LIFT

Low-Input Farming and Territories – Integrating knowledge for improving ecosystem based farming

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Environmental impact of ecological agriculture at the territorial level

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About the LIFT research project

Ecological approaches to farming practices are gaining interest across Europe. As this interest grows there is a pressing need to assess the potential contributions these practices may make, the contexts in which they function and their attractiveness to farmers as potential adopters. In particular, ecological agriculture must be assessed against the aim of promoting the improved performance and sustainability of farms, rural environment, rural societies and economies, together.

The overall goal of LIFT is to identify the potential benefits of the adoption of ecological farming in the European Union (EU) and to understand how socio-economic and policy factors impact the adoption, performance and sustainability of ecological farming at various scales, from the level of the single farm to that of a territory.

To meet this goal, LIFT will assess the determinants of adoption of ecological approaches, and evaluate the performance and overall sustainability of these approaches in comparison to more conventional agriculture across a range of farm systems and geographic scales. LIFT will also develop new private arrangements and policy instruments that could improve the adoption and subsequent performance and sustainability of the rural nexus. For this, LIFT will suggest an innovative framework for multi-scale sustainability assessment aimed at identifying critical paths toward the adoption of ecological approaches to enhance public goods and ecosystem services delivery. This will be achieved through the integration of transdisciplinary scientific knowledge and stakeholder expertise to co-develop innovative decision-support tools.

The project will inform and support EU priorities relating to agriculture and the environment in order to promote the performance and sustainability of the combined rural system. At least 30 case studies will be performed in order to reflect the enormous variety in the socio-economic and bio-physical conditions for agriculture across the EU.

Project consortium

No.	Participant organisation name	Country
1	**INRAE - Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement**	**FR**
2	VetAgro Sup – Institut d'enseignement supérieur et de recherche en alimentation, santé animale, sciences agronomiques et de l'environnement	FR
3	SRUC – Scotland's Rural College	UK
4	Teagasc – Agriculture and Food Development Authority	IE
5	KU Leuven – Katholieke Universiteit Leuven	BE
6	SLU – Sveriges Lantbruksuniversitet	SE
7	UNIBO – Alma Mater Studiorum – Universita di Bologna	IT
8	BOKU – Universitaet fuer Bodenkultur Wien	AT
9	UBO – Rheinische Friedrich-Wilhelms – Universitat Bonn	DE
10	JRC – Joint Research Centre – European Commission	BE
11	IAE-AR – Institute of Agricultural Economics	RO
12	KRTK – Közgazdaság- és Regionális Tudományi Kutatóközpont, a Közgazdaságtudományi Intézet	HU
13	IRWiR PAN – Instytut Rozwoju Wsi i Rolnictwa Polskiej Akademii Nauk	PL
14	DEMETER – Hellinikos Georgikos Organismos – DIMITRA	GR
15	UNIKENT – University of Kent	UK
16	IT – INRAE Transfert S.A.	FR
17	ECOZEPT Deutschland	DE

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List of acronyms and abbreviations

AEI	Agri-environmental impact
AONB	Area of outstanding natural beauty
CI	Composite indicator
CVM	Contingent Valuation Method
DCE	Discrete choice experiment
ES	Ecosystem service
EU	European Union
FMP	Farm management practice
HH	Hageland-Haspengouw
HW	High Weald
LC	Latent Class
NGO	Non-governmental organisation
NK	North Kent
REA	Rapid Evidence Assessment
SD	Standard deviation
S.E.	Standard error
SI	Sub-indicator
WTP	Willingness to pay

1 Summary

In the present deliverable, D4.3 of the LIFT project we provide insights on the environmental impact, which is termed here more precisely the agri-environmental impact (AEI), of ecological farm management practices using the ecosystem service concept at territorial level through a two-pronged approach. First, we present an indicator framework which uses one the one hand, evidence derived from an extensive systematic literature review quantifying the potential supply of 17 ecosystem services from 26 different (ecological) farm management practices, and on the other hand local, stakeholder-derived ecosystem service weights (which reflect relative ecosystem service demand) to obtain an overall AEI indicator for a given ecological farm management practice. The indicator framework is then applied to three case study regions across Belgium (Hageland-Haspengouw) and England (North Kent and the High Weald) to demonstrate the context-specific territorial-level AEI of ecological farm management practices. We demonstrate that at territorial level, though there is quite some variation in AEI of ecological farm management practices based on local contexts, semi-natural habitats, extensive livestock systems and cover crops have a high AEI across the three considered case study regions.

Second we present results from a discrete choice experiment (DCE) in which we quantify preferences for the aesthetic value of integrating ecological farm management practices into an agricultural landscape in Flanders (Belgium), England and Hungary. From this DCE, we find that, similarly to the findings from the AEI indicators, ecological management practices which target increasing (bio)diversity and maintaining green corridors within a landscape, such as semi-natural habitats and cover crops, illicit strong positive preferences from the general public. Our findings illustrate that considering local context and demand is important when evaluating AEI of farm management practices based on ecosystem services.

2 Introduction

Agroecosystems – ecosystems managed for the purpose of production of food and raw materials (Zhang et al., 2007) – symbolise the interaction between humans and nature on a large scale (Maes et al., 2020). Humans derive many direct benefits from agroecosystems in the form of provisioning ecosystem services (ESs) such as food production, clean water provisioning and medicinal resources (CICES, 2018). However, covering nearly 47% of the total EU land area (Maes et al., 2020), agroecosystems are also increasingly being recognised for their importance in providing indirect benefits through maintaining environmental resources and providing cultural services (Chan et al., 2012). Through ESs, agroecosystems represent a unique opportunity to merge human and environmental wellbeing, which is evidenced from the cornerstone-role they increasingly play in (sustainable) development and management programmes such as the European Green Deal and the European Union (EU) Biodiversity Strategy for 2030 (Maes et al., 2020).

In order to evaluate the environmental impact, which is termed here more precisely the agri-environmental impact (AEI), of (ecological[1]) farm management practices (FMPs), studies adopt the ESs concept (Turner and Daily, 2008). ESs can be defined as the direct or indirect contribution of ecosystems to human well-being (Haines-Young and Potschin, 2018). ESs are embedded within a dynamic socio-ecological system in which they form the link between socio-economic and ecological dimensions of an area. This link manifests itself on the one hand through the flow of services from the former to the latter dimension, where biodiversity underpins this flow by maintaining proper ecosystem (Barredo et al., 2015), and on the other hand through drivers of change which affect the ecological dimension either as a consequence of using the ESs or as indirect impacts through human activities, e.g. FMP (Barredo et al., 2015).

AEI assessments of (ecological) FMPs using ESs are often carried out at farm- or plot level. While this may provide the most relevant insights into AEI of FMP on certain ESs which are mainly measured at such smaller spatial scales (e.g. soil formation, production,…), this may also result in a skewed understanding of their impact on ESs whose delivery can only be measured at larger spatial scales (e.g. territorial level) or of ESs which experience complex interactions at larger spatial scales (Lindborg et al., 2017). Furthermore, ecological FMPs are hardly ever adopted in isolation. Instead, these often form part of a more system-wide approach to farming and are often adopted jointly in what we may call farming systems (Rega et al., 2018). As such, the consideration of various spatial scales when assessing AEI of (ecological) FMPs using the ES concept is particularly important to ensure relevance for future resource management decisions and policy development (Lindborg et al., 2017).

In this deliverable we supplement work carried out in WP3 of the LIFT project dealing with farm impact of ecological agriculture, in particular AEI, see D3.3 Van Ruymbeke et al., 2021, though a multi-facetted assessment of AEI of ecological FMP at the territorial level. To achieve this we adopt two distinct methodologies. First, we evaluate the AEI of FMP using AEI indicators based on expert-mediated quantitative data derived from an extensive systematic literature review. Here, we compose sub-indicators which quantify the potential supply of ESs, which we then supplement with stakeholder-attained information on ESs demand to evaluate the ability of a FMP to meet the demand of ESs (composite indicators) at territorial level. By aggregating the composite indicators into farming systems as delineated by Rega et al. (2018) we also provide a first attempt at evaluating trade-offs and synergies between ecological FMPs. Second, we conduct a discrete choice experiment (DCE) to explore people's preferences for rural landscapes shaped by the transition of farms towards ecological agriculture and elicit the public's willingness to pay (WTP), in terms of increase food price, for different elements of those landscapes.

3 Methodology

The AEI of ecological FMP was assessed at territorial level through two distinct methodologies:

1. AEI indicators evaluating AEI of FMPs based on ESs were composed by first calculating sub-indicator quantifying the impact of an individual FMP on an individual ES. Second, sub-

[1] Ecological practices are understood in LIFT as low-input practices and/or practices that are environmentally friendly. The originality of LIFT in this view is not to focus on a specific type of ecological approaches, but to cover the whole continuum of farming approaches, from the most conventional to the most ecological, including the widest range of ecological approaches. This comprises the existing nomenclatures such as organic farming, low-input farming, agroecological farming, etc. It also encompasses approaches that are not yet part of a nomenclature, but that can be identified with various criteria such as management practices, on-farm diversification etc. Thus, conventional practices mean non-ecological practices.

indicators were aggregated into composite indicator quantifying the overall AEI of an individual FMPs taking into consideration the demand for a given ES within a given area. Indicator composition was conducted under both WP3 and WP4 of the LIFT project, feeding into both D3.3 (farm level results; Van Ruymbeke et al., 2021) and D4.3 (territorial level results; present deliverable).

2. A discrete choice experiment was conducted quantifying the value and demand for aesthetic services derived from rural agricultural landscapes in Belgium, England and Hungary. The case study areas were selected for their similarities in dominant agriculture types (arable and integrated arable with livestock), while simultaneously **displaying** distinct socio-economic and cultural contexts; allowing us to evaluate how varying socio-economic/cultural contexts influence landscape preferences. The DCE was carried out solely under WP4 and provides insights only on territorial level AEI of ecological FMP.

3.1 Agri-environmental impact indicator composition

3.1.1 Sub-indicators

3.1.1.1 *Data collection: Rapid Evidence assessment*

Due to their ability to synthesise a wide berth of information in a relatively short period of time, evidence syntheses are able to meet the current need for evidence-based informed policy decisions in environmental planning (Collins et al., 2015). Types of evidence syntheses range from literature reviews through systematic review to meta-analysis, differentiated by the considered detail and rigour of data collection of each. Rapid evidence assessments (REAs) are designed to be less resource and time intensive – taking a couple of months to complete – while at the same time maintaining a transparent methodology and minimising bias (Collins et al., 2015; Varker et al., 2015). In addition to analysing the impact of interventions (e.g. ecological FMP), REAs enable a critical appraisal of the volume and characteristics of available evidence (Collins et al., 2015; Varker et al., 2015). An REA was thus performed in this exercise to evaluate the AEI of FMP using the evidence available in the secondary literature.

Steps in conducting the REA included first the selection of papers and inclusion criteria. For this, a search string from which secondary articles were derived during the REA was composed through an iterative process. This process consisted of formulating a separate search string for each individual FMP, combining these into a composite search string, and then evaluating the search string results against the inclusion of a set of pre-defined test papers (Beillouin et al., 2018). The list of selected FMPs (Appendix A, Table A1) included in this exercise was compiled using input provided by eight LIFT partners across eight European countries, combined with the extensive list of European FMPs identified in LIFT D1.1 (Rega et al., 2018).

Following this, inclusion criteria were used to screen the list of articles derived from the search string. Of the initial 2228 articles obtained by the search string, 647 articles were selected for inclusion in the REA through abstract and title screening. Due to time constraints, a targeted selection of the 647 articles was carried out for full text screening (Ottoy et al., 2018). Targeted sampling consisted of, where possible, randomly selecting five articles (of which one meta-analysis) per FMP cluster. This resulted in a total of 105 articles that were included in the final REA. At full text screening, 10 more articles were excluded based on exclusion criteria, resulting in a final corpus of 95 articles.

For each of the 95 synthesis articles included in the corpus, quantitative, and expert-mediated qualitative data for the link between FMP and supply of an ES was extracted into a database, whereby the supply of an ES was coded as 1 (negative impact), 2 (inconclusive impact) or 3 (positive impact). All articles included qualitative data, but not all included quantitative data. As such, only the former was used for AEI indicator composition. Observations are henceforth defined as expert-mediate qualitative observations reflecting the negative, inconclusive or positive supply of an ES from a FMP. As the REA concerned secondary literature, multiple observations of the same FMP-ES link could be extracted from a single article.

A comprehensive description of the REA process as well as the data extraction process can be obtained upon request from the authors.

3.1.1.2 *Composition*

AEI indicators reflect the potential supply of an ES from a single FMP (cluster) in the context of European agriculture. Due to the wide variety of individual FMPs included in the REA, and the resulting reduced number of observations per individual practice, AEI indicators are composed for FMP clusters. From here on out, FMPs will refer to clustered practices unless otherwise specified.

In order to compose indicators from the expert-mediated qualitative observations, a weighted arithmetic mean is calculated at farm level and territorial level separately, in which observations are weighted against the quality of the article from which they were derived. Relying on expert-mediated qualitative data derived from secondary literature, we are aware of a need to incorporate a measure of confidence in the conclusions put forward by the indicators. Due to the nature of this qualitative data, we are not able to incorporate traditional confidence measures such as confidence intervals. Instead, indicators are corrected for the quantity and quality of the underlying evidence as a way of internalising a measure of confidence (equation 4). The full process of indicator composition is illustrated visually in Figure 1. In total, observations for 26 FMPs and 17 ESs were extracted during the REA. As such, if linkages between all 26 practices and 17 ES were to be derived, a total of 442 indicators could be composed. However, as linkages were not found between all FMPs and all ESs, only 192 indicators are composed in total, 132 at farm level and 60 at territorial level.

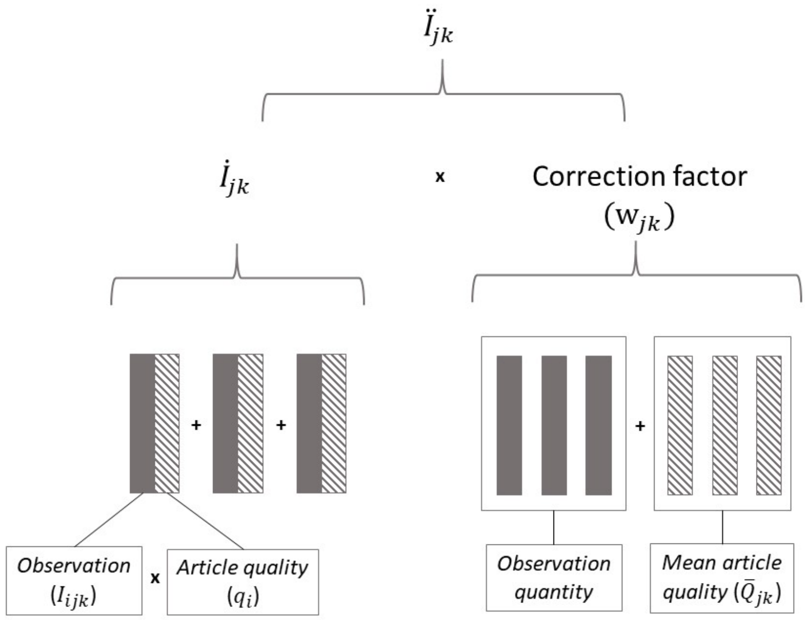

Figure 1. Visual representation of the indicator ($\ddot{I}_{jk}$) calculation process. The intermediate $\dot{I}_{jk}$ (the sum product across multiple observations (I_{ijk}) and their respective article quality score (q_i)) is multiplied by the correction factor (w_{jk}) to obtain $\ddot{I}_{jk}$ for each farm management practice j linked to ecosystem service k. The correction

factor is composed of a measure of the quantity of observations and the average article quality ($\bar{Q}_{jk}$) across all synthesis articles included in $\ddot{I}_{jk}$.

3.1.2 Composite indicators

CIs, reflecting overall AEI, are composed individually 26 FMPs Appendix A, Table A1). A weighted geometric aggregation is adopted to compose CIs, in which the AEI of a FMP is estimated by aggregating across said practices' impact on the potential supply of 17 ESs (Appendix A, Table A2). The impact of a FMP on the supply of an ES was quantified in previous work through the composition of SIs. An SI reflects the potential supply of an ES from a given FMP. To capture the demand for an ES in the CI composition, weights were attributed to each ES. Weights (Appendix A, Table A3) were elicited through stakeholder engagement in early 2021, and reflect the relative importance of an ES in a given case study region and at a given spatial level. To account for the region- and spatial level-specific nature of ES demand, different groups of local stakeholders were contacted for each of the three case study regions. A more detailed explanation regarding stakeholder consultations, as well as detailed socio-geographic descriptions of the case study regions is provided in section 3.2. CIs were composed as follows:

$$CI_j = \exp\left(\frac{\sum_{k=1}^{K} WE_k \ln \ddot{I}_{jk}}{\sum_{k=1}^{K} WE_k}\right) \tag{1}$$

The composite indicator (CI_j) was calculated for FMP (j) as a function of the product of SI ($\ddot{I}_{jk}$) derived for FMP j and ES k and WE_k, the case study-specific and scale-specific weights for ES k, divided by the sum of WE_k, for ES $k = 1 \ldots K$.

In applying a geometric aggregation technique for CI composition, we consciously make an assumption regarding limited compensability between CI components. To assess the impact of this assumption on our results, we re-compose CIs using an arithmetic rather than a geometric aggregation technique. A Kruskall-Wallis test is used to test for significant differences between both sets of CIs. Results hereof are summarised in section 4.

As is illustrated in Figure 2, SIs were used as CI components in the weighted geometric aggregation. SIs were calculated for each of the 26 FMPs linked to the 17 ESs. Data for SI composition was extracted from the academic literature through a REA which focussed on the supply of ESs from FMPs in European agroecosystems. SIs are expressed as a single, dimensionless indicator quantifying the potential supply of an ES from a FMP between -1 (negative impact on supply) to +1 (positive impact on supply).

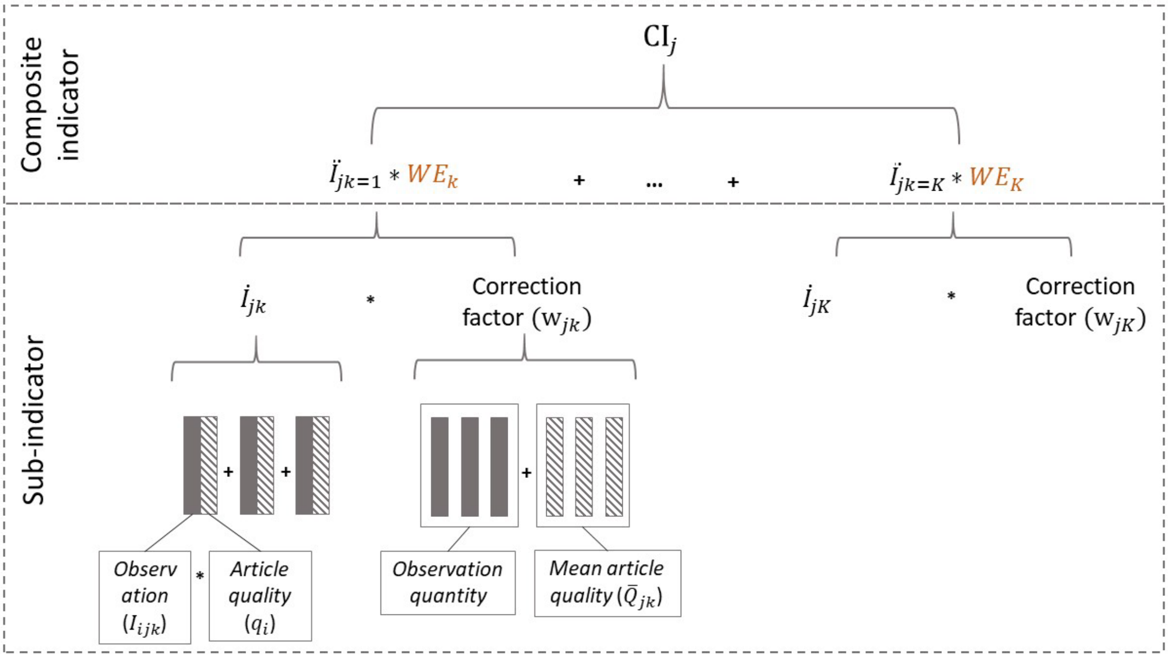

Figure 2. Graphical representation of the CI composition process, where CI_j for farm management practice j is composed of an aggregation of $\ddot{I}_{jk=1}$ through $\ddot{I}_{jk} = K$, each integrated with the respective ES weights $WE_{k=1}$ through $WE_{k=K}$. $\ddot{I}_{jk}$ itself is composed of intermediate $\dot{I}_{jk}$ (the sum product across multiple observations (I_{ijk}) and their respective article quality score (q_i)) multiplied by the correction factor (w_{jk}) for each farm management practice j linked to ecosystem service k.

If linkages between all 26 FMPs and 17 ESs would have been found during the REA, a total of 442 SI would have been composed. However, due to the missing evidence for certain FMP – ES linkages in the literature, only 193 SIs were composed in total, 133 at farm level and 60 at territorial level. It is important to note, however, that while this evidence is missing, it does not necessarily mean that the linkage for which it is missing does not exist. In composing the CIs such missing values are therefore treated as inconclusive observations ($SI = 0$). This is motivated by the reasoning that a lack of evidence for supply of an ES from a FMP in the literature does not beget a lack of demand for said service. In order to accurately reflect the demand-side characteristics of the socio-ecological system, we therefore treat missing values as inconclusive evidence.

3.1.2.1 *Weighting ES in different case study regions*

ES weights reflect the relative importance of ES within three case study areas across western Europe; Hageland-Haspengouw (Figure 3, Map (A)), located in Flanders, Belgium, and two case study areas, North Kent (Figure 3, Map (B)) and High Weald (Figure 3, Map (C)) located in southeastern England. A budget allocation method was implemented to elicit weights from 20 stakeholders during virtual workshops carried out in each case study area in early 2021. Stakeholders were prompted to distribute 100 points amongst the 17 presented ES at farm and territorial level separately. The spatial levels were distinguished through ES end-users. At farm level, stakeholders were prompted to consider the importance of ES from the point of view of a farmer, while at territorial level they were asked to consider importance from the point of view of the general public. In this way, ES weights capture the inter- and intra-regional differences in ES demand. Following the allocation of points by the stakeholders, an average score per ES was calculated and through group discussion the stakeholders were asked to reflect on this average score. At this point, potential amendments were possible to the individual scorings to account for any potential misunderstandings. The full list of ES weights per case study region can be found in Appendix A.

Located in the southeastern part of Flanders, Hageland-Haspengouw (HH) is a hilly region with a slope ranging from 0 to 15%. Loam and sandy-loam soils in the area are highly prone to erosion. The region is typified by both permanent crop production (mainly apples and pears) and arable/mixed-arable agriculture (Sevenant et al., 2002). HH spans across the two ecoregions 'Zuidoostelijke heuvelzone' and 'Krijt-leemgebieden' as defined by Sevenant et al. (2002). In total, nine stakeholders were consulted in the HH case study area. Four of which were research experts affiliated with a university, one was a research expert affiliated with a research institute, two were governmental representatives from the Flemish Environmental Department and the Flemish Land Agency, one was a member of an environmental NGO active in the region, and two were farmer representatives. Absent among stakeholders were farmers themselves.

The case study region of North Kent (NK) encompasses the part of South-east England lying between the high ground of the North Downs and the North Kent coast, stretching from the Isle of Thanet in the east to London in the west. The chalk hills of the North Downs in the south, where soils are predominantly clay with flints, give way to the gently undulating North Kent Plain, with its high-quality, fertile loam soils, in the north. The variations in soils support mixed farming practices, where arable, livestock, and horticulture exist alongside each other, generating a complex pattern of agricultural land uses (Natural England, 2015). However recent agricultural intensification has impacted the farmed landscape through the spread of arable land, particularly at the expense of traditional orchards and coastal grazing marsh (Cobb, 2010; Natural England, 2015). Six stakeholders were consulted to elicit weights for the ES at farm and territorial level in North Kent, of which four were farmers, one an agronomist and one a water company representative.

The High Weald (HW) Area of Natural Beauty (AONB) covers an area of sandstone hills and ridges in south-east England, situated between the chalk escarpments of the North and South Downs. The landscape is characterised by a mosaic of small farms and woodland. The HW is a rare example of a relatively intact medieval landscape in the United Kingdom, the product of grazing practices associated with traditional extensive livestock systems on poor soils (Tubbs, 1997; High Weald Joint Advisory Committee, 2019). There are also some horticultural farms on the higher ground, and concentrations of arable farmland in the lower lying areas in the Rother valley in the east. The HW is one of 46 designated AONBs in Britain (Landscapes for life, 2021). It's status as an AONB means that conservation and enhancement of the landscape is given high priority in the area (Landscapes for life, 2021). Seven stakeholders were consulted to elicit ES weights, of which three were AONB farmers, one a governmental organisation representative and 3 were representatives of the non-governmental organisation Kent Wildlife Trust.

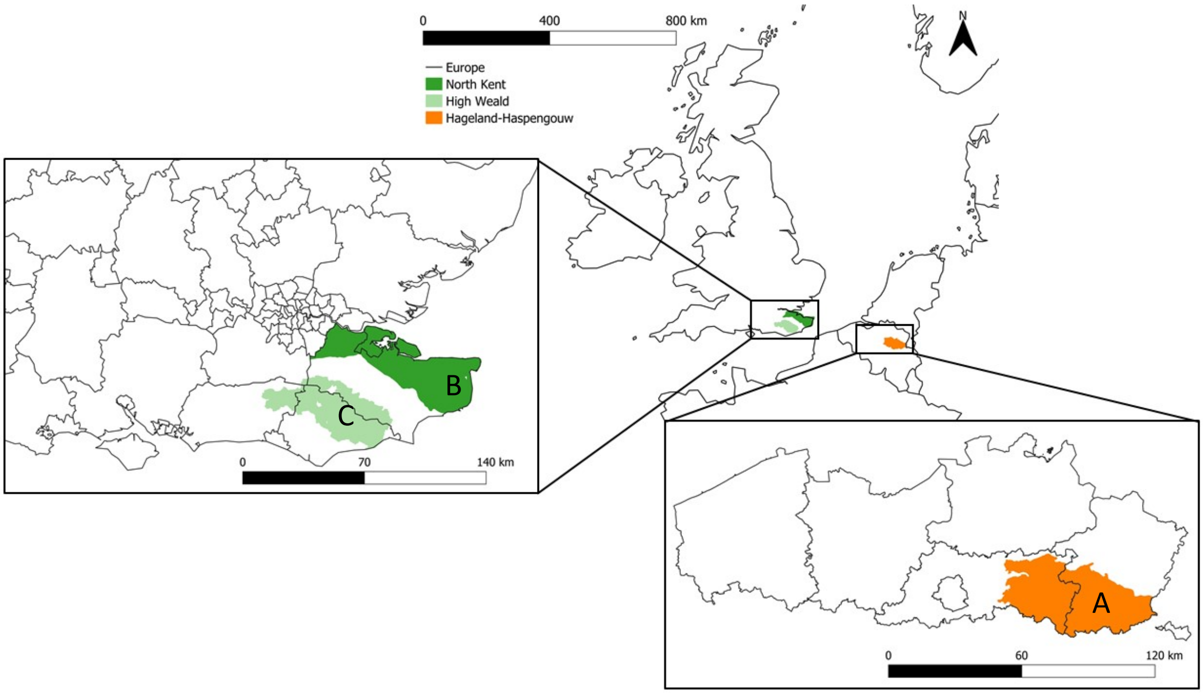

Figure 3. Map of case study regions in Hageland-Haspengouw (A), North Kent (B), and High Weald (C) situated in western Europe.

3.2 Discrete Choice Experiment (DCE)

As we are seeking to understand preferences for the way rural agricultural landscape may be changing in the future because of ecological agriculture, a stated preference technique, where respondents are asked to express their preference towards situations that have not occurred yet (in contrast with revealed preference ones, where preference information are derived from the observation of current behaviour) seemed particularly useful. In addition, because of the vast array of services that a rural landscape, where agricultural production is taking place, can generate to society, and the many ways to describe and visualise them, a DCE application seems to be the appropriate methodological choice, and was preferred for these reasons, to other stated preference techniques like the Contingent Valuation Method (CVM) (Carson, 2012).

DCEs are a stated preference technique which enable researchers to decompose people's preferences for goods or services into a range of dimensions, for which an economic value can also be elicited. They have been widely used in environmental valuation, as well as in other applied fields, most notably transportation, health and marketing (Tinch et al., 2019 have written a useful and accessible review of the usage of DCE in ES valuation).

3.2.1 Sampling and data collection

To evaluate public preferences for agricultural landscape elements associated with ecological FMPs, a DCE was implemented in three case study regions; Flanders (Belgium), England (United Kingdom) and Hungary (see section 3.3.4). The DCE was carried out in November 2021, targeting a representative sample in each country based on gender, age and education level. Respondents were selected through the panel agencies Bilendi in Belgium and Qualtrics in the United Kingdom and Hungary.

3.2.2 Discrete Choice Experiment (DCE) design

To select the relevant attributes and levels for this DCE, a first longlist of landscape attributes which were hypothesised to have an influence on people's preferences for rural landscapes was compiled through a literature review. The longlist was consequently shortened to make it suitable to be used for DCE, where the number of attributes and their levels determine the number and complexity of the choice cards to be shown to respondents, with an obvious impact on the cognitive effort for respondents. Though expert consultation and two rounds of pilot testing in each of the three case study regions, a total of seven attributes were selected for final inclusion in the DCE (Table 1). The first three attributes relate to seasonally-implemented FMPs, the following three relate to permanent changes to the landscape and a final attribute serves as a cost vehicle. Levels of each attribute reflect the degree of environmental friendliness (based on literature) of the management practices, ranging from conventional to highly ecological. The full set of attributes and levels are described in Table 1. A total of 18 choice cards were created using a D-efficient design. To reduce the cognitive burden amongst respondents, a blocked design was employed in which respondents were randomly presented with a subset of eight choice cards. Each choice card consisted of three scenarios; to different landscape scenarios and an opt-out.

Table 1. DCE design: attributes, attribute definitions and respective levels.

Attribute	Definition	Levels
Land coverage	The way in which agricultural parcels within the landscape are covered between the harvest of a main crop. Parcels may either be left bare after harvest (i.e., the soil remains visible after the winter and/or summer harvests) or not. If not left bare, soils may be covered by a cover crop, crop residue, spontaneous growth or some other form of land coverage.	1. Bare land 2. No bare land
Landscape diversity	The variety of crops and grazing animals that are visible within an agricultural landscape. This may vary from monoculture systems in which all parcels are sown with the same crop (e.g., wheat) and no grazing animals are visible within the landscape, to high diversity systems in which a wide variety (5 or more) of different crops are sown and a high density of grazing animals are interspersed within the landscape.	1. Monoculture 2. Low diversity 3. Medium diversity 4. High diversity
Crop dividers	The visible separation between parcels (used for cropping and livestock grazing) within an agricultural landscape. When separators are present, these may include unmanaged wildflowers and/bushed, or managed hedges, walls, and/or tree lines.	1. No visible separators 2. Wild, unmanaged separators 3. Clear, managed separators
Mechanisation level	The size of the machinery used on the farms that is visible within the landscape.	1. No mechanisation 2. Low mechanisation 3. Medium mechanisation 4. High mechanisation
Farm infrastructure	The size of the farm and its farm buildings that are visible within the agricultural landscape. Farm buildings include the farmstead, as well as any sheds, silos and other storage facilities.	1. Small buildings 2. Medium-sized buildings 3. Large buildings
Energy generating infrastructure	The type, size, amount and distribution of the equipment used to generate energy (solar panels and wind turbines) placed on and surrounding the farmstead.	1. Solar panels on roofs 2. Solar panels on roofs and ground 3. Wind turbines (25m high) and solar panels on ground 4. Wind turbines (>25m high) and solar panels on ground
Increase in the monthly price of a food basket (per household)[2]	The increase in the typical monthly food expenditure for the household for the purchasing of food derived from more integrated landscapes.	€/£ 5 — 850 Ft €/£ 10 — 1700 Ft €/£ 15 — 2600 FT €/£ 20 — 3500 Ft

[2] The price was expressed in local currency in each case study region, but was determined such that relative meaning was similar.

The monetary attribute was represented by an absolute increase in the monthly price of a typical food basket per household. A percentage change was also included during the pilot test of the questionnaire, however, respondents seemed to prefer the absolute change. Different monetary attributes have been used in the literature that included taxes (local or national), voluntary contributions to an environmental or conservation fund, and price of entrance/night at an hotel (for more recreational/tourism type of studies). Here, because we were targeting the general public, and considering both non-use and use values, we decided to link the transition to ecological agriculture, and the consequent change into the landscape, to food prices. Price increase levels were chosen to approximately represent, at their max level, an increase of about 10% over the average household expenditure (this was approximately the case for the United Kingdom and Belgium, while the maximum level represented a higher increase in Hungary).

In addition to evaluating preferences for agricultural landscapes integrating more ecological FMPs, we included a methodological assessment in this DCE. Specifically, we attempted to evaluate the impact of choice card design on landscape preferences by including three design treatments: i) choice cards in which the attributes were illustrated through a composite, photoshopped image with no text; ii) choice cards in which attributes were presented through individual photoshopped images with accompanying text; and iii) choice cards in which attributes were presented through pictograms with accompanying text. Figure 4 illustrates an example of a choice card from each design treatment.

Design treatment 1

Landscape A		Landscape B	

Increase in the price of a monthly food basket (per household)	£10	**Increase** in the price of a monthly food basket (per household)	£10

Design treatment 2

	Landscape A	Landscape B
Land coverage	No bare land	Bare land
Landscape diversity	Medium diversity	Monoculture
Crop dividers	No visible separators	Wild, unmanaged separation
Mechanisation levels	No machines	High mechanisation
Farm buildings	Large buildings	Small buildings
Energy generating infrastructure	Wind turbines (>25m high) and solar panels	Wind turbines (25m high) and solar panels
Increase in the monthly price of a typical food basket (per household)	£10	£10

Design treatment 3

	Landscape A	Landscape B
Land coverage	No bare land	Bare land
Landscape diversity	Medium diversity	Monoculture
Crop dividers	No visible separators	Wild, unmanaged separation
Mechanisation levels	No machines	High mechanisation
Farm buildings	Large buildings	Small buildings
Energy generating infrastructure	Wind turbines (>25m high) + solar panels	Wind turbines (up to 25m high) + solar panels
Monthly increase in the price of a typical food basket (per household)	£10	£10

Figure 4. Example of choice card one in each design treatment. Each card depicts the same scenarios made up of the same attribute levels. Design treatment 1 illustrates the composite image, design treatment 2 illustrates the individual images + text, and design treatment 3 illustrates the pictogram + text.

To obtain high-quality photoshopped images for the first and second design treatments, a professional photographer/photo editor was used within this task. To obtain realistic landscape scenarios, a 'master' image was used of Saddlescombe Farm, located 2 miles north of Brighton in the South of England. The farm lies on land owned by the National Trust (www.nationaltrust.org.uk), which is the largest conservation organisation in Europe, and looks after several houses, stretches of coastline, greenspaces and rural areas. Permission from the organisation was sought before using the photo (Figure 5). This scene was selected as it had the potential to allow several changes while maintaining a satisfactory degree of realism. It had a good balance of building, trees and greenspaces, and space to insert other elements. Parcels were already divided by line of trees, and that allowed for a simpler substitution with other separating elements. The size and number of the farm buildings, and the proximity of trees, also allowed to vary their number and size in an efficient and realistic way. Finally, it was also considered by the research team as a pleasant and beautiful enough scene to capture the attention of the respondents and better engage them with the experiment. After testing during the pilot studies, it was decided that this landscape sufficiently matched the landscapes present in Flanders, Belgium and Hungary such that no new 'master 'images were necessary to fit the other case study regions. This also allowed us to maintain the highest consistency in the comparison of preferences across the three countries.

Figure 5. Saddlescombe Farm – unedited view ©Bip Mistry.

3.2.3 Model estimation

DCEs are conceptually based in Lancaster's (1966) consumer model. Lancaster (1966) posit that consumers are assumed to derive utility from the different attributes of a good or service rather than from the good/service itself. In this way, DCEs assume that individuals' choices for hypothetical goods/services presented in alternatives are based on said alternatives' characteristics, or attributes. By prompting respondents to continuously select one of multiple presented alternatives, DCEs are able to elicit respondent's preferences for individual attributes of alternatives.

Alternatives are presented to respondents on choice cards. A single choice card contains 3-4 alternatives, forming a choice set. Figure 4 illustrates an example of such a choice card. By having respondents identify the alternative within each choice set that best reflects their preferences, attributes eliciting a higher preference can be identified. The underlying assumption is that when faced with a number of distinct alternatives, the chosen alternative provides the respondent with more utility than the non-chosen alternatives (Kessels et al., 2011).

Formally, the utility for any alternative *j* built within the experiment and presented to respondents is considered as being composed of a systematic component V_j and a stochastic error term ε_j^n, in accordance with the random utility model (McFadden, 2001):

$$U_j^n = V_j^n + \varepsilon_j^n \quad (2)$$

Now, if we take $V_j^n = \beta X_j^n$ with βX_j^n being a vector of parameters to be estimated and we consider the random errors as independently and identically Extreme Value Type 1 distributed, we obtain the classic Multinomial Logit model:

$$P_j^n = \frac{\exp(\mu\beta' X_j^n)}{\sum_{i\in C}\exp(\mu\beta' X_i^n)} \quad (3)$$

Equation (3) shows that probability of selecting the alternative *j* over another alternative *i* within a finite choice set *C*. In our experiment, respondents were asked to choose their favourite landscape alternative in accordance with its characteristics (the characteristics of the decision maker n can also be taken into consideration). Equation (3) can be then estimated with a Multinomial regression (Conditional logit model).

To account for preference heterogeneity, we estimate model specifications in equation (3) as a Mixed logit model (random parameter logit) (Hole, 2007). Mixed logit models estimate coefficients for the average preferences and the variance of preferences according to a user-specified distribution. Identifying individual-specific characteristics driving preference heterogeneity may be achieved through incorporating interactions between respondent characteristics and various attributes into the multinomial logit model. However, this requires a priori selection of only a number of key characteristics so as not to over-specify the model. Alternatively, a Latent Class (LC) model may be implemented to account for interpersonal heterogeneity in correlations among tastes for different attributes (Pacifico and Yoo, 2013).

The LC model assumes a sample consists of S number of latent classes. These classes capture unobserved heterogeneity amongst respondents by estimating different parameter vector in the corresponding utility function (Shen and Saijo, 2009). Unlike the ML model, the LC model is semi-parametric, therefore it does not require assumptions about the distribution of parameters across individuals. Furthermore, the LC model benefits from calculating probabilities of respondents belonging to each class. While each respondent is assumed to belong to one of the S proposed classes, the probability takes into account the uncertainty in this allocation (ibid). All estimates were estimated using dummy coding. Model estimation was performed in Stata version 15 (StataCorp, 2017).

4 Results

4.1 Agri-environmental impact indicators

4.1.1 Sub-indicators

The AEI indicators presented in this work quantify the potential supply of ESs from conventional and ecological FMPs. Compared to the analysis of the sub-indicators at farm level (see D3.3, Van Ruymbeke et al., 2021), significantly fewer sub-indicators were composed at territorial level (n=60). Combined with the higher mean number of observations ($\overline{N}^{obs}$) and synthesis articles ($\overline{N}^{art}$) at farm level, we can conclude that FMP-ES linkages are more commonly studied at the farm level than at the territorial level (Table 2).

Table 2. Mean calculations describing the difference in sub-indicator calculation between farm- and territorial level.

	Farm level	Territorial level
Mean number of indicators per farm management practice	6	1.85
Mean number of observations ($\overline{N}_{obs}$) per indicator	3.64	1.7
Mean number of articles ($\overline{N}_{art}$) per indicator	2.38	1.27
Mean correction factor ($\overline{w}$) across indicators	0.301	0.25
Mean consensus ($\bar{c}$) across indicators	0.75	0.91

Table 3 summarises the full set of territorial-level indicators. Here we see that extensive livestock systems have the highest positive impact on the supply of habitat creation/protection at territorial level ($I = 0.67, w = 0.67, c = 1, N^{obs} = 1, N^{art} = 1$). Simultaneously, agri-environmental schemes have the highest negative impact on the supply of disease and pest control ($I = -0.18, w = 0.18, c = 1, N^{obs} = 1, N^{art} = 1$). As both indicators are composed from a single observation, our confidence in their directionality is determined by the article quality. Despite its ranking, the magnitude of the indicator remains low; especially when compared to farm level indicators. Indeed, we see that indicator magnitude is low across all listed negative indicators in Table 3. Further we see that all negative indicators at territorial level have low w values, indicating a low article quality, and are almost all composed from a single observation

Figure 6 details all the indicators that were composed for extensive livestock systems, agri-environmental schemes, and semi-natural habitats at the territorial level[3]. Here we see that, though extensive livestock systems have the highest positive impact on an ES at territorial level, only one indicator was composed for this FMP. This illustrates that a high AEI on a single ES does not beget a high AEI across all ESs. The high number of indicators composed for extensive livestock systems at farm level implies that the lack of indicators at territorial level is caused by the lack of evidence in the literature. Indeed, as is illustrated in Table 2, across all FMPs fewer indicators were composed at territorial level compared to farm level. Further, Figure 6 illustrates that though the strongest negative indicator was composed for agri-environmental schemes and its impact on disease and pest control, the remaining indicators composed for this FMP have a positive directionality of a relatively high magnitude.

[3] Spider diagrams for all considered farm management practices can be found in Appendix A, Figure A1.

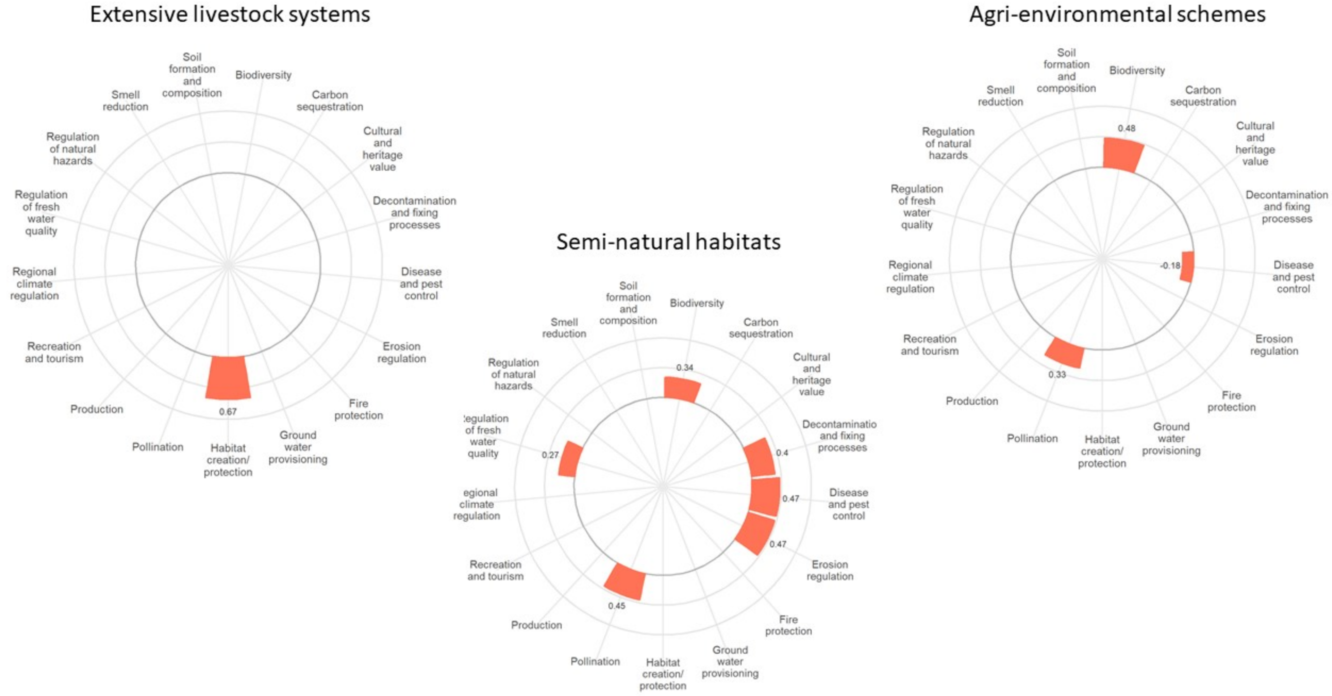

Figure 6. Plots illustrating the full set of indicators composed for extensive livestock systems, agri-environmental schemes, and semi-natural habitats at the territorial level. Lacking indicators illustrate an absence of evidence in the literature for a given FMP–ES link.

Table 3. Territorial-level sub-indicators linking farm management practices and ecosystem services (ESs). Correction factor (w), consensus (c), number of observations (N^{obs}) and number of articles (N^{art}) are included as supplementary measures to aid interpretation.

Farm management practice	Biodiversity	Carbon sequestration	Decontamination and fixing processes	Erosion regulation	Fire protection	Habitat creation/ protection	Pollination	Regional climate regulation	Regulation of fresh water quality	Regulation of natural hazards	Smell reduction	Soil formation and composition	Disease and pest control	Ground water provisioning	Production	Cultural and heritage value	Recreation and tourism
ES category (CICES, 2018)		Regulating and maintenance											Production			Cultural	
Agri-environmental schemes	0.48 w=0.71 c=0.63 N^{obs}=3 N^{art}=1						0.33 w=0.33 c=1 N^{obs}=1 N^{art}=1						-0.18 w=0.18 c=1 N^{obs}=1 N^{art}=1				0.28 w=0.28 c=1 N^{obs}=6 N^{art}=1
Agroforestry	0 w=0.46 c=1 N^{obs}=1 N^{art}=1								0 w=0.49 c=1 N^{obs}=1 N^{art}=1				0.40 w=0.40 c=1 N^{obs}=1 N^{art}=1				
Alternative weed management																	
Biological N fixation														0.12 w=0.12 c=1 N^{obs}=1 N^{art}=1			
Biological pest control													0.15 w=0.15 c=1 N^{obs}=1 N^{art}=1				
Conservation tillage		0.04 w=0.22 c=0.17 N^{obs}=6 N^{art}=3		-0.08 w=0.30 c=0.03 N^{obs}=5 N^{art}=2													

Cover crops		0.28 w=0.28 c=1 N^{obs}=2 N^{art}=2	0 W=0.34 c=1 N^{obs}=1 N^{art}=1	0.28 w=0.28 c=1 N^{obs}=2 N^{art}=2					0.43 w=0.43 c=1 N^{obs}=2 N^{art}=2			0.34 w=0.34 c=1 N^{obs}=1 N^{art}=1		0.45 w=0.45 c=1 N^{obs}=2 N^{art}=2	0.19 w=0.39 c=0.58 N^{obs}=2 N^{art}=1		
Crop livestock integration	0.12 w=0.12 c=1 N^{obs}=1 N^{art}=1	0.12 w=0.12 c=1 N^{obs}=1 N^{art}=1						0.12 w=0.12 c=1 N^{obs}=1 N^{art}=1		0.22 w=0.22 c=1 N^{obs}=1 N^{art}=1			0.12 w=0.12 c=1 N^{obs}=1 N^{art}=1	0.17 w=0.17 c=1 N^{obs}=2 N^{art}=1		0.12 w=0.12 c=1 N^{obs}=1 N^{art}=1	
Crop residue management												0.08 w=0.08 c=1 N^{obs}=1 N^{art}=1					
Crop rotation	0.12 w=0.12 c=1 N^{obs}=1 N^{art}=1	-0.12 w=0.12 c=1 N^{obs}=1 N^{art}=1															
Extensive livestock systems	0 w=0.72 c=0 N^{obs}=2 N^{art}=1					0.67 w=0.67 c=1 N^{obs}=1 N^{art}=1											
Intercropping	0.16 w=0.16 c=1 N^{obs}=1 N^{art}=1	0.16 w=0.16 c=1 N^{obs}=1 N^{art}=1	0.21 w=0.21 c=1 N^{obs}=2 N^{art}=1	0.16 w=0.16 c=1 N^{obs}=1 N^{art}=1			0.13 w=0.13 c=1 N^{obs}=1 N^{art}=1		0.16 w=0.16 c=1 N^{obs}=1 N^{art}=1								
Low agrochemical pesticide input																	
Low fertiliser input		0.12 w=0.12 c=1 N^{obs}=1 N^{art}=1							0.16 w=0.16 c=1 N^{obs}=2 N^{art}=2								
Low mechanisation																	
Mulching			0.13														

			w=0.13 c=1 N^{obs}=1 N^{art}=1														
Precision farming																	
Selection of breeds		0.14 w=0.14 c=1 N^{obs}=1 N^{art}=1					0.10 w=0.10 c=1 N^{obs}=1 N^{art}=1										
Semi-natural habitats	0.34 w=0.42 c=0.61 N^{obs}=13 N^{art}=5		0.40 w=0.40 c=1 N^{obs}=1 N^{art}=1	0.47 w=0.47 c=1 N^{obs}=1 N^{art}=1			0.45 w=0.45 c=1 N^{obs}=2 N^{art}=2		0.27 w=0.27 c=1 N^{obs}=3 N^{art}=2				0.47 w=0.47 c=1 N^{obs}=1 N^{art}=1				
Spatial heterogeneity	0.22 w=0.22 c=1 N^{obs}=3 N^{art}=1												0.40 w=0.40 c=1 N^{obs}=1 N^{art}=1				
Sustainable grazing	0.12 w=0.12 c=1 N^{obs}=1 N^{art}=1	0.01 w=0.19 c=0.33 N^{obs}=3 N^{art}=2		-0.12 w=0.12 c=1 N^{obs}=1 N^{art}=1					-0.12 w=0.12 c=1 N^{obs}=1 N^{art}=1								
Sustainable water management									0.16 w=0.16 c=1 N^{obs}=1 N^{art}=1								
Use of chemical fertiliser Inputs	0 w=0.18 c=0 N^{obs}=2 N^{art}=1																
Use of chemical pesticide Inputs																	
Use of organic fertilisers	0.13 w=0.13		0.12 w=0.12						-0.14 w=0.14		0.20 w=0.20	-0.14 w=0.14					

	c=1 N^{obs}=1 N^{art}=1		c=1 N^{obs}=1 N^{art}=1						c=1 N^{obs}=1 N^{art}=1		c=1 N^{obs}=3 N^{art}=2	c=1 N^{obs}=1 N^{art}=1					
Use of organic pesticides	0.13 w=0.13 c=1 N^{obs}=1 N^{art}=1																

Many indicators detailed in Table 3 are composed based on only a single indicator. However, as secondary literature is used as a data source, a single observation does not strictly imply limited evidence in the literature. Instead, a single observation is often a synthesis of evidence across various primary studies. The full corpus of 95 secondary studies utilised in this analysis themselves incorporate anywhere between 1 and 363 primary studies. A Pearson's correlation analysis found a significant correlation between the number of primary studies reported by the secondary literature and the quality score of the secondary literature ($r(128) = 0.561, p < 0.001$). From this we see that secondary studies of lower quality have a tendency not to report the number of primary studies from which evidence was synthesised. While this lack of information on the number of primary studies included may seem problematic for indicator interpretation, the correction factor is able to internalise this into the indicator magnitude, thus ensuring that this drawback is accounted for when interpreting the indicator(s).

4.1.2 Composite indicators

In order to assess the overall AEI of each FMP, a CI was calculated aggregating the sub-indicators across all ESs. CIs were composed for 21 of the 26 considered FMPs at territorial level. The fewer CIs at territorial level are the result of a reduced number of SIs, which in turn is the result of low evidence in the literature addressing the link between FMP and ES supply at this level. Missing FMP at territorial level include alternative weed management, low agrochemical pesticide input, low mechanisation, precision farming and the use of chemical pesticide inputs. Table 4 lists demonstrates the full set of CIs composed for FMPs at territorial level in Hageland-Haspengouw, North Kent and the High Weald.

From Table 4 we see that the FMPs that are considered conventional (intensive), have a tendency to perform poorly across all three case study areas at territorial level. However, we also see management practices that are otherwise considered agroecological, such as conservation tillage and sustainable water management, performing poorly. This illustrates the need to consider context-specific geographic and socio-economic characteristics of the case study areas when evaluating the AEI of FMP. Even though conservation tillage may be considered an agroecologically preferable practice (Wezel et al., 2014), if targeted areas experience a demand for certain services that cannot be supplied by conservation tillage, it will perform poorly, and potential agri-environmental benefits will not be optimised.

Table 4. Full set of composite indicators calculated at territorial level across all three case study regions: Hageland-Haspengouw, North Kent and High Weald. CIs may be interpreted as the agri-environmental impact of farm management practice, ranging between -1 and +1.

	Hageland-Haspengouw	North Kent	High Weald
Agri-environmental schemes	0.06	0.06	0.08
Agroforestry	0.01	0.01	0.01
Alternative weed management			
Biological N fixation	0.01	0.00	0.01
Biological pest control	0.00	0.01	0.00
Conservation tillage	-0.01	-0.01	0.00
Cover crops	0.15	0.12	0.08
Crop livestock integration	0.06	0.06	0.07
Crop residue management	0.01	0.00	0.00
Crop rotation	0.01	0.01	0.02
Extensive livestock systems	0.05	0.06	0.06
Intercropping	0.05	0.06	0.06
Low agrochemical pesticide input			
Low fertiliser input	0.01	0.02	0.01
Low mechanisation			
Mulching	0.00	0.00	0.01
Precision farming			
Selection of breeds	0.01	0.01	0.01
Semi-natural habitats	0.14	0.16	0.13
Spatial heterogeneity	0.04	0.04	0.03
Sustainable grazing	-0.01	-0.01	0.00
Sustainable water management	0.01	0.02	0.01
Use of chemical fertiliser inputs			
Use of chemical pesticide inputs			
Use of organic fertilisers	-0.01	-0.01	0.01
Use of organic pesticides	0.01	0.01	0.02

4.1.2.1 *Agri-environmental impact: farming systems*

The AEI indicators described above provide a unique opportunity to not only evaluate the impact of individual FMPs within an area, their commensurable nature also allows them to be aggregated to evaluate the AEI of groups of FMPs applied together. One such application would be to evaluate the AEI of farming systems (e.g. organic farming) characterised by a subset of FMPs. As such, in the following section we describe exploratory results from such an aggregation of individual FMP environmental impact into an overall AEI assessment of farming systems.

Adopting the categorisation of FMPs into farming systems proposed by (Rega et al., 2018), we aggregate the AEI for the relevant FMP to obtain an individual AEI score for each farming system. As such, the AEI of farming systems reflects the ability of the underlying FMPs to consolidate potential supply of and demand for ESs in a given area. This is achieved by adding the CIs for the relevant FMPs within each farming system. Trade-offs and synergies that may arise through the co-implementation of particular FMPs are implicit in the aggregation due to the fact that the underlying CIs may take both positive and negative values. The results of this aggregation exercise are displayed in Table 5.

Table 5. Agri-environmental impact of farming systems. Agri-environmental impact indicators are boundless, with larger positive values implying a stronger positive agri-environmental impact of the farming system.

	Hageland-Haspengouw	North Kent	High Weald
Agroecology	1.02	0.79	0.81
Organic farming	0.90	0.69	0.71
Low-input systems	0.89	0.69	0.71
Integrated farming systems	0.97	0.76	0.69
Conservation agriculture	0.45	0.30	0.27

The AEI indicators for farming systems described in Table 5 are boundless, with higher positive values implying a better AEI of a farming system and lower (or negative) values implying a worse impact. The farming systems with the highest overall farm-level AEI based on the underlying FMPs is agroecology and integrated farming in HH an NK. In the HW, the highest performing farming systems at territorial level are agroecology, organic farming and low-input systems. From these results we see that the AEI of farming systems is not the same across all case study regions This variation is determined by the differing impact of the FMPs and the underlying demand for ES within each case study area.

4.2 Discrete Choice Experiment (DCE)

A total sample of 2418 respondents across the three case study regions participated in the presented DCE; 1048 respondents in Flanders, 510 in Hungary and 860 in England. Socio-demographic characteristics of the sample per case study region are described in Table 6 with reference to the population characteristics. Samples across all three case study regions differ significantly from the population averages for age and education level. In the Flemish and English case study, this is reflected in a sample which is significantly older and more highly educated than the population average. The Hungarian sample is also older than the average Hungarian population, however, here the sample is slightly lower educated as well as being more male-dominated.[4]

[4] Remaining socio-demographic variables for all case study regions (e.g. income and household size) still require testing against the population averages. This will be carried out in subsequent work.

Table 6. Socio-demographic descriptions of sample in Flanders, Hungary and England.

Case study area	Flanders	Hungary	England
	n(%)	n(%)	n(%)
Sample size (n)	1048	510	860
Gender (female)	529 (50.48)	244 (47.84)**	491 (57.09)
Age (years)			
18-29	158 (15.44)	67 (13.14)	70 (8.14)
30-45	285 (28.86)	168 (32.94)	195 (22.67)
46-65	353 (34.51)***	217 (42.55)***	393 (45.70)***
>66	227 (22.19)***	58 (11.37)***	202 (23.49)***
Ethnicity			
Non-migration background	1008 (96.18)	NA	754 (87.67)
Migration background	37 (3.53)	NA	106 (12.33)
Education			
High	360 (34.35)	72 (14.12)	285 (33.14)
Medium	494 (47.14)	236 (46.27)	302 (35.12)
Low	360 (34.35)	202 (39.61)***	273 (31.74)
Annual net Income (€/Ft/£)			
High	393 (37.68)	49 (9.63)	203 (23.60)
Medium	356 (34.13)	170 (33.40)	328 (38.14)
Low	47 (5.06)	234 (45.97)	269 (31.28)
No response	168 (18.10)	33 (6.48)	49 (5.70)
Don't know	79 (8.51)	23 (4.52)	11 (1.28)
Household size			
<3	827 (78.91)	388 (76.23)	705 (82.07)
4-5	205 (19.56)	116 (22.79)	128 (14.90)
>6	16 (1.53)	5 (0.98)	26 (3.03)
of which children <16 years			
0	653(63.65)	386 (75.69)	537 (63.70)
1-2	43 (4.19)	72 (14.12)	43 (5.10)
3-4	329 (32.07)	40 (7.84)	261 (30.96)
>5	1 (0.10)	12 (2.35)	2 (0.24)
Household cars			
0	60 (5.73)	122 (23.92)	186 (21.63)
1-2	909 (86.74)	375 (73.53)	634 (73.72)
3-4	76 (7.25)	11 (2.16)	37 (4.30)
>4	3 (0.29)	2 (0.39)	3 (0.35)

Note: *, **, *** denote whether variable differs significantly from the population at the 10%, 5% and 1% level respectively

Table 7 describes the results of the Conditional logit model for all three case study regions, pooling results from the three design treatments. Results for the individual design treatment per case study region can be found Appendix B. From Table 7 we can see that across all three case study regions respondents show largely similar preferences for landscapes integrating of more ecological approaches to farming. Overall, respondents indicate a significant negative preference for the opt-out. This indicates that respondents prefer to make a choice between one of the presented ecological landscapes, and therefore have an underlying preference for at least a certain degree of ecological

FMPs integrated into the local agricultural landscape. Preferences for the degree of ecological FMP integration is illustrated by the model estimates for the remaining attribute levels.

Various attributes and levels experienced the same preferences across the three case study regions. Across all three case study regions, respondents indicated a strong significantly positive preference for land coverage (no bare land) between cropping seasons as opposed to bare land; for low, medium and high levels of landscape diversity as opposed to monoculture diversity; as well as for wild, unmanaged and clear, managed crop dividers as opposed to no crop dividers within an agricultural landscape.

Preferences for fixed landscape features associated with mechanisation levels, farm infrastructure and energy generating infrastructure within the landscape were seen to vary between the case study regions. Negative preferences for no mechanisation as opposed to large mechanisation were observed in the Hungarian and English case study regions, though these estimates were only significant at the 10% level. In the Flemish case study region, significant positive preferences were observed for low as opposed to high mechanisation levels. However, similarly, this estimate was only significant at the 10% level. Preferences for farm infrastructure were also largely similar across case study regions, with significant positive preferences observed for small as opposed to large buildings in all case study regions. Significant positive preferences were observed for medium-sized buildings as opposed to large buildings in Flanders and Hungary, but not England. Across all three case study regions, significant positive preferences were observed for the highest level of energy generating infrastructure within a landscape (wind turbines >25m high + solar panels) as opposed to the lowest level (only solar panels on the roofs of buildings). Finally, all respondents indicated a significantly negative preference for the payment vehicle.

Table 7. Conditional logit model estimates illustrating preferences for attribute levels in Flanders, Hungary and England.

	Flanders	Hungary	England
	β (S.E.)	**β (S.E.)**	**β (S.E.)**
Opt-out	-1.213*** (-8.64)	-1.649*** (-8.70)	-1.267*** (-10.48)
Land coverage			
No bare land	0.229*** (7.32)	0.171*** (4.01)	0.212*** (6.16)
Landscape diversity			
Low	0.591*** (15.00)	0.432*** (7.83)	0.435*** (9.96)
Medium	0.780*** (15.45)	0.477*** (7.29)	0.646*** (12.39)
High	0.978*** (19.63)	0.531*** (8.23)	0.751*** (13.77)
Crop dividers			
Wild, unmanaged separation	0.154*** (4.64)	0.107* (2.50)	0.210*** (5.64)
Clear, managed separation	0.177*** (4.37)	0.153** (2.81)	0.267*** (5.98)
Mechanisation level			
No mechanisation	(-0.03) 0.043	-0.187* (-2.02)	-0.130* (-1.96)
Low mechanisation	(0.59) 0.207*	-0.113 (-1.14)	0.048 (0.67)
Medium mechanisation	(2.19) (-0.03)	0.154 (1.15)	0.117 (1.25)
Farm infrastructure			
Small buildings	0.320*** (5.49)	0.301*** (3.82)	0.283*** (4.77)
Medium buildings	0.229*** (3.81)	0.241** (2.96)	0.076 (1.29)
Energy generating infrastructure			
Solar panels on roofs and ground	0.012 (0.33)	0.110* (1.97)	0.065 (1.50)
Wind turbines (up to 25m high) + solar panels	-0.037 (-0.71)	0.051 (0.67)	-0.008 (-0.14)
Wind turbines (>25m high) + solar panels	0.113* (2.25)	0.194** (2.70)	0.205*** (3.67)
Increase in the price of a typical food basket/household	-0.057*** (-14.23)	-0.000*** (-7.38)	-0.067*** (-15.06)
Observations	28296	13770	23220
N respondents	1048	510	860
Log-likelihood	-8112.6707	-3968.7	-6979
Chi-squared	1426.52	563.18	1162

Note: *, **, and *** denote whether the parameter is significant at the 10%, 5% and 1% level respectively. All parameters have been dummy-coded.

While preferences for many attributes and levels were similar across the case study regions, respondent preferences for certain attributes/levels were seen to vary. For example, a positive preference for medium mechanisation levels as opposed to high mechanisation (large machinery) was only observed for the Hungarian and Flemish but not the English sample. As such, a Mixed logit model was estimated to explicitly evaluate preference heterogeneity within the samples. The Mixed logit model output presented for Hungary and England in Table 8 and for Flanders in Table 9 demonstrates that there are some divergent preferences for these attributes and levels within and amongst the case study regions and design treatments. In Flanders we see significant heterogeneity in preferences for the opt-out, land coverage (no bare land), high landscape diversity as well as the highest level of energy generating infrastructure (wind turbines >25m high + solar panels) and the price vehicle. Specifically, we observe that while the majority of the Flemish sample has a negative preference for the opt-out, 10.38% of the sample seem to have a positive preference for this. Similarly, 31.30% of respondents indicate a negative preference for land coverage (no bare land), and 60.07% of respondents indicate to actually have a negative preference for the highest level of energy generating infrastructure. The remaining attribute levels for which heterogeneous preference were observed do not differ in directionality of the preference (i.e. positive or negative), but rather in the strength of the preference (i.e. magnitude of the coefficient).

In Hungary we see significant preference heterogeneity for the opt-out, land coverage (no bare land), high landscape diversity, no mechanisation, the highest level of energy generating infrastructure and for the price vehicle. Here we see that 37.83% of the sample have a negative preference for land coverage (no bare land) despite the model estimate for this level being significantly positive. Similarly, we observe that 28.44% of the Hungarian sample actually has a positive preference for no mechanisation as opposed to high mechanisation levels, 31.30% has a negative preference for the highest level of energy generating infrastructure, and 50% have a positive preference for the payment vehicle.

In England we observe significant preference heterogeneity for the opt-out, low, medium and high levels of landscape diversity, clear, managed crop dividers, medium mechanisation levels, as well as the highest level of energy generating infrastructure and the payment vehicle. However, only for the latter two attribute levels does this present itself in a group of respondents having positive preferences and another group having negative preferences. For the remaining attribute levels where preference heterogeneity is observed, preferences differ in strength (i.e. magnitude of the coefficient) rather than directionality. Indeed, for the highest level of energy generating infrastructure (wind turbines >25m high + solar panels) we see that 23.05% of respondents actually have a negative preference for this level as opposed to the lowest level (solar panels on roofs only). Similarly, 18.61% of respondents actually demonstrate a positive preference for the payment vehicle.

Despite heterogeneity in preferences, Mixed logit model estimates indicate that preferences for higher degrees of landscape diversity are largely positive across all case study regions and all design treatments. Standard deviation (SD) estimates for the attribute levels of land coverage, landscape diversity and crop dividers indicate that preferences amongst responses differ in the magnitude of the coefficients, but not the signs. In other words, some respondents demonstrate a very high preference for higher degrees of landscape diversity (compared to monoculture), while other demonstrate positive, yet slightly smaller preferences. Most noteworthy from the Mixed logit model estimates, however, is the significant heterogeneity observed amongst respondent preferences for the opt-out across all case study regions. Tables 8 and 9 demonstrate that estimates for the standard deviations (σ) of preference estimates (β) are sufficiently large such that there is a group of respondents who have a positive preference for the opt-out. Though further analysis will be carried out in future work, a LC model was fit to the Flemish sample treated with the pictogram design treatment to evaluate the observed preference heterogeneity from the Mixed logit model estimates (Table 9).

Table 8. Mixed logit model estimates for the Hungarian and English case study regions. Parameter estimates (β) and standard errors (S.E.) describe preferences for the attribute levels with reference to the baseline level, while the standard deviation (σ) describes the heterogeneity in preferences within the sample.

	Hungary		England	
	β (S.E.)	**σ (S.E.)**	**β (S.E.)**	**σ (S.E.)**
Opt out	-3.854***	2.587***	-4.548***	2.238***
	(-12.72)	(15.34)	(-10.68)	(10.60)
Land coverage				
No bare land	0.204***	0.658***	-0.006	0.321*
	(3.81)	(10.36)	(-0.08)	(2.39)
Landscape diversity				
Low	0.522***	0.077	0.653***	-0.428*
	(7.99)	(0.65)	(6.47)	(-2.55)
Medium	0.586***	0.014	0.977***	-0.321*
	(7.40)	(0.12)	(8.12)	(-2.17)
High	0.668***	0.375*	1.586***	-0.980***
	(8.91)	(2.24)	(11.87)	(-6.49)
Crop dividers				
Wild, unmanaged separation	0.142*	0.044	0.229**	0.045
	(2.54)	(0.40)	(2.58)	(0.28)
Clear, managed separation	0.197**	-0.155	0.596***	0.429***
	(2.84)	(-1.73)	(5.36)	(3.68)
Mechanisation level				
No mechanisation	-0.282*	0.495***	-0.354*	-0.289
	(-2.53)	(4.28)	(-2.16)	(-1.49)
Low mechanisation	-0.158	0.133	-0.220	-0.158
	(-1.31)	(0.82)	(-1.20)	(-0.83)
Medium mechanisation	0.124	-0.252	-0.476*	0.420*
	(0.76)	(-1.56)	(-1.98)	(2.12)
Farm infrastructure				
Small buildings	0.346***	0.064	-0.093	-0.118
	(3.61)	(0.70)	(-0.67)	(-1.00)
Medium buildings	0.246*	-0.033	-0.364*	0.186
	(2.46)	(-0.27)	(-2.42)	(1.24)
Energy generating infrastructure				
Solar panels on roofs and ground	0.069	-0.015	0.051	-0.028
	(1.00)	(-0.15)	(0.46)	(-0.20)
Wind turbines (up to 25m high)	0.011	0.038	0.073	0.012
+ solar panels	(0.14)	(0.37)	(0.57)	(0.10)
Wind turbines (>25m high)	0.195*	0.400***	0.463***	0.628***
+ solar panels	(2.25)	(3.95)	(3.46)	(5.41)
Increase in the price of a typical	-0.000***	-0.001***	-0.141***	0.158***
food basket/household	(-7.85)	(-14.10)	(-10.51)	(12.94)
Observations	13770		7560	
N respondents	510		860	
Log-likelihood	-3634.35		-1860.81	
Chi-squared	668.69		488.10	

Note: *, **, and *** denote whether the parameter is significant at the 10%, 5% and 1% level respectively. All parameters have been dummy-coded.

From the LC model estimates for the Flemish sample treated with the pictogram design treatment described in Table 9 we see that two distinct classes can be identified amongst respondents based on individual attribute preferences. The main attribute level preferences distinguishing the two classes are the estimates for the opt-out. From Table 9 we can see that respondents in class 1 (21.9% of the sample) have a significant positive preference for the opt-out, while respondents in class 2 (78.1% of the sample) have a strong negative preference for the opt-out. Further, class 2 can be distinguished by its significantly positive preference both for clear, managed separation for crop dividers compared to no separation, as well as for medium-sized buildings as opposed to large buildings within the local agricultural landscape. Lastly, Table 9 demonstrates that class 1 has significant negative preferences for more intrusive energy generating infrastructure within an arable landscape compared two class 2. This can be seen from the significant negative preferences for the attribute levels 'solar panels on roofs and ground' and 'wind turbines (up to 25m high) + solar panels' compared to a positive preference amongst class 2 for the attribute level 'wind turbines (>25m high) + solar panels'.

As has been mentioned previously, a methodological evaluation was also included in this analysis. Specifically, we expect that within the different case study regions, preferences for attributes and levels will differ based on design treatments, as certain design treatments (e.g. composite images) are likely to better capture aesthetic preferences than others (e.g. pictograms + text). Results of the conditional logit (Table B1) and well as mixed logit (Table B2 and Table B3) for each design treatment sample across the three case study areas can be found in Appendix B. Here we see that preferences for certain attributes and levels seem to vary between the design treatments as well as the case study areas. This is particularly the case for crop dividers, mechanisation levels, and energy generating infrastructure, where see a difference in the significance of preferences based on the design treatment. From the mixed logit results reported in Table B2 and Table B3, we also see variation in respondent's preferences across the design treatments.

Table 9. Multinomial Logit (Mixed logit) model estimates for the Flemish sample across all design treatments and Latent Class (CL) model estimates for the pictogram design treatment for the Flemish sample. Parameter estimates (β) describe preferences for the attribute levels with reference to the baseline level, while the standard deviation (σ) describes the heterogeneity in preferences within the sample.

	Mixed logit model		LC model design 3	
			Class 1	Class 2
	β (S.E.)	**σ** (S.E.)	**β** (S.E.)	**β** (S.E.)
Opt out	-3.439***	2.729***	0,96**	-3,01***
	(-15.71)	(21.40)	-3,12	(-15,64)
Land coverage				
No bare land	0.249***	0.511***	0,32***	0,22***
	(7.01)	(10.73)	(-3,43)	(-6,94)
Landscape diversity				
Low	0.662***	-0.148	0,60***	0,61***
	(14.51)	(-1.59)	(-4,94)	(-13,5)
Medium	0.880***	-0.093	0,66***	0,82***
	(15.44)	(-0.83)	(-4,77)	(-14,33)
High	1.162***	0.689***	1,02***	1.00***
	(20.34)	(8.94)	(-7,25)	(-19,49)
Crop dividers				
Wild, unmanaged separation	0.183***	0.053	0,33**	0,12**
	(4.55)	(0.48)	(-3,16)	(-3,07)
Clear, managed separation	0.226***	0.039	0,21	0,18***
	(4.64)	(0.44)	(-1,64)	(-3,55)
Mechanisation level				
No mechanisation	-0.045	0.117	0,04	-0,04
	(-0.59)	(0.68)	(-0,25)	(-0,54)
Low mechanisation	0.014	-0.211*	0,14	-0,0
	(0.16)	(-2.23)	(-0,77)	(-0,01)
Medium mechanisation	0.162	-0.092	0,19	0,19
	(1.42)	(-0.66)	(-0,82)	(-1,57)
Farm infrastructure				
Small buildings	0.318***	0.025	0,34*	0,31***
	(4.71)	(0.36)	(-2,34)	(-4,41)
Medium buildings	0.216**	-0.100	0,21	0,23**
	(3.07)	(-1.13)	(-1,30)	(-3,16)
Energy generating infrastructure				
Solar panels on roofs and ground	-0.006	0.043	-0,26*	0,07
	(-0.14)	(0.66)	(-2,31)	(-1,58)
Wind turbines (up to 25m high) + solar panels	-0.047	0.102	-0,25*	0,00
	(-0.83)	(1.20)	(-2,00)	(-0,03)
Wind turbines (>25m high) + solar panels	0.125*	-0.490***	-0,18	0,17**
	(2.05)	(-6.47)	(-1,28)	(-2,88)

Increase in the price of a typical food basket/household	-0.070*** (-14.26)	0.065*** (12.91)	-0,04*** (-4,12)	-0,06*** (-13,73)
Observations	28296		9423	
N respondents	1048		349	
Log-likelihood	-7362.42		-7463.23	
Chi-squared	1500.50		NA	
CAIC	NA		5369.93	
BIC	NA		5336.93	

Note: *, **, and *** denote whether the parameter is significant at the 10%, 5% and 1% level respectively. All parameters have been dummy-coded.

Finally, a WTP analysis was used to estimate how much respondents in each of the three case study regions would be willing to pay for a marginal increase in each of the considered attribute levels relative to the base-line level. Table 10 describes the WTP estimates. Base-line levels were identified during analysis as the most conventional levels, with all subsequent levels thus illustrating a shift towards landscapes integrating more ecological farming practices. From Table 10 we can see that across all three case study regions, respondents are most willing to pay to increased levels of landscape within an agricultural landscape. Particularly, respondents in the Flemish sample are willing to pay €17.17 for a marginal increase of high landscape diversity as opposed to monoculture. In the Hungarian sample this is 2159.31Ft (€5.90) and in the English sample this is £8.66 (€10.28). Respondents in all three sample are also willing to pay a relatively large amount for small as opposed to large infrastructure within the agricultural landscape (€5.62 in Flanders, 1224.49Ft/€3.34 in Hungary and £4.34/€5.15 in England).

Differences in the willingness to pay between the case study regions is observed for wild, unmanaged crop dividers, for which the English sample is willing to pay £4.94/€5.86; more than twice as much compared to the Flemish and Hungarian samples. Similarly, the Hungarian sample is willing to pay 4460.10Ft/€12.18 for an intermediate level of energy generating infrastructure (solar panels on roofs and ground), which is two orders of magnitude more than the Flemish (€0.12) and English (€0.19) samples are willing to pay.

Table 10. Willingness to pay (WTP) estimates for each of the three case study regions. Estimates are expressed in local currency: euros (€) in Flanders, Hungarian forint (Ft) (and euro (€) equivalents) in Hungary, and pound sterling (£) in England.

	Flanders (€) (upper,lower bounds)	Hungary (Ft/€ eq.) (upper,lower bounds)	England (£/€ eq.) (upper,lower bounds)
Land coverage			
No bare land	4.02 (5.64,5.40)	696 / 1.90 (269.22,1122.78)	3.07 / 3.64 (1.23,4.91)
Landscape diversity			
Low	10.38 (8.49,12.26)	1755.28 / 4.79 (1148.01,2362.55))	5.07 / 6.02 (2.81,7.33)
Medium	13.89 (10.89,19.52)	1940.24 / 5.30 (1142.89,2737.58)	7.88 / 9.35 (4.83,10.93)
High	17.17 (14.82,19.52)	2159.31 / 5.90 (1520.85,2797.77)	8.66 / 10.28 (5.91,11.41)
Crop dividers			
Wild, unmanaged separation	2.70 (1.48,3.93)	435.07 / 1.19 (70.65,79.77)	4.94 / 5.86 (2.69,7.18)
Clear, managed separation	3.11 (1.84,4.37)	621.11 / 1.70 (236.96,1005.26)	3.14 / 3.73 (1.09,5.18)
Mechanisation level			
No mechanisation	-0.03 (-2.22,2.16)	-760.16 / -2.08 (-1454.50,65.82)	-4.50 / -5.34 (-7.70,-1.29)
Low mechanisation	0.75 (-1.79,3.29)	-461.22 / -1.26 (-1207.53,285.10)	-1.34 / -1.59 (-5.09,2.41)
Medium mechanisation	3.63 (0.17,7.09)	627.14 / 1.71 (-504.01,1758.30)	2.04 / 2.42 (-2.62,6.70)
Farm infrastructure			
Small buildings	5.62 (3.22,8.02)	1224.49 / 3.34 (437.24,2011.74)	4.34 / 5.15 (1.08,7.60)
Medium buildings	4.02 (1.65,6.40)	981.46 / 2.68 (191.44,177149)	0.18 / 0.21 (-2.83,3.19)
Energy generating infrastructure			
Solar panels on roofs and ground	0.22 (-1.10,1.53)	4460.10 / 12.18 (191.44,1771.49)	0.16 / 0.19 (-1.97,2.29)
Wind turbines (up to 25m high) + solar panels	-0.66 (-2.48,1.17)	205.47 / 0.56 (-388.68,799.62)	1.60 /1.90 (-1.32,4.51)
Wind turbines (>25m high) + solar panels	1.99 (0.32,3.65)	790.49 / 2.16 (252.20,1328.77)	4.99 / 5.92 (2.33,7.66)

5 Conclusion

In this deliverable we present results of two distinct territorial level impact assessments of (ecological) FMPs using the ES concept. Through the composition of AEI indicators we present a framework which could be easily adopted in other case study regions based on the available literature and stakeholder consultation. By applying this framework to three case study regions across Belgium and England, we present concrete evidence for the output of these AEI indicators. We find that, across all three case study areas, semi-natural habitats had the highest AEI at territorial level in NK and the HW, while in HH this was cover crops. However, cover crops had the second highest AEI in NK and the HW, while semi-natural habitats had the second highest AEI in HH. Also obtaining a high AEI at territorial level across the three case study areas was extensive livestock systems, intercropping and crop-livestock integration.

While conventional FMPs generally have a lower AEI than agroecological FMPs, we find that the latter may also have low AEIs. For example, FMPs using non-chemical inputs, such as organic fertilisers and pesticides, biological pest control and biological N fixation all have relatively low AEIs across the three case study areas, both at farm and territorial level. This demonstrates that while certain agroecological FMPs have a tendency to have a positive impact on potential ES supply, the demand for ES is what determines whether the potential benefits are realised in an area. This variation in demand illustrates that not all FMPs are suited for all geographic and socio-economic contexts, as that FMPs that have a high AEI in one region may perform poorly in another, highlighting the importance of considering local demand when determining AEI of FMPs.

In a second, distinct assessment, we quantify AEI of FMPs at territorial level through a more traditional approach of a DCE. Applied across three case study regions in Flanders (Belgium), Hungary and England, we see that preferences amongst the general public for landscape features, and by extension FMPs, that increase landscape (bio)diversity are largely positive and similar across the three regions. We further observe that preferences for more permanent features established within an agricultural landscape, such as (energy generating) infrastructure size are more varied between the case study regions. Combined with the varying levels of WTP for a marginal increase in the presence of such FMPs, results demonstrate a context-specific component to which FMPs are most desirable within a given region. While we also demonstrate variation in preferences for landscape features based on treatment designs, more concrete conclusions on this would require further analysis. A potential for future expansion on this work would be to try to disentangle the impact of design treatment on respondent's preferences to identify which design treatment is most suited to eliciting aesthetic preferences.

Overall, results from these two AEI assessments seem to indicate that there is a context-specific component to the AEI of ecological FMPs. The presented results provide interesting insights for land management decisions and policy recommendation in that they illustrate at the territorial level, ecological FMPs which are applied at a larger scale and which focus on maintaining landscape (bio)diversity and green connectivity seem to have the highest AEI regardless of the context. Further, we demonstrate that when considering the AEI of more localised FMPs e.g. cover crops, or FMPs which result in more permanent, obtrusive changes to the agricultural landscape, it is important to consider the local contexts and ES demands.

6 Deviations or delays

None.

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9 Appendix A: Agri-environmental impact indicators supplementary materials

Table A1. Final list of farm management practices included in the impact indicator framework, adapted from Rega et al. (2018).

Farm management practice (practice clusters)	Individual farm management practices within the clusters	
Use of chemical fertiliser inputs	- Use of inorganic fertiliser / chemical fertiliser - Agrochemical input – fertilisers - Mineral fertiliser	
Low fertiliser input	- Low nutrient input - Reduced fertiliser application - Low-solubility mineral fertilisers	
Biological N fixation	- Biological nitrogen fixation - Legume-cereal rotations	- Legumes - Pulse crops
Use of organic fertilisers (incl. manure)	- Manure fertiliser - Farmyard manure - Organic manure	
Use of chemical pesticide inputs	- Use of inorganic pesticide inputs - Herbicide input	- Insecticide input - Agrochemical input - pesticides
Biological pest control	- Bio-control - Biological pest control - Natural pest control	- Plant extract bio-control - Diversionary strategy
Use of organic pesticides	- Biological insecticide - Amendments	- Copper - Sulphur
Low agrochemical pesticide input	- Reduced herbicide application - Reduced insecticide use - Low pesticide input - Seed selection	- Crop variety improvements - Varietal diversity - Local variety - Insect-resistant crops
Alternative weed management strategies	- Fumigation - Mechanical weeding - Push-pull system	- Manual weeding - IPM
Cover crops	- Catch crop - Clover	
Conservation tillage	- Strategic tillage - Reduced soil cultivation - Minimum tillage - Shallow tillage - No tillage	- Occasional tillage - Ridge till - Asynchronous tilling - Direct sowing
Crop rotation	- Crop sequence - Dryland rotation	- Irrigated rotation - Diversification of crop rotation
Crop residue management	- Crop sequence - Dryland rotation	- Irrigated rotation - Diversification of crop rotation
Mulching	- Organic mulching - mulching	
Sustainable water management	- Deficit irrigation - Reduced irrigation	- No irrigation - Flooding

	- Drainage	
Agroforestry	- Agroforestry	
Extensive livestock systems	- Transhumance - Silvopasture	
Crop livestock integration	- Animal circulation - Crop-livestock integration - Grassland – livestock integration	
Semi-natural habitats	- Diversified field edges - Conservation buffers - Border planting - Ecological compensation areas - Ecological focus area - (Agro) ecological infrastructure (management) - Grassy buffer strips	- Habitat Semi-natural habitat - Wildlife plots - Hedgerows - Insectary strips - Living fences - Noncrop plantings - Beneficial fauna
Spatial heterogeneity	- Diversification - Farm heterogeneity	- Spatial diversity - Patch intensification
Agri-environmental schemes	- Agri-environmental schemes	
Sustainable grazing	- Grass ley - Ley farming - Perennial leys with legumes - Improved pastures - Grassland mixtures - Grazing	- Grazing on crop residues - Low density of livestock - Low stocking rates - Use of fallow - Rotational grazing
Selection of breeds (genetic diversity, traditional/local breeds)	- Breed selection - Genetic diversity - Local breed	
Low mechanisation	- No mechanisation - Low mechanisation	- Manual cuts - Blade mowing machine cuts
Precision farming	- Precision farming - Precision livestock farming	
Intercropping	- Alley intercropping - Intercropping - Multiple intercropped species	- Relay intercropping - Polyculture

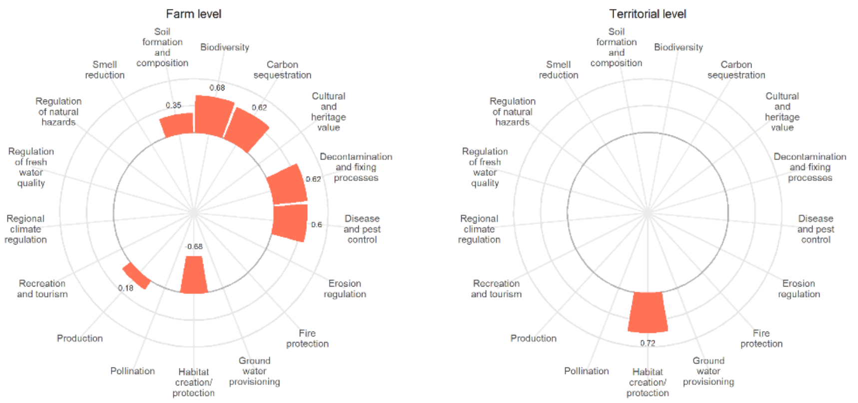
Table 11. List of ecosystem services included in the indicator framework.

Ecosystem service category	Ecosystem service
Regulating and maintenance services	Carbon sequestration (global climate regulation)
	Erosion regulation
	Regulation of natural hazards
	Soil formation and composition
	Biodiversity
	Habitat creation/protection
	Pollination
	Regional climate regulation
	Regulation of fresh water quality
	Decontamination and fixing processes
	Smell reduction
	Fire protection
Provisioning services	Ground water provisioning
	Pest control
	Disease control
	Cultivated crop production
	Livestock for food and materials
	Financial value (e.g. income)
Cultural services	Recreation and tourism
	Cultural and heritage value

Table A3. Weights used in aggregation of composite indicators for case study regions: Hageland-Haspengouw (HH), North Kent (NK) and the High Weald (HW).

	Farm			Territorial		
ES	**HH**	**NK**	**HW**	**HH**	**NK**	**HW**
Biodiversity	0.18	0.13	0.45	1.00	0.67	0.84
Carbon sequestration	0.03	0.13	0.41	0.67	1.00	1.00
Cultural and heritage value	0.16	0.05	0.19	0.82	0.30	0.79
Decontamination and fixing processes	0.03	0.08	0.16	0.06	0.10	0.37
Disease and pest control	0.39	0.33	0.36	0.49	0.23	0.10
Erosion regulation	0.28	0.14	0.33	0.72	0.40	0.10
Fire protection	0.00	0.00	0.00	0.31	0.00	0.00
Ground water provisioning	0.20	0.13	0.19	0.78	0.63	0.48
Habitat creation/protection	0.21	0.12	0.24	0.65	0.55	0.70
Pollination	0.40	0.18	0.29	0.46	0.34	0.60
Production	1.00	1.00	1.00	0.69	0.25	0.33
Recreation and tourism	0.14	0.05	0.21	0.63	0.59	0.72
Regional climate regulation	0.16	0.02	0.15	0.76	0.39	0.40
Regulation of fresh water quality	0.17	0.15	0.32	0.47	0.84	0.49
Regulation of natural hazards	0.14	0.05	0.18	0.71	0.47	0.49
Smell reduction	0.04	0.00	0.00	0.00	0.01	0.01
Soil formation and composition	0.49	0.12	0.36	0.76	0.34	0.20

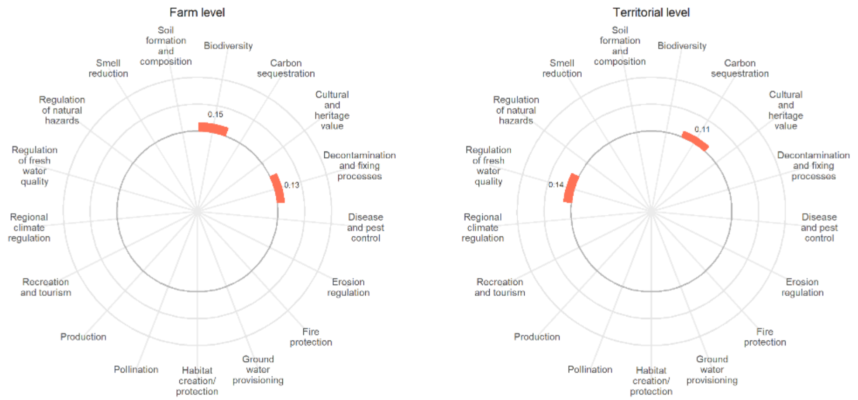
Extensive livestock systems



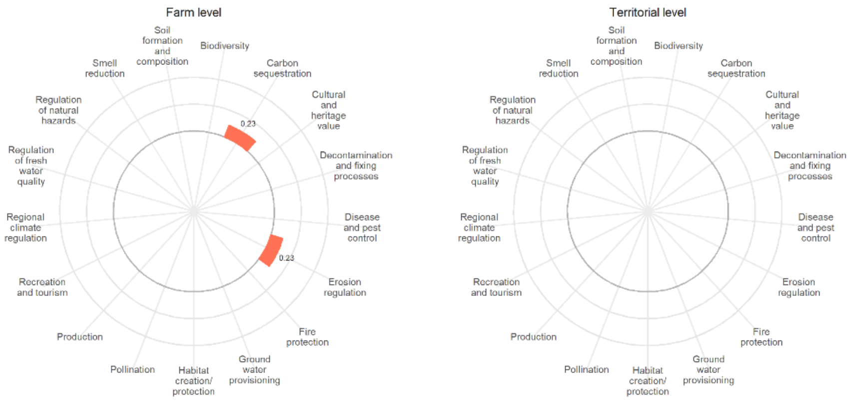
Intercropping

Low agrochemical pesticide input

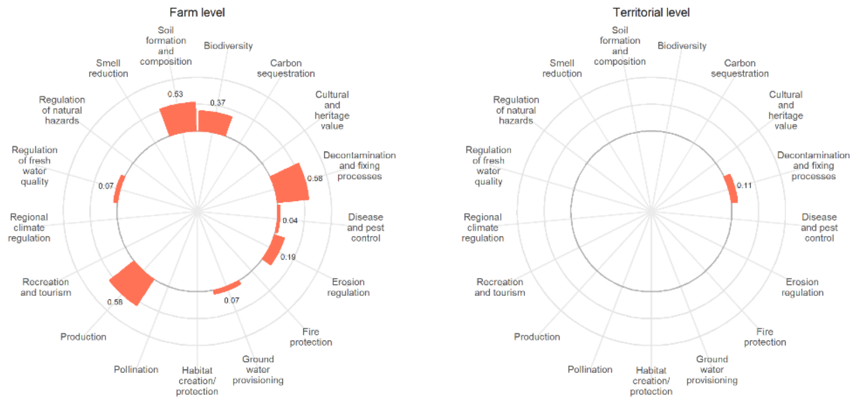
Low fertiliser input



Low mechanisation

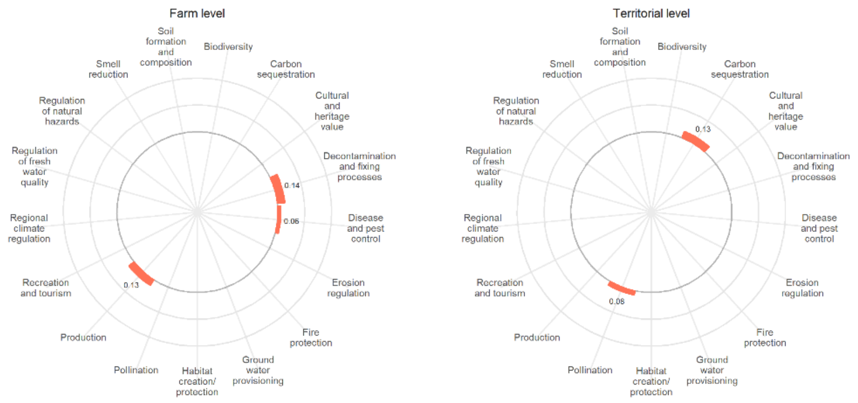


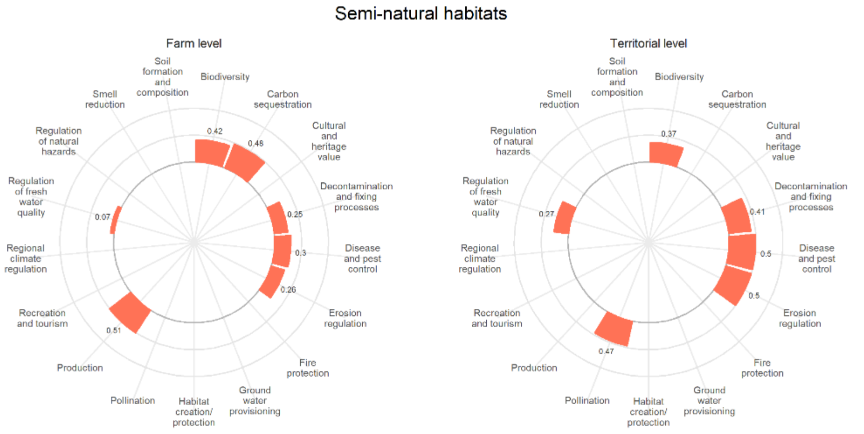
Mulching

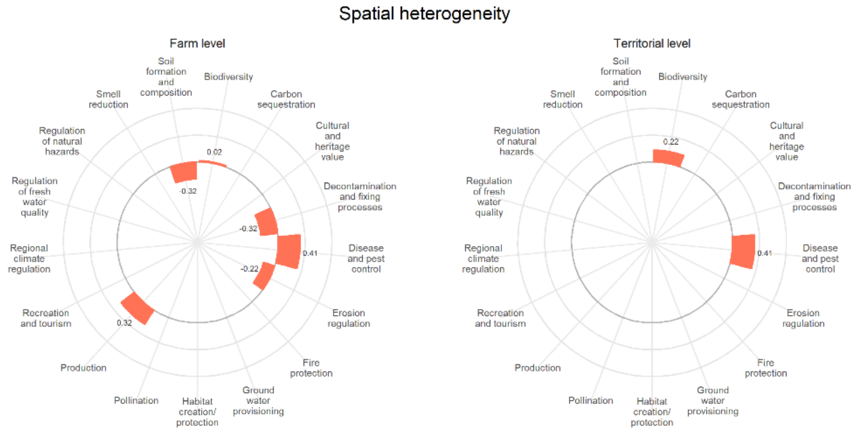


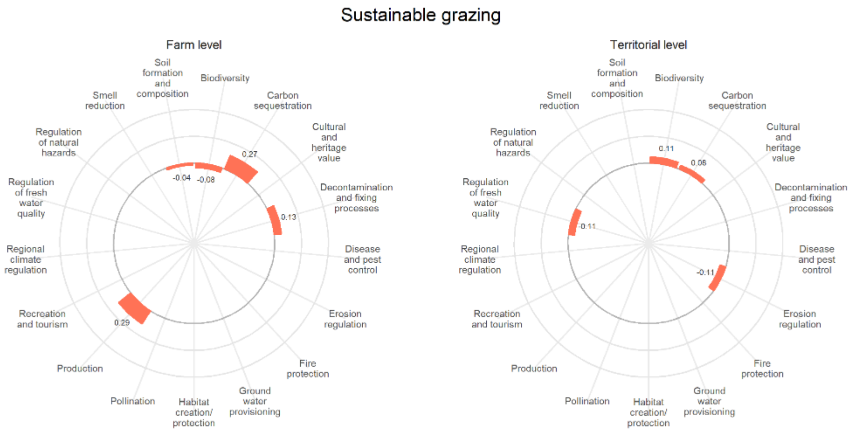
Precision farming

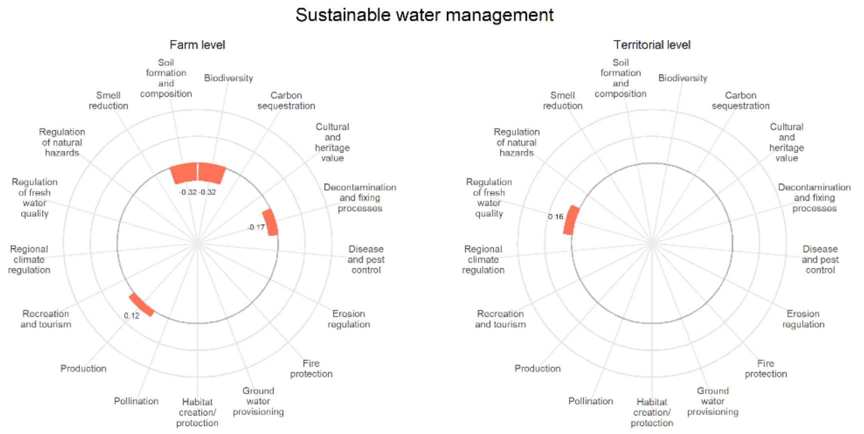
Selection of breeds



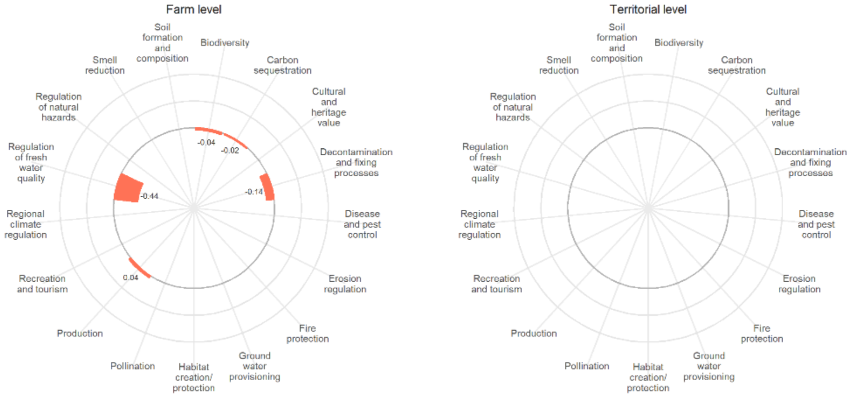

Semi-natural habitats
Farm level
Territorial level
0.42
0.48
0.07
0.25
0.3
0.26
0.51
0.37
0.27
0.41
0.5
0.5
0.47


Spatial heterogeneity
Farm level
Territorial level
0.02
-0.32
-0.32
0.41
-0.22
0.32
0.22
0.41


Sustainable grazing
Farm level
Territorial level
0.27
-0.04
-0.08
0.13
0.29
0.11
0.08
0.11
-0.11


Sustainable water management
Farm level
Territorial level
-0.32
-0.32
-0.17
0.12
0.16

Use of chemical fertiliser inputs



Use of chemical pesticide inputs

Use of organic fertilisers

Use of organic pesticides


Agri-environmental schemes
Agroforestry
Alternative weed management
Biological N fixation
Farm level
Territorial level
Soil formation and composition
Biodiversity
Carbon sequestration
Cultural and heritage value
Decontamination and fixing processes
Disease and pest control
Erosion regulation
Fire protection
Ground water provisioning
Habitat creation/ protection
Pollination
Production
Recreation and tourism
Regional climate regulation
Regulation of fresh water quality
Regulation of natural hazards
Smell reduction

Biological pest control

Conservation tillage

Cover crops

Crop livestock integration

Figure A1. Spider diagrams composed for the full set of management practices for which sub-indicator impact indicators were calculated. Indicators are displayed for each management practice at farm and territorial level separately. Missing indicators illustrate a lack of evidence included in the rapid evidence assessment for a particular management practice-ES linkage.

10 Appendix B: Discrete Choice Experiment (DCE) further analyses

Table B1. Conditional logit model estimates illustrating preferences for attributes in Flanders, Hungary and England across all three design treatments: Composite images, individual images with text, and pictograms with text.

	Flanders			Hungary			England		
	Composite	**Indiv. Images**	**Pictograms**	**Composite**	**Indiv. Images**	**Pictograms**	**Composite**	**Indiv. Images**	**Pictograms**
	β **(S.E.)**	***β*** **(S.E.)**	***β*** **(S.E.)**	***β*** **(S.E.)**	***β*** **(S.E.)**	***β*** **(S.E.)**	***β*** **(S.E.)**	***β*** **(S.E.)**	***β*** **(S.E.)**
Opt out	-2.30***	-0.72**	-0.77***	-2.373***	-1.73***	-1.14***	-2.13***	-0.75**	-1.29***
	(-8.87)	(-2.93)	(-3.3)	(-6.57)	(-5.31)	(-3.6)	(-8.34)	(-3.24)	(-7.19)
Land coverage									
No bare land	-0.1	0.44***	0.33***	0.002	0.3***	0.22**	-0.01	0.46***	0.20***
	(-1.92)	(-7.79)	(-6.01)	(-0.02)	(-3.74)	(-2.66)	(-0.22)	(6.55)	(3.69)
Landscape diversity									
Low	0.80***	0.46***	0.52***	0.557***	0.36***	0.4***	0.55***	0.40***	0.33***
	(-10.65)	(-7.39)	-7.57	(-5.07)	(-4.14)	(-4.23)	(-6.56)	(5.31)	(4.60)
Medium	1.05***	0.65***	0.64***	0.769***	0.27***	0.38***	0.76***	0.60***	0.52***
	(-10.94)	(-7.79)	(-7.71)	(-5.69)	(-2.78)	(-3.70)	(-7.53)	(6.30)	(6.65)
High	1.45***	0.77***	0.77***	1.05***	0.38***	0.15	1.15***	0.54***	0.57***
	(-15.55)	(-8.69)	(-9.65)	(-8.16)	(-3.92)	(-1.41)	(-11.13)	(5.95)	(6.18)
Crop dividers									
Wild, unmanaged separation	0.15*	0.13*	0.18**	0.1	0.11	0.11	0.12	0.14*	0.33***
	(-2.50)	(-2.23)	(-2.98)	(-1.18)	(-1.54)	(-1.44)	(-1.84)	(2.17)	(4.97)
Clear, managed separation	0.36***	0.164*	0.03	0.34***	0.1	0.008	0.48***	0.12	0.21**
	(-4.44)	(-2.47)	(-0.46)	(-3.41)	(-1.05)	(-0.09)	(-5.62)	(1.52)	(2.84)
Mechanisation level									

No mechanisation	-0.13	0.23*	-0.12	-0.06	-0.29	-0.22	-0.25*	0.05	-0.30**
	(-1.09)	(-2.01)	(-1.15)	(-0.35)	(-1.86)	(-1.33)	(-2.03)	(0.42)	(-2.75)
Low mechanisation	-0.19	0.15	0.12	-0.17	-0.24	0.05	-0.16	0.21	-0.09
	(-1.43)	(-1.18)	(-0.97)	(-1.05)	(-1.32)	(-0.27)	(-1.25)	(1.65)	(-0.69)
Medium mechanisation	-0.3	0.36*	0.5**	-0.18	0.14	0.47*	-0.30	0.38*	0.13
	(-1.78)	(-2.08)	(-3.18)	(-0.75)	(-0.61)	(-2.03)	(-1.74)	(2.23)	(0.87)
Farm infrastructure									
Small buildings	-0.17	0.4***	0.71***	0.001	0.38**	0.52***	-0.03	0.51***	0.29**
	(-1.77)	(-3.82)	(-6.95)	0	(-2.81)	(-3.56)	(-0.25)	(4.49)	(2.90)
Medium buildings	-0.28**	0.38***	0.54***	-0.03	0.35**	0.4**	-0.24*	0.33**	0.01
	(-2.62)	(-3.61)	(-5.35)	(-0.24)	(-2.63)	(-2.64)	(-2.21)	(2.98)	(0.12)
Energy generating infrastructure									
Solar panels on roofs and ground	0.05	-0.03	-0.01	0.12	0.03	0.17	0.13	0.01	0.01
	(-0.70)	(-0.39)	(-0.13)	(-1.25)	(-0.33)	(-1.72)	(-1.58)	(0.19)	(0.15)
Wind turbines (up to 25m high) + solar panels	0.07	-0.07	-0.12	0.19	-0.13	0.11	0.08	-0.15	0.11
	(-0.81)	(-0.66)	(-1.38)	(-1.5)	(-0.92)	(-0.79)	(-0.86)	(-1.44)	(1.06)
Wind turbines (>25m high) + solar panels	0.32***	0.08	-0.04	0.34**	-0.01	0.28*	0.38***	-0.04	0.33***
	(-3.37)	(-0.91)	(-0.41)	(-2.89)	(-0.1)	(-2.16)	(-3.75)	(-0.38)	(3.57)
Increase in the price of a typical food basket/household	-0.09***	-0.04***	-0.05***	-0.05***	-0.04***	-0.04***	-0.10***	-0.05***	-0.07***
	(-11.56)	(-6.03)	(-6.90)	(-4.21)	(-4.55)	(-3.97)	(-11.01)	(-6.59)	(-9.01)
Observations	9558	9315	9423	4671	4644	4455	7560	7857	7803
N respondents	354	345	349	173	172	165	280	291	289
Log-likelihood	-2478.34	-2717.61	-2795.56	-1.183	-1359.97	-1349.24	-2104.86	-2403.21	-2401.85
Chi-squared	548.21	541.05	506.5	241.45	206.41	169.42	476.50	370.55	408.86

Table B2. Mixed logit model estimates for the three DCE designs (composite images, individual images, and pictograms) for the English and Hungarian case study regions. Parameter estimates (β) describe preferences for the attribute levels with reference to the baseline level, while the standard deviation (σ) describes the heterogeneity in preferences within the sample.

	Hungary						**England**					
	Composite		**Individual image**		**Pictogram**		**Composite**		**Individual image**		**Pictogram**	
	β (S.E.)	**σ (S.E.)**	**β (S.E.)**	**σ (S.E.)**	**β (S.E.)**	**σ (S.E.)**	**β (S.E.)**	**σ (S.E.)**	**β (S.E.)**	**σ (S.E.)**	**β (S.E.)**	**σ (S.E.)**
Opt out	-4.88***	-3.07***	-3.62***	2.48***	-2.65***	-4.88***	-4.55***	2.24***	-2.45***	2.52***	-2.23***	1.65***
	(-7.44)	(-6.06)	(-7.19)	(-8.19)	(-5.28)	(-7.44)	(-10.68)	(10.60)	(-6.78)	(11.69)	(-8.12)	(9.52)
Land coverage												
No bare land	0.00	-0.19	0.41***	0.87***	0.25*	0.83***	-0.01	0.32*	0.52***	0.90***	0.27***	0.44***
	(-0.01)	(-1.11)	(-3.82)	(-7.04)	(-2.36)	(-0.01)	(-0.08)	(2.39)	(6.03)	(9.80)	(3.95)	(3.88)
Landscape diversity												
Low	0.66***	0.07	0.48***	0.03	0.50***	-0.07***	0.65***	-0.43*	0.49***	-0.25	0.41***	0.15
	(-5.37)	(-0.27)	(-4.06)	(-0.16)	(-4.06)	(-5.37)	(6.47)	(-2.55)	(5.25)	(-1.74)	(4.43)	(1.12)
Medium	0.97***	0.52*	0.38**	-0.07	0.41**	0.97***	0.98***	-0.32*	0.75***	0.19	0.72***	0.06
	(-6.34)	(-2.43)	(-2.72)	(-0.42)	(-2.83)	(-6.34)	(8.12)	(-2.17)	(6.45)	(0.82)	(6.62)	(0.43)
High	1.44***	1.00***	0.54***	0.23	0.16	1.44***	1.59***	-0.98***	0.71***	0.81***	0.73***	0.58***
	(-8.67)	(-5.6)	(-4.03)	(-1.45)	(-1.13)	(-8.67)	(11.87)	(-6.49)	(6.14)	(5.62)	(6.54)	(3.66)
Crop dividers												
Wild, unmanaged separation	0.17	-0.17	0.17	0.10	0.09	0.17	0.23**	0.05	0.20*	0.11	0.42***	0.37**
	(-1.55)	(-0.96)	(-1.68)	(-0.51)	(-0.83)	(-1.55)	(2.58)	(0.28)	(2.41)	(0.58)	(4.94)	(2.69)
Clear, managed separation	0.46***	-0.11	0.15	-0.32	-0.02	0.46***	0.60***	0.43***	0.22*	-0.05	0.25**	0.26
	(-3.56)	(-0.59)	(-1.18)	(-1.82)	(-0.17)	(-3.56)	(5.36)	(3.68)	(2.18)	(-0.40)	(2.62)	(1.79)
Mechanisation level												
No mechanisation	-0.09	0.95***	-0.45*	-0.54**	-0.20	-0.09	-0.35*	-0.29	0.00	0.46**	-0.34*	-0.30
	(-0.42)	(-5.04)	(-2.24)	(-2.65)	(-0.95)	(-0.42)	(-2.16)	(-1.49)	(0.00)	(3.13)	(-2.53)	(-1.52)
Low mechanisation	-0.27	-0.06	-0.29	0.35	0.02	-0.27	-0.22	-0.16	0.18	-0.06	0.03	0.38*
	(-1.17)	(-0.34)	(-1.34)	(-1.88)	(-0.10)	(-1.17)	(-1.20)	(-0.83)	(1.04)	(-0.47)	(0.21)	(2.07)
Medium mechanisation	-0.37	0.40	0.21	0.10	0.48	-0.37	-0.48*	0.42*	0.34	-0.16	0.32	-0.07
	(-1.23)	(-1.68)	(-0.73)	(-0.31)	(-1.61)	(-1.23)	(-1.98)	(2.12)	(1.52)	(-0.95)	(1.74)	(-0.26)
Farm infrastructure												

Small buildings	-0.02	0.11	0.51**	0.12	0.54**	-0.02	-0.09	-0.12	0.57***	-0.23	0.43***	-0.26*
	(-0.13)	(-0.89)	(-2.90)	(-0.75)	(-2.97)	(-0.13)	(-0.67)	(-1.00)	(4.11)	(-1.66)	(3.63)	(-1.98)
Medium buildings	-0.09	-0.22	0.44*	-0.04	0.43*	-0.09	-0.36*	0.19	0.30*	0.07	0.04	-0.24
	(-0.49)	(-1.30)	(-2.45)	(-0.27)	(-2.31)	(-0.49)	(-2.42)	(1.24)	(2.10)	(0.50)	(0.32)	(-1.66)
Energy generating infrastructure												
Solar panels on roofs and ground	-0.03	-0.09	-0.04	0.10	0.30*	-0.03	0.05	-0.03	-0.05	0.15	-0.04	0.11
	(-0.24)	(-0.51)	(-0.29)	(-0.65)	(-2.29)	(-0.24)	(0.46)	(-0.20)	(-0.51)	(1.33)	(-0.44)	(0.61)
Wind turbines (up to 25m high) + solar panels	0.13	-0.02	-0.248	0.203	0.273	0.13	0.07	0.01	-0.25*	0.09	0.01	-0.12
	(-0.81)	(-0.09)	(-1.65)	(-1.09)	(-1.69)	(-0.81)	(0.57)	(0.10)	(-2.05)	(0.72)	(0.04)	(-0.67)
Wind turbines (>25m high) + solar panels	0.30	-0.32	-0.10	0.58***	0.35*	0.30	0.46***	0.63***	-0.05	0.43**	0.36**	0.47**
	(-1.89)	(-1.85)	(-0.60)	(-3.35)	(-2.26)	(-1.89)	(3.46)	(5.41)	(-0.43)	(2.72)	(3.17)	(2.90)
Increase in the price of a typical food basket/household	-0.07***	0.12***	-0.06***	0.09***	-0.07***	-0.07***	-0.14***	0.16***	-0.08***	0.10***	-0.08***	0.08***
	(-4.50)	(-8.58)	(-4.57)	(-8.12)	(-4.94)	(-4.50)	(-10.51)	(12.94)	(-7.39)	(9.76)	(-8.38)	(9.22)
Observations	4671		4644		4455		7560		7857		7803	
N respondents	173		172		165		280		291		289	
Log-likelihood	-1112.12		1231.031		1214.563		-1860.81		-2121.93		-2255.40	
Chi-squared	141.79		257.88		269.36		488.1		562.56		292.89	

Table B3. Mixed logit model estimates for the three DCE designs (composite images, individual images, and pictograms), and Latent Class (CL) model estimates for the pictogram design, all for the Flemish case study region. Parameter estimates (β) describe preferences for the attribute levels with reference to the baseline level, while the standard deviation (σ) describes the heterogeneity in preferences within the sample.

Flanders	**Mixed logit model**						**LC model**	
							Pictograms	
	Composite		**Individual Images**		**Pictograms**		**Class 1**	**Class 2**
	β (S.E.)	**σ** (S.E.)	**β** (S.E.)	**σ** (S.E.)	**β** (S.E.)	**σ** (S.E.)	**β** (S.E.)	**β** (S.E.)
Opt out	-5.57***	3.44***	-2.81***	3.05***	-2.64***	2.91***	0.96**	-3.01***
	(-11.21)	(-10.12)	(-7.42)	(-10.27)	(-7.09)	(-11.75)	-3.12	(-15.64)
Land coverage								
No bare land	-0.12*	0.07	0.48***	0.67***	0.4***	0.61***	0.32***	0.22***
	(-1.97)	(-0.48)	(-7.07)	(-7.66)	(-5.89)	(-7.28)	(-3.43)	(-6.94)
Landscape diversity								
Low	0.94	0.47***	0.51***	-0.04	0.61***	-0.17	0.60***	0.61***
	(-10.55)	(-3.33)	(-6.49)	(-0.33)	(-7.30)	(-1.11)	(-4.94)	(-13.5)
Medium	1.26***	0.50***	0.71***	-0.09	0.77***	0.11	0.66***	0.82***
	(-11.74)	(-3.38)	(-6.98)	(-0.71)	(-7.45)	(-0.73)	(-4.77)	(-14.33)
High	1.77***	0.80***	0.96***	0.81***	0.96***	0.69***	1.02***	1.00***
	(-15.83)	(-4.37)	(-9.20)	(-5.92)	(-9.53)	(-5.39)	(-7.25)	(-19.49)
Crop dividers								
Wild. unmanaged separation	0.23**	0.05	0.14*	0.19	0.21**	0.32*	0.33**	0.12**
	(-2.96)	(-0.43)	(-2.00)	(-1.31)	(-2.83)	(-2.56)	(-3.16)	(-3.07)
Clear. managed separation	0.45***	0.13	0.25**	0.23	0.04	-0.16	0.21	0.18***
	(-4.78)	(-0.78)	(-2.89)	(-1.80)	(-0.50)	(-1.15)	(-1.64)	(-3.55)
Mechanisation level								
No mechanisation	-0.21	0.35*	0.21	-0.08	-0.19	-0.44*	0.04	-0.04
	(-1.41)	(-2.41)	(-1.53)	(-0.37)	(-1.38)	(-2.54)	(-0.25)	(-0.54)
Low mechanisation	-0.28	-0.16	0.07	-0.07	0.14	-0.2	0.14	-0.0

	(-1.75)	(-0.90)	(-0.46)	(-0.26)	(-0.95)	(-1.24)	(-0.77)	(-0.01)
Medium mechanisation	-0.53*	0.15	0.23	-0.34	0.61**	0.08	0.19	0.19
	(-2.51)	(-0.73)	(-1.09)	(-1.73)	(-3.13)	(-0.23)	(-0.82)	(-1.57)
Farm infrastructure								
Small buildings	-0.27*	-0.06	0.36**	0.2	0.85***	0.04	0.34*	0.31***
	(-2.28)	(-0.65)	(-2.91)	(-1.70)	(-6.90)	(-0.24)	(-2.34)	(-4.41)
Medium buildings	-0.42**	0.03	0.36**	0.27*	0.63***	0	0.21	0.23**
	(-3.19)	(-0.20)	(-2.88)	(-2.02)	(-5.01)	(-0.03)	(-1.30)	(-3.16)
Energy generating infrastructure								
Solar panels on roofs and ground	-0.05	-0.09	-0.03	0.06	-0.04	-0.07	-0.26*	0.07
	(-0.51)	(-0.82)	(-0.30)	(-0.46)	(-0.51)	(-0.66)	(-2.31)	(-1.58)
Wind turbines (up to 25m high)	0.03	-0.15	-0.03	-0.12	-0.22*	0.34*	-0.25*	0.00
+ solar panels	(-0.28)	(-1.35)	(-0.30)	(-0.67)	(-2.13)	(-2.20)	(-2.00)	(-0.03)
Wind turbines (>25m high)	0.30**	-0.42**	0.14	-0.35*	-0.07	-0.61***	-0.18	0.17**
+ solar panels	(-2.68)	(-2.96)	(-1.32)	(-2.27)	(-0.66)	(-4.21)	(-1.28)	(-2.88)
Increase in the price of a	-0.12***	0.11***	-0.06***	0.06***	-0.06***	0.04***	-0.04***	-0.06***
typical food basket/household	(-11.07)	(-9.95)	(-6.57)	(-7.82)	(-7.05)	(-4.64)	(-4.12)	(-13.73)
Observations	9558		9315		9423		9423	
N respondents	354		345		349		349	
Log-likelihood	-2228.31		-2433.73		-2550.72		-7463.23	
Chi-squared	500.05		567.76		489.67		NA	
CAIC	NA		NA		NA		5369.93	
BIC	NA		NA		NA		5336.93	