no requirement, 25% or 50%) of greenhouse gases net emissions relative to the estimated net emissions before the start of the contract, estimated from the use of nitrogen fertilisers (mineral and manure) and fuel, and cultivation practices (ploughing, cover crops, etc.) that impact the amount of carbon stored in soils.
- *Biodiversity*. Increase in the number of flowering and vascular plant species (no requirement, 5 flowering plants species, 10 flowering plants species) present on 10% of arable land (*for arable version*) / on permanent grasslands (*for mixed version*).
- *Water quality*. Reduction (no requirement, 25% or 50%) of the run-off of nutrients, pesticides and sediments at the edge of field, estimated based on the slope, soil type, and recorded cultivation practices (cover crops, buffer strips, fertiliser use, etc.), relative to the estimated runoff before the start of the contract.

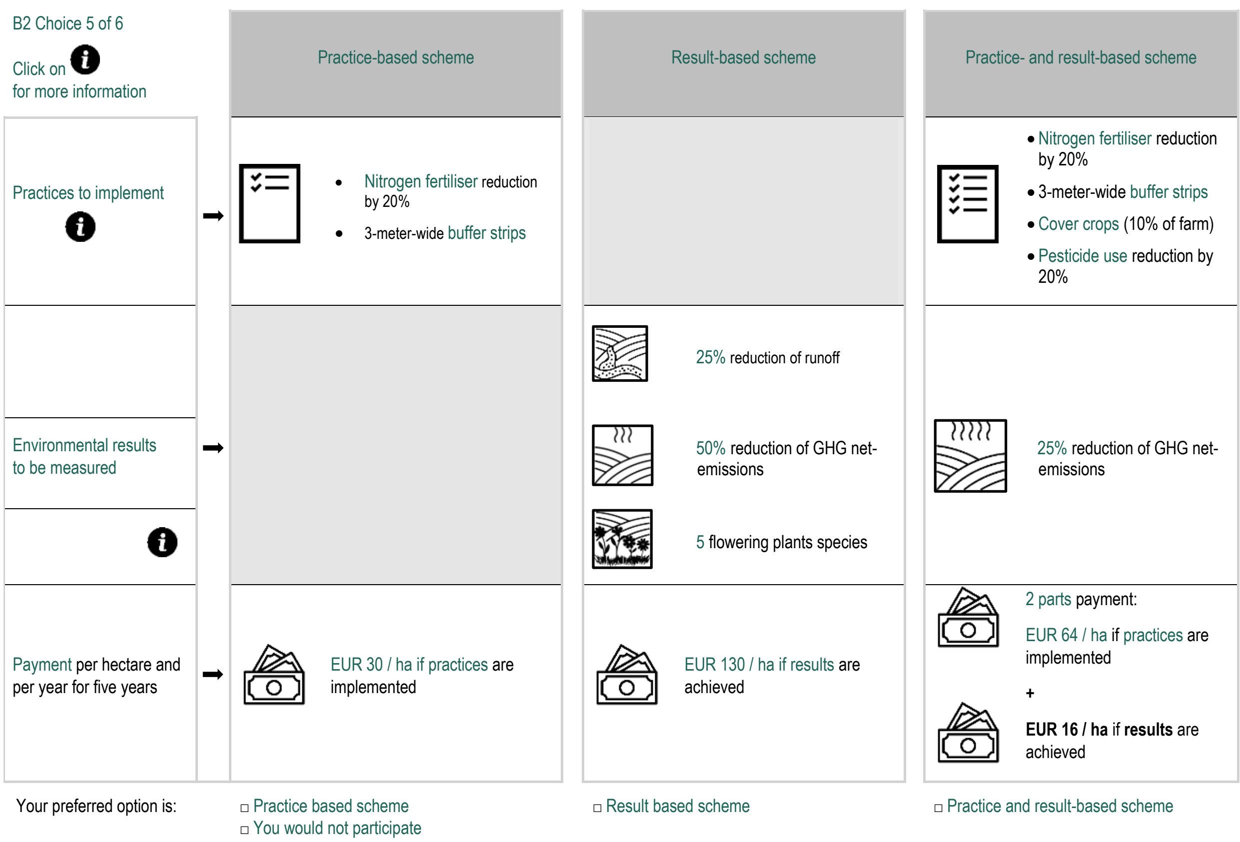
The survey states that under environmental results-based schemes, farmers are free to adopt any practices that they consider most suitable to achieve those results. Note that the biodiversity objective is purely based on measured results, while the water quality and climate change mitigation objectives are based on modelled/simulated results.

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

The survey also notes that, under all schemes, participants would be asked to report on the adoption of practices and/or achievement of environmental results at the end of each year; that all reports would be reviewed each year; and that 5% of farms would be selected for field controls.

Figure 4.1 shows an example of the choice cards included in the survey; for each choice card, responding farmers have to choose one option among three, considering a range of requirements and the resulting payment. A total of 36 choice cards were generated as the minimum number needed to generate efficient (low variance) parameter estimates. The cards were organised in six blocks (six blocks each containing six choice cards) and each farmer was presented with only one block (six choice cards).

Figure 4.1. Example of choice card



4.2.3. Attitudinal or behavioural questions

This section includes questions about participant attitudes or behaviours that are relevant to the choice exercise, such as their views on the importance of improving agricultural sustainability, attitudes towards participating in policy measures, and beliefs about the value or likelihood of co-ordinated actions, etc. As shown in the literature review, behavioural aspects such as dispositional factors (personality, risk tolerance and environmental concerns), social factors (social norms and expectations) and cognitive factors (ability to understand costs and benefits of their actions and the way programmes work) are important for farmers' willingness to enrol in agri-environmental schemes. These questions typically appear *after* the choice exercise, so that responses to the choice exercise are not affected by these questions. The final survey includes twelve behavioural questions.

The related behavioural factors identified in the literature review that are relevant for understanding farmers' motivations to enrol and participate into agri-environmental schemes include:

- Questions to identify *unreliable responses / protest answers* (Cognitive)
- *Value belief norm model*. This model is used for predicting behaviour and can be broken down into sub-factors that affect intentions: social norms, attitudes, values, ecological worldview, awareness of consequences and ascription of responsibility (Dispositional and Social)
- *Perceived efficacy*. Perceptions of the environmental efficacy of adopting best management practices (Cognitive)
- *Theory of planned behaviour*. Theory used for predicting behavioural intentions; it can be broken down into three factors: social norms, attitudes, and perceived behavioural control (Dispositional and Social)
- *Risk attitudes and risk perception* (Dispositional)
- *Time preferences* (Dispositional and Social)
- *Shifting baseline theory*. Perceptions of environmental change, perceived need for action (Dispositional and Social)
- *Trust and uncertainty* (Dispositional and Social).

4.3. Results and conclusions

4.3.1. Sample and farmer characteristics

The sample consisted of 731 complete submitted answers to the questionnaire (Table 4.1), including 270 responses for the mixed farming version of the questionnaire and 461 for the arable version of the questionnaire. In terms of participation per country, 357 farmers completed the questionnaire in Finland, 230 in Sweden and 144 in the Netherlands.

Table 4.1. Respondents

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

4.3.2. Respondents' socio-demographic and farm characteristics

The average farm size within the sample was 160 hectares, including 70.8 hectares of arable land. On average, farmers owned 75 hectares of land; 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%) 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 (see Annex Table 4.D.2 and Annex Table 4.D.3 for more details on farmer characteristics).

4.3.3. Respondents' behavioural characteristics

Farmers in the sample varied in their tolerance for risk (from risk averse to farmers who were more willing to take risks), but the majority tended to make choices now to influence outcomes farther into the future. Generally, farmers' responses regarding their willingness to adopt new farming practices and willingness to take risks were evenly distributed, from strongly disagree to strongly agree. In contrast, only a minority of farmers displayed preferences for the present, while most tended to be more long-term oriented in their decision making. Roughly 70% of farmers stated that they made farming decisions to achieve outcomes that may not result for many years Annex Figure 4.C.1 presents these results in more detail).

With regards to farmers' attitudes towards the environment, most farmers in the sample were satisfied with the environment around their farms and acknowledged the threat of global warming, but disagreed about the degree to which they felt responsible for either local or global environmental issues such as global warming. While most respondents believed that farmers in their area were willing to adopt (or had already adopted) farming practices to improve environmental outcomes, as an indicator of the social norm, about 30% were agnostic about whether other farmers would be willing to adopt such practices (Annex Figure 4.C.2 details on attitudes towards environmental issues.)

Finally, about half of the respondents had low levels of confidence in the ability to monitor the environmental improvements that would be achieved through the schemes proposed. There were large variations in respondents' perceptions of their ability to adopt the proposed practices and their ability to achieve the environmental results, as well as the potential effects of these on farm profitability. Most farmers would not adopt the proposed practices or work to achieve the environmental objectives presented in the questionnaire in the absence of any payment, and most were in favour of more government spending and agri-environmental payments. A majority of farmers found the survey complex and mentioned having to ignore some of the options' characteristics in order to be able to make choices on the cards.[5] Annex Figure 4.C.3 provides more detail on farmers' perception of the choice experiment.

4.3.4. Contract characteristics

As explained in Section 2, respondents were presented six choice cards with three contract options: practice-based, results-based and hybrid. In each of these choice cards they had to choose between one contract and the option of not participating in any of the offered schemes. The contracts varied by the nature of the attributes and levels of the particular attributes (Table 4.2).

In the following analysis, farmers' choices are explained first by the scheme characteristics, and then by individuals' characteristics, including behavioural factors.

Table 4.2. Attributes and their levels presented on choice cards

Attributes and constants	Levels and associated variables
Alternative specific constants (ASC): Constants capturing the baseline preference for alternative scheme designs	ASC No participation: constant for the alternative not to participate (reference) ASC Practice-based: constant for practice-based alternatives ASC Hybrid: constant for hybrid alternatives ASC Results-based: constant for results-based alternatives
A : Practice-based requirements from list below	Level 1: First 2 practices to be implemented (reference level) Level 2: First 4 practices to be implemented Level 3: All 3 practices to be implemented
B: Water quality objectives: reduction of nutrient, pesticide and sediment runoff (measured at the edge of field)	Level 0: Payment will not depend on water quality results (reference level) Level 1: 25% reduction of runoff Level 2: 50% reduction of runoff
C: Climate Change (CC) mitigation: Reduction of GHG net-emissions from farm (GHG emissions minus soils carbon sequestration)	Level 0: Payment will not depend on climate change mitigation results (reference level) Level 1: 25% reduction of GHG net-emissions Level 2: 50% reduction of GHG net-emissions
D: Biodiversity objectives: Number of specified flowering plant species present on 10% of the farm acreage	Level 0: Payment will not depend on biodiversity results (reference level) Level 1: 5 flowering plant species Level 2: 10 flowering plant species
E: Share of payment conditioned on results	0 % (in practice-based alternatives only) 10, 20, 30, 50, 70, 90 % (in hybrid alternatives only) 100 % (in results-based alternatives only)
F: Payment in euros per hectare and per year	0: In the option "I would not participate" 30, 80, 130, 180, 230, 280

4.3.5. Farmers' preferences for AES designs

Overall preferences

Roughly one-third of farmers preferred not to participate in any of the schemes based on the characteristics presented. Farmers selected practice-based schemes more often than hybrid and results-based schemes (Table 4.3).

Table 4.3. Share of choices for each alternative scheme design on the choice cards, overall, per farm specialisation and per country, percentage

%	All	Arable farmers	Mixed farmers	Finland	Sweden	Netherlands
Practice- based	26.93	26.68	27.35	30.63	25.36	20.25
Hybrid	20.59	19.67	22.16	22.88	21.45	13.54
Results-based	16.39	15.4	18.09	16.15	18.91	12.96
Would not participate	36.09	38.25	32.41	30.35	34.28	53.24

A conditional logit model was conducted to understand which attributes of the schemes had the most weight in these choices.[6] The model estimates provide information on the importance of the attributes, and their levels, in farmers' decision making. Table 4.4 presents the marginal Willingness-to-accept (WTA) of farmers or the monetary amount that farmers would need to receive in order to accept the corresponding attribute, for each of the contract characteristics. Higher values of WTA indicate that farmers have a stronger aversion to that attribute.

Table 4.4. Overall farmer preferences for AES designs: Results from the conditional logit model and associated estimates of farmers' willingness to accept

Conditional Logit Model				WTA estimates		
	Estimate		Robust standard errors[1]	Estimate (EUR)		Robust standard errors
ASC practice-based	-1.097	***	0.095	182.2	***	14.4
ASC hybrid	-0.861	***	0.129	142.9	***	21.7
ASC results-based	-1.483	***	0.113	246.2	***	19.1
Practices level 2 (ref 1)	-0.187	***	0.064	31.1	***	10.4
Practices level 3 (ref 1)	-0.313	***	0.067	52.0	***	10.9
Water level 1 (ref 0)	-0.271	***	0.084	45.0	***	13.4
Water level 2 (ref 0)	-0.333	***	0.058	55.4	***	9.2
CC level 1 (ref 0)	-0.247	***	0.063	41.0	***	10.2
CC level 2 (ref 0)	-0.286	***	0.070	47.6	***	11.4
Biodiversity 1 (ref 0)	-0.029		0.064	4.9		10.7
Biodiversity 2 (ref 0)	-0.053		0.070	8.8		11.5
Share conditioned on result (%)	-0.003	**	0.001	0.4	**	0.2
Payment level (€/ha/year)	0.006	***	0.000			
Number of respondents	731					
Number of observations	4386					
AIC	11 326.35					
BIC	11 409.37					
LL	-5 650.18					

1. Robust Standard Errors computed using the sandwich estimator (R, Apollo package).
*: robust p-value < 0.10; **: robust p-value < 0.05, ***: robust p-value <0.01.

The three model constants, ASC practice-based, ASC hybrid and ASC results-based capture respectively farmers' preferences for joining a practice-based scheme with a requirement to adopt the first two practices of the menu of options, for joining a hypothetical hybrid scheme including only a requirement to adopt the first two practices of the menu of options but without accounting for the result requirements, and for joining a results-based scheme, without accounting for the result requirements. The negative signs of the constants reflect the cost of joining such schemes, which are not associated with the other attributes included in the model. These costs also include all costs associated with unobserved preferences of farmers for the three-scheme designs. Note that these constants are not directly comparable. For comparison of farmers' relative preferences for alternative scheme designs, see Table 4.5, Table 4.6and Table 4.7 which include all dimensions of scheme designs.

Table 4.5. Farmers' estimated Willingness to Accept for practice-based AES

Level of requirements	Mean WTA (EUR/ha/year)
Level 1: First 2 practices	182.2
Level 2: First 4 practices	213.3
Level 3: All 6 practices	234.2

Table 4.6. Farmers' estimated Willingness to Accept for results-based AES

Level of requirements	Mean WTA (EUR/ha/year)
Schemes with only 1 environmental objective	
Biodiversity only	246.2
Water 1 only	291.2
CC1 only	287.2
Water 2 only	301.6
CC2 only	293.8
Schemes with 2 environmental objectives	
Biodiversity and CC1	291.2
Biodiversity and Water 1	287.2
Biodiversity and CC2	301.6
Biodiversity and water 2	293.8
Schemes with 3 environmental objectives	
Biodiversity, water 1 and CC1	332.2
Biodiversity, water 1 and CC2	338.8
Biodiversity, water 2 and CC1	342.6
Biodiversity, water 2 and CC2	349.2

Table 4.7. Farmers' estimated Willingness to Accept for Hybrid AES

Level of requirement	Mean WTA (EUR/ha/year)					
	Share of payment conditioned on results					
	10%	20%	30%	50%	70%	90%
First 2 practices						
First 2 practices, biodiversity	146.9	150.9	154.9	162.9	170.9	178.9
First 2 practices, biodiversity, water 1	191.9	195.9	199.9	207.9	215.9	223.9
First 2 practices, biodiversity, water 2	202.3	206.3	210.3	218.3	226.3	234.3
First 2 practices, biodiversity, CC 1	187.9	191.9	195.9	203.9	211.9	219.9
First 2 practices, biodiversity, CC 2	194.5	198.5	202.5	210.5	218.5	226.5

Level of requirement	Mean WTA (EUR/ha/year)					
	Share of payment conditioned on results					
	10%	20%	30%	50%	70%	90%
First 2 practices, biodiversity, water 1, CC 1	232.9	236.9	240.9	248.9	256.9	264.9
First 2 practices, biodiversity, water 1, CC 2	239.5	243.5	247.5	255.5	263.5	271.5
First 2 practices, biodiversity, water 2, CC 1	243.3	247.3	251.3	259.3	267.3	275.3
First 2 practices, biodiversity, water 2, CC 2	249.9	253.9	257.9	265.9	273.9	281.9
First 4 practices						
First 2 practices, biodiversity	178	182	186	194	202	210
First 2 practices, biodiversity, water 1	223	227	231	239	247	255
first 2 practices, biodiversity, water 2	233.4	237.4	241.4	249.4	257.4	265.4
First 2 practices, biodiversity, CC 1	219	223	227	235	243	251
First 2 practices, biodiversity, CC 2	225.6	229.6	233.6	241.6	249.6	257.6
First 4 practices, biodiversity, water 1, CC1	264	268	272	280	288	296
First 4 practices, biodiversity, water 1, CC 2	270.6	274.6	278.6	286.6	294.6	302.6
First 4 practices, biodiversity, water 2, CC 1	274.4	278.4	282.4	290.4	298.4	306.4
First 4 practices, biodiversity, water 2, CC2	281	285	289	297	305	313
All 6 practices						
All 6 practices, biodiversity	198.9	202.9	206.9	214.9	222.9	230.9
All 6 practices, biodiversity, water 1	243.9	247.9	251.9	259.9	267.9	275.9
All 6 practices, biodiversity, water 2	254.3	258.3	262.3	270.3	278.3	286.3
All 6 practices, biodiversity, CC 1	239.9	243.9	247.9	255.9	263.9	271.9
All 6 practices, biodiversity, CC 2	246.5	250.5	254.5	262.5	270.5	278.5
All 6 practices, biodiversity, water 1, CC1	284.9	288.9	292.9	300.9	308.9	316.9
All 6 practices, biodiversity, water 1, CC 2	291.5	295.5	299.5	307.5	315.5	323.5
All 6 practices, biodiversity, water 2, CC 1	295.3	299.3	303.3	311.3	319.3	327.3
All 6 practices, biodiversity, water 2, CC2	301.9	305.9	309.9	317.9	325.9	333.9

Note: The red line in Table 3.7 indicates the threshold from which practices-based schemes are preferred over hybrid schemes.

Farmers preferred to be asked to implement fewer practices with lower levels of environmental results. For example, in practice-based contracts, requirement for farmers to adopt the first four practices was significantly less likely to be chosen than those requiring adoption of only two practices. Similarly, a contract with a requirement to adopt all six practices was even less likely to be chosen. The additional payment associated with having to adopt the first four practices instead of the first two practices in practice-based and hybrid schemes is estimated at EUR 31/ha to keep participation rates constant, while farmers would require an additional EUR 52/ha to adopt all six practices instead of only the first two.

Participation rates were responsive to increased water quality measures and GHG emissions reductions, but not to biodiversity outcomes. Increasing stringency for reaching water quality outcomes resulted in significantly fewer farmers choosing a results-based or hybrid scheme for a given payment level. A 50% reduction in nutrient runoff had a stronger negative effect on choosing a results-based contract than a requirement for a reduction of 25% in nutrient runoff. Similarly, farmers had negative preferences for stronger climate change (CC) objectives in results-based and hybrid schemes. Together, these two attributes are associated with higher WTA values: that is, for farmers to accept to join an AES (hybrid or results-based) requiring them to reduce their runoff by 25%, rather than a similar contract without water quality related objectives, farmers would require an additional payment of about EUR 45/ha, rising to EUR 55.4 for a 50% reduction. For farmers to commit to a 25% reduction in GHG net-emissions from the farm, relative to a similar contract with no objective related to GHG net-emissions, would require an additional payment of EUR 41/ha, rising to EUR 47.6 for a commitment to reduce emissions by 50%.[7] In contrast, objectives related to biodiversity do not appear to be a deterrent to farmers' participation and choice of an option. That is, farmers' choice of an AES did not seem to be impacted by the presence of biodiversity results-based objectives.

Finally, the share of the payment based on results had a negative effect on their choice of a hybrid AES: the higher the share dependent upon the achievement of specific results, the less likely farmers were to choose this option. Farmers would require an additional EUR 0.40/ha for a one percentage point increase in the share (e.g. EUR 4/ha for 10% of the payment conditioned on results, EUR 8/ha for 20%, EUR 12/ha for 30% and up to EUR 36 per hectare if 90% if the payment was conditioned on results).[8]

The total payment for alternative schemes are presented in Table 4.5 for practice-based AES, Table 4.6 for results-based AES, and Table 4.7 for hybrid schemes. The red line in Table 4.7 indicates the threshold from which practices-based schemes are preferred over hybrid schemes.

Results show that hybrid schemes are always preferred to practice-based schemes with the same level of requirement when only biodiversity objectives are included in the hybrid schemes (first rows of the three level of requirement blocks in Table 4.7). This result holds despite the fact that such hybrid payment schemes include practice-based requirements based on biodiversity objectives and a share of payment conditioned on results. However, as soon as water quality protection and climate change mitigation objectives are added to the hybrid scheme requirements, pure practice-based schemes are preferred to hybrid schemes with the same requirements in terms of practices to be implemented.

We also note that hybrid schemes are always preferred to results-based schemes with the same environmental objectives.

Heterogeneity by country and farm specialisation

In terms of cross-country and cross-specialisation comparisons, the relatively small sample size means that the results should be interpreted with caution. Nevertheless, the relative preferences of farmers for AES designs were similar between the countries studied, and consistent with the overall analysis presented above Annex Table 4.D.1 and Annex Table 4.D.3. While farmers in the Netherlands, and in Sweden to a lesser extent, displayed higher WTA values than Finnish farmers, the sample sizes in the Netherlands and Sweden were small.

The share of payments conditioned on results mattered for mixed farmers, while arable farmers did not appear to be significantly deterred by the share of results-based payment in their choice of AES. Similarly, having to adopt four practices of the list of practices, instead of only the first two, did not appear to have a significant effect on arable farmers' choices, whereas it did have a significant negative effect for mixed farmers. For example, arable farmers were not deterred by having to establish cover (or catch) crops on 10% of their arable land and having to reduce their pesticide use by 20% while mixed farmers were.

The results (Table 4.8) also show that arable farmers tended to require higher payment levels than mixed farmers to participate in equivalent AES, but the additional payments associated with higher levels of requirements were higher for mixed farmers than for arable farmers (with the exception of the second level of water quality objectives).

Table 4.8. Willingness to accept estimates per farm specialisation

WTA estimates (Delta Method) Based on Conditional Logit	Pooled			Arable			Mixed farming		
	Estimate (EUR)		Robust Standard Errors	Estimate (EUR)		Robust Standard Errors	Estimate (EUR)		Robust Standard Errors
ASC practice-based	182.2	***	14.4	200.6	***	18.24	149.9	***	23.17
ASC hybrid	142.9	***	21.7	166.6	***	27.79	99.4	***	34.73
ASC results-based	246.2	***	19.1	258.3	***	24.75	221.4	***	29.9
Practices 2 (ref 1)	31.1	***	10.4	18.9		13.36	50.2	***	16.33
Practices 3 (ref 1)	52.0	***	10.9	43.6	***	13.4	65.5	***	18.66
Water 1 (ref 0)	45.0	***	13.4	36.8	**	16.79	59.3	***	22.37
Water 2 (ref 0)	55.4	***	9.2	74.2	***	11.9	30.9	**	14.56
CC 1 (ref 0)	41.0	***	10.2	52.7	***	12.84	25.4		17.09
CC2 (ref 0)	47.6	***	11.4	59.4	***	14.63	28.8		18.31
Biodiversity 1 (ref 0)	4.9		10.7	9.1		13.78	0.6		17.23
Biodiversity 2 (ref 0)	8.8		11.5	-4.4		13.87	29.9		19.94
Share conditioned on result	0.4	**	0.2	0.2		0.2248	0.7	**	0.2739

Note: *: p-value < 0.10; **: p-value < 0.05, ***: p-value <0.01.

The role of behavioural factors in explaining farmers' preferences

A latent class analysis was conducted to determine which farmer characteristics explained preferences for contract attributes. First, clusters of farmers were generated to reduce the number of socioeconomic and behavioural characteristics as explanatory variables to class membership. All clusters were independent from each other, meaning that a respondent could belong to cluster 1 in terms of their farm characteristics, while they may belong to cluster 2 or 3 based on their own individual characteristics. The details of the process are explained in Annex 4.E.

The latent class analysis shows that preferences for AES design were strongly associated with behavioural characteristics and environmental preferences, but not with farm and farmers' characteristics. Based on the clusters, two classes of farmers based on behavioural characteristics explain most of the differences between farmers' WTA:

- *Class 1.* Includes a majority of respondents (63.35%) who displayed a more positive attitude towards AESs, as shown by the positive sign of the constants for the three designs of AESs. Farmers belonging to class 1 displayed the expected preferences for all scheme characteristics: the higher the requirements in terms of practices and results, the less likely they were to join, and the higher the share of payment conditioned upon results, the less likely they were to choose hybrid AES. These farmers tended to give relatively more value to the longer-term consequences of their actions; to perceive a need for environmental change; and to be more aware of the effects of farming on the environment, while also feeling more responsible for environmental issues than farmers belonging to class 2. This result aligns well with the Theory of Planned Behaviour and the Value-Belief-Norm models, in which awareness of consequences, ascription of responsibility and perceived behavioural control are described as key factors shaping intentions of behavioural change. Finnish farmers were more likely than farmers from the Netherlands to belong to this class. Farmers who reported more positive feedback to the survey were also more likely to belong to class 1. They were also on average more confident in their ability to adopt the practices or achieve the results required by the proposed schemes.
- *Class 2.* Farmers that were more risk averse (behavioural cluster 1) were more likely to belong to class 2, and therefore to prefer not to join AES. These farmers tended to express a lower perceived need for environmental change; less awareness of the consequences of farming on the

environment; and lower levels of ascription of responsibility and behavioural control over environmental quality. This can explain the relatively stronger negative effect of all AES requirements on their choices to join an AES and their overall negative perception of AES, whatever their design. Farmers who found the survey too complex, found that the payments were too low, gave lower levels of credibility to the survey and provided less consistent answers were more likely to belong to this class. These farmers also stated being less confident in their ability to adopt the practices or to achieve the objectives set in the proposed AESs, while fearing that these would put their farm profitability at risk. Finally, they also tended to have lower levels of trust in the monitoring of the proposed AESs. Class 2 of farmers comprised 36.7% of the sample. They were likely to increase the average WTA in the conditional logit analysis.

Table 4.9 presents WTA estimates for these two classes of farmers, based on their individual characteristics (age, education, status), behavioural characteristics (risk, time, and environmental attitudes), and their responses to follow-up questions.[9]

Farmers belonging to class 2 showed strong negative preferences towards all three AES designs, while farmers belonging to class 1 preferred to adopt any AES rather than not participating, as demonstrated by the significant and positive values of the three Alternative Specific Constants (ASC). The relative preferences between the three designs, practice-based, results-based or hybrid schemes, everything else constant, remained the same however, with both classes preferring hybrid schemes over practice-based schemes and over results-based schemes.

Table 4.9. WTA estimates for farmers' behavioural classes

Based on Conditional Logit	Estimate (EUR)		Robust standard errors	Estimate (EUR)		Robust standard errors
ASC practice-based	-130.3	***	34.69	383.2	***	43.79
ASC hybrid	-174.8	***	37.2	343	***	72.49
ASC results-based	-60.1		32.0	377.7	***	53.02
Practices 2 (ref 1)	35.6	***	11.0	113.9	***	33.34
Practices 3 (ref 1)	53.7	***	11.6	185.9	***	39.7
Water 1 (ref 0)	45.5	***	13.8	69.17		72.53
Water 2 (ref 0)	41.4	***	9.4	98.05	***	28.35
CC 1 (ref 0)	29.3	**	10.4	98.04	***	29.75
CC2 (ref 0)	41.0	***	11.7	98.51	***	30.85
Biodiversity 1 (ref 0)	12.6		10.7	-4.421		28.34
Biodiversity 2 (ref 0)	17.4		13.2	23.59		31.69
Share conditioned on result	0.4	**	0.2	1.084		1.161

Note: *: p-value < 0.10; **: p-value < 0.05, ***: p-value <0.01.

4.4. Conclusions

In contrast to the cost-effectiveness analysis performed based on policy simulations, the choice experiment shows that farmers always tended to prefer hybrid contracts (payment depends on both implementing practices and achieving results), or practice-based schemes over results-based contracts. The references between practice-based and hybrid schemes depended on the level of results-based requirement included in the hybrid schemes. For low levels of results-based objectives (biodiversity only), hybrid schemes were preferred over practice-based schemes including the same practice-based requirements. When introducing requirements to reduce nutrient runoff to improve water quality and/or requirement to reduce net GHG emissions to mitigate climate change in hybrid schemes, practices-based schemes were always preferred over hybrid schemes including the same practice-based requirements. These preferences were stable across farm type (arable and mixed) and farmer behavioural characteristics.

The results from the conditional logit estimation reveal several notable findings. First, farmers preferred less complicated to more complicated contracts. The average willingness to accept contracts with a low level of environmental requirements for practice-based schemes (i.e. adopting two practices) is EUR 182/ha/year. The average willingness to accept for adopting a hybrid scheme with the lowest level of environmental requirements (adopting two practices and achieving biodiversity objectives) varies from EUR 147/ha/year if 10% of the payment in conditioned upon results being achieved up to EUR 179/ha/year if 90% of the payment is conditioned upon results. In the case of results-based schemes, the average amount farmers would require to adopt a contract with the lowest level of environmental requirements (i.e. biodiversity objectives only) is EUR 246/ha/year. Those estimates increased with the level of environmental requirements. For example, in the case of practice-based schemes, relative to the option with two practices, the payment level would need to increase by 17% for contracts requiring the adoption of four practices and by 28% for practice-based contracts requiring the adoption of six practices.

Second, as expected, stricter environmental requirements would require higher payments to incentivise farmers to join the scheme. For example, in the case of hybrid payments and relative to “First 2 practices, Biodiversity and 10% share of payment conditioned on the results”, a requirement to reduce nutrient runoff by 25% or 50% would require an increase in payment by EUR 45/ha (31%) or an increase in payment by EUR 55.4/ha (38%), respectively. The additional payment needed to convince farmers to sign up into contracts that required farmers to reduce net GHG emissions by 25% or 50% are EUR 41/ha and EUR 48/ha, respectively.

Third, for hybrid contracts, which combine elements of both the results-based and practice-based schemes, the greater the share of the payment conditioned on achieving results, the higher the payment required by farmers. Farmers require an additional payment of EUR 0.4/ha for each percentage increase in the payment share based on achieving results (e.g. EUR 4/ha for 10% of the payment conditioned on results, EUR 8/ha for 20%, EUR 12/ha for 30% and up to EUR 36/ha if 90% of the payment is conditioned on results).

Fourth, arable farmers tended to show greater willingness to accept levels in order to participate in AES contracts, regardless of contract type (hybrid, results-based or practice-based). For hybrid contracts, the offered payment (EUR 167/ha) needed to be 68% higher for arable farms than the payment needed for mixed farmers to participate (EUR 99/ha).

Finally, one advantage of choice experiments is that they can identify the role that behavioural factors play in farmers’ willingness to accept AES contracts. Using a latent class model estimation, we show that farmers that were more risk averse, who expressed a lower need for environmental change, and were less aware of the consequences of farming on the environment tended to have higher WTA. Strikingly, payments needed to be twice as large as the average payment for those farmers to participate in AES contracts. This premium is consistent with previous work that argues that results-based schemes expose farmers to a higher uncertainty of the amount of payment and therefore necessitate a risk premium. An analysis of the potential effectiveness of a Payment-by-Results approach to the delivery of environmental public goods and services supplied by Agri-Environment Schemes (Schwartz, 2008[5]; Andeltová, 2018[6]; Zabel and Roe, 2009[7]), and that concern for the environmental is likely to positively affect enrolment in agri-environmental schemes (Toma and Mathijs, 2007[8]; Best, 2010[9]; Läpple and Rensburg, 2011[10]);

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Annex 4.A. Summary of focus groups and pilot survey

Focus groups

Focus groups are meetings organised by a chair, usually someone co-ordinating the survey, to obtain feedback on the survey from participants from the pool of potential survey respondents. They are particularly helpful to gain information on how to improve surveys along a number of dimensions. One is to improve the consequentiality of the survey (i.e. the survey conveys that respondents' answers have real consequences influencing policy design). Focus groups help to determine the best language to be used to convey to respondents that their answers have real consequence. The second is to improve the comprehension of the experiment by participants (i.e. do supported activities make sense? Are choices credible and achievable? Are payments too high or low?). Clearly explaining the process of the experiment itself is an essential component for farmers to understand how to make choices about their preferred options. Finally, the third is to improve the information provided about the potential agri-environmental schemes so that farmers make informed choices about the potential options.

Ideally, focus groups should be held physically to facilitate the interaction among participants. Due to the effects of the COVID-19 pandemic, in Argentina, Finland and the Netherlands, the focus groups were organised online and were successful at delivering feedback.

In Finland, five farmers specialised in different crops and with different farm sizes, participated in the focus group. In Argentina there were six farmers, some of which were tenants and others were landowners and also with different specialisations. In the Netherlands, five farmers that specialised in mixed farming (both crops and livestock) participated in the focus groups.

The focus groups provided essential feedback about the comprehension of the survey, the information provided about the practices and the design of the choice cards. Notably, farmers were particularly concerned with how some of the instructions and measurement of the practices were communicated. As a result, the description of the choice experiment and of the individual practices were revised to take into account the concerns which significantly improved comprehension. Further, the way that the schemes and certain practices were described was changed significantly as farmers perceived that the questionnaire was too normative and in favour of results-based schemes.

Pilot survey

A pilot survey based on the current design of the questionnaire and choice cards was launched in the beginning of September 2020 and completed in January 2021. Argentina, Canada, Finland, and Sweden participated in the pilot survey. The pilot survey served both to test the overall questionnaire design and to calibrate the payments and parameters for the choice card experiment.

In general, conducting pilots is instrumental in the efficient design of choice experiments which provide more precise model estimates (even with relatively small sample sizes). To generate an efficient design, prior values are needed for the model parameters (the weights of each attribute in respondents' choices). Pilots are the best instruments for obtaining reliable prior values. The pilot also permits to the test the full questionnaire with farmers.

In collaboration with the partnering institution in each participating country, a translated version of the survey was input into LimeSurvey in which they sent out the link to the survey along with an explanation about the process, an explanation of anonymity, the goals of the survey and a suggested time in which to complete it. In each country, the survey was sent to over 100 farmers with the goal to have at least 20 completed responses of the survey in each country. To have representation of both crop cultivation farmers and those with a mix between crops and livestock, each country except for Argentina that focused on crop farms, sent the survey to an equal number of farmers in each group. All responses were anonymous, and the surveys were stored on a secured OECD server.

The data collection began in November 2020 and continued through January 2021. The data collection took longer than expected due to the relatively low response rate of the survey. While this delayed data collection, it was clear that monetary incentives would be needed to both increase the response rate and the speed of the data collection. As a result, monetary incentives will be included in the launch of the final survey in March 2021.

Overall, the survey was accessed by 1 212 individuals from Sweden, Finland, Argentina, and Canada. Over 76% (n=932) of the respondents did not pass the landing page of the survey, so did not start answering it. To address this issue, the length of the introduction on the first page was reduced and checks were in place to ensure that there are no errors in moving forward past the first page. Of the remaining 280 participants, 88 were screened out through the screening question, showing that the screening is working well, and only mixed farmers and arable farmers were kept in the survey. There was further dropout throughout the survey.

Due to the complexity of the choice cards and the payment schemes, the survey includes comprehension questions. This was another point in which farmers dropped out of the survey (~14 individuals). It is reassuring that a large share of respondents (80%) provided the correct answer to these quiz questions, showing that the explanations provided were clear. Results from the initial analysis suggested that the questions to ensure that farmers understand the structure of payments under the different alternatives are expanded. These will be included in the final survey.

Data collection

Data collection for the choice experiment survey was conducted in partnership with the respective partner organisations in Finland, the Netherlands, and Sweden. The finalised survey instrument was adapted to each country context and was implemented on LimeSurvey. In each country, the survey invitation was sent by email to a large sample of representative farmers. The email informed farmers about the purpose of the survey and the role it may play in policy making. Monetary incentives were used to increase response rates, and they varied by country in the value and type. In Finland and Sweden, farmers were informed that they would be entered into a lottery to win a prize (roughly EUR 50) if they completed the survey. In the Netherlands, farmers each received a small amount for their participation.

Data collection occurred during May and June 2021. We obtained a total of 731 submitted answers to the questionnaire, including 270 responses for the mixed farming version of the questionnaire and 461 for the arable version of the questionnaire. In terms of participation per country, 357 farmers completed the questionnaire in Finland, 230 from Sweden, and 144 from the Netherlands.

Annex 4.B. Methodological framework

General methodological framework for the analysis of discrete choice data

The Conditional Logit Model

Respondents were asked to choose their preferred contract alternative on a series of six choice cards in the survey. We analyse this choice data using first a Multinomial Logit (McFadden, 1974[11]), which is based on the Random Utility Theory. Under this framework, the utility provided by an alternative contract *i* to individual *n*, $U_{i,n}$, can be decomposed in a deterministic and observable element $V_{i,n}$, and a random term, $\varepsilon_{i,n}$, as follows:

$$U_{i,n} = V_{i,n} + \varepsilon_{i,n}$$

The observable part is a linear function of the characteristics of the contract (its attributes). On each choice card, farmers were presented with 3 different alternative contracts, each having different characteristics. We call X_i the vector of *K* attributes *k* of a contract *i* presented to farmers on a choice card. The observable part of the utility function is therefore defined as:

$$V(X_i) = \sum_{k=1}^{K} \beta_{ik}\, x_{ik}$$

With β_{ik} the weight of alternative *i*'s attribute *k* on utility. These betas are the parameters of interest that we aim to estimate.

In the context of the current choice experiment with labelled alternatives, V_i is a function of different attributes depending on the alternative that is being considered:

In a practices-based alternative, the observed part of the utility is a function of the practices to be implemented ($X_{practices}$), the level of payment ($X_{payment}$) and a constant reflecting the general preferences for practices-based schemes that not reflected in the attributes presented on the choice card ($\delta_{practices}$, called the Alternative Specific Constant ASC). Therefore, the utility associated with a practice-based alternative is defined as:

$$V_{practices} = \delta_{practices} + \beta_{practices}X_{practices} + \beta_{payment}X_{payment}$$

In a results-based alternative, the observed part of the utility is a function of the results to be achieved in terms of water quality (X_{water}), climate change mitigation (X_{cc}) and biodiversity ($X_{biodiversity}$), and the level of payment ($X_{payment}$) and a constant reflecting the general preferences for results-based schemes that not reflected in the attributes presented on the choice card (δ_{result})results-based:[10]

$$V_{result} = \delta_{result} + \beta_{water}X_{water} + \beta_{cc}X_{cc} + \beta_{biodiversity}X_{biodiversity} + \beta_{payment}X_{payment}$$

In a hybrid scheme alternative, the observed part of the utility is a function of both the practices to be implemented ($X_{practices}$), and the results to be achieved in terms of water quality (X_{water}), climate change mitigation (X_{cc}) and biodiversity ($X_{biodiversity}$), the share of payment conditioned upon results (X_{share}), the level of payment ($X_{payment}$) and a constant reflecting the general preferences for results-based schemes that not reflected in the attributes presented on the choice card (δ_{hybrid}):

$$V_{hybrid} = \delta_{hybrid} + \beta_{practices}X_{practices} + \beta_{water}X_{water} + \beta_{cc}X_{cc} + \beta_{biodiversity}X_{biodiversity} + \beta_{share}X_{share} + \beta_{payment}X_{payment}$$

We work under the assumption that, on a choice card, a farmer *n* will choose the alternative *i* that would provide them with the highest level of utility, so that the probability that an individual *n* chooses alternative *i*, over alternative *j* on choice card C_t is:

$$P_{in} = P\left[V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}, \forall j \in C_t, j \neq i\right]$$

Assuming that the random term ε_{in} is Identically and Independently Distributed (IID) following a Gumble distribution, we obtain the conditional logit model (McFadden, 1974[11]), with the probability of individual n choosing alternative *i* over *J* other alternatives on a choice card defined as:

$$P_{in} = \frac{exp(\beta_i^{'} X_i)}{\sum_{j=1}^{J} exp\left(\beta_j^{'} X_j\right)}$$

The beta parameters of the model are estimated using maximum likelihood.

The Latent Class Model

When introducing a discrete distribution of betas in the population we obtain the latent class model, which identifies classes of respondents that share the same preferences (same betas). Conditioned on belonging to class s, the probability of individual n choosing alternative *i* is defined as in the conditional logit model by:

$$P_{in|s} = \frac{exp(\beta_{s_i}^{'} X_i)}{\sum_{j \in C} exp(\beta_{s_j}^{'} X_j)}$$

The unconditional probability of choice over T choices is therefore defined as:

$$P_{in} = \sum_{s=1}^{S} M_{n,s} \prod_{t=1}^{T} \frac{exp(\beta_s x_{it})}{\sum_{j=1}^{J} exp(\beta_s x_{jt})}$$

With Mn,s the probability that individual n belongs to class s.

$$M_{n,s} = \alpha_s Z_n + \mu_{ns}$$

This probability itself is estimated using a Multinomial logit model and depends on individuals' characteristics (vector Zn) as follows:

$$M_{n,s} = \frac{exp(\alpha_s' Z_n)}{\sum_{s=1}^{S} exp(\alpha_s' Z_n)}$$

With αs the vector parameters representing the weights of individual characteristics Zn in the probability of class membership.

In the next section we present how these two modelling approaches (conditional logit and latent class models) were successively implemented in the analysis of the choice experiment data.

Overview of the analysis and model specifications

Data validation: before proceeding to the analysis, the range of responses for each variable was checked and compared to expected values and the coherence of responses was verified for the values entered for the farm acreage and repartition between arable land, grassland and other type of land. We identified one respondent with responses outside the range of expected values to all questions and a systematic choice of "I would not participate" on the choice cards. This respondent was therefore considered as a protest respondent and their responses considered as unreliable and was dropped for the analysis. All other respondents were kept in the dataset. Responses to the current usage of fertilisers were also inconsistent between respondents and were not included in the analysis.

The first analysis of farmers' choices and preferences for alternative AES designs was performed using a conditional logit model on the overall data, and then per country and per farm specialisation. All these models share the same specifications and account for the panel structure of the data (each respondent making a series of six choices, the six choices of a single respondent are not independent): robust standard errors, t-ratios and associated p-values are computed using the 'sandwich' estimator, which corrects standard errors accordingly. The Apollo software in R (Hess and Palma, 2019[12]) was used for the choice modelling. Farmers' Willingness to Accept (WTA) were estimated based on the conditional logit models results, as the ratio of the parameter associated over the attribute of interest and the price parameter, through the Delta method using the same package on R. For a full description of the Delta method and how it can be used to estimate WTA, please refer to (Daly, Hess and de Jong, 2012[13])

We then proceeded to a clustering of all respondents based on their socio demographic, farm and behavioural characteristics as well as their baseline agri-environmental characteristics on Stata. We used a K-means partitioning, based on the Dice similarity coefficient for clusters based on binary variables, and the Gower coefficient for clusters relying on a mix of continuous and binary variables. The number of clusters for each clustering exercise was determined using a combination of the following criteria: the within sum of squares for different numbers of clusters (2 to 20) (Makles, 2012[14]) and the ability to generate clusters of reasonable size with distinct and significant different characteristics that are coherent, while keeping the number of clusters reasonably low as these need to be usable in the latent class analysis.

Using the cluster membership as explanatory variables for the different classes of respondents, we performed a latent class analysis with the Apollo software in R (Hess and Palma, 2019[12]) in order to identification of groups of farmers with homogeneous characteristics and preferences.

Annex 4.C. Descriptive statistics and variable definitions

Annex Table 4.C.1. Descriptive statistics: Farm characteristics

Descriptives for farm characteristics

Variable	Nb of observations	Mean (SD)	Min	Max
Total Farm Land (ha)	723	160.1 (266.3)	1.0	3 500.0
Including:				
Arable Land (ha)	705	70.8 (106.7)	0.0	1 760.0
Permanent Grassland (ha)	671	10.3 (26.8)	0.0	350.0
Average Field Size (ha)	721	6.8 (16.2)	0.0	200.0
Livestock (for mixed farming systems):				
Dairy cattle (livestock units)	92	53.1 (65)	0.0	425.0
Beef cattle (livestock units)	137	44.9 (71.5)	0.0	550 137.0
Sheep (livestock units)	94	56.8 (100.7)	0.0	500.0
Other livestock (nb)	98	1825.4 (16174.6)	0.0	160 000.0
Distance closest grazing field (km)	258	0.2 (0.8)	0.0	10.0
Distance most distant grazing field (km)	258	5.4 (10)	0.0	70.0
Distance most of grazing fields (km)	251	3.3 (18.8)	0.0	216.0
Land tenure: Owned (ha)	698	74.9 (206.2)	0.0	4 550.0
Land tenure: Leased (ha)	640	33.2 (62.2)	0.0	850.0
Land tenure: Commons (ha)	487	15.1 (50.2)	0.0	500.0
Workforce on farm:				
Full-time workforce	572	1.4 (1.6)	0.0	18.0
Part-time workforce	547	1.4 (1.7)	0.0	20.0
Share farm income in household income (%)	528	36.7 (27.6)	0.0	100.0

Annex Table 4.C.2. Descriptive statistics: Farm characteristics (*continued*)

Further descriptives for farm characteristics

	Frequency	Percentage	Cumulative
Other source of income			
No	184	25.6	25.6
Yes	534	74.4	100
Organic farming			
No	611	83.6	83.6
Yes	120	16.4	100

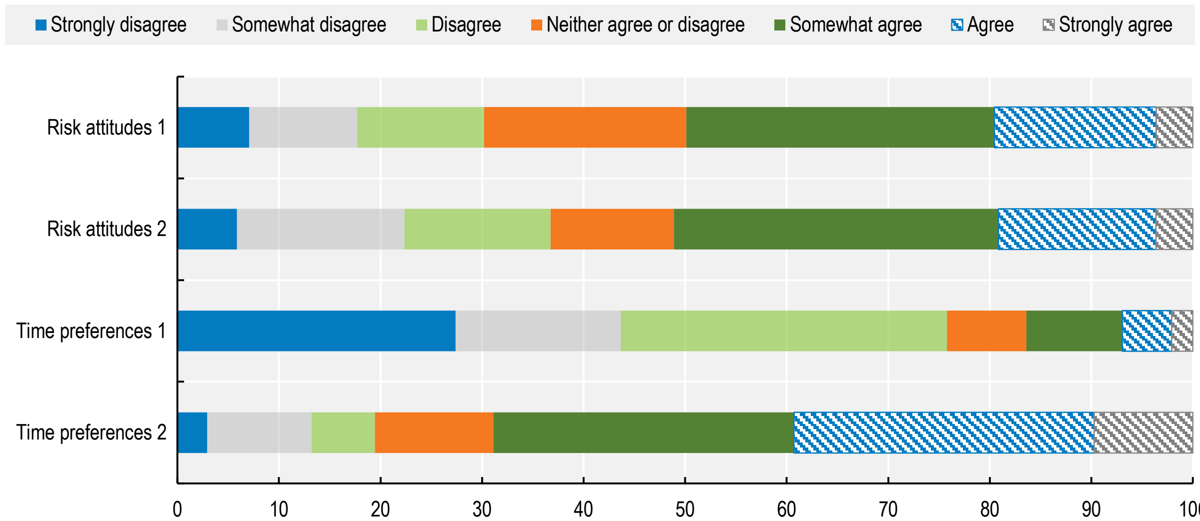
Annex Table 4.C.3. Descriptive statistics: Socio-demographic characteristics

Descriptives for socio-demographic characteristics

Variable	Frequency	Percentage	Cumulative
Gender			
Female	62.0	8.6	8.6
Male	650.0	89.7	98.3
Prefer not to say	10.0	1.4	99.7
Other	3.0	0.4	100.0
Age			
18 - 34	39.0	5.4	5.4
35 - 44	116.0	16.0	21.4
45 - 54	193.0	26.7	48.1
55 - 64	219.0	30.3	78.3
> 65	142.0	19.6	97.9
Prefer not to say	15.0	2.1	100.0
Education			
None	2.0	0.3	0.3
Minimum compulsory	27.0	3.7	4.0
High school diploma in agriculture	108.0	14.9	18.9
High school diploma not in agriculture	78.0	10.8	29.7
Vocational training in agriculture	174.0	24.1	53.8
Vocational training not in agriculture	98.0	13.6	67.4
University degree in agriculture	92.0	12.7	80.1
University degree not in agriculture	100.0	13.8	93.9
Other	44.0	6.1	100.0
Farmer status			
Full-time farmer	419.0	58.2	58.2
Part-time farmer	264.0	36.7	95.5
Farm employee	4.0	0.6	96.1
Other	33.0	4.6	100.0

Annex Figure 4.C.1. Risk and time attitudes

Statements used to elicit attitudes to risk and time preferences are presented in Annex Table 4.C.4

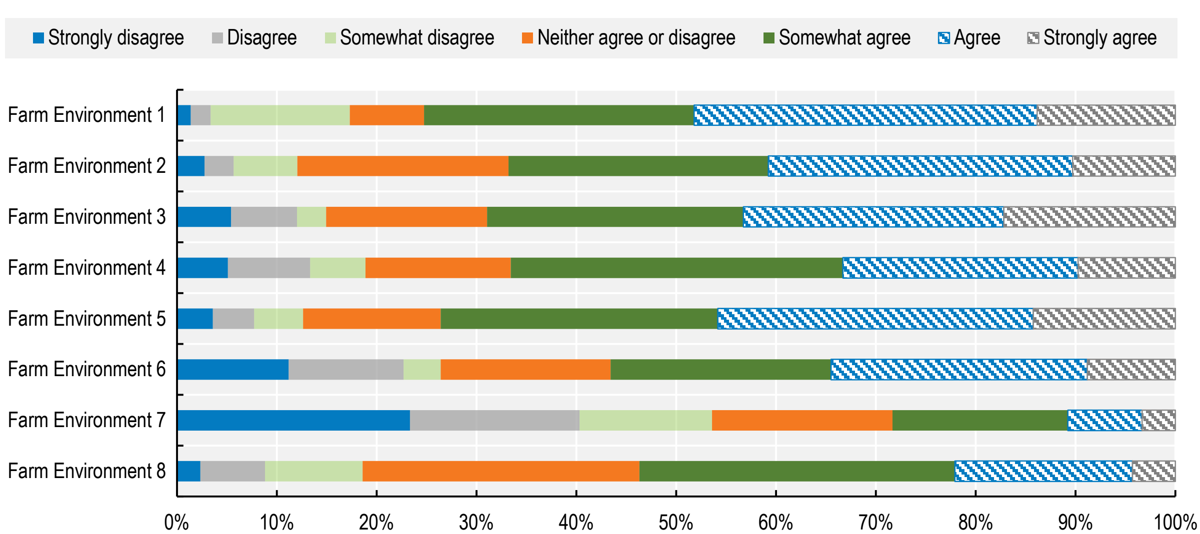


Annex Table 4.C.4. Statements used to elicit risk attitudes and time preferences

Risk attitudes 1	I am willing to adopt new farming practices that may or may not pay off in the future
Risk attitudes 2	I am generally willing to take risks when managing my farm
Time preferences 1	My farm management decisions are only influenced by the consequences of my actions within the current farming season and not beyond
Time preferences 2	Often, I manage my farm in order to achieve outcomes that may not result for many years

Annex Figure 4.C.2. Awareness of and ascription of responsibility for environmental issues

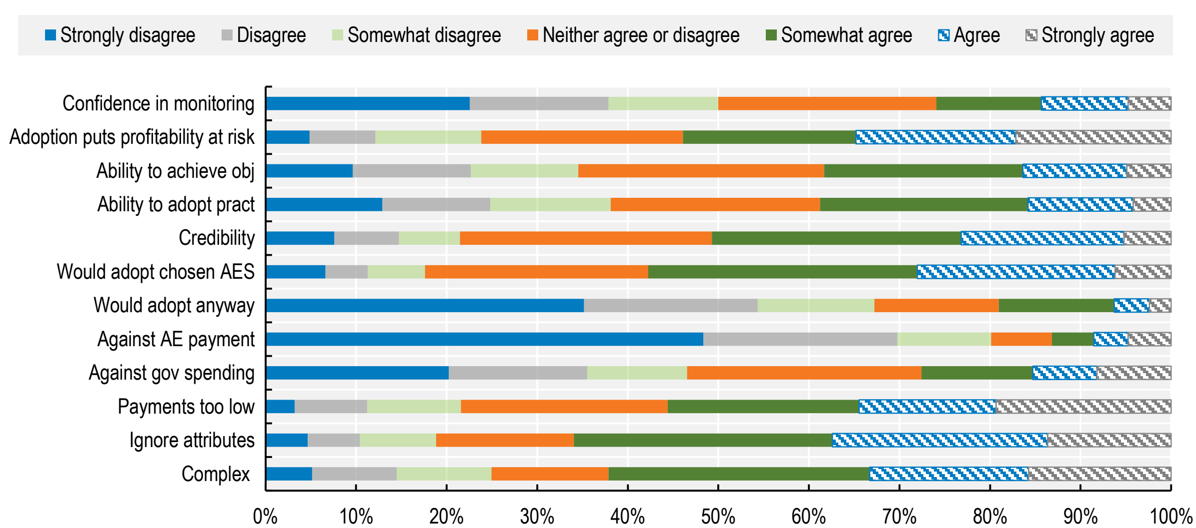
Statements used for elicitation are presented in Annex Table 4.C.5



Annex Table 4.C.5. Statements used to elicit attitudes towards the environment

Farm environment 1	The environment around me is doing okay (shifting baseline theory – perception of environmental change)
Farm environment 2	The environment around me has gotten better over the past five years (shifting baseline theory – perception of environmental change)
Farm environment 3	Global warming is a serious threat (perception on environmental issues)
Farm environment 4	Farming practices directly impact the health of the environment (awareness of consequences)
Farm environment 5	Farming using environmentally friendly practices can improve the health of the environment (awareness of consequences)
Farm environment 6	I feel responsible for local environmental issues (ascription of responsibility)
Farm environment 7	I feel responsible for international or global environmental issues (e.g. global warming) (ascription of responsibility)
Farm environment 8	The farmers in my area are willing to adopt (or have already adopted) farming practices to improve environmental outcomes (social norms)

Annex Figure 4.C.3. Responses to survey follow-up questions



Annex 4.D. Model extensions and detailed tables

To complement the main analysis, we analyse separately the choices made by farmers from each participating country and for each farm specialisation (mixed farmers or arable farmers).

Annex Table 4.D.1. Cross country comparison of farmers' preferences for AES designs: Results from conditional logit models

Conditional Logit Model	Finland			Sweden			Netherlands		
	Estimate		Robust Standard Errors	Estimate		Robust Standard Errors	Estimate		Robust Standard Errors
ASC practice-based	-1.011	***	0.139	-0.967	***	0.166	-1.447	***	0.220
ASC hybrid	-0.624	***	0.181	-0.872	***	0.232	-1.383	***	0.321
ASC results-based	-1.413	***	0.162	-1.398	***	0.207	-1.644	***	0.244
Practices 2 (ref 1)	-0.147		0.090	-0.324	***	0.114	-0.022		0.159
Practices 3 (ref 1)	-0.291	***	0.092	-0.279	**	0.125	-0.461	***	0.166
Water 1 (ref 0)	-0.400	***	0.117	-0.259	*	0.155	0.125		0.194
Water 2 (ref 0)	-0.416	***	0.085	-0.207	**	0.099	-0.334	**	0.135
CC 1 (ref 0)	-0.352	***	0.094	-0.112		0.103	-0.207		0.145
CC 2 (ref 0)	-0.318	***	0.097	-0.245	**	0.125	-0.337	*	0.189
Biodiversity 1 (ref 0)	-0.177	*	0.091	0.217	**	0.109	-0.190		0.169
Biodiversity 2 (ref 0)	-0.093		0.098	0.062		0.128	-0.218		0.164
Share conditioned on result	-0.003	**	0.001	-0.002		0.002	-0.002		0.003
Payment level	0.007	***	0.001	0.005	***	0.001	0.004	***	0.001
Number of respondents	357			230			144		
Number of observations	2142			1380			864		
AIC	5481.22			5481.22			2043.05		
BIC	5554.93			5554.93			2104.95		
LL	-2727.611			-1814.703			-1008.523		

*: robust p-value < 0.10; **: robust p-value < 0.05, ***: robust p-value <0.01
Note that a Likelihood Ratio Test shows that the difference between the coefficents associated with 2 levels of the CC attribute (CC1 and CC2) in Finland is not significantly different from 0 (p-value = 0.729), similarly a LR test shows that the difference between Practices 2 and 3 in Sweden is not significantly different from 0 (p-value = 0.671), neither are Water 1 and Water 2 in Sweden (p-value =0.729).

Annex Table 4.D.2. Estimated willingness to accept per country

WTA estimates (Delta Method) UR	Finland Estimate (EUR)		Finland Robust Standard Errors	Sweden Estimate (EUR)		Sweden Robust Standard Errors	Netherlands Estimate (EUR)		Netherlands Robust Standard Errors
ASC practice-based	137.2	***	16.9	181.3	***	29.0	368.4	***	67.7
ASC hybrid	84.7	***	24.7	163.8	***	44.0	352.0	***	102.2
ASC results-based	191.7	***	22.2	262.2	***	38.0	418.3	***	85.3
Practices 2 (ref 1)	19.9		12.1	60.9	***	19.9	5.5		40.2
Practices 3 (ref 1)	39.5	***	12.2	52.3	**	22.9	117.3	***	42.2
Water 1 (ref 0)	54.3	***	15.1	48.6	*	28.3	-31.9		52.7
Water 2 (ref 0)	56.5	***	11.0	38.9	**	18.5	85.0	***	30.3
CC 1 (ref 0)	47.8	***	12.7	21.0		19.0	52.6		35.5
CC2 (ref 0)	43.2	***	12.9	46.1	**	23.0	85.9	*	46.6
Biodiversity 1 (ref 0)	24.1	*	12.5	-40.8	**	20.6	48.5		43.5
Biodiversity 2 (ref 0)	12.6		13.2	-11.6		24.2	55.4		40.9
Share conditioned on result	0.5	**	0.2	0.4		0.4	0.5		0.7

Note: *: p-value < 0.10; **: p-value < 0.05, ***: p-value <0.01.

Annex Table 4.D.3. Comparison of farmers' preferences for AES designs by farm specialisation: Results from conditional logit models

Conditional Logit Model	Pooled			Arable			Mixed farming		
	Estimate		Robust standard errors	Estimate		Robust standard errors	Estimate		Robust standard errors
ASC practice-based	-1.097	***	0.095	-1.212	***	0.122	-0.904	***	0.152
ASC hybrid	-0.861	***	0.129	-1.007	***	0.164	-0.600	***	0.208
ASC results-based	-1.483	***	0.113	-1.560	***	0.147	-1.336	***	0.178
Practices 2 (ref 1)	-0.187	***	0.064	-0.114		0.081	-0.303	***	0.105
Practices 3 (ref 1)	-0.313	***	0.067	-0.264	***	0.082	-0.395	***	0.116
Water 1 (ref 0)	-0.271	***	0.084	-0.222	**	0.106	-0.358	**	0.141
Water 2 (ref 0)	-0.333	***	0.058	-0.448	***	0.075	-0.186	**	0.090
CC 1 (ref 0)	-0.247	***	0.063	-0.319	***	0.077	-0.153		0.106
CC2 (ref 0)	-0.286	***	0.070	-0.359	***	0.089	-0.174		0.113
Biodiversity 1 (ref 0)	-0.029		0.064	-0.055		0.083	-0.003		0.104
Biodiversity 2 (ref 0)	-0.053		0.070	0.027		0.084	-0.180		0.122
Share conditioned on result	-0.003	**	0.001	-0.001		0.001	-0.004	**	0.002
Payment level	0.006	***	0.000	0.006	***	0.000	0.006	***	0.001
Number of respondents			731			461			270
Number of observations			4386			2766			2766
AIC			11326.35			7053.31			4266.18
BIC			11409.37			7130.34			4336.26
LL			-5650.176			-3513.654			-2120.092

Note: *: robust p-value < 0.10; **: robust p-value < 0.05, ***: robust p-value <0.01.

In order to confirm the robustness of the results obtained under alternative specifications of the utility functions, the models were ran using a single ASC constant capture farmers' preferences for joining a scheme that are not captured by the attributes included on the choice cards. The share attribute was coded as continuous in the hybrid alternative and the share attribute in the other two design options is considered as two additional independent variables: either 0% (practice-based) or 100% (results-based), to avoid a discontinuous jump in WTA for the share attribute at approximatively 0 and approximatively 100. Therefore, the variable `share' as a continuous variable in the utility function associated with hybrid schemes would only apply for a range from 10% to 90% (which was the range used within the hybrid schemes). The observable parts of the utility functions are now defined as:

$$V_{practices} = \delta_{asc} + \beta_{share0}X_{share0} + \beta_{practices}X_{practices} + \beta_{payment}X_{payment}$$

$$V_{result} = \delta_{asc} + \beta_{share100}X_{share100} + \beta_{water}X_{water} + \beta_{cc}X_{cc} + \beta_{biodiversity}X_{biodiversity} + \beta_{payment}X_{payment}$$

$$V_{hybrid} = \delta_{asc} + \beta_{share}X_{share} + \beta_{practices}X_{practices} + \beta_{water}X_{water} + \beta_{cc}X_{cc} + \beta_{biodiversity}X_{biodiversity} + \beta_{payment}X_{payment}$$

The results obtained using this specification are presented in Annex Table 4.D.4, which yields the following values of WTA in Annex Table 4.D.5.

Annex Table 4.D.4. Results of the Conditional logit model under a specification with 1 single ASC and the share attribute is specific to each scheme design

30/03/2022		n	731	LL	-5649.8
MNL		obs	4386	Adjust. R2	0.0685
				AIC	11327.6
				BIC	11417.01
Conditional Logit Model					
	Estimate	**Rob.std.err.**	**Rob.t-ratio(0)**	**Rob.p-val(0)**	
ASC	-0.909	***	0.142	-6.394	0.000
Practices 1	0.063		0.074	0.861	0.389
Practices 2	-0.166	**	0.070	-2.392	0.017
Practices 3	-0.294	***	0.068	-4.310	0.000
Water 1 (ref 0)	-0.264	***	0.085	-3.113	0.002
Water 2 (ref 0)	-0.326	***	0.060	-5.390	0.000
CC 1 (ref 0)	-0.239	***	0.064	-3.752	0.000
CC2 (ref 0)	-0.276	***	0.073	-3.802	0.000
Biodiversity 1 (ref 0)	-0.022		0.063	-0.343	0.732
Biodiversity 2 (ref 0)	-0.042		0.070	-0.603	0.547
All payments based on practice	-0.214	*	0.121	-1.770	0.077
Share conditioned on result [10 to 90%]	-0.002	**	0.001	-2.297	0.022
All payments based on results	-0.582	***	0.124	-4.682	0.000
Payment level	0.006	***	0.000	16.510	0.000

Annex Table 4.D.5. WTA estimates derived from Annex Table 4.D.4

	WTA estimates (Delta Method) Estimate (EUR)		Rob.std.err.	Rob.t-ratio(0)	Rob.p-val(0)
ASC	152.30	***	25.47	5.98	0.000
Practice 1	Not significantly different from 0				
Practice 2	27.85	**	11.27	2.471	0.014
Practice 3	49.29	***	11.03	4.469	0.000
Water 1 (ref 0)	44.16	***	13.55	3.26	0.001
Water 2 (ref 0)	54.53	***	9.578	5.694	0.000
CC 1 (ref 0)	40.01	***	10.38	3.854	0.000
CC2 (ref 0)	46.31	***	11.79	3.927	0.000
Biodiversity 1 (ref 0)	3.60		10.52	0.3423	0.732
Biodiversity 2 (ref 0)	7.07		11.66	0.6065	0.544
All payments based on practice	35.89	*	19.79	1.814	0.070
Share conditioned on result [10 to 90%]	0.41	**	0.1756	2.339	0.020
All payments based on results	97.55	***	19.96	4.888	0.000

The WTA for alternative scheme designs are then computed, accounting for all their characteristics, to compare the results with our initial findings. These WTA values are obtained by summing up the marginal WTA values for each of the attributes and the ASC reported in Annex Table 4.D.5. The results show that the WTA results under this new specification are very close to the initial specification and, most importantly, all the report's interpretation based on relative preferences hold.

Practice-based schemes

Level of requirements	Initial analysis Mean WTA (EUR/ha/year)	Analysis using specification MNL Mean WTA (EUR/ha/year)
Level 1: First 2 practices	181.7	188.19
Level 2: First 4 practices	212.8	216.04
Level 3: All 6 practices	233.7	237.48

Results-based schemes

Level of requirements	Initial analysis Mean WTA (EUR4/ha/year)	Analysis using specification MNL Mean WTA (EUR/ha/year)
Biodiversity only	245.8	249.85
Water 1 and CC1	331.7	334.02
Water 2 and CC2	348.7	350.69

Hybrid schemes

Level of requirement	Mean WTA (EUR 4/ha/year)					
	20% of payment conditioned on results		50% of payment conditioned on results		80% of payment conditioned on result	
	Initial spec.	US2 spec	Initial spec.	US2 spec	Initial spec.	US2 spec
First 2 practices + Biodiversity 1	151.3	160.5	163.8	172.8	176.3	185.1
First 4 practices + Water 1 and CC1	268.2	272.5	280.8	284.9	293.3	297.2
First 4 practices + Water 2 and CC2	285.2	289.2	297.7	301.5	310.3	313.8
All 6 practices + Water 1 and CC1	289.2	294.0	301.7	306.3	314.2	318.6
All 6 practices + Water 2 and CC2	306.1	310.6	318.7	323.0	331.2	335.3

Annex 4.E. Heterogeneity in farmer preferences (clusters)

Clustering farmers according to their characteristics

As a first step before the latent class analysis, with the objective to reduce the number of variables to be included as explanatory variables to the class membership, we generate several clustering of respondents: described below. Note that all clustering are independent from each other, meaning that a respondent could belong to cluster 1 in terms of their farm characteristics, while they may belong to cluster 2 or 3 based on their own individual characteristics.

The first clustering separates farmers according to their farm's characteristics: farmers are separated in three clusters, which characteristics are presented in Table A E.1. Note that farm specialisation (mixed farming or arable farming) is not a determinant of cluster membership despite being included for the clustering.

Annex Table 4.E.1. Description of three clusters of farm characteristics

Clusters of farm characteristics	Mean (SD)			Bartlett's test
Variables	Cluster 1 N=162	Cluster 2 N=243	Cluster 3 N=263	
Total land (ha)	198.4 (381.1)	175.6 (185.6)	133.6 (264.7)	***
Arable land (ha)	89.7 (149.4)	91.8 (92.0)	41.8 (84.1)	***
Specialisation (% in mixed farming)	33.3 (47.3)	42.4 (49.5)	37.3 (48.4)	
Share of land owned (%)	54.0 (48.5)	75.7 (309.6)	57.0 (44.1)	***
Other income (%)	100.0 (0.0)	30.9 (46.3)	100.0 (0)	***
Share farm income in household (%)	52.1 (9.5)	95.1 (8.4)	14.5 (10.7)	***

Note: *: p-value < 0.10; **: p-value < 0.05, ***: p-value <0.01

- Cluster 1 (Farm 1, n=162): Largest farms (198 hectares on average, including 89.7 ha of arable land), about half of the farmland in ownership, with all farms having another source of income available for the household, and the income from the farm representing about half of the household income (52.1% in average)
- Cluster 2 (Farm 2, n=243): Medium farms (175.6 hectares on average, including 91.8 ha of arable land), with in average about three-quarters of the farmland in ownership, with only a third of farms having another source of income available for the household than the farm revenues, therefore the income from the farm representing the largest share of the household income (95.1% in average)
- Cluster 3 (Farm 3, n=263): Smallest farms (133.6 hectares on average, including 41.8 ha of arable land), with in average slightly more than half of the farmland in ownership, with most of the household income coming from other sources of income (only 14.5% of the household income being generated by the farm activity on average).

The second clustering separates farmers according to their socio-demographic characteristics: farmers are separated in three clusters (Annex Table 4.E.2).

Annex Table 4.E.2. Description of three clusters of farmers characteristics

Clusters of farmers' characteristics	Mean (SD)			Bartlett's test
Variables (%)	Cluster 1 N=219	Cluster 2 N=229	Cluster 3 N=270	
Gender				
Female	11.0 (31.3)	6.1 (24.0)	8.9 (28.5)	***
Age				
18 - 34	10.0 (30.1)	0.0 (0.0)	6.30 (24.3)	***
35 - 44	30.6 (46.2)	0.0 (0.0)	17.8 (38.3)	***
45 - 54	55.3 (49.8)	0.0 (0.0)	26.7 (44.3)	*
55 - 64	0.0 (0.0)	67.2 (47.0)	24.1 (42.8)	
> 64	0.0 (0.0)	32.8 (47.0)	23.3 (42.4)	
Education				
None	0.4 (6.8)	0.0 (0.0)	0.4 (6.1)	
Minimum compulsory	2.7 (16.4)	4.8 (21.4)	3.7 (18.9)	***
High school diploma in agriculture	18.7 (39.1)	21.4 (41.1)	6.7 (25.0)	***
High school diploma not in agriculture	8.7 (28.2)	12.7 (33.3)	11.1 (31.5)	**
Vocational training in agriculture	27.4 (44.7)	29.3 (45.6)	16.7 (37.3)	***
Vocational training not in agriculture	10.5 (30.7)	10.5 (30.7)	17.8 (38.3)	***
University degree in agriculture	19.2 (39.5)	10.0 (30.1)	10.0 (30.1)	***
University degree not in agriculture	7.76 (26.8)	5.2 (22.3)	26.3 (44.1)	***
Other	4.6 (20.9)	6.1 (24.0)	7.4 (26.2)	***
Farmer Status				
Full-time farmer	95.4 (20.9)	90.8 (28.9)	0.0 (0.0)	***
Part-time farmer	0.0 (0.0)	0.0 (0.0)	97.8 (14.8)	***
Farm employee	1.3 (11.7)	0.4 (6.6)	0.0 (0.0)	***
Other	3.2 (17.6)	8.7 (28.3)	2.2 (14.8)	***

Note: *: p-value < 0.10; **: p-value < 0.05, ***: p-value <0.01

- *Cluster 1 (Farmer 1, n=219):* Relatively more female farmers (11%), younger farmers, with a larger share having a university degree in agriculture, mostly full time farmers
- *Cluster 2 (Farmer 2, n=229):* Relatively fewer female farmers (6%), older farmers, with a larger share having the minimum compulsory education, a high school diploma or a vocational training in agriculture, mostly full time farmers
- *Cluster 3 (Farmer 3, n=270)*: Average share of female farmers (8.6%), average age similar to the overall sample, with a larger share with a university degree not in agriculture or a vocational training not in agriculture, part-time farmers

The third clustering separates farmers according to their current agri-environmental practices: farmers are separated in three clusters (Annex Table 4.E.3).

Annex Table 4.E.3. Description of 3 clusters of current agri-environmental practices

Clusters of current AE Practices	Mean (SD)			Bartlett's test
Variables	Cluster 1 N=166	Cluster 2 N=340	Cluster 3 N=148	
Field size (ha)	8.7 (19.8)	5.5 (14.3)	7.9 (17.6)	***
Manure injection (ref: does not use manure injection)	42.8 (49.6)	20.9 (40.7)	30.4 (46.2)	***
Cover crops	1.9 (0.8)	0.1 (0.3)	1.1 (0.9)	***
Green fallow	14.3 (22.3)	5.39 (12.4)	5.5 (14.4)	***
Landscape	0.4 (0.8)	0.6 (0.9)	2.1 (0.9)	

Clusters of current AE Practices	Mean (SD)			Bartlett's test
Buffer	0.5 (0.8)	0.8 (1.0)	2.3 (0.9)	**
Currently engaged in an AES (%)	65.7 (47.6)	80.9 (39.4)	81.8 (38.8)	***
Never participated in an AES (%)	27.1 (44.6)	7.4 (26.1)	10.1 (30.3)	***
Organic farming	16.9 (37.6)	12.9 (33.6)	26.4 (44.2)	***

Note: *: p-value < 0.10; **: p-value < 0.05, ***: p-value <0.01

- *Cluster 1 (AEpract 1, n=166):* Large fields, larger share injecting manure (43%), more use of cover crops, larger share of arable land in green fallow (14%), but scarcer presence of buffer strips next to water courses, relatively fewer currently engaged in an AES (66%), and larger share who have never participated in an AES (27%),
- *Cluster 2 (AEpract 2, n= 340):* Small fields, smaller share injecting manure (21%), lowest use of cover crops, small share of arable land in green fallow (5%), medium presence of buffer strips next to water courses, most engaged in an AES (81%), few organic farmers (12%)
- *Cluster 3 (AEpract 3, n=148):* Medium fields, medium share injecting manure (30%), medium use of cover crops, small share of arable land in green fallow (5.5%), but largest presence of buffer strip next to water courses (majority or all fields), most engaged in an AES (82%), largest share of organic farmers (26%).

The fourth clustering separated farmers according to their behavioural (time and risk) and environmental preferences: farmers are separated in two clusters (Annex Table 4.E.4).

Annex Table 4.E.4. Description of 2 clusters of behavioural characteristics of farmers

Clusters of behavioural characteristics	Mean (SD)		Bartlett's test	T-test
Variables	Cluster 1 N= 254	Cluster 2 N=448		
Time				
Time preferences 1	-0.9 (1.6)	-1.6 (1.5)		***
Time preferences 2	0.4 (1.5)	1.1 (1.4)		***
Risk				
Risk attitudes 1	-0.5 (1.5)	0.6 (1.5)		***
Risk attitudes 2	-0.4 (1.6)	0.4 (1.5)		***
Environment				
Farm environment 1	1.7 (1.2)	1.2 (1.3)		***
Farm environment 2	1.0 (1.4)	1.0 (1.3)		
Farm environment 3	-0.3 (1.6)	1.5 (1.3)	***	***
Farm environment 4	-0.4 (1.5)	1.1 (1.3)	***	***
Farm environment 5	0.1 (1.5)	1.5 (1.2)	***	***
Farm environment 6	-1.3 (1.5)	1.2 (1.3)	**	***
Farm environment 7	-2.2 (1.0)	0.1 (1.5)	***	***
Farm environment 8	0.1 (1.4)	0.8 (1.2)	*	***

Note: *: p-value < 0.10; **: p-value < 0.05, ***: p-value <0.01

- *Cluster 1 (Behaviour 1, n= 254):* Strongest preferences for present (/ present biais), more risk averse, lower perceived need for environmental action, less awareness of consequences and perceived control, lower sense of responsibility over local and global environmental issues
- *Cluster 2 (Behaviour 2, n= 448):* Longer term thinking, less risk averse, perceive more need for environmental action, show more awareness of consequences of farming on the environment,

more awareness of consequences (Farming using environmentally friendly practices can improve the health of the environment), and sense of responsibility for local and global environmental issues

And finally, the fifth clustering separates farmers according to their answers to the follow up questions, measuring their attitudes towards the questionnaire itself: farmers are allocated to one of two clusters.

Annex Table 4.E.5. Testing for cluster differences

Clusters of follow up questions	Mean (SD)		Bartlett's test	t-test
Variables	Cluster 1 N=298	Cluster 2 N=386		
Complex	1.0 (1.8)	0.4 (1.6)	**	***
Ignore attributes	1.1 (1.7)	0.6 (1.5)	**	***
Payments too low	1.5 (1.5)	0.1 (1.5)		***
Against government spending	-0.3 (2.0)	-0.7 (1.7)	***	***
Against AE payment	-1.9 (1.7)	-1.6 (1.8)		**
Would adopt anyway	-2.1 (1.4)	-0.7 (1.7)	**	***
Would adopt chosen AES	-0.3 (1.6)	1.2 (1.0)	***	***
Credibility	-0.5 (1.6)	1.0 (1.1)	***	***
Ability to adopt practice	-1.5 (1.4)	0.8 (1.1)	***	***
Ability to achieve objective	-1.1 (1.5)	0.8 (1.1)	***	***
Adoption puts profitability at risk	1.6 (1.5)	-0.1 (1.4)		***
Confidence in monitoring	-1.5 (1.7)	-0.02 (1.6)		***

Note: *: p-value < 0.10; **: p-value < 0.05, ***: p-value <0.01.

- *Cluster 1 (Followup 1, n= 298):* Find the survey more complex, are more likely to have ignores attributes in their choices, slightly more to be against more government spending, less likely to adopt the proposed measures without payment, provide less genuine answers (i.e. state they would adopt the chosen AES), gave less credibility to the survey, feel less able to adopt the practices or to achieve the results presented on the choice cards → protesters
- *Cluster 2 (Followup 2, n=386):* The symmetric of cluster 1.

Each farmer is allocated to one of the clusters for each category of variables and we use the cluster allocation to describe the class membership in the latent class model below.

Annex Table 4.E.6. Results of the latent class model, with two distinct classes of farmers in terms of AES preferences

Latent class model	Class 1 (63.35%)					Class 2 (36.65%)				
2 classes	Estimate		Rob.std.err.	Rob.t-ratio(0)	Rob.p-val(0)	Estimate		Rob.std.err.	Rob.t-ratio(0)	Rob.p-val(0)
Preferences										
ASC practice-based	0.925	***	0.195	4.732	0.000	-3.456	***	0.283	-12.209	0.000
ASC hybrid	1.240	***	0.214	5.802	0.000	-3.094	***	0.545	-5.672	0.000
ASC results-based	0.427	**	0.208	2.049	0.040	-3.406	***	0.400	-8.526	0.000
Practices 2 (ref 1)	-0.253	***	0.084	-3.013	0.003	-1.027	***	0.270	-3.807	0.000
Practices 3 (ref 1)	-0.381	***	0.090	-4.243	0.000	-1.677	***	0.321	-5.226	0.000
Water 1 (ref 0)	-0.323	***	0.106	-3.037	0.002	-0.624		0.673	-0.927	0.354

Latent class model	Class 1 (63.35%)					Class 2 (36.65%)				
2 classes	Estimate		Rob.std.err.	Rob.t-ratio(0)	Rob.p-val(0)	Estimate		Rob.std.err.	Rob.t-ratio(0)	Rob.p-val(0)
Water 2 (ref 0)	-0.293	***	0.069	-4.228	0.000	-0.884	***	0.264	-3.347	0.001
CC 1 (ref 0)	-0.208	***	0.077	-2.708	0.007	-0.884	***	0.256	-3.458	0.001
CC2 (ref 0)	-0.291	***	0.086	-3.383	0.001	-0.888	***	0.279	-3.187	0.001
Biodiversity 1 (ref 0)	-0.089		0.077	-1.161	0.246	0.040		0.255	0.156	0.876
Biodiversity 2 (ref 0)	-0.123		0.097	-1.266	0.206	-0.213		0.285	-0.748	0.455
Share conditioned on result	-0.003	**	0.001	-2.417	0.016	-0.010		0.010	-0.935	0.350
Payment level	0.007	***	0.001	12.293	0.000	0.009	***	0.001	8.166	0.000
Class membership										
Constant	-		-	-	-	-1.396	***	0.277	-5.041	0.000
Farmer cluster 2 (ref cluster 1)	-		-	-	-	-0.207		0.255	-0.812	0.417
Farmer cluster 3 (ref cluster 1)	-		-	-	-	0.385		0.256	1.503	0.133
Behaviour cluster 2 (ref cluster 1)	-		-	-	-	0.625	***	0.221	2.834	0.005
Follow up cluster 2 (ref cluster 1)	-		-	-	-	2.020	***	0.209	9.644	0.000
Finland (ref Netherlands)	-		-	-	-	0.812	***	0.266	3.056	0.002
Sweden (ref Netherlands)	-		-	-	-	0.388		0.283	1.370	0.171

Note: *: robust p-value < 0.10; **: robust p-value < 0.05, ***: robust p-value <0.01. Number of observations=3960; Log-likelihood=-3967.93; AIC=8002; BIC=8209.

Annex Table 4.E.7. Summary statistics describing the two classes of the latent class model

	Class 1		Class 2	
	Mean	sd	Mean	sd
Total land area (ha)	166.71	319.91	146.83	147.78
Arable land area (ha)	66.24	108.47	81.47	106.92
Mixed farmers (ref: arable) (0/1)	.39	0.49	.34	0.47
Share of land owned (1=100%)	.68	2.43	.57	0.51
Other income available for household (0/1)	.80	0.40	.64	0.48
Share of farm income in household income (%)	47.28	35.31	63.82	35.91
Female (ref: male) (0/1)	.10	0.29	.06	0.24
Age1: 18-34	.05	0.22	.06	0.24
Age2: 35-44	.19	0.39	.13	0.34
Age3: 45-54	.27	0.45	.27	0.45
Age4: 55-64	.32	0.47	.28	0.45
Age5: >65	.15	0.36	.22	0.41
Status: Farm employee (0/1)	.01	0.08	0	0.06
Status: Full-time farmer (0/1)	.5	0.50	.7	0.46
Status: Other (0/1)	.05	0.22	.05	0.21
Status: Part-time farmer (0/1)	.44	0.50	.25	0.44
Field size - average (ha)	5.56	12.46	8.78	20.10

	Class 1		Class 2	
	Mean	sd	Mean	sd
Use of manure injection (0/1)	.23	0.42	.38	0.49
Use of cover crops**	.79	0.95	.82	0.97
Area in green fallow (ha)	8.45	17.03	6.71	14.90
Landscape**	.9	1.08	.79	1.04
Buffer**	1.16	1.15	.93	1.14
Currently in AES (0/1)	.86	0.35	.64	0.48
Never been in AES (0/1)	.06	0.25	.22	0.42
Organic (0/1)	.22	0.42	.08	0.28
Time preferences 1*	**-1.39**	**1.56**	**-1.37**	**1.64**
Time preferences 2*	**.95**	**1.41**	**.71**	**1.59**
Risk attitudes 1*	**.43**	**1.46**	**-.32**	**1.64**
Risk attitudes 2*	**.16**	**1.58**	**-.02**	**1.59**
Farm environment 1*	**1.19**	**1.36**	**1.72**	**1.17**
Farm environment 2*	**.92**	**1.38**	**1.1**	**1.42**
Farm environment 3*	**1.05**	**1.57**	**.44**	**1.73**
Farm environment 4*	**.81**	**1.50**	**.17**	**1.60**
Farm environment 5*	**1.33**	**1.31**	**.36**	**1.60**
Farm environment 6*	**.54**	**1.73**	**-.11**	**1.88**
Farm environment 7*	**-.53**	**1.73**	**-1.15**	**1.73**
Farm environment 8*	**.62**	**1.30**	**.34**	**1.32**
Survey too complex*	**.45**	**1.54**	**.95**	**1.92**
Ignored attributes*	**.8**	**1.44**	**.84**	**1.81**
Payments were too low*	**.29**	**1.49**	**1.51**	**1.62**
Against gov. spending*	**-.75**	**1.73**	**-.15**	**1.98**
Against AE payments*	**-1.72**	**1.75**	**-1.74**	**1.68**
Would adopt anyways*	**-1.14**	**1.63**	**-1.61**	**1.75**
Would adopt chosen AES*	**1.03**	**1.14**	**-.2**	**1.73**
Credibility *	**.81**	**1.28**	**-.44**	**1.68**
Ability to adopt practices*	**.39**	**1.48**	**-1.12**	**1.61**
Ability to achieve objectives*	**.39**	**1.46**	**-.84**	**1.64**
Adoption puts profitability at risk*	**.23**	**1.56**	**1.42**	**1.65**
Confidence in monitoring*	**-.28**	**1.70**	**-1.34**	**1.75**

Notes
For statements "Farm environment" 1 to 8 see Table A C.5 for definitions.
For "Risk" and "Time" statements see Table A C.4 for definitions.
* Likert scale from -2 "Strongly disagree" to +2 "Strongly agree"
** Scale: 0: "None of the cultivated fields (less than 10% of arable land)",
1: "A minority of cultivated fields (between 10% and 49% of arable land)", 2: "A majority of cultivated fields (between 50 and 90% of arable land)", 3: "All cultivated fields (more than 90% of arable land)".
In bold: Variables included in clusters that significantly explain class membership.

Notes

[1] In this chapter, results-based payments are based on modelled rather than measured environmental results for nutrient runoff and GHG emissions, given the fact that these are non-point source pollution, hence extremely difficult and costly to measure at field parcel level directly. In contrast, payments related to the biodiversity objective is based on measurable results

[2] Other commonly-used methods include contingent valuations and best-worst scaling. According to Holmes, Adamowicz and Carlsson (2017, p. 134[3]), choice experiments (CEs) offer a number of advantages over other methods, and after consideration of other possible methods, the overall objectives of this project, and the available resources, the choice experiment method was selected.

[3] In the context of this project, "attribute" refers to a specific policy design element: examples include environmental policy objectives, contract length, contract flexibility, payment basis, payment level, beneficiary eligibility conditions, monitoring and compliance design (e.g. monitoring frequency and type, penalties/sanctions, etc.), services provided (e.g. technical assistance). Level refers to the value(s) of the attribute that are tested in the experiment. For example, levels for the attribute of contract length could be 5, 10 and 20 years.

[4] Additional details on the methods are shown in Annex 4.F.

[5] Note that the results presented in this report hold when dropping individuals who answered that they strongly agreed with statements: (i) the survey was too complex or (ii) they had to ignore some of the attributes. However, the willingness to accept for the alternative specific constants (ASC practice-based, ASC hybrid and ASC results-based) are lower when dropping the individuals who thought the choices were too complex or stated they ignored some attributes, meaning that the overall willingness to accept of farmers for the different schemes are lower in this case. Importantly, the relative preferences between scheme designs and between attributes remain stable.

[6] All models were estimated using the Apollo software on R (Hess and Palma, 2019[12]) (see also Hess and Palma, Apollo version 0.01, www.ApolloChoiceModelling.com.). A mixed logit model was also used, yielding similar results.

[7] It is interesting to note that the increase in farmers' marginal willingness to accept for both water quality improvement and climate change mitigation requirements is not linear, with a relatively lower payment requirements to go from a 25% emissions reduction to a 50% reduction than what is required on average for the first 25% of reduction.

[8] Note that, in hybrid schemes, the share of payments conditioned on results on the choice cards presented to farmers only took values between 10% and 90%, so that the results are to be interpreted only within this range in hybrid schemes.

[9] A first latent class model was estimated using all clusters to explain class membership. This leads to a loss of 1044 observations (174 respondents) due to missing values in the respondents' characteristics. Farm characteristics and current AE practices were not significantly explaining class membership, so we removed these variables from the latent class model to increase the number of observations. The results are similar whether the clusters of farm characteristics and AE practices are included or not, so we only present the results of the model excluding them from the analysis (Annex 4.E.7), reducing the loss of observations to 426 observations (71 respondents) not included in the latent class analysis.

[10] Note: An alternative specification for the utility functions of the three scheme designs were used to check the robustness of results. The results are presented in Annex 4.D and show that the results hold.

Making Agri-Environmental Payments More Cost Effective

Agri-environmental payment schemes which operate as voluntary programmes that pay farmers to achieve certain environmental criteria have gained increasing interest and popularity amongst policy makers and farmers. There is growing evidence, however, that the majority of such schemes that have been implemented have had little environmental effectiveness. Building on past OECD work, this report identifies and discusses “best practice” design principles for cost-effective agri-environmental payment schemes. To this end, the report reviews the literature, develops a Policy Spectrum Framework that classifies payment types based on key design features for achieving cost-effective outcomes, and presents policy simulations undertaken to assess the cost-effectiveness of different payment designs and a multi-country choice experiment conducted with farmers to explore their preferences for different types of payments, ranging from practice-based to results-based payments.

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