Abstract:

Ensuring that farmers' ex ante preferences are accounted for is crucial for the design of effective agri-environmental contracts. We present a systematic review of 127 discrete choice experiment (DCE) studies of farmers' preferences with respect to agri-environmental contracts. DCE studies evaluate two central features of farmers' behaviour: 1) their willingness to accept land use prescriptions, such as fertiliser use, application of pesticides, restrictions on cropping, livestock management, integration of silvopasture, maintaining soil health or water use restrictions; and 2) their responses to variations in incentive and commitment criteria, such as reward schemes, monitoring regimes, technical assistance, flexibility of agreements, administrative burden and collaborative implementation. Our analysis considers how these different elements are interlinked and applied in experiments to simulate farmers' decision-making processes. We examine recent methodological improvements in explaining farmer behaviour, including the accommodation of preference heterogeneity, the combining of discrete (enrolment) and continuous decisions, and the incorporation of farmers' sense of identity. DCEs have been applied for the ex ante analysis of different policy instruments to inform the European Common Agricultural Policy and agri-environmental schemes outside the EU. The results of this systematic review may be useful in informing the future design of such agri-environmental programs. The database underpinning this systematic literature review may help peer scientists to a) compare, validate and triangulate their own findings with respect to other experimental approaches, b) use previous willingness-to-accept (WTA) measures as priors for their own study design and c) identify research gaps regarding farmers' preferences for agri-environmental measures.

Keywords:

Choice modelling, stated preferences, discrete choice experiments, agri-environmental policy, agri-environmental contracts, environmental governance, ex ante evaluation

JEL codes:

Q15, Q51, Q57

1. Introduction

The environmental benefits of agri-environmental measures hinge on the widespread adoption and implementation of specific practices across large areas (Wilson and Hart, 2001; Siebert et al., 2006; Dessart et al., 2019). Moreover, since most of these measures are voluntary, their success depends on farmers' actual willingness to participate. The willingness of farmers to participate in agri-environmental measures is strongly influenced by their perceptions, available resources, and options – all of which are affected by behavioural factors and opportunity costs (Schaub et al., 2023). Understanding the behavioural factors driving farmer decision-making is essential, as these factors are found to play a more significant role in actual adoption of agri-environmental measures than sociodemographic factors (Thompson et al., 2023). This situation has stimulated research into farmers' acceptance of various policy mechanisms that lead to more efficiently designed environmental policies and a better alignment of policy instruments with stakeholder preferences (Lienhoop and Schröter-Schlaack, 2018).

Experimental approaches to designing agricultural environmental policies have gained significance, as they allow for assessing the expected costs and benefits of new policy proposals before implementation (El Benni et al., 2022). Economic experiments are conducted in controlled settings to establish causal relationships among different variables (Lefebrve et al., 2021). This enables the testing of the acceptance of variations in policy instruments and enhances legitimacy for policy action (Thoyer and Préget, 2019). In addition, experiments can address the shortcomings of existing research, such as avoiding social desirability and strategic bias that may arise from using self-declared measures in surveys (Dessart et al., 2019). Given the potential for impact assessment, ex ante evaluation of policy measures became an integral part of the EU Common Agricultural Policy (CAP) under EU financial regulation (Thoyer and Préget, 2019). In addition to randomised controlled trials (RCTs) and field experiments, discrete choice experiments (DCEs) are commonly used for ex ante agricultural policy evaluation, as they provide a tool to study both the individual and joint influences of various policy characteristics (Hanley and Czajkowski, 2019).

DCEs are particularly suitable for assessing the design of prospective policies because they facilitate cost-effective investigations of the preferences of a large group of representative respondents. In addition, DCEs enable us to quantify preferences for different environmental practices and institutional contract features in monetary terms (Colen et al., 2016). In particular, DCEs allow for measuring policy-relevant aspects, such as compensation premiums needed for farmers to participate in particular schemes (Espinosa-Goded et al., 2010) or predicting adoption rates of agri-environmental measures before the introduction of changes in long-term agricultural policies (Waldman and Richardson, 2018).

Despite a considerable number of available DCE-based studies on farmers' contractual design preferences for agri-environmental measures, the existing evidence is scattered. Previous studies have attempted to summarise the empirical literature and outline the influence of selected contract elements on the acceptance of agri-environmental climate measures (AECM)[1] in Europe (Mamine et al., 2020; Tyllianakis and Martin-Ortega, 2021). However, these studies have not sufficiently elucidated the specific management constraints or contextual factors within which these contract elements were investigated. This review aims to fill this gap and systematically analyse preferences for agri-environmental measures by specifically considering land use prescriptions imposed on farmers. Thus, a) preferences for agri-environmental contracts are made comparable, and b) research gaps can be clearly noted.

This paper contributes to the current literature in four major ways. First, this paper provides a structure of empirical evidence by systematically reviewing the current state of the literature on farmers' stated preferences for agri-environmental measures. Second, it identifies how applications of DCEs to farmers' preferences have evolved over time, exploring common patterns and differences in terms of geographical regions, agricultural measures, and contract design features, and depicts methodological advances. Third, it considers empirical findings and highlights areas where the evidence is mixed and likely context dependent. Finally, it identifies gaps in the literature, highlights design features that remain under-researched and makes recommendations for future research.

2. Discrete Choice Experiments – in a nutshell

DCEs are a survey-based stated preference method commonly used for nonmarket valuation in controlled experimental settings (Colen et al., 2016). The theoretical foundations of DCEs are based on Lancaster's theory of value, which states that goods do not have inherent value but rather that their value stems from the attributes that describe them (Lancaster, 1966). Depending on the attributes' levels, goods can be described differently and accordingly valued by respondents. In DCEs, combinations of attribute levels are used to construct alternatives of goods. These combinations are created by researchers in the experimental design to capture trade-offs between different attributes.

[1] European "funding mechanism aiming to provide financial support to farmers to contribute to the protection or enhancement of biodiversity, soil, water, landscape, or air quality, or climate change mitigation or adaptation"
https://www.project-contracts20.eu/glossary/agri-environment-climate-measures/

Power analysis and Monte Carlo simulations are employed to optimise the design and determine necessary sample sizes (Rose and Bliemer, 2013). A series of choice sets, each usually containing two alternatives, is then presented to participants, who are asked to select their preferred option for each choice scenario (Colen et al., 2016). This process allows researchers to elicit participants' preferences and quantify the value they place on different attributes within the context of the study.

The analysis of choices and thereby valuation of attribute levels is based on random utility theory, which states that an individual's utility depends on a deterministic and random utility component (McFadden, 1974). The parameters of the deterministic component of the utility function can be estimated, and the marginal rate of substitution, representing the trade-off between individual attributes, can be calculated. If an attribute serves as the payment vehicle, measures of willingness to pay or willingness to accept can be constructed, which are particularly relevant for policy design. In the context of agri-environmental measures, DCEs can help determine the cost of compliance with different contracts.

Compared to revealed preference methods, which are based on observed actual behaviour, DCEs offer several advantages. First, a DCE allows researchers to elicit preferences for goods and services that do not yet exist, making it popular for conducting ex ante policy analysis, i.e., evaluating policies before implementation. Second, DCEs enable the establishment of causal relationships through the systematic variation of the attribute levels of the presented alternatives (Hanley and Czajkowski, 2019). Third, compared to incentivised economic experiments, no incentives contingent on behaviour are needed, and involved trade-offs are less obvious to the respondents, which mitigates strategic response bias (Villamayor-Tomas et al., 2019).

One primary drawback of DCEs is the nature of hypothetical bias, as responses are based on hypothetical scenarios rather than actual observed behaviour (Colombo et al., 2020). In other words, there is a risk that participants behave differently in the survey as they would in reality. To address this issue, insights from mechanism design theory have been used to derive three conditions to restore incentive-compatible behaviour in DCEs and hence alleviate the disadvantages of DCEs (Carson and Groves, 2007). First, participants must believe that their responses will influence policy. Second, the payment vehicle must be coercive. Last, survey participation should be seen as a "take it or leave it" offer to discourage strategic behaviour during the survey.

Due to the mentioned advantages and relatively inexpensive implementation with large sample sizes, DCE studies are employed in policy design to investigate the acceptance and cost effectiveness of differently designed policy measures. In the context of agricultural environmental policy, DCEs are frequently used to examine the acceptance of various agri-environmental climate measures and calculate necessary compensation payments for these measures.

This literature review examines the contexts in which DCEs have been applied, the attributes used to describe agri-environmental measures, and the compensation payments resulting from these studies.

3. Literature search

The systematic literature search was carried out in both ISI Web of Science and Google Scholar. We followed a structured approach to synthesise the empirical literature on DCEs conducted with farmers to learn about their preferences for agri-environmental measures. The *Reporting Standards for Systematic Evidence Syntheses in Environmental Research (ROSES)* formed the basis of the applied research protocol to provide reliable, valid, and replicable results (Haddaway et al., 2018). Figure 1 depicts the process of the search, screening and critical appraisal of the literature. For more detail, please see supplementary material 1.

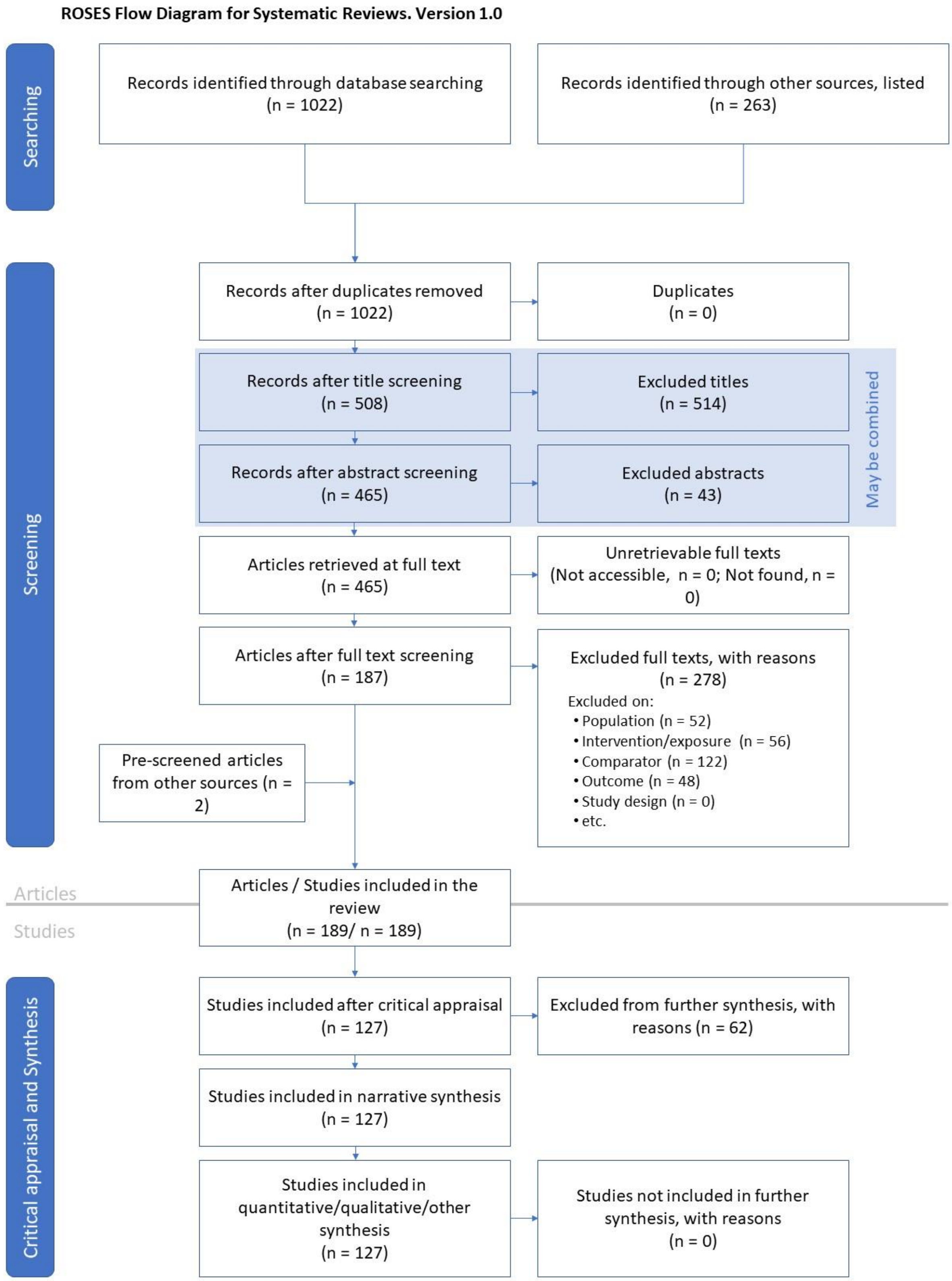

Figure 1: Flow chart depicting the literature search process

Starting in 2020, we scanned the peer-reviewed academic literature of articles published in English. To capture the diversity of definitions concerning agri-environmental programmes, we deliberately searched for keywords, such as "payments for ecosystem services", "common agricultural policy" or "conservation agriculture", along with "agri-environment" in combination with "farmer preferences". The abstracts were then screened in detail to verify whether the studies actually focused on agri-environmental programmes. In the subsequent reading, special attention was given to whether the applied attributes of the experimental designs specifically dealt with constraints in the sense of land use prescriptions or contract design features. The extended methodology of the review, including the extensive search string, protocol, sources searched, selection criteria, and complete list of studies, is available in supplementary materials A and B. In the end, our analysis included papers that were published until September 2023. In total, we identified 127 studies that met our criteria.

4. Brief overview of existing studies

The earliest DCE study on farmers' agri-environmental policy preferences was published in 2006 and studied farmers' valuation of agrobiodiversity on Hungarian small farms (Birol et al., 2006). Since then, DCEs have been applied around the globe to improve agri-environmental policy design.

The geographical distribution of DCEs shows in which countries farmer preferences have been strongly investigated and where on the other hand, there are still many blind spots. The vast majority of studies identified were carried out in Europe (55 studies) and assessed preferences towards participation in AECM of the CAP.

In North America (10 studies), conservation programs such as the CRP have been the most prominent subject of preference studies in the US (Petrolia et al., 2021). In contrast, in Latin America (11 studies), the research focus has been primarily on the institutional design of payments for ecosystem services (PES), using preference elicitation to evaluate trade-offs between different land uses (Lliso et al., 2020; Torres et al., 2013).

Only a relatively small number of countries in Africa (25 studies) have been the subject of DCE studies focusing on conservation agriculture practices (e.g., Waldman et al., 2017). Such studies of farmers' preferences have recently been carried out mostly in East Africa (Ethiopia, Kenya, Tanzania, Malawi and Madagascar) and West Africa (Nigeria, Benin and Mali).

Concerning Asia, DCEs addressed mostly smallholder farmers in China (4 studies) in the context of PES (Chen et al., 2009) or conversions to organic agriculture (Hope et al., 2008).

5. Stated preference-based evidence for agri-environmental policies

To structure the systematic review of the literature, we follow the observation by Le Coent et al. (2017), who distinguish between two types of DCE studies conducted with farmers (depicted in detail in Figure 2 below):

1) Studies whose attributes address land use prescriptions through agricultural activities, and

2) Studies whose attributes relate to institutional economic and agri-environmental contract design.

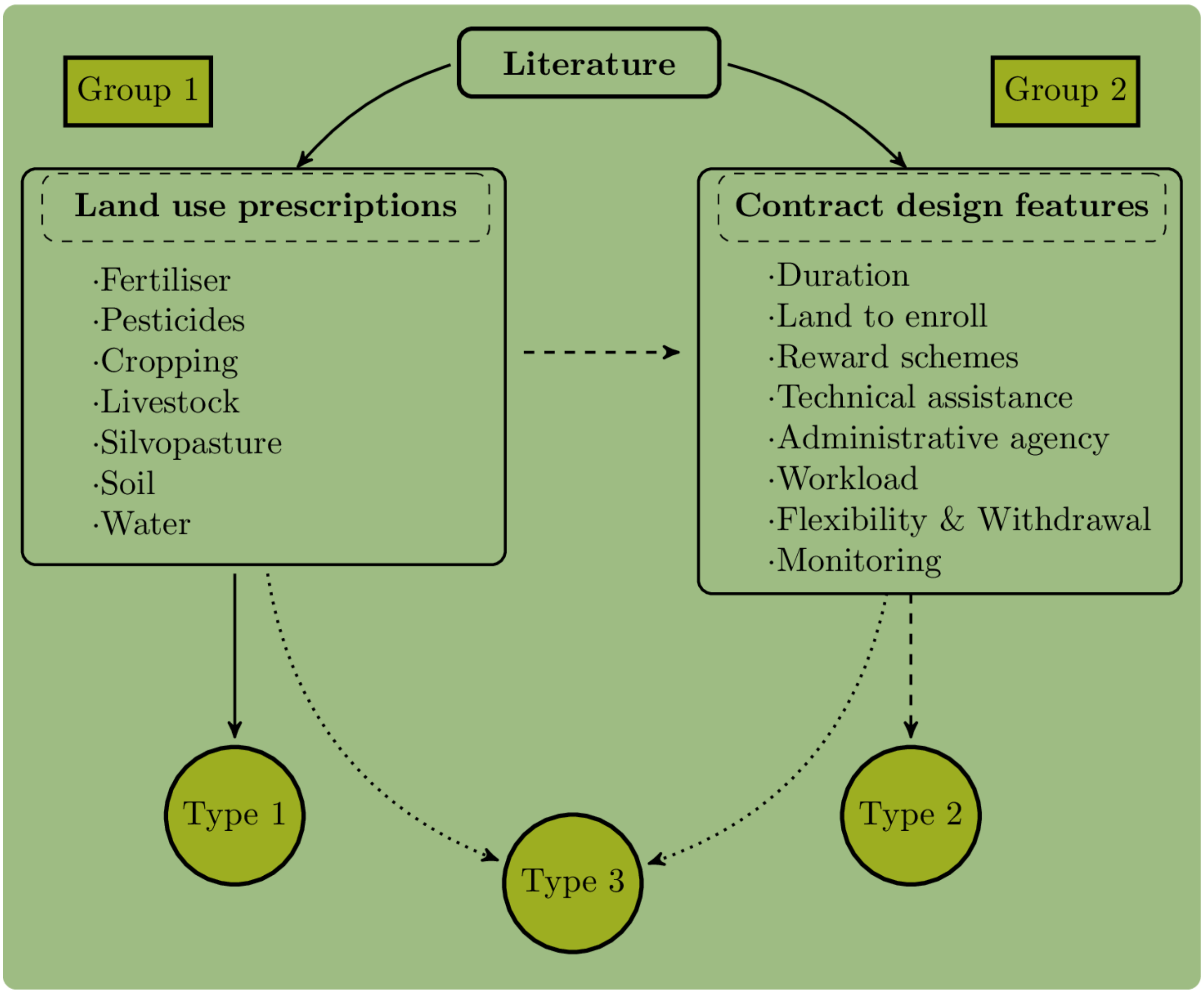

Figure 2: Classification of DCE studies with farmers

The first group of DCEs addresses preferences for land use prescriptions to be implemented when participating in agri-environmental measures. The attributes of the studies address concrete environmental measures and regulations of agricultural activities that should be part of the agri-environmental measures. These studies examine land use prescriptions, such as fertiliser use or stocking density, and hence involve trade-offs between sustainable practices and profitability. The attributes of these types of DCE applications reflect marginal changes in land use prescriptions that aim to mitigate negative environmental impacts or enhance the environmental status of agricultural land. Prominent examples of land use prescriptions are limits on fertiliser applications (Latacz-Lohmann and Breustedt, 2019), prescribed crop rotations (Schaafsma et al., 2019) and livestock management requirements (Danne and Musshoff, 2017).

The second group of studies, in contrast, focuses on preferences related to the contractual elements of agri-environmental measures. Similar to the studies in the first category, these studies establish a context that includes factors such as reductions in fertiliser or pesticide usage, as well as practices related to soil conservation. However, there is a notable departure in experimental design: the attributes under scrutiny do not describe agricultural activities and recommendations but instead specify contract elements that either quantify the commitment needed for a contract or encompass mechanisms designed to motivate farmers to participate in such contracts. These attributes may manifest as aspects such as contract duration, monitoring procedures, or various reward and incentive mechanisms. Consequently, these studies aim to evaluate the effectiveness of specific institutional frameworks and policy mechanisms through DCEs, as demonstrated in the works of Le Coent et al. (2017) and Mamine et al. (2020).

The following sections provide more detail on the presented dichotomy of DCE studies and their overlap in terms of studies that combine both elements.

5.1. Land use prescriptions

After an in-depth screening of the literature, we segregated the land use prescriptions into seven categories: (1) fertiliser application, (2) use of pesticides, (3) water use constraints, (4) soil health improvements, (5) cropping practices, (6) livestock management, and (7) silvopasture integration. While Figure 3 depicts the stacked and individual distribution of land use prescriptions studied in DCE studies, the following subchapters discuss each land use prescription in detail.

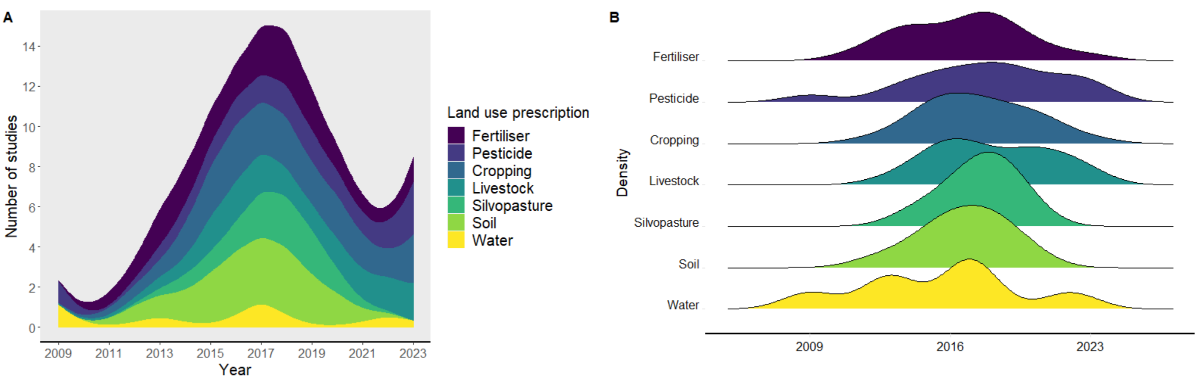

Figure 3: A. Stacked plot and B. Ridgeline density plot of land use prescriptions over time

Fertiliser application (21 studies)

The literature on DCEs that assess farmers' acceptance of land use prescriptions is extensive and focuses particularly on preferences for policies affecting the permitted use of fertilisers. The DCE literature either examines farmers' willingness to restrict conventional fertilisation or explores preferences for alternative pathways of organic fertilisation methods. The prescriptions for fertilisers manifest themselves in dose reductions of fertiliser applications or in policies to implement organic fertilisation practices in which mineral fertilisers are prohibited.

DCE studies conducted in Europe looked at needed per hectare compensation payments for percentage dose reductions in fertiliser applications in the UK (Beharry-Borg et al., 2013), Denmark (Christensen et al., 2011), Belgium (Lizin et al., 2015) and France (Vaissière et al., 2018), eliciting compensation payments ranging from 85 to 130 Euro/ha/yr, depending on the intensity of reduction (see Table 1 for more detail). Moreover, a complete ban on fertiliser and pesticide use has been investigated in the Netherlands, leading to needed compensation payments above 670 Euro/ha (Thiermann et al., 2023). With regard to organic alternatives, German farmers largely preferred the option of "mineral and organic fertilisation allowed" over "no fertilisation" or "organic fertilisation allowed" (Latacz-Lohmann and Breustedt, 2019).

Outside the context of the CAP, studies did not explicitly examine the willingness to accept (WTA) in payments per ha but found other measures to express compensation for more restrictive fertilisation measures. One study assessed rice farmers' preferences in Benin for selling their product independently as opposed to under a contract with specific requirements, such as the precise application of fertiliser or a complete ban on fertiliser. Although smallholder farmers appreciated the economic advantages of marketing under a contract, strict organic requirements were found to undermine the adoption of contract farming (Van den Broeck et al., 2017). Similar evidence was found in China, where rice farmers accepted lower payments in exchange for an eco-label on their product, indicating a reduction in fertiliser application (Chang et al., 2017).

In the context of PES in Costa Rica, farmers preferred fertiliser use prescriptions over agroforestry or no fertiliser use at all, as these latter options were perceived as too incisive in farmers' production of agricultural goods (Allen and Colson, 2019).

Pesticide application (14 studies)

Similar to the research conducted on fertiliser prescriptions, studies covering the topic of pesticides either address dose reductions or elicit preferences for alternative environmentally friendly pest control measures.

In France, winegrowers were surveyed to assess their willingness to accept dose reductions in vineyards in combination with permission for localised use of pesticides to control residual weeds, finding reluctance of winegrowers to reduce the use of herbicides and application of localised chemical weed control (Kuhfuss et al., 2016). In contrast, upstream farmers in Thailand prefer the application of bioinsecticides over planting grass strips to improve downstream water quality (Sangkapitux et al., 2009).

Instead of enforcing prescriptions on the dose of herbicides, other studies looked at alternative options of pest control that go beyond the application of chemicals. In Thailand, farmers showed preferences for creating native bee habitats outside their farmlands over implementing more accurate and bee-friendly use of herbicides (Narjes and Lippert, 2016). Similarly, in Benin, farmers particularly value the ecological benefits of nets compared to spraying insecticides (Vidogbéna et al., 2015). Having the option to choose between mechanical weed control and the application of herbicides, German farmers prefer the former, even though mechanical weed control is more costly and labour intensive. This behaviour is explained by farmers' increased scepticism towards chemicals due to the growing resistance of crops to herbicides (Danne and Musshoff, 2017).

Water use constraints (7 studies)

A relatively small body of literature is concerned with water management practices and water use constraints. The focus of these studies can generally be divided into two subgroups. First, some of the studies deal with prescriptions for flooding in certain regions to protect bird populations. The aim here is to quantify the compensation payments needed to delay flooding of rice fields to provide threatened bird species with sufficient time for breeding (Herring et al., 2022).

The second type of water use constraint looks at preferences for different irrigation systems to apply water resources more efficiently and avoid potential water scarcity. Whereas no clear preferences for water-saving technologies could be found in Thailand (Sangkapitux et al., 2009) or Tanzania (Kadigi et al., 2013), farmers in Burkina Faso prefer drip irrigation systems over waste water use (Houessionon et al., 2017).

Soil health improvements (22 studies)

There is a clear geographical divide with respect to the focus of the policy intervention. While tillage and mulching are investigated within preference studies in Western countries, terracing and other conservation agriculture practices are considered in preference studies in the global south. One major reason for this difference is that no-tillage practices go along with costly external inputs such as agrochemicals, which have rarely been affordable in the past to many farmers, e.g., in Africa

(Williamson et al., 2008). In the eastern part of sub-Saharan Africa, farmers are mostly exposed to a dry climate and steeply sloped terrain, leading to high levels of soil erosion through either winds or runoff from heavy rains. One way to address these high levels of erosion is to implement different kinds of terraces (Ferro-Vázquez et al., 2017), which constitute "flat contoured plots divided by vertical steps of stone [which] eases the cultivation and checks the erosion of the soil" (Grove and Sutton, 1989). These terraces are particularly relevant for marginal, steep terrains, which are typically prone to runoff production and soil erosion (Socci et al., 2019).

DCE studies addressing terracing were exclusively conducted in Ethiopia, where different forms of on-farm soil conservation measures were presented to respondents. A comparison of DCE applications regarding terracing practices showed that compensation payments for adopting terracing measures were similar. The hypothetical policies did not directly pay out money to the farmers, as is the case in most other studies in this review. Policies offered improved access to credit and technical advice. The authors argued that this policy is sufficient and more suitable to convince farmers to participate (Kassahun and Jacobsen, 2015; Tarfasa et al., 2018; Kassahun et al., 2020).

Farmers in Malawi are indifferent towards projected tillage practices. However, increasing levels of subsidies can potentially crowd in preferences for additional intercropping and residue mulching on fields (Ward et al., 2016).

In the EU, DCE studies have investigated preferences for conservation ploughing methods (Aslam et al., 2017) or tillage reduction (Zandersen et al., 2016; Jørgensen et al., 2020). In Spain, there is significant heterogeneity in preferences towards tillage practices. Farmers tend to believe that tillage is an inevitable measure to overcome resistant weed species and to avoid soil water evaporation. These beliefs translate into the enormous compensation payments needed to reduce tillage in Spain (Villanueva et al., 2015).

Cropping practices (22 studies)

Studies that we filed under the term "cropping practices" primarily address crop choice innovations and classical aboveground cropping prescriptions. Hereby, preferences are assessed by attributes regarding the type of crop cultivation and the restrictiveness of intercropping or crop rotations.

The majority of the studies in this category focus not on the characteristics of single cropping practices but on comparing farmers' preferred choices between different cropping practices, such as intercropping vs. the uptake of innovative and more resistant crops. Additionally, benefits, e.g., in yield or soil fertility, due to changes in management are considered in these studies. Quite obviously, farmers always attached a positive value to these benefits. However, the influence of those benefits on farmers' contract choice varied widely across countries.

While the benefits of increased yield do not trade off the perceived negative perception of cropping prescriptions in France (crop rotation expressed in rice return time on the same plot; Jaeck and Lifran, 2014), the benefit of soil improvement is the most important attribute for the choice of smallholder farmers for climate change adaptation options in Nepal (Khanal et al., 2018). Evidence from Austria shows that the importance of the benefits in terms of increased gross margin varies with different crop choices. While for grassland cultivation, the benefit of increased gross margin does not matter (in comparison to AES payment), it is of greatest importance for the choice of cash-crop and short-rotation coppice management (Pröbstl-Haider et al., 2016).

In the French West Indies, farmers are highly sceptical towards novel pesticide-tolerant crop innovations and prefer agroecological solutions such as intercropping or improved fallow options (Blazy et al., 2011). Similarly, in Thailand, farmers are reluctant to adopt agroforestry practices and prefer the uptake of new drought-resistant crops. This decision comes as little surprise, as switching to agroforestry involves considerably more effort than intercropping and is often even considered a complete agricultural system change (Kanchanaroek and Aslam, 2018).

Addressing the redesigning of the CAP in Germany, farmers show preferences for permitted legume intercropping in ecological focus areas, as they are willing to forgo 21 Euro per ha (Schulz et al., 2014).

In the African context, Ethiopian farmers clearly preferred applying compost to their farmlands instead of legume intercropping (Tarfasa et al., 2018). In Malawi, multiple studies have focused on farmers' preferences for intercropping practices, finding that farmers perceive intercropping and tillage as substitute practices (Ward et al., 2016), that the groundnut intercropping system is the most preferred system among farmers (Ortega et al., 2016), and that there are low preferences for climate-resistant cropping options (Schaafsma et al, 2019).

Livestock management (18 studies)

Livestock and grassland land use prescriptions are closely interlinked, as resources obtained from grassland management are commonly used as fodder to feed livestock (Luoto et al., 2003). This situation either involves cutting and collecting grass through machines on grasslands (Latacz-Lohmann and Breustedt, 2019) or free grazing by cows on pasture (Danne and Musshoff, 2017; Aslam et al., 2017).

Cutting grass with machines may harm ground-breeding bird populations, as the timing of cutting grass may interfere with particular breeding periods (Luoto et al., 2003). A common policy intervention is thus to delay the date of cutting grass to ensure that bird breeding activities are over. Moreover, certain flowers bloom in particular periods and should not be cut before they can reproduce or provide food for insects. In that case, the farmer faces the following trade-off: the later they cut the grass, the higher the chances are of preserving bird populations. However, the later they cut the grass, the lower the quality of fodder for the livestock. The attribute used to reflect that trade-off is the "delay of mowing date" used by studies in Germany (Canessa et al., 2023; Latacz-Lohmann and Breustedt, 2019) and France (Vaissière et al., 2018).

In Ethiopia, livestock farmers operate under free grazing or cut-and-carry systems. Free grazing regimes often suffer from soil erosion due to overgrazing, which is why cut-and-carry, relying on the cooperation of farmers, is suggested. Age and labour cost are key determinants of the willingness to cooperate in cut-and-carry systems, particularly as young farmers have positive expectations of cooperation. More preference heterogeneity is explained by the steep plots of land owned by the farmer. The steeper the plots are and thus the higher the cost of labour is, the higher the expectations of cooperation (Kassahun et al., 2019).

Regarding the second mode of feeding, allowing too many cattle on the pasture decreases the recovery rate of flowers and eventually leads to the depletion of grassland quality. Similar to cutting grass with machines, policy interventions here are aimed at improving levels of bird populations by restricting grazing activities either through cattle density on pasture or periods when cattle are banned from pasture. Attributes to describe the farmers' decision-making process in these situations are "intensive vs. extensive grazing", "grazing period" or "cattle density". Finally, some studies precisely quantify the compensation for cattle density. In Portugal, farmers require 493 Euro/ha per cattle of compensation (Santos et al., 2015). This level is substantially higher than that found in Germany (171 Euro/ha per cattle; Latacz-Lohmann and Breustedt, 2019), but it is justified by the particularly high opportunity costs of extensive grazing in the study area.

Silvopasture integration (13 studies)

This category of land use prescriptions summarises measures that involve long-term biodiversity[2]-enhancing projects that go beyond conventional cropping practices. Silvopasture in general is

[2] by "biodiversity" we refer to alpha-diversity, meaning the taxonomic diversity of species within a particular system (Hanley and Perrings, 2019).

understood as an integrated land use system combining trees, forage and livestock (Jose and Dollinger, 2019). The inclusion of trees is often associated with numerous environmental benefits, such as enhanced microclimate, increased levels of biodiversity, reduced wind speed, improved soil fertility and a decrease in nutrient runoff (Schoeneberger et al., 2012). Moreover, silvopastoral systems are found to enhance carbon storage in agricultural landscapes (Mosquera-Losada et al., 2018).

Although there are a multiplicity of advantages that farmers accrue from silvopasture, research on farmers' ex ante willingness to integrate these measures remains limited. In Ecuador, farmers are willing to convert 1 ha of their land for agroforestry in return for lowering the credit interest rate by 3% (Cranford and Maurato, 2014). In Thailand, farmers highly favour drought-resistant crops over agroforestry (Kanchanaroek and Aslam, 2018).

Table 1. Summary of land use prescriptions

Land use prescriptions				
Class	*Attribute*	*Study*	*Country*	*WTA*
Fertiliser	Dose reduction	Beharry-Borg et al. (2013)	UK	30 Euro/acre for 25% reduction 45 Euro/acre for 50% reduction
		Christensen et al. (2011)	Denmark	128 Euro/ha ban all fertiliser
		Vaissière et al. (2018)	France	-
		Van den Broeck et al. (2017)	Benin	5 Cent price premium on 1kg rice for precise application 20 Cent price premium on 1kg rice for complete ban
		Lizin et al. (2015)	Belgium	85 Euro/ha for 25% reduction
		Chang et al. (2017)	Taiwan	23 Euro/ha/year for ecolabel use
		Blazy et al. (2011)	Guadalupe (France)	n.s.
		Thiermann et al., (2023)	Netherlands	672.09 Euro/ha/year for complete ban
	Organic alternatives	Latacz-Lohmann & Breustedt (2019)	Germany	154 Euro/ha organic fertiliser 232 Euro/ha organic + mineral fertiliser

		Allen & Colson (2019)	Costa Rica	156 Euro/ha for organic agriculture
		Houessionon et al. (2017)	Burkina Faso	208 Euro/ha for organic matter
		Shittu et al. (2018)	Nigeria	152 Euro/ha for manure
		Kadigi & Mlasi (2013)	Tanzania	75/ha
		Czajkowski et al. (2019)	Poland	n.s.
Pesticides	Dose reduction	Bennett et al. (2018)	China	12.6 – 32.4 CNY/ha per % in reduction
		Do Prado et al. (2023)	Brazil	321 Euro/ha/yr and 525 Euro/ha/yr for 25% and 50% reduction in pesticides
		Kuhfuss et al. (2016)	France	194 Euro/ha allowing localised use of pesticides
		Lapierre et al. (2023)	France	347 Euro/ha/year for banning pesticides
		Van den Broeck et al. (2017)	Benin	10 Cent price premium on 1kg for ban on pesticides
		Thiermann et al., (2023)	Netherlands	n.s.
	Organic alternatives	Sangkapitux et al. (2009)	Thailand	3 Euro/ha/year for applying bio-insecticides for each % of their agricultural area
		Narjes & Lippert (2016)	Thailand	n.s.
		Vidogbéna et al. (2015)	Benin	3Euro for fast effective net
		Danne et al. (2019)	Germany	-
		Blazy et al. (2011)	French West Indies	n.s.
		Kanchanaroek & Aslam (2018)	Thailand	n.s.
		Chèze et al. (2020)	France	n.s.
		Silberg et al. (2006)	Malawi	10.3% of maize yield
		Salazar-Ordóñez et al. (2021)	Spain	193-349 Euro/ha (in bundles with other attributes)

Cropping	Crop rotation	Jaeck & Lifran (2014)	France	ambivalent LCA
		Tarfasa et al. (2018)	Ethiopia	Compost >> Crop Rotation
	Intercropping	Schulz et al. (2014)	Germany	25 Euro/ha for planting legumes on EFAs
		Lapierre et al. (2023)	France	n.s.
		Ward et al. (2016)	Malawi	10.6 - 33.3 Euro/acre/year
		Schaafsma et al. (2019)	Malawi	Sorghum >> Pigeon pea
		Ortega et al. (2016)	Malawi	Groundnut >> Soy >> Pigeon pea
		Blazy et al. (2011)	French West Indies	2438 Euro/ha
		Silberg et al. (2006)	Malawi	13-27% of maize yield
	Cover crops	Villanueva et al. (2015)	Spain	4Euro/ha
		Salazar-Ordóñez et al. (2021)	Spain	67-127 Euro/ha depending on intensity
Livestock	Mowing date	Canessa et al. (2023)	Germany	410.70 Euro/ha late mowing
		Latacz-Lohmann & Breustedt (2019)	Germany	5 Euro/ha/day
		Vaissière et al. (2018)	France	-
		Thiermann et al., (2023)	Netherlands	33.99 Euro/ha for delaying mowing dates for two weeks
	Cut and carry	Kassahun & Jacobsen (2015)	Ethiopia	56 days of labor and 387 Birr subsidy
	Grazing	Wachenheim et al. (2018)	USA	increase to 130.0202% of county rental rate
		Espinosa-Goded et al. (2010)	Spain	16-48 Euro/ha/yr
		Aslam et al. (2017)	UK	29 Euro/ha (intensive to extensive)
		Greiner (2016)	Australia	3 Euro/ha for short and 10 Euro/ha for long banning
		Danne & Musshoff (2017)	Germany	0.029 c/kg per day of additional grazing

	Cattle density	Santos et al. (2015)	Portugal	493 Euro/ha per cattle
		Latacz-Lohmann & Breustedt (2019)	Germany	171 Euro/ha per cattle
		Czajkowski et al. (2019)	Poland	49.8 Euro/ha
Silvopasture	Plant trees	Trenholm et al. (2017)	Canada	10.2 - 65.22 Euro/acre/year
		Pröbstl-Haider et al. (2016)	Austria	927 Euro/ha/year
	Agroforestry	Cranford & Mourato (2014)	Ecuador	3% reduction in interest rate for agroforestry
		Kanchanaroek & Aslam (2018)	Thailand	412 Euro/ha/year
		Raes et al. (2017)	Ecuador	n.s.
		Shittu et al. (2018)	Nigeria	7.86 Euro/ha/year
		Haile et al. (2019)	Ethiopia	0.28 Euro/ha/year
Soil	Terracing	Kassahun & Jacobsen (2015)	Ethiopia	25 days of labor and 177 Birr subsidy
		Tarfasa et al. (2018)	Ethiopia	Terracing & trench >> planting biomass Vegetative bund >> soil bund >> fanya juu
		Tesfaye & Brouwer (2012)	Ethiopia	Soil bund >> fanya juu >> stone bund
	Tillage	Aslam et al. (2017)	UK	101 Euro/ha
		Ward et al. (2016)	Malawi	n.s.
		Gramig & Widmar (2017)	USA	3,14 – 4,69 Euro/acre
		Zandersen et al. (2016)	Denmark	25 – 100 Euro/ha
		Villanueva et al. (2015)	Spain	176.30 Euro/ha
		Wachenheim et al. (2018)	USA	-
		Jørgensen et al. (2020)	Denmark	1% of expected yield for 2.77% of tillage reduction
	Mulching	Ward et al. (2016)	Malawi	0.30 - 0.57 Euro/ % of acreage

		Jørgensen et al. (2020)	Denmark	-
Water	Pollution	Beharry-Borg et al. (2013)	UK	ambivalent LCA
		Christensen et al. (2011)	Denmark	51.6 Euro/ha flexible buffer zone width
	Technology	Houessionon et al. (2017)	Burkina Faso	65 Euro/ha waste water use 327 Euro/ha drip irrigation
		Kadigi & Mlasi (2013)	Tanzania	n.s.
		Sangkapitux et al. (2009)	Thailand	n.s.
		Nthambi et al. (2021)	Kenya	-

Monetary values in Euro and 2022 PPP; “n.s.” – not significant & not reported in study; “-“ – no monetary compensation calculated

5.2. Contract design features

In this section, we examine the literature regarding the attributes used to describe the contract features of agri-environmental measures. Therefore, we make use of existing classifications of contract features of agri-environmental measures proposed by Mettepenningen et al. (2013) and Engel (2016). Similar to Mamine et al. (2020), we also distinguish between commitment and incentive attributes, where the former captures the effort, action or task needed to fulfil a contract, while the latter represent mechanisms to motivate farmers to engage in a contract. While Figure 4 below highlights the stacked and individual distribution of contract design features studied in DCE studies over time, the subsequent subchapters discuss findings of individual contract design features in detail.

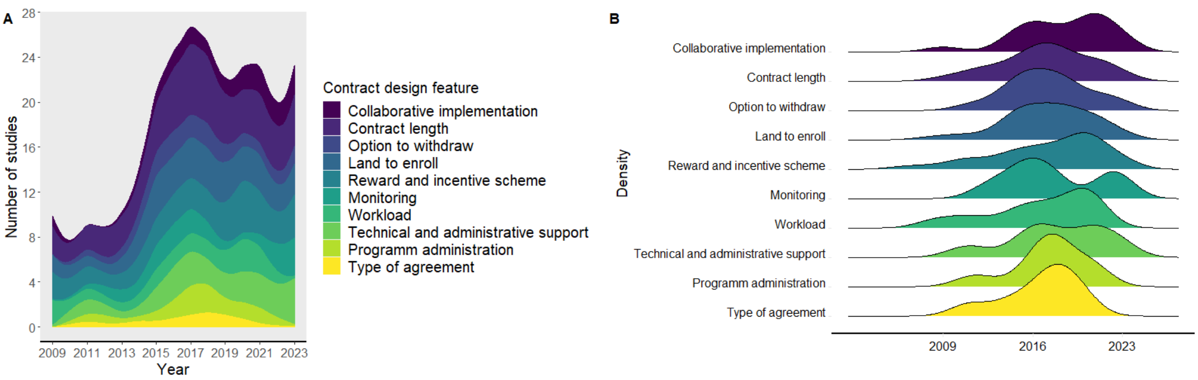

Figure 4: A. Stacked plot and B. Ridgeline density plot of contract design features over time

Duration (commitment - 54 studies)

The duration of the policy schemes has been the most popular contract design feature analysed. From the policy perspective, arranging long-term agreements to establish more resilient ecosystems is desirable to reach environmental goals and reduce the administrative burden and therefore the incurred transaction costs (Ducos et al., 2009). The opinions of farmers towards contract length are ambivalent. On the one hand, long-term agreements facilitate planning ahead and guarantee a certain income for a defined period, providing stability. On the other hand, many farmers are more reluctant to enter long-term agreements to maintain a certain flexibility in land management options (Bougherara and Ducos, 2006).

All studies that included program duration coded this element as years of commitment. The range of this attribute clearly varied with the thematic focus of the research. For grassland and cattle management, which affected the density of cattle per ha, the duration ranged between 1 and 20 years. Policies that included prescriptions on fertilisation, soil management or cropping practices applied timeframes between 1 and 10 years. In either case, longer durations of contracts were perceived as negative and thus always associated with higher needed compensation payments.

Reward and incentive scheme (incentive - 37 studies)

In most cases, preference studies with farmers include remuneration per ha as the payment vehicle for compensating farmers for imposed policy measures. Independent of the land use prescription, many other financial incentives are subject to the contract design for hypothetical policy schemes. This includes bonus payments (Vaissière et al., 2018), price premiums on agricultural products (Chang et al., 2017; Tanaka et al., 2022), access to credit (Kassahun et al., 2019), and payment distribution rules (Lliso et al., 2020).

Multiple studies conducted in Africa included the coverage of certain household expenses as incentives for participation in policy programs. In Kenya, landholders prefer water provisions and water cost waiving over direct cash payments (Balana et al, 2011). In contrast, in Nigeria, there is no significant evidence whether offering 100% cash, 100% in-kind payments (such as improved seeds, organic manure, farm equipment) or a mix of both as payment has an effect on agri-environmental program uptake (Shittu et al., 2018). In Ethiopia, farmers demonstrate strong preferences for food, compared to cash, as a mode of payment when being involved in tree planting activities (Haile et al, 2019).

Often, farmers incur upfront costs when implementing new environmental policies, encompassing significant and long-lasting opportunity costs for participants in terms of the net value of production foregone (Kuhfess et al., 2017). These transaction costs might resemble an important bottleneck for the uptake of new programs. In the US, cost covering has no effect on farmer enrolment in agri-environmental programs (Sorice et al., 2011; Wachenheim et al., 2018a; Yeboah et al., 2015).

In Europe, bonus payments as a medium to accelerate the uptake of environmental policy have been studied extensively. In Spain, farmers see a trade-off between per-hectare payments and fixed one-off payment per contract, as they are willing to accept a decrease in 20.5 Euro/ha of annual payments in return for a one-off payment (Espinosa-Goded et al., 2010). In France, farmers are willing to forgo 157 Euro/ha/year to receive a bonus paying 200 Euro/ha/year for meeting biodiversity criteria, leaving 43 Euro/ha/year of cost to the implementer of the programme (Vaissière et al., 2018). With respect to winegrowers in France, including a threshold bonus, meaning a payment issued when a threshold level of area enrolled in the scheme was attained, is particularly effective. In that case, farmers are even willing to forego larger amounts of annual payments, as the bonus would pay (Kuhfuss et al., 2016).

Taking up the collective approach, various studies have examined farmers' preferences for either individual or collective payments in Africa. In Uganda, farmers involved in watershed management have a clear preference for individual payments over community payments (Geussens et al., 2019). A similar finding arises in Tanzania, involving a collective payment to a village development fund for the maintenance of the agroforest created by the community. However, this collective payment does not alter farmers' decisions to participate in the PES programme (Kaczan et al., 2013).

In many developing countries, access to credit appears to be a major barrier that prevents farmers from engaging in nature conservation activities. In Ecuador, improved credit conditions indeed foster the uptake of agroforestry practices (Cranford and Mourato, 2014). The concept of facilitating access to credit by applying sustainable land management practices has also been applied in Ethiopia in the context of soil management practices, using loan repayment as a payment vehicle (Kassahun et al., 2019; Tarfasa et al., 2018; Tesfaye and Brouwer; 2012).

Payment distribution rules, the mechanism under which farmers are paid, play an important role in farmer participation in agri-environmental measures. When comparing rules based on land, effort or simply paying everyone equal, landholders in Colombia favour distribution rules based on rewarding applied effort, highlighting the importance of fairness in PES payments (Lliso et al., 2020).

Tax reductions were also used as an incentive mechanism in Australia and the US. In both cases, farmers prefer a payment over tax relief (Kreye et al., 2017; van Putten et al., 2011).

Technical and administrative support (incentive - 27 studies)

The successful implementation of agri-environmental measures requires that farmers be well informed about the proper execution of certain programs. For many environmental programs, technical intermediaries between policy makers and farmers assist and inform new environmental programs (Schomers et al., 2015). In contrast to other contract design attributes, studies assessing preferences for technical assistance tend to focus purely on the institutional design of programs and are thus not often combined with attributes regarding land use prescriptions.

Several dimensions of assistance were included in the DCE. Studies in developing countries include the services of intermediaries to increase the credibility of agricultural projects (Costedoat et al., 2016; Lliso et al. 2020) or offer physical training for the successful implementation of policy schemes (Khanal et al., 2018). While in Colombia (Lliso et al., 2020) and Mexico (Costedoat et al., 2016), farmers do not have preferences for advisory service providers, smallholders in Nepal would give up 6 euros of their monthly earnings for adequate capacity building in climate change adaptation programs (Khanal et al., 2018).

Other studies include services that aim to decrease farmers' transaction costs of enrolling in and successfully integrating a program. These applications usually test the option of having technical assistance while implementing AECM (Hasler et al., 2019; Espinosa-Goded et al., 2010; Van Putten et al., 2011; Kuhfuss et al., 2016; Lienhoop and Brouwer, 2015; Franzén et al., 2016; Häfner and Piorr, 2021). In that instance, farmers are consistently willing to forego compensation payments to receive advice.

Land to enrol (commitment - 36 studies)

This attribute was initially coded as the "share of farmland enrolled in the programme", unambiguously leading to larger needed compensation payments for larger areas put under contract. However, over time, this changed towards discrete continuous approaches, confronting farmers first with a discrete choice on the contract option and second with the area involved in the schemes (Latacz-Lohmann and Breustedt, 2019; Vaissière et al., 2018; Kuhfuss et al., 2016). This discrete-continuous approach allows researchers to identify farmers' preferred contracts to further disentangle determinants of land allocation for farmers' preferred contracts.

Administrative Agency (commitment - 16 studies)

In particular, for studies that aim to determine general terms of agreement for a conservation scheme, issues of procedural equity and thus choice of contract providers were the subject of preference studies. In addition to ensuring distributional equity, farmers in Colombia favour community participation in the design process of PES schemes, hence striving for procedural equity as well (Lliso et al., 2020).

This context was also investigated in Africa, where very different results were found. Farmers prefer NGOs as contract providers over community development associations (Shittu et al., 2018). Similar evidence is found in Zambia, where farmers also prefer NGOs to local governments as contract providers (Vorlaufer et al., 2017). In Ethiopia, however, farmers prefer agri-environmental measures provided by the regional government (Tarfasa et al., 2019). This observation was justified by existing supply networks of agricultural inputs of regional governments, including fertiliser and improved seeds to smallholder farmers in the area.

Workload and administrative burden (commitment - 22 studies)

Another important trade-off that farmers must address is the needed time that they must invest to successfully implement a program. Clearly, the more time they need for the administration and performance of an environmental program, the less likely they are to sign a contract. Common attributes to capture the workload of a program are “administrative commitment” (Ruto and Garrod, 2009; Chèze et al., 2020; Mariel and Meyerhoff, 2018), reflecting the needed paperwork or “labour days” (Van den Broeck et al., 2017; Hope et al., 2008), which display the physical work effort of the policy measure. Workload is considered a somewhat generic attribute relevant to all land use prescriptions. In the context of developing countries, workload was interpreted as labour days that must contribute to the policy measure (Kassahun and Jacobsen, 2015; Tarfasa et al., 2018; Ortega et al., 2016; Jacobsen et al., 2018), whereas in Europe, it was seen as administrative effort and paperwork (Mariel and Meyerhoff, 2018; Ruto and Garrod, 2009). Clearly, in all cases, farmers dislike placing more effort into program administration, independent of paperwork or physical workload.

Termination (incentive - 17 studies)

Closely linked to the duration of a contract, withdrawal from an agreement is included as an option in some preference studies. Farmers highly appreciate the option to cancel a contract if they realise that they cannot effectively implement a program on their land. This option gives farmers additional flexibility (Christensen et al., 2011).

The design of the contract element is quite similar across the literature and in almost all cases binary coded, meaning a farmer either has the option to withdraw from the contract or does not have the option. Few studies have extended this idea by incorporating unexpected external conditions (Greiner, 2016) or minimum contract durations (Broch and Vedel, 2012), after which the potential release option can be realised.

This feature was mostly included in studies involving prescriptions on livestock. The rationale is that prescriptions on livestock and grassland management mostly address the mode of harvesting fodder for cattle. Having the option to terminate a contract allows farmers to react to weather extremes and cut grass before it becomes unusable as fodder (Greiner, 2016). In Australia, farmers particularly value an option to suspend the programme for one year under extreme weather circumstances (Greiner, 2016).

Monitoring (commitment - 18 studies)

Policy makers clearly want to ensure that farmers comply with the imposed land use prescriptions. Therefore, a share of the total population of farmers who are enrolled in an agri-environmental program are subject to monitoring. Regarding the CAP, monitoring involves farm visits by authorities to see if farmers are complying with regulations such as mowing dates and farm area for conservation programs (Bartolini et al., 2012). Being monitored by authorities involves a risk of sanctioning. Thus, AECM uptake is affected by the intensity of monitoring.

Most studies dealing with crop and soil prescriptions added the monitoring attribute in their choice scenarios. This addition is intuitive, as the feasibility of checking compliance with certain policies varies with the type of policy in place. The application of fertilisers is more difficult to monitor due to the prescriptions imposed on tillage.

The vast majority of DCE studies including a monitoring attribute were conducted in developed countries and coded the attribute as the "share of farmers monitored" (Villanueva et al., 2015; Broch et al., 2013; Mariel and Meyerhoff, 2018), ranging from 1% to 30%. In the case of soil protection programs, there is no effect of monitoring on program enrolment (Mariel and Meyerhoff, 2018; Villanueva et al., 2015).

Other studies provided options, such as self or external monitoring (Canessa et al., 2023; Greiner, 2016; Thiermann et al., 2023) and regular or irregular control (Li et al., 2017), or even provided options regarding the monitoring agency (Kreye et al., 2017). Self- and nongovernmental monitoring seemed to positively affect farmers' choices regarding programme enrolment (Canessa et al., 2023; Thiermann et al., 2023).

In Tanzania, farmers show preferences for monitoring schemes under which farmers are accountable to their peers. In turn, farmers dislike policy options and external monitoring agencies (Kaczan et al., 2013).

Table 2. Summary of contract design features

Contract design features

Feature	*Attribute*	*Study*	*Country*	*WTA*
Duration (Commitment)	These features have been assessed in greater detail by Mamine et al. (2020)			
Land to enroll (Commitment)				
Reward scheme (Incentive)	in-kind	Balana et al. (2011)	Kenya	-
		Shittu et al. (2018)	Nigeria	17.5 Euro/ha (50% cash and 50% in kind)
		Haile et al. (2019)	Ethiopia	14.85 Euro/ha (food instead of cash)
	Installation cost	Wachenheim et al. (2018)	USA	–0.2108% of lands rental rate
		Yeboah et al. (2015)	USA	n.s.
		Sorice et al. (2011)	USA	-
	Certfication	Hope et al. (2008)	India	-
		Chang et al. (2017)	Taiwan	NTD$ 717
	Bonus payments	Espinosa-Goded et al. (2010)	Spain	30-46Euro/ha/yr for 1000 upfront payment
		Vaissière et al. (2018)	France	174 Euro/ha/yr for conditional 200 Euro/ha/yr bonus
		Kuhfuss et al. (2016)	France	120 Euro/ha/yr for 30 Euro/ha/yr bonus payment
		Šumrada et al. (2022)	Slovenia	Forego 47 Euro/year/ha for receiving 40 Euro/year/ha when target enrollment in area is reached
		Thiermann et al., (2023)	Netherlands	forego 336.80 Euro per ha for a 1000 collective bonus for achieveing environmental results

		Thiermann et al., (2023)	Netherlands	forego 294.59 Euro per ha for a 5000 Euro individual bonus for ditch inundation on their farm
	Community payment	Geussens et al. (2019)	Uganda	131 Euro required for communal payment 87 Euro required for 50/50 individual communal payment
		Kaczan et al. (2013)	Tanzania	n.s.
		Costedoat et al. (2016)	Mexico	Cash > collective agricultural productive project > community public good
	Tax reduction	Kreye et al. (2017)	USA	Payment per acre >> Tax reduction >> Depredation payment >> SHA agreement
		Putten et al. (2011)	Australia	ambivalent, depending on LC
	Access to credit (as payment vehicle)	Kassahun et al. (2019)	Ethiopia	(payment vehicle)
		Tarfasa et al. (2018)	Ethiopia	(payment vehicle)
		Cranford & Mourato (2014)	Ecuador	(many scenarios)
		Tesfaye & Brouwer (2012)	Ethiopia	(payment vehicle)
	Payment distribution	Lliso et al. (2020)	Colombia	n.s.
Technical support (Incentive)	Credibility of program	Costedoat et al. (2016)	Mexico	n.s.
	Training	Khanal et al. (2017)	Nepal	6 Euro of monthly earning

		Šumrada et al. (2022)	Slovenia	Mandatory training: Forego 76 Euro/ha/year when selecting the training service Forego 60 Euro/ha/year when training is annual farm expert visits
	Technical assistance	Espinosa-Goded et al. (2010)	Spain	reduction of 6-13% of compensation payments
		Lienhoop & Brouwer (2015)	Germany	258 Euro/ha
		Hasler et al. (2019)	Denmark, Estonia	31 Euro/ha/year (Denmark) 130 Euro/ha/year (Estonia)
		Franzén et al. (2016)	Sweden	[graphical representation of coefficents]
		Putten et al. (2011)	Australia	n.s.
		Trenholm et al. (2017)	Canada	157 Euro/acre/year
		Kuhfuss et al. (2016)	France	115 Euro/ha/year
		Tanaka et al. (2022)	Japan	n.s.
Administrative agency (Commitment)		Lliso et al. (2020)	Colombia	n.s.
		Vorlaufer et al. (2017)	Zambia	NGO >> Government
		Shittu et al. (2018)	Nigeria	NGO >> Community Developement Association >> Government >> private
		Tarfasa et al. (2018)	Ethiopia	Regional goverment >> NGO
		Tesfaye & Brouwer (2012)	Ethiopia	Local government >> regional government

		Häfner and Piorr (2021)	Germany	horizontal/stakeholder-including institution >> regional government
Termination (Incentive)	Deviate from aims	Greiner (2016)	Australia	6.2 Euro/ha/year
	Cancel contract	Christensen et al. (2011)	Denmark	164 Euro/ha/year
		Broch & Vedel (2012)	Denmark	1467 Euro/ha
		Czajkowski et al. (2019)	Poland	51-167 Euro/ha/year
		Zandersen et al. (2016)	Denmark	7.4 Euro/ha/year
		Hasler et al. (2019)	Denmark, Estonia	46-148 EURO/ha/year
		Mariel & Meyerhoff (2018)	Germany	48-155 EURO/ha/year
		Li et al. (2017)	China	623 Euro/ha/year
Monitoring (Commitment)	Share monitored	Villanueva et al. (2015)	Spain	n.s.
		Mariel & Meyerhoff (2018)	Germany	n.s.
		Broch & Vedel (2012)	Denmark	48 Euro/ha/% of monitored farmers
	Monitoring agency	Canessa et al. (2023)	Germany	134.2 Euro/ha/year
		Greiner (2016)	Australia	n.s.
		Kreye et al. (2017)	USA	n.s.
		Kaczan et al. (2013)	Tanzania	33 Euro/acre/year moderate conditionality 71 Euro/acre/year high conditionality
		Tanaka et al. (2022)	Japan	342 Euro/year/ha additional compensation when done by farmer instead of external expert

		Thiermann et al., (2023)	Netherlands	forego between 427 and 458 Euro per ha if monitoring organised by bird director or bird protector
	Criteria	Šumrada et al. (2022)	Slovenia	337 Euro/year/ha lower payments in case of results based monitoring compared to prove implementation of prescribed practices 129 Euro/year/ha lower payment for hybrid monitoring (instead of monitoring only prescribed practices)
Workload (Commitment)	Administrative commitment	Ruto & Garrod (2009)	EU	6-8% of annual hectare payments for higher workload
		Chèze et al. (2020)	France	109-151 Euro/ha/yr (contract or certification)
		Mariel & Meyerhoff (2018)	Germany	156.2 Euro/ha/yr (medium to high effort)
	Labor days	Ortega et al. (2016)	Malawi	high labor (instead of low labor) requirement traded off with 8.4% of maize yield
		Hope et al. (2008)	India	-
		Jacobsen et al. (2018)	Kenya	Increase of 8.8kg of yield for increased labor requirement
		Van den Broeck et al. (2017)	Benin	3 Cent price premium on 1kg for ban on pesticides
		Kassahun et al. (2019)	Ethiopia	(payment vehicle)

	Banerjee et al. (2021)	Scotland	1.47 Euro per acre for additional hour per week
	Silberg et al. (2020)	Malawi	9.2% of additional maize yield for high labor requirement

Monetary values in Euro and 2022 PPP; “n.s.” – not significant & not reported in study; “-“ – no monetary compensation calculated

5.3. Applicability of DCE typology and combination of land use prescriptions with contract design features

Despite the established dichotomy of DCE studies, the analysis reveals a strong interdependence between land use prescriptions and contract design features. This is illustrated at the bottom of Figure 3 in which we further distinguish between three different types of studies.

In the first type of study, the attributes focus solely on preferences with respect to land use prescriptions. These studies serve as a preliminary analysis of agri-environmental measures and aim to determine whether farmers are willing to implement land use prescriptions. Since the attributes usually represent various land use prescriptions, these studies investigate which type of measure is preferred by farmers. Overall, the focus of these studies is relatively broad, and only a small proportion of studies fall into this category.

The second type of study takes it a step further. In that case, land use prescriptions that are to be achieved are defined in advance. Consequently, the attributes of these studies solely address the necessary institutional framework conditions facilitating the implementation of predefined land use prescriptions. In such cases, it is already known that farmers are generally willing to implement land use prescriptions. Therefore, the attributes aim to fine-tune the contract of agri-environmental measures. The focus of these studies is more specific compared to the first type.

On the other hand, the third type of study combines both groups, and the attributes target both land use prescriptions and contract design features. The idea is to explore through interactions of the individual attributes whether farmers are willing to implement particular land use prescriptions and whether specific incentive mechanisms can leverage implementation. This type of study is conducted when alternative land use prescriptions are often not available. The focus is also specific compared to the first group, and most studies fall into this category. Figure 5 illustrates in which instances attributes of both classes have been combined.

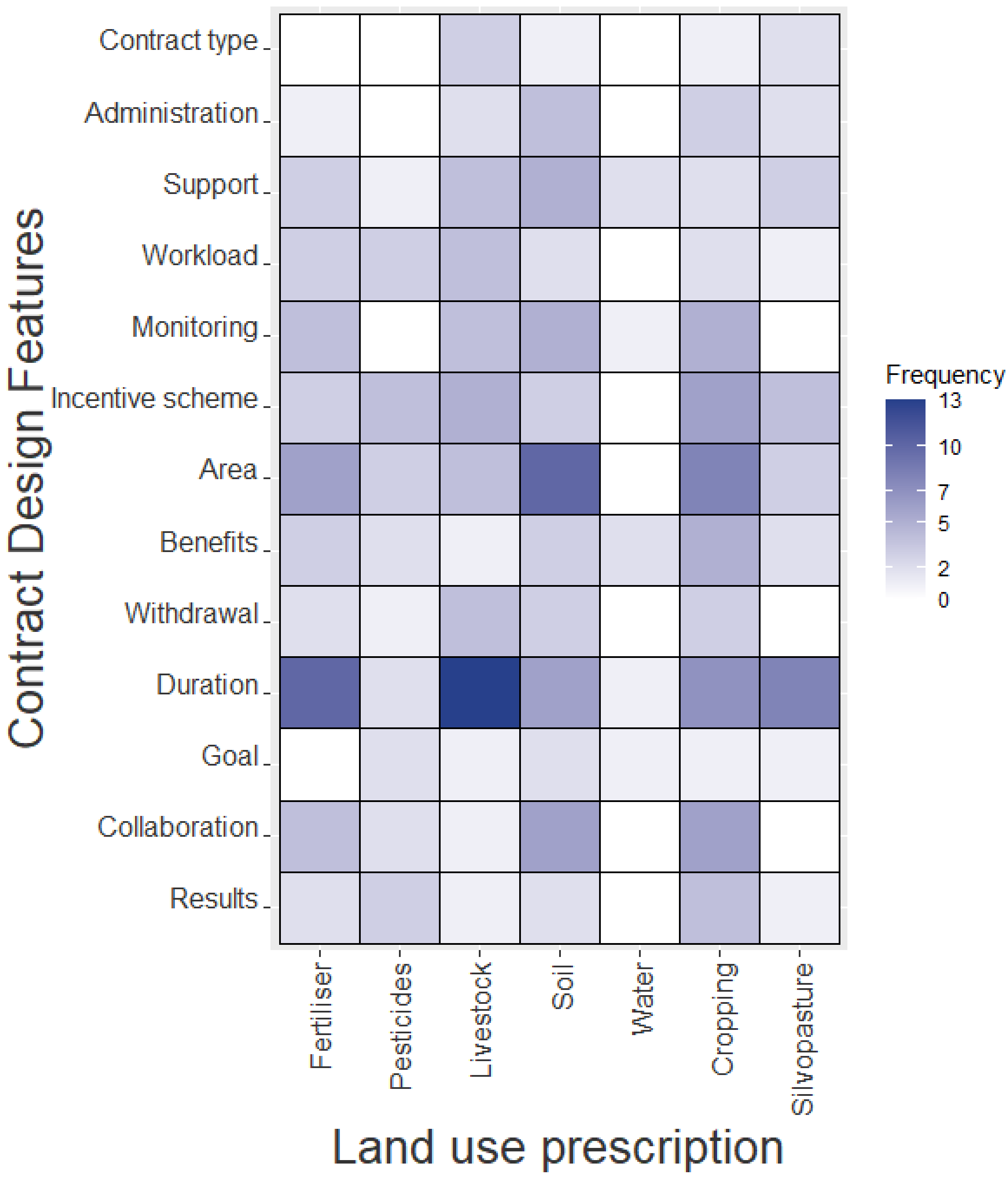

Figure 5: Heatmap of land use prescriptions and contract design features

Most notably, the duration and area attributes were combined most frequently with other land use prescriptions, such as livestock and soil prescriptions. As mentioned earlier, certain contract design features do make particular sense with precise land use prescriptions, such as combining grazing prescriptions with the option to withdraw from an agreement to react to exceptional circumstances (e.g., extreme weather conditions) and cut grass for fodder at the optimal time (Czajkowski et al., 2021; Greiner, 2016; Wachenheim et al., 2018a). Other popular combinations are prescriptions on fertilisation with the duration of an agreement or soil management practices and incentive schemes.

First, thinking about longer-term contracts makes sense, as the effects on the ecosystem are long-lasting and therefore need time to recover (Beharry-Borg et al., 2013; Latacz-Lohmann and Breustedt, 2019). The second combination, soil management and reward schemes, is used frequently, as it is being studied, particularly in Africa, using in-kind payments as incentives for participation (Geussens et al., 2019; Kassahun et al., 2020; Shittu et al., 2018).

Many of the considered studies examined several contract design features in parallel. Figure 6 shows which features were combined with which frequency. Incentive and commitment features in particular are frequently combined. The core idea of the choice scenarios of DCE studies is to show alternatives in which the participants face trade-offs between the differently depicted attribute levels and choose the alternative that provides the highest utility. The commitment features tend to address obligations for farmers and subsequently contribute negatively to the willingness to participate in contract of agri-environmental measures. The incentive features, on the other hand, reflect supportive elements of contract implementation and are usually perceived positively. With that in mind, unsurprisingly, commitment and incentive features are combined to investigate trade-offs. For example, termination and duration (Bennett et al., 2018), reward schemes and area (Kisaka and Obi, 2015), and technical support and duration (Lienhoop and Brouwer, 2015) are often jointly applied as attributes to characterise contracts for agri-environmental measures.

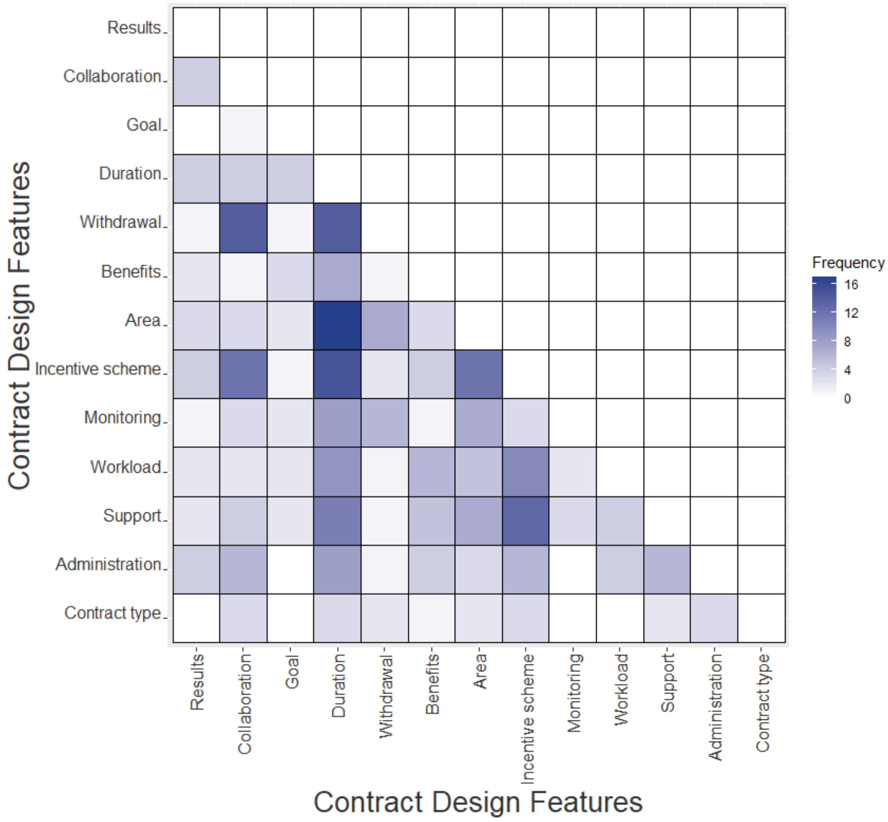

Figure 6: Heatmap of combinations of contract design features (upper right triangle and diagonal intentionally blanked out)

In summary, land use prescriptions and contract design features should not be regarded independently; both dimensions must be considered jointly in the DCE for meaningful policy assessment. It is crucial that both aspects are included in the design of DCEs because farmers trade off the entire setup of a policy to make their decision, considering all aspects of the contract: land use prescription, contract design, and payment.

For example, farmers may agree with grazing prescriptions and the payment level. However, if the measure involves a high administrative burden, they may choose not to participate, despite what preference studies might suggest. A similar situation arises in peatland management. Although farmers may agree with water level increases and the associated payment, influential determinants of cooperation must be examined simultaneously (Häfner and Piorr, 2021).

Hence, studies that only consider land use prescriptions and ignore other factors that promote or hinder farmers' decisions may be misleading.

5.4. Observable characteristics explaining preference heterogeneity

Explaining preference heterogeneity is essential to comprehend which segments of the population are likely to adopt agri-environmental measures. Therefore, many DCE studies have included observable factors of preference heterogeneity in addition to attributes. These primarily encompass sociodemographic farmer characteristics, such as age, gender, and income, as well as psychological aspects, such as risk perception and beliefs about climate change. Furthermore, farm characteristics, such as land size, farm ownership, and soil quality, are often collected to interact with DCE attributes and consequently infer enrolment in agri-environmental measures.

Regarding farmer characteristics, it appears that relatively lower-income farmers (Blazy et al., 2011), those with off-farm income (Allen et al., 2014; Bastian et al., 2017; Giefer et al., 2017), farmers experienced in AECM (Latacz-Lohmann and Breustedt, 2019; Lienhoop and Brouwer, 2015), and members of farmer organisations (Cortés-Capano et al., 2021; Espinosa-Goded et al., 2010) are more inclined to participate in AECM. Additionally, climate change beliefs and the perception that pesticides harm the environment contribute to AECM participation (Chèze et al., 2020; Khanal et al., 2018). Ambiguous effects are observed for age, education, and gender.

Conversely, when examining farm characteristics, farm ownership and management intensity are decisive factors for enrolment in agri-environmental measures. Generally, the more intensive the farming practices are, the less willingness there is to participate in AECM (Breustedt et al., 2013; Danne et al., 2019). Concerning ownership, farms operating on their own property are more willing to implement agri-environmental measures (Schaafsma et al., 2019; Shittu et al., 2018). Ambiguous effects are observed for productivity and the size of managed land.

Table 3. Observable factors of preference heterogeneity and their effect on enrolment in agri-environmental measures

Farmer characteristics	*Effect on participation in agri-environmental measures*	*Source*
Age	+	Khanal et al. (2018)
	-	Alló et al. (2015); Bhatta et al. (2022); Blazy et al. (2011); Šumrada et al. (2022)
Education	+	Allen and Colsen (2019); Alló et al. (2015); Hansen et al. (2018); Lienhoop and Brouwer (2015)
	-	Giefer et al. (2021); Villanueva et al. (2017)
Environmental beliefs	+	Chèze et al. (2020); Tanaka et al. (2022)
Experience	+	Lapierre et al. (2023); Latacz-Lohmann and Breustedt (2019); Lienhoop and Brouwer (2015)
Gender (female)	+	Allen and Colsen (2019);
	-	Giefer et al. (2021)
Income	-	Blazy et al. (2011); Sangkapitux et al. (2018)
Membership	+	Cortés-Capano et al. (2021); Espinosa-Goded et al. (2010); Sangkapitux et al. (2018)

Off farm income	+	Allen and Colsen (2019); Bastian et al. (2013); Giefer et al. (2021)
Risk averse	-	Lapierre et al. (2023)

Farm characteristics	*Effect on participation in agri-environmental measures*	*Source*
Intensity	-	Breustedt and Latacz-Lohmann (2013); Li et al. (2017)
Organic farming	+	Lapierre et al. (2023)
Ownership	+	Haile et al. (2019); Schaafsma et al. (2019); Shittu et al. (2018)
Productivity of land	+	Mariel and Meyerhoff (2018)
	-	Cortés-Capano et al. (2021)
Size	+	Khanal et al. (2018)
	-	Mariel and Meyerhoff (2018)

Aside from interacting observable farm or farmer traits with attributes, latent class models are frequently employed. Latent class models capture preference heterogeneity across segments (classes) of the population and assume uniform parameter estimates within the same class (Greene and Hensher, 2003). The probabilities of class membership are estimated for each individual based on socioeconomic covariates, such as age (Geussens et al, 2017; Kassahun and Jacobsen, 2015; Sardaro et al., 2016), education (Geussens et al, 2017; Van den Broeck et al., 2017), experience (Canessa et al., 2023; Houessionon et al., 2017; Ortega et al., 2016; Rakotonarivo et al., 2017), gender (Geussens et al, 2017), income (Broch and Vedel, 2012; Geussens et al, 2017), risk perception (Tyllianakis et al., 2023), farm characteristics such as farm size (Houessionon et al., 2017), land characteristics (Jaeck and Lifran, 2014), ownership (Broch and Vedel, 2012), soil and water quality (Chang et al., 2017; Raes et al., 2017; Zanderson et al., 2016), or organic farming status (Lapierre et al., 2023; Rocchi et al., 2017).

6. Discussion and conclusions

This systematic literature review provides insights into the trade-offs farmers face regarding implementing agri-environmental measures on their farmland. In the remainder of this paper, we will look at a) methodological developments, b) links to current policy discussions and c) potential avenues of future research.

6.1. Trends and methodological developments

In terms of methodological advancements and the underlying econometric framework, we now highlight three selected avenues that have received particular attention in the literature.

First, there has been an increasing use of econometric estimation methods that account for preference heterogeneity. Notably, mixed logit models have been employed, allowing researchers to specify distributions of preference parameters. Unlike multinomial logit models, these methods relax fundamental assumptions, such as the assumption that all respondents have identical preferences and that the error term is independent and identical for all alternatives and respondents. As a result, these improved estimation models lead to better model fit, extract more information from the data, and provide a better explanation of choices.

Second, substantial progress has been made regarding modelling the choice situations, extending the discrete contract selection to be followed by a continuous choice. In this approach, participating farmers first select the preferred contract and then specify the size of the area they would like to enrol under the contract (Kuhfuss et al., 2016; Vaissière et al., 2018; Latacz-Lohman and Breustedt 2019). This two-step discrete-continuous process yields more information from the DCE and allows for the optimisation of contracts for agri-environmental measures. However, this has to be treated with caution, as unobserved factors influencing contract choice might affect the choice of land under contract. To control for this selection bias, Bourguignon et al. (2007) compare various selection bias correction models using Monte Carlo simulations, which are then applied to explain the continuous choice of land enrolled in contracts. In a recent study with German farmers, Latacz-Lohmann and Breustedt (2019) employed this two-step discrete-continuous procedure to develop a contract optimisation model for a specific conservation scheme.

Third, beyond preferences, researchers attempt to incorporate other determinants of behaviour using DCEs. For instance, identities, defined as "a set of meanings that define who one is when one is an occupant of a particular role in society, a member of a particular group, or claims particular characteristics that identify him or her as a unique person" (Burke and Stets, 2009), are linked to the implementation of different land uses (McGuire et al., 2015). In addition to influencing preferences, identities also affect farmers' utility for contract attributes, which are captured separately from the choice situations. Subsequently, the individual parameters are estimated in a hybrid choice model. Hybrid choice models have seen limited application in the agricultural sector, focusing thus far only on farmers' environmental identities and biogas investment decisions (Zemo and Termansen, 2021). Regarding the ongoing debate about "What is a 'Good Farmer'?" (Burton et al., 2020), future studies may explore the extent to which different identities (such as “productivist”, “conservationist” or “civic-minded”) explain participation in agri-environmental measures.

6.2. Policy contexts and reflection

Within the EU's Common Agricultural Policy, there are ongoing debates and revisions with respect to restructuring the budgetary allocations and thus the conditions under which payments are issued (Runge et al., 2022). The post-2020 CAP reform seeks to provide farm income support, conditional on respecting specific environmental standards. Moreover, the reform features a more decentralised design, meaning that member states formulate their own strategic plans according to local specificities (Petsakos et al., 2022). Hence, recently, new design features of incentives and delivery models of payments have been investigated. These include, for instance, the willingness to accept result-based schemes (Niskanen et al., 2021; OECD, 2022) or features to incentivise cooperation, e.g., through threshold bonuses (Kuhfuss et al., 2016). In a wider context, the EU Green Deal combines several goals to make future EU policies more sustainable, including the Farm-to-Fork Strategy, which has the intention of making food systems fair, healthy and environmentally friendly (European Commission, 2020). To meet the requirements of the policy objectives, future DCEs could investigate the extent to which farmers in Europe are interested in label-based approaches as alternative incentives to participate in agri-environmental measures. Moreover, EU policy envisages that the implementation of other policy instruments should be aligned with farmer preferences, for example, under the Nature Restoration Law, which seeks to address the use of agricultural lands for natural habitat (European Commission, 2022).

A different policy instrument applied around the globe is PES, which in many cases has a strong focus on the conservation of biodiversity (Matzdorf et al., 2014). To design PES schemes effectively, consideration of complex human-nature relationships becomes inevitable (Van Hecken et al., 2015). While past research has primarily looked at the willingness and ability to participate in PES schemes (Jones et al., 2020), the current academic discourse addresses the multiple equity dimensions in PES scheme design (Loft et al., 2020; Friedman et al., 2018). The execution of schemes requires substantial engagement not only by individual actors alone but also by communities working strongly together (Ingram et al., 2014). Hence, some DCEs contained policy incentives in PES schemes that ensure social equity through preferences for group accounts and involvement in decision-making processes (Lliso et al., 2020). Experimental evidence from real effort tasks conducted in Southeast Asia has shown that participants are willing to invest more effort in conservation activities once they realise that distributional equity is ensured, meaning that all participants are paid equally per prepared seed bag (Loft et al., 2020). A recent DCE followed up on this debate by considering community participation in PES scheme designs and thus addressed the procedural equity dimension (Lliso et al., 2020).

6.3 Research gaps

Several novel features have appeared during the past 15 years to increase the compliance and conditionality of agri-environmental contracts. In addition to different forms of monitoring, as tested by Kaczan et al. (2013), result-based payments and collaborative approaches are being discussed as innovative contract modes to increase the uptake of AECMs (OECD, 2022; Olivieri et al., 2021; Sattler et al., 2023). While in some countries these features have already been piloted or even implemented, DCE could be used to test whether these contract elements are accepted also elsewhere.

Results-based approaches

The majority of current agri-environmental policies intend to reward farmers for prescribed management practices. Critics argue that these schemes inhibit farmers' flexibility in managing their lands (Matzdorf and Lorenz, 2010). If, for example, farmers were rewarded for achieving environmental results instead of detailed management practices, farmers could decide on their own how to carry out programmes and thus make the best use of their knowledge and own experiences (Bartkowski et al., 2021). From a theoretical perspective, result-based payments are argued to be more cost-effective than practice-based schemes, as farmers will adopt fewer but more targeted abatement measures on their lands when being paid for results (Sidemo-Holm et al., 2018). Recent empirical evidence supports this argument and suggests that result-based payments are more cost effective than practice-based payments (Wuepper and Huber, 2022). The idea of result-based payments is particularly important in light of the incurred transaction costs of agri-environmental measures. Empirical studies attempting to quantify farmers' transaction costs indicate that there is substantial heterogeneity of costs between farmers due to different programme requirements, farm characteristics or geographical circumstances (Mettepenningen et al., 2013). Authorities are rarely aware of individual farm cost structures and hence reimburse farmers for agri-environmental practices based on average cost calculations. This information asymmetry often leads to self-selecting contracts, meaning that only scheme participants with lower-than-average costs are likely to engage in agri-environmental measures (Ferraro, 2008; Latacz-Lohmann and Breustedt, 2019). Accounting for farm heterogeneity in practice-based contracts implies tailoring contracts to individual farms' needs, potentially leading to exorbitant transaction costs. Result-based payments may alleviate this issue by allowing farmers to choose the option that might be most cost effective for them (Niskanen et al., 2021). Hence, under a regime of result-based payments, there might not be a need for sophisticated guidelines. Instead, farmers would pursue the most cost-efficient measures to achieve predefined results.

However, result-based payments are not without risks, as environmental outcomes may not materialise due to external influencing factors, such as unexpected weather conditions (Ayambire and

Pittman, 2021; Burton and Schwarz, 2013). Moreover, among the risks is the potential decline in participation rates, leading to fewer AECM implementations compared to equivalent action-based schemes (Matzdorf and Lorenz, 2010). A potential solution to this issue could be a hybrid option consisting of an independent basic payment complemented by a results-dependent premium payment (White and Hanley, 2016). Recent evidence from the UK (Tyllianakis and Martin-Ortega, 2023) and Germany (Canessa et al., 2023) shows that hybrid contracts are the preferred type of contract among farmers.

Currently, limited applied DCE research includes precise results-based payments in their frameworks. In a few cases, these payments have involved predefined biodiversity targets expressed in species abundance (Sorice et al., 2011; Tanaka et al., 2022; Thiermann et al., 2023), yield projections (Waldman et al., 2017), success of tree planting activities (Schaafsma et al., 2019) or water quality improvements (Niskanen et al., 2021). There is abundant room for further progress in determining how farmers compare practice- and result-based programs once they truly have the option to select between the two.

Future studies should examine which incentive mechanisms prove effective for farmers so that they opt for result-oriented AECMs. Further research on hybrid schemes, bonus payments, and labelling approaches indicating farmers' environmental commitment could be considered for this purpose.

Collective approaches

Another important contract feature involves incentives to work collectively and implement agri-environmental measures at a landscape scale. Recent empirical evidence from public goods games suggests that farmers are more cooperative, as experts predict, suggesting that farmers might also join efforts to work collectively within AECM (Rommel et al., 2022).

This practice has become common in the Netherlands, thus producing the term "Dutch model". Within this Dutch model, farmers form collectives that negotiate agri-environmental contracts with local entities (Franks and McGloin, 2007). These collectives have the advantage that through collaboration at a landscape scale, scheme effectiveness is improved (Westerink et al., 2017), and governmental transaction costs are decreased (Barghusen et al., 2022). However, empirical evidence suggests that these collectives incur higher private transaction costs due to the higher coordination efforts between individual parties (Westerink et al., 2017).

From a risk perspective, there is no guarantee that all farmers will contribute equally to the collective and thus may free ride on the efforts of peer collective members. In the context of agroforestry, Swiss farmers show little interest in coordinating actions, as this strongly depends upon beliefs about other farmers' interests in coordinating actions (Villamayor-Tomas et al., 2019). With respect to rewetting peat soils in Germany, part-time farmers and those without formal agricultural training perceive support for cooperation as beneficial (Häfner and Piorr, 2021). Other studies have looked at collective approaches by including attributes that represent the threshold number of farmers that must participate in a scheme to be implemented successfully (Kuhfuss et al., 2016) or require at least five farmers within a municipality to sign the same AECM contract (Villanueva et al., 2015). Shifting from the agricultural context to forest disease control, evidence from Finland shows that the success of utilising an agglomeration bonus as a means of spatial coordination largely relies on factors such as the pre-existing disease impact, anticipated disease spread, and attitudes to engage in local cooperation (Sheremet et al., 2018).

Future research might move in the direction of the Dutch model, in which farmers work in cooperatives together and thus form a separate institution. The decision-making processes of these cooperatives may look very different from traditional individual choices. Here, research could look at preferences of working together and at how choices of the cooperative with respect to sustainable land management practices may look. Moreover, since intermediaries play an important role in advising farmers and coordinating projects, prospective DCEs should investigate farmers' preferences for the role of intermediaries in agri-environmental measures. While there is a plethora of research on the issue of providing advisory services, there is still a gap in what specific type of advisory intermediaries should be given. Future research should focus on shaping the role of intermediaries to facilitate the implementation of agri-environmental measures.

Apart from the results-based and collaborative approaches, there are numerous other topics in the DCE literature dealing with farmers' contracts of agri-environmental measures that have not been adequately explored. First, there are mixed results in terms of farmers' preferences across alternative reward schemes and payment mechanisms. Future research could take a closer look at the exact causes of the conflicting preferences. Furthermore, the heatmaps (Figure 5 and Figure 6) show various blank spots regarding attribute combinations. Further research could address these issues and investigate new contract constellations.

6.4 Conclusion

This review synthesised how DCEs have been used to inform the design of agri-environmental policies. In the past, DCEs have contributed to the governance of ecosystem services in agricultural landscapes by assessing farmers' ex ante preferences for agri-environmental measures. Therefore, quantifying farmers' preferences for different land use prescriptions and contract design features has been essential for ex ante policy analysis. For farmers, the provision of environmental goods and market goods often implies trade-offs, and knowing their preferences for the different policy features may be important to achieve a necessary level of commitment that facilitates policy implementation and integration.

We conclude that DCEs provide valuable insights into the preference structure and decision-making processes of individuals. While DCEs can be useful for policy design, they should be complemented by other methods (El Benni et al., 2023). Therefore, policy makers are advised to draw from a comprehensive toolkit, including other experimental approaches based on revealed preferences such as field experiments and randomised controlled trials (RCTs), as well as qualitative research to complement DCE results. This triangulation of methods helps balance the strengths and weaknesses of each approach (Colen et al., 2016).

In particular, DCEs are often attributed with relatively low internal validity compared to lab experiments, as they rely on stated rather than revealed preferences. Artefactual field experiments, which operate in abstract settings and thus exhibit reduced design complexity, perform comparatively well at establishing causal relationships and thus exhibit high internal validity. However, as the level of contextualisation increases, the external validity also improves, albeit at the expense of internal validity. This trade-off can be addressed through the triangulation of different methods.

In addition to experimental approaches, ex post analyses or retrospective approaches with large external validity offer valuable insights into the efficiency of agri-environmental measures (Thompson et al., 2023). Hence, to understand the primary drivers of agri-environmental program design and uptake, policy analysis should not be limited to DCEs but should be complemented by other tools.

Future research can build on the presented literature review in multiple ways. First, researchers can use extracted data from the supplementary material as priors for the experimental design of future studies. Second, this systematic review offers a starting point to analyse thematic blind spots of complementary experimental and non-experimental methods that would provide policy makers with a solid evidence base of agri-environmental contract design. In that vein, policymakers are advised to seek evidence from revealed preference methods before making policy decisions. Last, although many studies stress the value of behavioural insights from economic experiments for agri-environmental policy design (El Benni et al., 2023; Palm-Forster and Messer, 2021), there is little evidence how these findings eventually translate into policy. Future research may intend to trace the process from evidence to policy.

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