SOILGUARD

## Sustainable soil management to unleash soil biodiversity potential and increase environmental, economic and social wellbeing.

Grant Agreement no. 101000371

# D4.2 Report on Region-Specific Economic and Socio-Cultural Values of Soil-Mediated Contributions to People (SmCPs)

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# 1 Background and introduction

Soil biodiversity is essential for the provision of multiple of nature's contributions to people (NCPs) , such as nutrient cycling, food production, water filtration and habitat provision (Deliverable 4.1), and is threatened by continuing land degradation through human activities (IPBES, 2018). In line with the conceptual framework of IPBES, we refer to these NCPs as "soil-mediated contributions to people (SmCPs)", acknowledging the diversity of nature's values. Taking a plural-values perspective and integrating diverse values into decisions within the policy cycle, will improve decision outcomes, as many studies have shown, particularly in cases where local or relational values vary between different social groups or stakeholders (Pascual *et al.*, 2023). Recognizing the multiplicity of people's values for soil biodiversity and supporting land management practices can help ensure that resource management decisions consider the needs and perspectives of different stakeholders, thereby promoting more just and sustainable outcomes (Pascual *et al.*, 2023).

Thus far, soil management widely lacks the integration of plural values which is problematic particularly in the light of climatic pressures and resulting soil degradation. Extreme weather events such as heat waves and resulting drought or heavy rainfalls pose increasing challenges for land use practices (Orwin *et al.*, 2015). When soil management prioritise only one or a few values, such as maximizing agricultural productivity or minimizing erosion, other important values may be overlooked or even compromised. For example, focusing only on maximizing crop yields may lead to soil degradation and loss of biodiversity, ultimately undermining the long-term sustainability of agricultural systems. Neglecting a wide range of SmCPs and their values, soil management may fail to address the increasing vulnerability of soils to stressors, leading to further degradation and loss of resilience. Thus, here, we focus on the integration of plural values employing a variety of valuation methods to provide a more holistic picture of needs and preferences within human-nature relations (Chan, Satterfield and Goldstein, 2012).

The integration of plural values in soil management will require in-depth knowledge not only of people's values for SmCPs but also of factors that influence how these SmCPs are perceived and prioritised by people (IPBES, 2022). Based on the adapted typology of nature's values in the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services' (IPBES) framework, we explore values for SmCPs and influencing factors of this value in three SOILGUARD regions (Figure 1). Figure 2 demonstrates, how the integrated socio-economic valuation of SmCPs is placed in the SOILGUARD project. The valuation is based on the analysis of soil functions and data on the provision of SmCPs in quantitative terms. In particular, the cost-based valuation includes data and information on multifunctionality that is measured on the study sites. Furthermore, we identified and defined together with WP 2 the attributes for describing biodiversity-friendly management options that were regarded in-depth in the three SOILGUARD regions. By considering different potential factors influencing the value statements such as people's views on the good quality of life, their worldviews, their relationships with nature (life frames), socio-cultural and monetary values of SmCPs as well as people's knowledge, attitudes, and behaviour, we recognise the richness of the relationships of people with nature. Figure 1 gives an overview of the conceptualisation of diverse nature's values – here also regarded as influencing factors on the value of SmCPs – and how these are considered in the empirical study. The results are incorporated into the evidence chains and policy recommendation.



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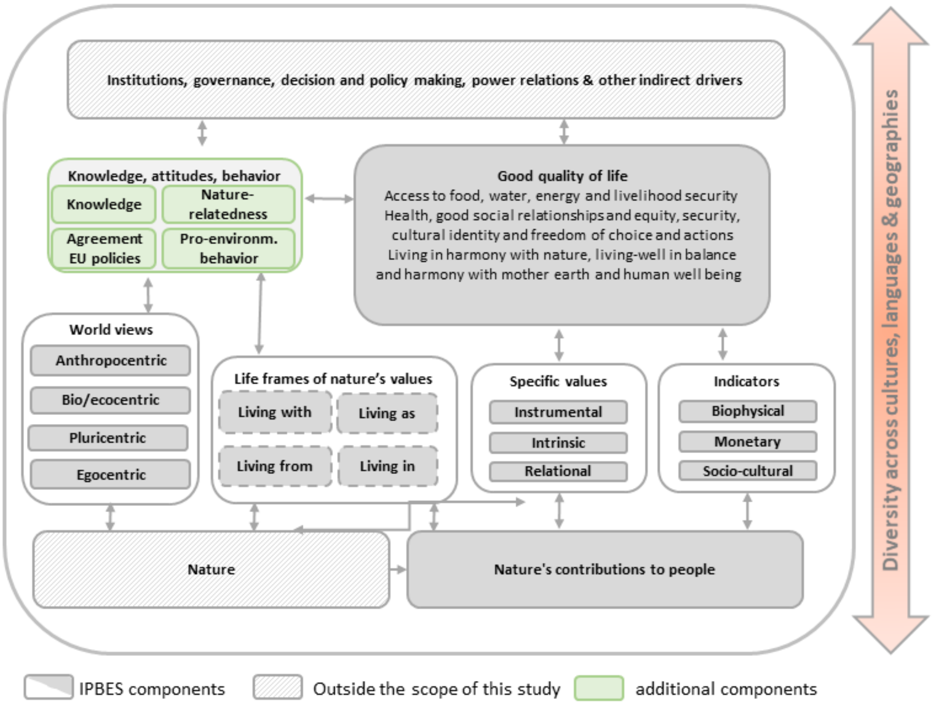


*Figure 1. Adapted overview of multiple conceptualisations of nature's diverse values (IPBES, 2022).*

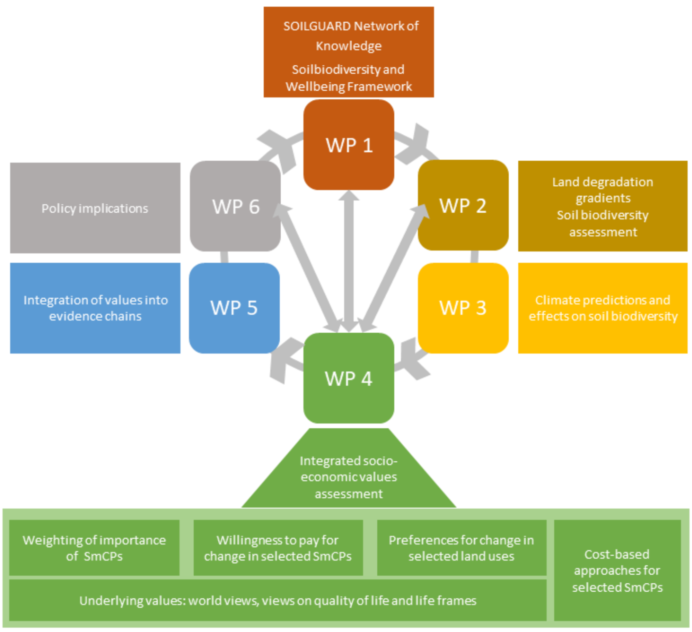


*Figure 2. Integrated socio-economic valuation and linkages to other SOILGUARD work packages.*



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The main objective of this deliverable is to assess the socio-economic values for SmCPs in selected SOILGUARD regions within an integrated valuation framework (see SOILGUARD D4.1) and explore determinants of the elicited values based on different conceptualisations of human-nature relationships as described by IPBES (2022). By this, we address the main objectives of SOILGUARD WP 4 to understand region-specific factors that influence SmCP value and to quantify region-specific socio-economic values of SmCPs while also contributing to a better understanding of so far understudied plural values of soil biodiversity and SmCPs. To better understand how socio-economic values are associated with soil biodiversity and sustainable soil management, we are interested in the following research questions:

(i) What are the economic and socio-cultural values for selected SmCPs of the different regions in SOILGUARD?
(ii) How do the main influencing factors of nature's values coincide or differ between SOILGUARD regions?
(iii) Do economic and socio-cultural values for SmCPs and landscape preferences coincide or differ between SOILGUARD regions?

As we employ a multi-method approach and rely on various data, we first give a detailed description of our data collection and methodology (Chapter 2). In Chapter 3, we present our results as follows: First, we examine the cost-based valuation derived from behaviour-based methods for selected SmCPs in all SOILGUARD regions. Next, we analyse the potential influencing factors of nature's values, such as socio-economic background, knowledge, attitudes, and behaviour, as well as underlying values, such as worldviews, views on quality of life and life frames based on a representative population survey in three selected SOILGUARD regions. Then, we present economic and socio-cultural values for SmCPs and landscape preferences for these three selected regions, elicited with statement-based methods (here also referred to as preference-based valuation). Subsequently, we discuss how the different valuation results are combined to an integrated valuation and how values coincide or differ between SOILGUARD regions and to what extent. In Chapter 4, we present main conclusions from the valuation for SOILGUARD in particular and for soil biodiversity research in general.

# 2 Methodology

Given the societal importance of sustainable soil management, an integrated socio-economic valuation of SmCPs associated with sustainable soil management is essential to aid in better decision-making for soil management practices and conservation. For the integrated socio-economic valuation of SmCPs and management options, we adopted a multi-method approach (Figure 3). To account for the different conceptualizations of nature, nature's contributions to people and human-nature relationships and how these multiple ways of understanding affect people's attitudes, behaviour and decisions, our approach combines methods from different families, including behaviour-based and statement-based methods. According to the IPBES (2022), the cost-based valuation belongs to the family of behaviour-based methods and elicits economic values for the SmCPs food and feed production, soil formation and protection, and climate regulation. Within the statement-based methods, we conducted a representative population survey, that allowed for both economic and socio-cultural valuation. In the economic valuation, a discrete choice experiment was performed to shed light on the value of several SmCPs in accordance with different soil and landscape attributes. In the socio-cultural valuation, the ranking of all SmCPs highlights the value of different SmCPs for the



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population in non-monetary terms. The valuation is complemented with the examination of factors influencing SmCP perception as well as elicitation of landscape preferences with the LANDPREF tool. The data collection procedure for the different methods is described in the following. Following the Grant Agreement (no. 101000371), data will be stored at the SOILGUARD data repository (WP 5).

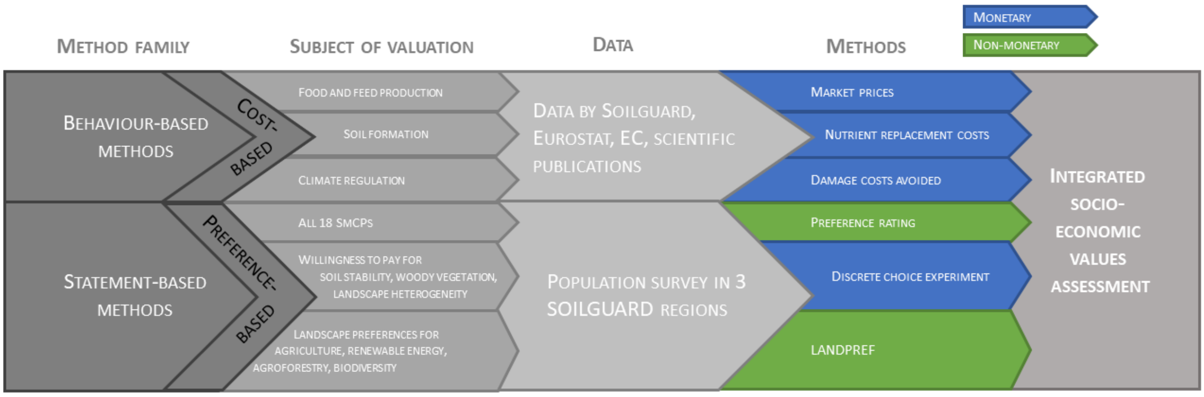


*Figure 3. Components of the integrated socio-economic valuation approach: Selection of SmCPs, management and landscape preferences, data and methods.*

## 2.1 Behaviour-based (cost-based) methods: data collection and analysis

Upon consultation with members of WP1, WP2 and WP5, three SmCPs were determined to be economically valued with the cost-based valuation for the 7 EU NUTS-2 regions, including food and feed production, soil formation and protection and climate regulation. Although changes in the hydrological cycle resulting from improved carbon stocks, including improvements in the water holding capacity of soils, can provide a significant societal benefit especially in arid regions, through discussions with the SOILGUARD partners no feasible valuation approach of this contribution could be identified. Discussions on integrating values on SmCPs within the evidence chains of WP5 will continue and further efforts will be carried out to determine if a valuation of this important contribution can occur. Nonetheless, this contribution is valued non-monetarily through the socio-cultural valuation of SmCPs alongside the other SmCPs, as described in the following sections.

The biophysical data collected in WP2 served as the basis for the cost-based valuation, and details on this type of valuation can be found in section 4.2.1 of the Integrated Valuation Framework of Deliverable D4.1. WP2 analysed sites with different degradation levels (low, medium, high) and two different management types (conventional and organic) (see for detailed information D2.1) of the 7 EU NUTS-2 regions including Latvia (Boreal region), Middle Jutland/Syddanmark (continental region), Murcia (Mediterranean region), South Transdanubia (Pannonian region), Southern Ireland (Atlantic region), West Finland (Boreal region), West Flanders (Atlantic region). According to D2.1 the main indicators of land degradation – classified in different land degradation levels (low, medium, high) – are soil erosion by water and soil organic carbon decline. The impact of land degradation as well as soil management on soil biodiversity (see D2.3) determine soil multifunctionality and the provision of SmCPs, which are assessed in monetary terms with cost-based methods. The 7 EU NUTS-2 regions were for focus of the cost-based valuation, and in the following, the valuation of the three different SmCPs is described, regarding the data basis and the methods applied.



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Basically, the SmCPs provided by soil biodiversity mostly have the character of so-called public goods for which no markets exist and thus, no information on their value is available. Ideally, the value would be best derived from the individual preferences that are reflected in the societal demand for the SmCPs in question. In cases where preference-based economic methods are not applicable for different reasons (e.g., complexity of the good) and market prices are available (for the good itself or a substitute), market prices or costs of substitution or replacement could be used as a proxy to estimate the economic value. However, the value assessed based on cost-based methods represents the lower bound for the economic value.

### 2.1.1 Food and feed production

For the valuation of food and feed production, data on yields from various types of crops from the different study sites SOILGUARD sites in the 7 EU NUTS-2 regions – collected by WP2 – are used. Specifically, WP2 considered grazed grassland for Ireland and Norwegian spruce for Finland in this evaluation. In the other study sites including Belgium, Denmark, Hungary, Latvia, and Spain, agricultural products were valued. The specific crops investigated at each study site can be found in Table 1. For Norwegian spruce in Finland, the average price over the period 2019-2023 was provided in €/$m^3$; therefore, the mass of wood harvest in kilograms was converted to the volume in cubic meters given an overall average density of spruce to be 509.22 kg/m3 (Salem *et al.*, 2013).

*Table 1. Crop prices used in the valuation of food and feed production.*

| Site | Crop | Market price | Source |
|---|---|---|---|
| Belgium | Potatoes | 15.25 €/100 kg | (Eurostat, 2024) |
| Denmark | Spring barley | 20.66 €/100 kg | (Eurostat, 2024) |
| Latvia | Winter wheat | 20.73 €/100 kg | (Eurostat, 2024) |
| | Rye | 15.94 €/100 kg | (Eurostat, 2024) |
| Spain | Wheat | 24,24 €/100 kg | (Eurostat, 2024) |
| | Oats | 22.71 €/100 kg | (Eurostat, 2024) |
| | Barley | 22,51 €/100 kg | (Eurostat, 2024) |
| Finland | Norway spruce | 67.96 €/m3 | (Luke, 2024) |
| Hungary | Cereals (average of prices of soft wheat, durum wheat, rye, barley, feed barley, malting barley, oats, maize, Sorghum, Triticale) | 21.43 €/100 kg | (Eurostat, 2024) |
| | Sunflower | 44.24 €/100 kg | (Eurostat, 2024) |
| | Legumes (average of prices of soya, green beans, green peas) | 106.27 €/100 kg | (Eurostat, 2024) |
| | Pulses (average of prices of dried beans, dried peas) | 62.18 €/100 kg | (Eurostat, 2024) |



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|---|---|---|---|
| Ireland | Grazed grassland | 75 €/t | (O'Donovan, Hennessy and Creighton, 2021) |

The cost-based approach for this SmCP employs the **market price method**, focusing on the yield effects of conversion from conventional to organic farming. Average market prices for the different crops were used for the valuation. Data (selling prices) was obtained from Eurostat for the years 2019-2023, and the average over these 5 years was calculated and used for the valuation (Eurostat, 2024). A 30% premium was applied to organic crops since more precise prices for organic crops could not be found and sources indicate an average price increase for organic crops to be close to this premium (Crowder and Reganold, 2015; European Commission, 2024). This highlights the economic trade-offs by weighing the potentially higher yields of conventional methods due to increased fertiliser usage against the long-term benefits of organic farming for soil health and ecosystem resilience. No price premiums were used for the mixed species grasslands sites in Ireland and the continuous cover forestry in Finland given that such value differences are not integrated into market activity to a significantly high degree as is the case with organic food products.

### 2.1.2 Soil formation

In order to economically value the SmCP soil formation, the avoided costs of inorganic fertilisation were considered, for example when switching from conventional to organic farming. Sustainable soil practices such as organic farming or other practices that lead to a shift from medium or high degradation to low or medium degradation can improve nutrient cycling and reduce the need for fertilisers. For such changes, the difference in the averages of the study sites of the nitrogen and phosphorus concentrations of the soil within the first 10 cm of soil depth, taking into account the bulk density of the soil, was estimated using the data set produced in WP2. Following the methodology laid out in Deliverable D4.1, these differences were valued with the avoided costs of inorganic nitrogen and phosphorus fertilisers (Fan, Henriksen and Porter, 2018), for which average EU-wide market prices were obtained from the European Commission.

The valuation of soil formation and soil protection is based on the **Nutrient Replacement Cost Method (NRCM)**. This method calculates the costs of fertilisers needed to maintain or restore soil productivity, thereby eliciting a value of the nutrient cycling service provided by ecosystems. It requires detailed information on the availability of nitrogen (N) and phosphorus (P) in the soil as well as market prices for fertilisers. Since the values provided by WP2 were given in kg N/kg of soil and mg P per kg of soil, they were converted to have an area basis. For this, the values determined in the laboratory had to be multiplied by the bulk density ($g/cm^3$) * sampling depth (10cm). Fertiliser prices for nitrogen and phosphorus (Table 2) from the European Commission for the years 2019-2023 were utilised, averaging over all months and years (European Commission, 2024).

### 2.1.3 Climate Protection

Finally, the SmCP climate regulation was assessed by assuming changes in the amount of carbon stored in the soil, for example when switching from conventional to organic farming. Data on carbon content and bulk density of the first 10 cm of soil were obtained from the WP2 dataset. For the economic valuation, the social cost of carbon from the German Federal Environmental Agency was used, as described below.



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Climate regulation focuses on the ability of soil ecosystems to store carbon and thus contribute to climate change mitigation. The valuation process includes an assessment of the soil's organic carbon content and the use of the **avoided damage cost approach**, which takes into account the social cost of carbon emissions, i.e. the damage to society caused by greenhouse gas emissions and climate change (Table 2).

*Table 2. Data and methods for economic valuation of SmCPs.*

| SmCP | Valuation method | Value | Reference |
|---|---|---|---|
| Food and feed production | Market price method | Varies with crop type and region | (Eurostat, 2024) (O'Donovan, Hennessy and Creighton, 2021) (Luke, 2024) |
| Soil formation and protection (nutrient cycling) | Nutrient Replacement Cost Method (NRCM) | 399.38 €/ t N<br>574.75 €/ t P | (European Commission, 2024) |
| Regulation of climate | Damage Costs Avoided approach | 254 €/ t $CO_2$-eq. | (Navrud, 2023) |

## 2.2 Statement-based (preference-based) methods

### 2.2.1 Data collection

To gain an understanding of the importance of individual SmCPs and society's preferences for landscape and management options, we conducted a representative population survey in three selected SOILGUARD regions. The regions were selected to represent a variety of biomes (i.e. arable, grassland) and climatic regions (i.e. Mediterranean, temperate) covered by SOILGUARD (for a detailed justification for the selection of the countries see Technical Report for RP1 and D4.1). Spain, Ireland and Denmark were selected for sampling to cover the range of climates, and for these countries readily available samples could be recruited through the survey company and remain within the financial limit of the budget for this valuation. Given the difficulty of obtaining representative samples at the EU NUTS-2 region level (n >400 households needed, see more details below), we sampled the whole population of each country instead of the regions. Steps were taken to ensure that a representative sample could be obtained for each country. Although this sampling procedure does not focus down to the level of NUTS-2 regions, it does provide the opportunity to analyse country-wide changes in the provision of SmCPs, taking into account sustainable soil management and consequent improvements in soil biodiversity.

The survey was programmed online using survey software from SurveyEngine (https://surveyengine.com/). This company was also responsible for recruiting the online sample respondents for the pilot and for the final sample in the three countries. The sample respondents were recruited according to hard quotas for age and gender and soft quotas for income and education. For the age, income and education categories, the survey company was provided with brackets of 5 or more categories, defining the percentage of the population required in each bracket. The survey company used these quotas to recruit respondents for the sample, only allowing respondents to participate if the quota had not already been reached. Given these quotas, difficulties were faced in



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gathering enough respondents from the different brackets to ensure a representative sample, and these challenges resulted in delays in receiving and subsequently analysing the data.

An initial draft of the survey was tested with the WP4 team and other institutions within the SOILGUARD project to get feedback on the understanding of the questions and the question order. The draft was programmed in English before being translated into Danish, Spanish and Irish. For the Irish sample, respondents were given the option of completing the survey in either English or Irish. Feedback from the SOILGUARD partners on the draft was integrated and the final survey was created and piloted with 100 respondents from each country. The results of the pilot were evaluated to ensure that the functionality of the survey was maintained, that the quotas set were working and that the responses to the survey questions were in the expected direction to ensure that respondents understood the questions.

The survey started with information on the topic of the survey, an ethics statement concerning confidentiality and how the survey is not eliciting personal data (following consultation with Leitat as the responsible institution for WP9 on ethics requirements), and a question asking for the participant's consent to participating in the survey. Next, screening questions on socio-demographics were posed to ensure that quotas were met (see Appendix A. for the full questionnaire). This was followed by questions on respondents' knowledge of soil management, attitudes towards EU soil management policy and nature relatedness, environmental behaviour, and underlying value constructs such as worldviews, life frames and quality of life (Table 3). For all social constructs, we rely on a wide basis of extant research (Appendix B).

*Table 3. Overview of survey components, items and indicators.*

| **Category** | **Items** | **Indicators (reference where applicable)** |
|---|---|---|
| **Socio-demographic characteristics** | | |
| | Age<br>Gender<br>Household size<br>Household net income<br>Time living in region | Year of birth<br>F, M, div.<br>No. of people<br>€/month<br>No. of years |
| Knowledge, attitudes and behaviour towards soil sustainability and the environment | | |
| Knowledge | Familiarity with statements on soil sustainability<br>Perception of climate change | Agreement with 7 statements based on IPBES report<br>Selection of one of four statements |
| Attitudes | Attitudes towards EU policies and programs<br><br>Nature-relatedness | Agreement with 6 statements based on EU Farm to Fork Strategy and CAP specific objectives<br>Agreement with 6 statements based on NR-6 (Nisbet et al., 2013) |
| Behaviour | Pro-environmental behaviour | Participation frequency in 3 descriptions of behaviour per category (Larson et al., 2014):<br>- Environmental citizenship<br>- Conservation lifestyle<br>- Land stewardship<br>- Social environmentalism |
| **Underlying value constructs** | | |



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| | Worldviews | Indication of importance for 4 statements per value orientation (Sockhill et al., 2022):<br>- Egoistic value orientation<br>- Altruistic value orientation<br>- Biospheric value orientation<br>- Pluricentric value orientation |
| | Life frames | Agreement with 3 statements per life frame (IPBES 2022, O'Connor and Kenter, 2019):<br>- Living from nature<br>- Living with nature<br>- Living in nature<br>- Living as nature |
| | Quality of life | Agreement with 4 statements per life quality (TNS Political and Social, 2014):<br>- Access to food, water, energy and livelihood security<br>- Health, good social relationships and equity, security, cultural identity and freedom of choice and actions<br>- Living in harmony with nature, living-well in balance and harmony with mother earth and human well being |
| **Socio-economic valuation of SmCPs and landscape components** | | |
| Socio-cultural valuation | Ranking of SmCPs<br><br>Weighting of SmCPs | Identification of five most important SmCPs for regional landscape<br>Allocation of 100 points across five most important SmCPs |
| Economic valuation | Discrete Choice Experiment | Indication of willingness to pay for change in three landscape components and SmCPs based on Choice Cards:<br>- Soil stability<br>- Woody vegetation<br>- Landscape heterogeneity |
| Landscape preferences | Rating of landscape components (LANDPREF)<br><br>Motivation of choice | Preferences for different land uses and visualised landscape components:<br>- Agricultural land<br>- Biodiversity<br>- Renewable energy<br>- Agroforestry<br>Selection of one of seven statements |

In the next part, respondents were asked about their perceptions of the provision of SmCPs for the socio-cultural valuation. We refrained from asking respondents to rate the importance of each SmCP on a Likert scale, as the variability of these responses was low in the tests and also in the qualitative interviews with stakeholders. It was therefore felt that better information could be obtained by asking respondents to rank the top 5 SmCPs and then allocating 100 points between them. This procedure allowed for reflecting the weighted importance of the SmCPs by the respondents.

The perceived general and relative importance of SmCPs can vary greatly (Schmidt *et al.*, 2017), leading respondents to rate all SmCPs as highly important. However, this assessment may shift when they are faced with limitations, such as having a restricted number of points to allocate. Following this socio-cultural valuation of SmCPs, respondents were asked to participate in the discrete choice experiment to determine their preferences and willingness to pay for three different attributes of sustainable soil management.



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In the final part, respondents were directed to the LANDPREF website to complete the landscape preference assessment (for more detailed information, see Appendix C and Deliverable 4.1) in another socio-cultural valuation exercise and were asked follow-up questions about their choices in the assessment. The images for the LANDPREF tool were designed by a subcontracting graphic designer and programmed by an App developer into the LANDPREF web application: https://2023.landpref.org. Both subcontractors have been involved in the design and implementation of previous applications of the LANDPREF tool (Schmidt *et al.*, 2017).

### 2.2.2 Data analysis

#### 2.2.2.1 Socio-cultural valuation of SmCPs

We applied a mixed analytical approach that includes various steps. First, we tested all constructs that were part of the population survey for their Cronbach-α values to check for consistency in their scales, which is especially relevant for those constructs that were adapted or expanded.

Subsequently, we performed descriptive analyses (i.e., means, standard deviation) of

- socio-demographic characteristics (i.e., age, gender education, household size, household net income, time lived in the area),
- knowledge, behaviour and attitudes (i.e., knowledge on soil biodiversity, pro-environmental behaviour), and
- underlying value constructs (i.e., worldviews, life frames, and good quality of life)

from the survey respondents in each region (Denmark, Ireland, and Spain). Finally, we conducted a socio-cultural valuation based on ranking and weighting the SmCPs. To account for variations in sample sizes and enable a more meaningful comparison of the proportional representation of phenomena across different regions, we compare relative frequencies or percentages of occurrences per region rather than absolute counts. By assessing relative frequencies of SmCPs most often selected under the five most important (number of TOP 5 selections/respondents per country), we obtain a comprehensive overview of the most critical SmCPs in each region (ranking). By analysing the mean number of points allocated to SmCPs, we can identify which of these critical SmCPs are prioritised and valued most highly across different regions.

#### 2.2.2.2 Economic valuation (WTP) with statement-based method

In addition to the socio-cultural valuation, a discrete choice experiment was conducted in the population survey. This method allows the elicitation of preferences and willingness to pay (WTP) for changes in the provision of SmCPs and is part of the standard set of environmental economic valuation methods (Deliverable 4.1).

In this approach, respondents are provided with a description of a scenario in which they can make choices among different alternatives with attributes that vary in their levels. One of these attributes has a cost associated with the levels of the other attributes. An example choice set can be seen in Table 4. The initial set of attributes and their levels were thoroughly discussed with SOILGUARD project members to ensure that a sufficient coverage of SmCPs could be valued and furthermore made useful for incorporation into the evidence chains. Initially, as portrayed in D4.1, the aim was to incorporate those SmCPs into the discrete choice experiment that were weighted the highest among the



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stakeholders in the regions. However, the higher ranking SmCPs such food and feed protection or pollination were deemed incompatible since food and feed protection is already economically valued in the cost-based valuation and pollination is not further considered in SOILGUARD. Given the importance of soil stability and the relation to other parts of SOILGUARD, this was included as an attribute and was quantified in the levels through changes in the average annual soil erosion rates across each country (as the status quo) (Panagos *et al.*, 2015) and approximate improvements of 70% and 40%. Increases in woody vegetation as well as having more heterogeneous landscapes may not only improve biodiversity but might provide more aesthetically pleasing landscapes. This relates to several SmCPs, especially the non-material SmCPs including physical and psychological experiences as well as learning and inspiration for which there is a lack of such studies in the literature. For woody vegetation, the average coverage per 100 $m^2$ in each country served as the status quo and improvements of 40% and 70% were included in the levels. Lastly, for heterogeneous landscapes single crops served as the status quo and an improvement to multiple crops served as the alternative level.

*Table 4. Example choice set from the discrete choice experiment for Denmark.*

| | **Option 1** | **Option 2** | **Status Quo** |
|---|---|---|---|
| Soil stability | 2 Olympic stadiums of soil loss | 1 Olympic stadium of soil loss | 3 Olympic stadiums of soil loss |
| Woody vegetation | 40% increase | 70% increase | 8.5 $m^2$ for every 100 $m^2$ of land |
| Landscape | Single crop | Multiple crops | Single crop |
| Additional household expenditure | 50 € | 100 € | 0 € |
| **Which would you choose?** | ○ | ○ | ○ |

The respondents were shown a series of such choice sets (6 per respondent), with the two options varying in the levels of the attributes across the choice sets. If respondents chose the status quo more than three times, an additional question appeared to ask for the reasons for frequently opting out to help identify protest respondents (Meyerhoff and Liebe, 2006).

The choices of the respondents were modelled with statistical software in order to understand how the population makes trade-offs concerning the supply of the attributes given the assumed costs. Following estimation of the model, the marginal willingness to pay for increases in the levels of attributes was determined. Appendix D describes the attributes and their levels as well as the statistical analysis of the discrete choice experiment.



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#### 2.2.2.3 Assessment of landscape preferences

To test for differences of landscape preferences between regions, we use the non-parametric Kruskal-Wallis and post-hoc Dunn's test (Dunn, 1964). Despite small deviations in Denmark, the general balance of landscape preferences within each regional sample (Table 11) warrants the following approach. In each region, we identify groups of respondents with similar landscape preferences for the proposed land uses by using Hierarchical Cluster Analysis (HCA) with the data collected through LANDPREF. We used Ward's linkage method (Ward Jr., 1963) as agglomerative technique to minimise within-cluster variance and Bray-Curtis dissimilarity index (Bray and Curtis, 1957), which considers the presence and abundance of preferences in samples but does not explicitly account for joint absences of preferences. These settings group respondents with focus on differences in the composition of landscape preferences rather than the magnitude of those preference values. HCA is performed for each region's sample individually and clusters are characterised and analysed comparatively.

# 3 Results and discussion

## 3.1 Behaviour-based (cost-based) valuation

For the three SmCPs food and feed production, soil formation (i.e. nitrogen and phosphorous accumulation) and climate regulation, the cost-based valuation was carried out for the 7 EU NUTS-2 regions. Table 5 indicates average changes (in % compared to the reference value) in the provision of the SmCPs across the sites of the regions for the corresponding country. The changes indicate both the impact of conventional versus alternative land uses as well as the effect of different land degradation levels on SmCP provision.

The valuation uses data from WP2 measurements at the sites characterised by conventional or alternative land use and low, medium or high level of degradation). Based on this data the effects – on average – of changes in land use or land degradation can be derived. Whereas in some regions and for the provision of some SmCPs a change from conventional to organic agriculture produced positive results in terms of food and feed production, some regions exhibited a decrease. For example, in Belgium the food production is 2% lower on organic sites compared to conventional sites (98% compared to 100%), thus, we assume that a change from conventional to organic farming will decrease the SmCP food and feed production, whereas a shift from conventional to organic will lead to a higher SmCP provision in Denmark. The data collected from the conventional sites indicate the reference (100%).Two different effects influence the changes: Switching to organic agriculture often implies reduced yields in comparison to conventional agriculture. However, organic products receive a high price premium on the market and generate more economic value for the same quantity in comparison to conventional products. Although the economic value is lower in switching to organic agriculture for some regions, consideration of changes in other SmCPs is necessary in order to obtain a more holistic picture of such agricultural regimes, e.g., an increase in resilience towards environmental effects on sustainable managed soils. It should be noted that the data base has some limitations. We have no measured data from long time series, the database only refers to one single year. Data on crop yields are self-reported and not measured. Regarding the conversion to organic farming, there is no information on how long the arable land has been managed organically, which has an impact on yield and, above all, yield stability. Land degradation effects indicated in Table 5 can be interpreted accordingly. For example: in Spain data from sites with two different degradation levels are available (low and medium degradation). The food production is on average 125% on low degraded soils



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compared to medium degraded soils with 100% as the reference value. We assume that management measures that influence soil degradation will have an positive impact on SmCP provision. In the respective countries, always the highest degradation level where data were available serves as the reference level.

*Table 5. Average changes in SmCPs for the SOILGUARD sites of the different EU NUTS-2 regions in the corresponding countries (red colour indicates a lower SmCP provision compared to the reference value, green a higher SmCP value).*

| | **Management type** | | **Degradation level** | | |
|---|---|---|---|---|---|
| Country | Conventional | Organic | Low | Medium | High |
| Food and Feed | | | | | |
| Belgium | 100% | 98% | 98% | | 100% |
| Denmark | 100% | 93% | | 94% | 100% |
| Finland | 100% | 118% | | | |
| Hungary | 100% | 110% | 137% | 144% | 100% |
| Ireland | 100% | 100% | 121% | 100% | |
| Latvia | 100% | 60% | | 111% | 100% |
| Spain | 100% | 49% | 141% | 100% | |
| N accumulation | | | | | |
| Belgium | 100% | 81% | 76% | | 100% |
| Denmark | 100% | 99% | | 86% | 100% |
| Finland | 100% | 147% | | | |
| Hungary | 100% | 183% | 40% | 45% | 100% |
| Ireland | 100% | 82% | 155% | 100% | |
| Latvia | 100% | 76% | | 154% | 100% |
| Spain | 100% | 72% | 119% | 100% | |
| P accumulation | | | | | |
| Belgium | 100% | 150% | 121% | | 100% |
| Denmark | 100% | 101% | | 92% | 100% |
| Finland | 100% | 71% | | | |
| Hungary | 100% | 112% | 39% | 86% | 100% |
| Ireland | 100% | 86% | 49% | 100% | |
| Latvia | 100% | 174% | | 88% | 100% |
| Spain | 100% | 106% | 120% | 100% | |
| Climate Regulation | | | | | |
| Belgium | 100% | 112% | 86% | | 100% |
| Denmark | 100% | 97% | | 93% | 100% |
| Finland | 100% | 81% | | | |
| Hungary | 100% | 111% | 138% | 121% | 100% |
| Ireland | 100% | 86% | 97% | 100% | |
| Latvia | 100% | 112% | | 106% | 100% |
| Spain | 100% | 135% | 162% | 100% | |



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With respect to the SmCP soil formation (described by N and P accumulation), switching from conventional to alternative land use also resulted in differences for the nitrogen and phosphorous accumulation. In most cases, organic agriculture profited from higher economic value for phosphorus accumulation across the regions, but nitrogen accumulation painted a differentiated picture. For nitrogen accumulation, almost all cases with lower economic value for organic agriculture did see a positive economic value when making the comparison across the levels of degradation for a given region.

The results for the SmCP climate regulation – based on measurements of the carbon storage in soils, which is affected by the management type and the degradation level – indicate improvements with an improvement of the degradation level. Switching to alternative land use often resulted in more carbon storage (and thus, more positive effect on the climate regulation function of soils), but some cases in the other direction were found among the regions.

The economic values for the estimated average changes in SmCP provision given management regime change (i.e. conventional vs. alternative) and degradation level are shown in Table 6.

*Table 6. Economic value (in €/ha) for the average change in SmCP provision given management regime change and degradation level (red colour indicates a lower value of the SmCP (losses), green a higher SmCP value (benefits).*

| | **Management type** | **Degradation level** |
|---|---|---|
| **Country** | Average losses/ benefits associated with a change from conventional to alternative management regime (€/ha) | Average losses/ benefits associated with a change in land degradation (either from high > medium or medium > low, see Table 5) (€/ha) |
| Food and Feed | | |
| Belgium | -142.27 € | -101.64 € |
| Denmark | -97.83 € | -82.54 € |
| Finland | 3.69 € | |
| Hungary | 360.31 € | -2,971.19 € |
| Ireland | 0.00 € | 0.03 € |
| Latvia | -509.04 € | 112.90 € |
| Spain | -258.83 € | 129.69 € |
| N accumulation | | |
| Belgium | -3.04 € | -3.68 € |
| Denmark | -0.01 € | -0.32 € |
| Finland | 0.35 € | |
| Hungary | 5.92 € | -21.14 € |
| Ireland | -1.31 € | 2.89 € |
| Latvia | -2.27 € | 3.69 € |
| Spain | -0.73 € | 0.38 € |
| P accumulation | | |
| Belgium | 0.51 € | 0.27 € |
| Denmark | 0.01 € | -0.09 € |



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| | | |
|---|---|---|
| Finland | -0.03 € | |
| Hungary | 0.07 € | -1.48 € |
| Ireland | -0.22 € | -1.02 € |
| Latvia | 0.36 € | -0.09 € |
| Spain | 0.01 € | 0.03 € |
| Climate Regulation | | |
| Belgium | 2,182.79 € | -2,797.04 € |
| Denmark | -629.85 € | -1,325.75 € |
| Finland | -9,639.43 € | |
| Hungary | 1,796.82 € | -10,925.50 € |
| Ireland | -6,594.06 € | -1,315.91 € |
| Latvia | 2,743.81 € | 1,380.08 € |
| Spain | 4,134.18 € | 6,235.83 € |

## 3.2 Statement-based (preference-based) valuation

### 3.2.1 Socio-demographic characteristics

After the elimination of respondents with under five minutes response time, our regional samples comprised a total of 414 respondents in Denmark, 440 respondents in Spain and 411 respondents in Ireland (Table 7). Despite the hard and soft quotas provided to the survey company, this elimination of respondents slightly adjusted the fulfilment of the final quotas for representative samples in each country. For Ireland, the gender ratio met the quota. In Denmark, the final sample contained a few more males, and the Spanish sampled comprised fewer response from females than envisioned for the quota. The mean age of respondents was highest in Denmark and lowest in Spain. Respondents in Spain and Ireland indicated a higher education level than respondents in Denmark, whereas respondents from Denmark and Ireland stated a higher income level than respondents from Spain. Yet, the highest share in household net income is indicated by Denmark, closely followed by Ireland and distantly followed by Spain. Well two-thirds (68 %) of the respondents in Spain indicated to have lived in their region for > 20 years, followed by Denmark (57 %) and Ireland (53 %). Despite these small differences between samples, socio-demographic characteristics are largely similar across regions, allowing for meaningful comparisons between analyses.

*Table 7. Description of the sample: Socio-demographic characteristics.*

| | **Denmark** | **Spain** | **Ireland** |
|---|---|---|---|
| **n** | 414 | 440 | 411 |
| **Gender** | | | |
| Female | 52.2% | 40.7% | 51.1% |
| Male | 47.6% | 58.9% | 48.7% |
| Diverse | 0.2% | 0.2% | 0% |
| No response | 0% | 0.2% | 0.2% |
| **Age** | | | |
| Mean in years | 47.54 | 45.29 | 46.2 |



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| | | | |
|---|---|---|---|
| **Education** | | | |
| No formal education or training | 2.2% | 0% | 0.2% |
| Primary education | 5.8% | 3.0% | 1.2% |
| Lower secondary education | 4.6% | 10.0% | 6.3% |
| Upper secondary education | 13.8% | 18.0% | 19.7% |
| Technical or vocational | 32.1% | 4.5% | 11.2% |
| Advanced certificate / Completed, apprenticeship | 9.7% | 20.9% | 18.7% |
| Bachelor's degree | 20.5% | 31.1% | 24.3% |
| Postgraduate degree (i.e., master's degree) | 9.9% | 10.5% | 16.1% |
| Doctorate (Ph.D.) | 1.4% | 2.0% | 2.2% |
| **Household size** | | | |
| mean | 2.5 | 3.2 | 3.4 |
| **Household net income** | | | |
| Under €1,000 | 3.1% | 7.7% | 5.4% |
| €1,000 to less than €2,000 | 11.8% | 32.3% | 14.4% |
| €2,000 to less than €3,000 | 16.7% | 28.2% | 19.2% |
| €3,000 to less than €4,000 | 16.9% | 16.4% | 20.4% |
| €4,000 to less than €5,000 | 17.9% | 6.1% | 15.1% |
| €5,000 or more | 21.5% | 5.0% | 20.0% |
| No response | 12.1% | 4.3% | 5.6% |
| **How long have you been living in this region?** | | | |
| Less than 5 years | 11.8% | 11.1% | 14.4% |
| 5 to less than 10 years | 13.8% | 8.4% | 13.1% |
| 10 to less than 20 years | 17.6% | 12.0% | 19.7% |
| 20 years or longer | 56.8% | 68.4% | 52.8% |

### 3.2.2 Knowledge, behaviour, attitudes, and underlying value constructs

Knowledge of soil biodiversity, environmental behaviour, and attitudes towards climate change, nature and policies as well as underlying value constructs, such as worldviews, life frames, and quality of life have been assessed for each region (Table 8 and graphical depictions in Appendix F). First, we scrutinised social constructs using Cronbach's alpha, and all demonstrated robust internal consistency, with coefficients exceeding the threshold of 0.7, indicating reliability.

Knowledge on soil sustainability and management effects is most noticeable in Ireland, closely followed by Spain, both with an average of almost 4.1 points on a scale from 1 (little knowledge) to 5 (extensive knowledge).

Perception of the cause of climate change is strongest among the respondents of Spain, where 78% believe that "climate change is happening and that humans are largely causing it" (Denmark: 73%, Ireland: 74%). The level of agreement to EU policies on biodiversity and sustainable land management practices (based on CAP Objectives and Farm to Fork Strategy) on a scale from 1 (strongly disagree) to



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5 (strongly agree) was highest in Ireland (mean value: 4.15) and Spain (mean value: 4.14), and lower agreement in Denmark (mean value: 3.8).

Nature relatedness is higher in Spain compared to Denmark and Ireland. In regard of pro-environmental behaviour, most respondents across all three regions indicate a frequent “conservation lifestyle”, which entails recycling behaviour, environmentally friendly consumption of products, and conservation of water an energy at home. Less practiced behaviour relates to “environmental citizenship” (i.e., to donate money for environmental protection, to sign petitions or to base their vote on environmental issues), “land stewardship” (i.e. to apply environmental measures in own back yard, to volunteer in community or participate in studies related to the protection of wildlife), or “social environmentalism” (i.e., connect with others over the environment, address environmental issues with others, participate actively in a group).

Denmark tends to exhibit a higher egoistic value orientation (mean value: 3.8) compared to Spain and Ireland (mean values: 3.4 and 3.4, respectively). Altruistic value orientation is highest in Ireland (mean value: 5.3), followed closely by Spain (mean value: 5.2). Biospheric value orientation is highest in Spain (mean value: 5.3) and lowest in Denmark (4.7). Pluricentric value orientation is highest in Ireland (mean value: 4.7) and again lowest in Denmark (4.3).

Life frames are generally lower in Denmark than in Spain and Ireland. While in Spain, respondents emphasised living with nature (i.e., coexisting harmoniously with nature and recognizing the importance of preservation of ecosystems and biodiversity; mean value: 4.3) and living in nature (i.e., humans immersing themselves in natural environments; 4.2), and living as nature (i.e. viewing humans as integral part of nature and recognizing interconnectedness; 4.0). Living from nature (i.e., emphasizing a close connection to nature, where humans rely directly on natural resources for their livelihoods and wellbeing) are highest in Denmark (4.0).

Access to food, water, energy, and livelihood security is highest in Denmark (mean value: 3.5), followed by Ireland and Spain (mean values: 3.1, and 3.0, respectively). Health, good social relationships, and equity security are relatively similar across all regions. The perception of living in harmony with nature and human well-being is consistent across the regions. Of these three value categories, the last one ranks has the highest mean values across all regions, indicating it is the most important one. For a more detailed look into the responses to the individual items of each construct, see Appendix E.). Overall, the results suggest variability in knowledge, attitudes, behaviour, and underlying value constructs among the three regions, reflecting diverse perspectives and priorities.

*Table 8. Description of aggregated values for knowledge, attitudes, behaviour and underlying value constructs (* indicates the category was assessed on the basis of several statements).*

| **(Aggregated) Variables** | **Cronbach’s α** | **Denmark** | | **Spain** | | **Ireland** | |
|---|---|---|---|---|---|---|---|
| | | **ø** | **SD** | **ø** | **SD** | **ø** | **SD** |
| **Knowledge** | | | | | | | |
| Level of knowledge* | 0.85 | 3.62 | 1.00 | 4.07 | 0.92 | 4.09 | 1.09 |
| **Attitudes** | | | | | | | |
| Perception of climate change | | 1.34 | 0.65 | 1.28 | 0.60 | 1.31 | 0.58 |
| Level of agreement to EU policies* | 0.87 | 3.80 | 1.03 | 4.14 | 0.91 | 4.15 | 0.98 |



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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Nature relatedness* | 0.86 | 3.44 | 1.12 | 3.92 | 1.00 | 3.70 | 1.03 |
| **Behaviour** | | | | | | | |
| **Pro-environmental behaviour** | | | | | | | |
| Environmental citizenship* | 0.75 | 2.55 | 1.17 | 2.64 | 1.13 | 2.52 | 1.10 |
| Conservation lifestyle* | 0.72 | 3.83 | 1.06 | 4.09 | 0.89 | 4.03 | 0.95 |
| Land stewardship* | 0.7 | 2.61 | 1.29 | 2.53 | 1.26 | 2.66 | 1.21 |
| Social environmentalism* | 0.83 | 2.41 | 1.27 | 2.57 | 1.21 | 2.38 | 1.17 |
| **Underlying value constructs** | | | | | | | |
| **Worldviews** | | | | | | | |
| Egoistic value orientation* | 0.73 | 3.79 | 1.27 | 3.39 | 1.38 | 3.43 | 1.34 |
| Altruistic value orientation* | 0.84 | 4.84 | 1.16 | 5.21 | 0.99 | 5.26 | 0.94 |
| Biospheric value orientation* | 0.9 | 4.65 | 1.23 | 5.26 | 0.94 | 5.13 | 0.98 |
| Pluricentric value orientation* | 0.8 | 4.29 | 1.14 | 4.64 | 1.23 | 4.72 | 1.18 |
| **Life frames** | | | | | | | |
| Living from nature* | 0.65 | 4.00 | 0.95 | 3.93 | 0.93 | 3.90 | 0.89 |
| Living with nature* | 0.75 | 3.97 | 0.92 | 4.25 | 0.82 | 4.20 | 0.86 |
| Living in nature* | 0.8 | 3.94 | 1.01 | 4.23 | 0.86 | 4.18 | 0.84 |
| Living as nature* | 0.79 | 3.59 | 1.11 | 3.96 | 0.99 | 3.95 | 0.97 |
| **Quality of life** | | | | | | | |
| Access to food, water, energy and livelihood security* | 0.67 | 3.52 | 1.12 | 3.00 | 1.16 | 3.06 | 1.24 |
| Health, good social relationship and equity, security, cultural identity and freedom of choice and actions* | 0.71 | 3.73 | 1.01 | 3.62 | 1.01 | 3.65 | 1.05 |
| Living in harmony with nature, living-well in balance and harmony with mother earth and human wellbeing* | 0.71 | 3.76 | 1.00 | 3.75 | 0.94 | 3.75 | 1.01 |

### 3.2.3 Assessment of socio-cultural values for soil-mediated contributions to people

Comparative analysis of SmCPs revealed differences and similarities in socio-cultural values in Denmark, Spain, and Ireland (Table 9). The relative frequencies of selection of SmCPs under the most important five SmCPs in the region are calculated per region (ranking). Point values are aggregated per SmCP and then averaged by dividing by the number of points for each SmCP by the number of times the SmCP was chosen in the top five (weighting).

The ranking exercise revealed varying priorities in the regions, providing insight into their environmental and societal concerns. In Denmark, top priorities are energy production (44 %), maintaining options for future generations (39 %) and food and feed production (34 %), as those were most frequently selected among the top five most important SmCPs. Weighting shifted the priorities as it demonstrates strong preferences for additional SmCPs such as regulation of climate (mean value: 25), regulation of air quality (mean value: 24), and energy production (mean value: 23). This means, there is a common understanding that energy production, maintenance of options and food production are important contributions in Denmark, if prioritised, however, contributions like climate



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regulation and air quality are given more weight by several respondents. Energy production is prioritised by a large number of respondents and simultaneously yield high weighting results, making this a distinctive concern in Denmark.

In Spain, both air quality (41 %) and climate regulation (41 %) are prioritised among the top five SmCPs and simultaneously receive high point values in the weighting exercise (regulation of air quality mean points: 27, climate regulation mean points: 25). While the majority of respondents consider water quantity particularly significant (34 %), water quality receives greater emphasis in weighting (mean points: 25).

In Ireland, food and feed production emerges as the top priority (35 %) under the majority of respondents, followed by water quality (35 %) and air quality (33 %). The weighting exercise exhibited strong preferences for climate regulation (mean points: 24) and regulation of air quality (mean points: 23) as well, but pollination ranked higher than in the other countries (mean points: 23). Despite some similarities in the top three highly regarded SmCPs, regional differences in the magnitudes of these preferences exist as well in the preferences of the rest of the SmCPs.

The comparative analysis of SmCPs across Denmark, Spain, and Ireland revealed varying priorities, with energy production, maintenance options, and food production being top concerns in Denmark, while air quality and climate regulation were prioritised in Spain, and food and feed production led in Ireland. Weighting exercises underscored additional importance placed on climate regulation and air quality, highlighting regional differences in socio-cultural values and environmental concerns.

*Table 9. Results of the socio-cultural valuation of SmCPs. Ranking: relative frequencies of selection of SmCPs under the most important five SmCPs per region. Weighting: Point values for SmCPs per total number of respondents (i.e. number of individuals ranking this SmCP under their top five)*

| | **Denmark** | | | **Spain** | | | **Ireland** | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ranking | Weighting | | Ranking | Weighting | | Ranking | Weighting | |
| **SmCP** | Top 5 in % | ⌀ Points | SD | Top 5 in % | ⌀ Points | SD | Top 5 in % | ⌀ Points | SD |
| Habitat creation | 33.3 | 20.78 | 11.76 | 25.5 | 21.81 | 9.41 | 25.7 | 20.72 | 10.86 |
| Pollination | 19.8 | 21.60 | 11.64 | 23.8 | 23.92 | 12.77 | 31.4 | 23.22 | 12.34 |
| Regulation of air quality | 28.0 | 23.88 | 11.88 | 41.1 | 26.64 | 12.35 | 33.4 | 23.13 | 11.03 |
| Regulation of climate | 29.7 | 24.50 | 12.24 | 41.1 | 24.52 | 11.37 | 25.9 | 24.22 | 10.74 |
| Regulation of freshwater quantity | 25.8 | 20.80 | 9.18 | 33.6 | 22.51 | 9.37 | 35.5 | 22.69 | 9.56 |
| Regulation of freshwater quality | 30.2 | 21.30 | 10.57 | 32.8 | 24.63 | 11.92 | 34.8 | 21.70 | 9.06 |
| Soil formation and protection | 25.4 | 18.67 | 10.54 | 30.4 | 18.18 | 6.81 | 22.0 | 18.85 | 9.00 |
| Regulation of hazards and extreme events | 31.2 | 20.62 | 8.93 | 31.4 | 19.16 | 10.68 | 26.6 | 18.55 | 9.83 |
| Regulation of detrimental organisms | 22.22 | 18.01 | 8.06 | 23.1 | 18.04 | 10.74 | 14.3 | 17.05 | 8.93 |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Energy production | 44.0 | 22.97 | 10.55 | 35.3 | 19.85 | 10.17 | 32.5 | 22.34 | 11.55 |
| Food and feed production | 34.3 | 21.55 | 9.94 | 31.1 | 18.71 | 8.84 | 35.2 | 21.44 | 11.55 |
| Production of materials | 19.1 | 16.86 | 9.42 | 20.2 | 17.11 | 9.72 | 15.2 | 16.69 | 7.06 |
| Learning and inspiration | 20.0 | 18.24 | 8.72 | 22.9 | 18.90 | 7.19 | 20.0 | 17.17 | 9.11 |
| Physical and psychological experiences | 38.2 | 18.85 | 10.78 | 38.7 | 16.65 | 9.24 | 30.2 | 17.43 | 8.39 |
| Supporting identities | 18.8 | 17.18 | 11.97 | 22.6 | 14.58 | 8.29 | 21.4 | 14.52 | 9.06 |
| Maintenance of options | 39.1 | 14.91 | 8.39 | 35.8 | 15.25 | 8.19 | 25.4 | 15.75 | 9.98 |
| Production of medicinal resources | 17.4 | 16.04 | 8.47 | 28.2 | 16.79 | 8.49 | 19.5 | 18.20 | 7.88 |
| Regulation of ocean acidification | 23.4 | 18.94 | 13.13 | 17.5 | 16.19 | 10.21 | 18.0 | 16.51 | 9.34 |

### 3.2.4 Assessment of Willingness-to-Pay for Different Attribute Levels

By means of a discrete choice experiment, the economic value of several characteristics in relation to sustainable soil management was elicited. For each of the countries, a conditional logit model was estimated given the choices of the respondents in the series of choice sets. A dummy variable, the alternative specific constant (ASC), was created to model the choice of respondents to move from the status quo to one of the two offered options (i.e. taking the value of 0 if one of the options was chose and 1 if the status quo was chosen). The coefficients of the model, the marginal willingness to pay for the attributes for a 1% improvement (i.e. for soil stability and coverage of woody vegetation) or switching to heterogeneous landscapes and the summary statistics are provided in Table 10.

*Table 10. Estimation results from the discrete choice experiment.*

| | **Denmark** | **Spain** | **Ireland** |
|---|---|---|---|
| **n** | 414 | 440 | 411 |
| **Coefficients** | | | |
| ASC | 0.011 (0.080) | -0.338*** (0.076) | -0.226*** (0.085) |
| Soil stability | 0.002** (0.001) | 0.009*** (0.001) | 0.005*** (0.001) |
| Woody vegetation | 0.007*** (0.001) | 0.000 (.001) | 0.003*** (0.001) |
| Landscape heterogeneity | 0.331*** (0.050) | 0.277*** (0.047) | 0.334*** (0.049) |
| Cost | -0.031*** (0.005) | -0.036*** (0.005) | -0.029*** (0.005) |
| **Marginal willingness to pay (€/person-year)** | | | |
| ASC | 3.42 (2.622) | -93.90*** (2.132) | -78.65*** (2.919) |
| Soil stability | 0.77** (0.035) | 2.40*** (0.036) | 1.70*** (0.035) |
| Woody vegetation | 2.15*** (0.044) | 0.13 (0.025) | 1.06*** (0.036) |
| Landscape heterogeneity | 107.53*** (2.101) | 77.03*** (1.489) | 116.49*** (2.321) |



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| Model statistics | | | |
|---|---|---|---|
| Log-likelihood-null | -2704.59 | -2807.82 | -2620.98 |
| Log-likelihood | -2641.08 | -2713.13 | -2562.53 |
| AIC | 5292.16 | 5436.26 | 5135.05 |
| BIC | 5321.25 | 5465.65 | 5164.11 |
| Observations | 2484.00 | 2640.00 | 2466.00 |
| Pseudo R2 | 0.02 | 0.03 | 0.02 |

Significance levels: ***p < 0.01, **p < 0.05, *p < 0.1. Standard errors in parentheses. ASC = alternative specific constant.

Overall, statistically significant results were obtained for several of the attributes in the countries. For all countries, the coefficient for the cost variable was significant and negative. This indicates that respondents do not give up money willingly but rather only do so in order to obtain more of the three attributes including soil stability, woody vegetation and landscape heterogeneity. The coefficients for these attributes were positive across all regions and almost always significant. This follows economic theory that rational agents do not give money willingly and therefore make trade-offs between the provision of the attributes and the given costs (i.e. higher prices lead to switching to the status quo).

Given that Denmark and Ireland are characterised by lower soil erosion rates than Spain, the willingness to pay for improved soil stability in these countries is lower. However, the results indicated high economic value for improving soil stability and reducing soil erosion with a range from 0.77 € to 2.40 € per person and year for a 1% improvement across the countries.

Improvements in woody vegetation were not seen as important in Spain in comparison to Denmark and Ireland. In Denmark and Ireland, the population is willing to pay 2.15 and 1.06 € per person and year for a 1% increase in woody vegetation cover, respectively.

Changing to heterogenous landscapes as opposed to typical monocultures in agricultural areas near to respondents was preferred in all countries and ranged from 77.03 to 116.49 € per person and year across the countries. Furthermore, the significant and negative coefficient for the ASC variable in Spain and Ireland indicate a change from the status quo (see Table 4) to one of the two offered options is preferred.

The results of this statement-based economic valuation highlight some fundamental differences to the economic valuation from the behaviour-based method family. The cost-based valuation assumes market prices, replacement cost prices and social costs of carbon, and these assumptions have to a certain degree been relativised to the given country (i.e. average market prices of crops according to the countries). For other important aspects of SmCPs, no market exists, which make the statement-based methods imperative. The discrete choice experiment allows for direct elicitation of the preferences and willingness to pay of the public in the different countries. The results indicate some differences between countries such three times as high a value for soil stability in Spain than in Denmark, although Spain did not indicate a significant preference for woody vegetation. Despite these differences, all the countries indicated strong preferences for landscape heterogeneity with subtler differences between the countries. These results as well as the similarities and differences highlighted



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in the socio-cultural valuation of the SmCPs demonstrate the need for the integrated valuation and consideration of the plural values of sustainable soil management.

### 3.2.5 Assessment of Landscape Preferences (LANDPREF)

The comparison of the regional samples in regard of the respondents' landscape preferences based on the Kruskal-Wallis test reveals small, yet statistically significant differences between samples for agricultural use and agroforestry (Table 11). Dunn's test discloses lower preference values for agriculture in Denmark than in Ireland and Spain but higher likings for agroforestry compared to Ireland and Spain. Preferences for renewable energy is equally low among all regions and preferences for natural landscape elements such as such as flowering field margins, individual trees and hedgerows and corresponding wildlife is equally high in all regions.

*Table 11. Results from Kruskal-Wallis' and post-hoc Dunn's Tests for landscape preferences and regions.*

| | **Agriculture** | | | **Renewable Energy** | | | **Agroforestry** | | | **Biodiversity** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DK | IR | ES | DK | IR | ES | DK | IR | ES | DK | IR | ES |
| Mean value | 1.97 | 2.12 | 2.27 | 1.70 | 1.59 | 1.61 | 2.13 | 1.85 | 1.91 | 1.96 | 1.96 | 2.00 |
| Standard deviation | 0.96 | 1.03 | 0.96 | 0.86 | 0.93 | 0.89 | 0.93 | 0.91 | 0.89 | 0.93 | 0.90 | 0.94 |
| Results Kruskal-Wallis Test | | | | | | | | | | | | |
| Chi$^2$ | 19.4 | | | 3.15 | | | 20.34 | | | 0.89 | | |
| p-value | **<0.05** | | | 0.2 | | | **<0.05** | | | 0.64 | | |
| Results Dunn's Test | | | | | | | | | | | | |
| Groups | B | A | A | A | | | B | A | A | A | | |

While the comparison of mean values of the full regional sample conveys the impression that landscape preferences are quite homogeneous between the regions, HCA allows for a more nuanced investigation. Here, respondents with similar preference composition (i.e. low/medium/high values) across all land uses (i.e. agriculture, renewables, agroforestry, biodiversity) are grouped into "clusters". Clusters are named after the land use with the highest rating, except the cluster "multifunctional use", which is characterised by similar ratings of all land uses. Given the comparatively little support for renewable energy structures in the landscape across all regions, it is not surprising to find it is the only LANDPREF item that does not define one of these clusters. Though cluster characteristics are similar across the regions with one cluster (per region) consisting of respondents favouring (=choosing a high level of) biodiversity structures, one cluster favouring agriculture, one cluster favouring agroforestry, and one cluster preferring a multifunctional landscape, there is a high variability in cluster size (Figure 4).



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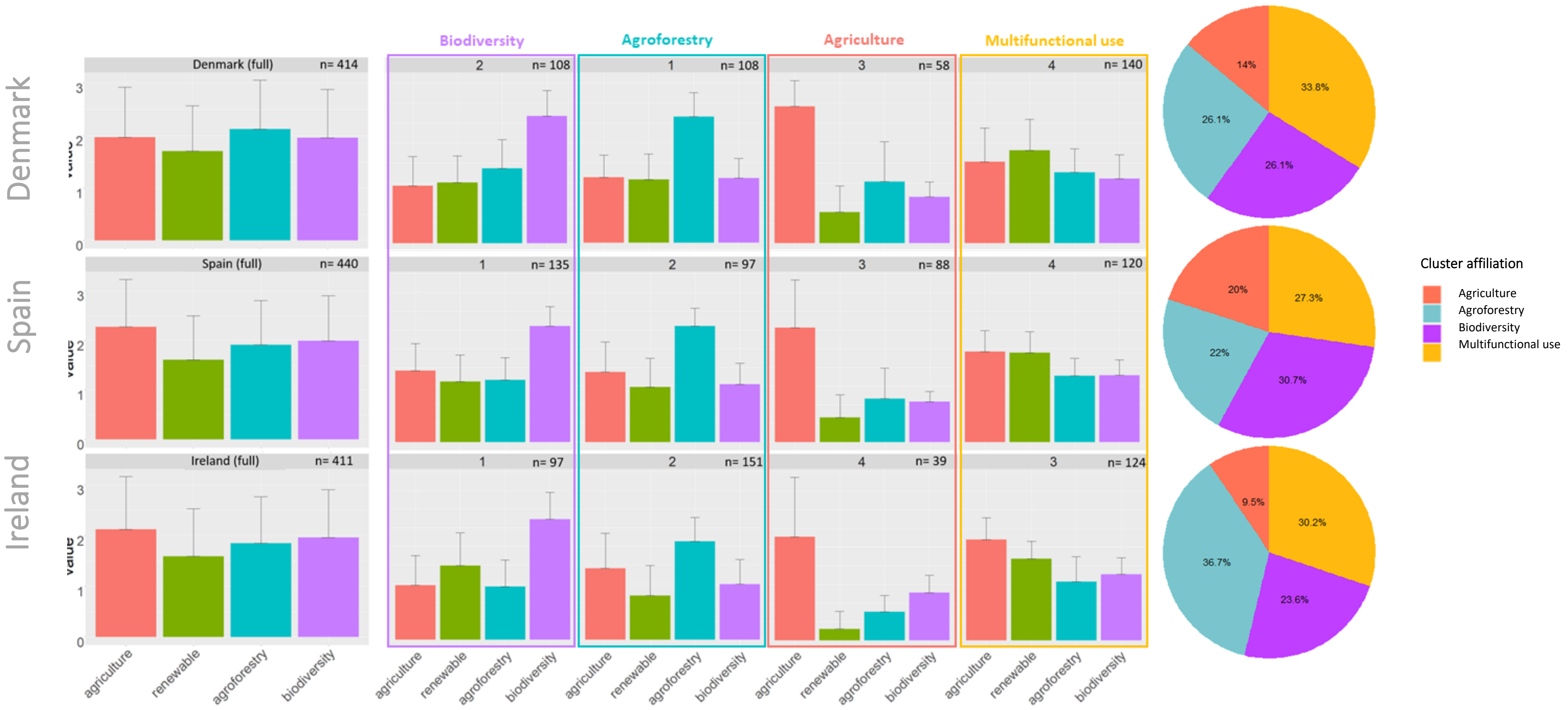


*Figure 4. Mean preferences of full regional sample (left column of boxes) and regional preference clusters (four per region) for land use management in Denmark, Spain, and Ireland. Clusters arranged and labelled according to emphasised preference in cluster. Pie graphs represent the distribution of respondents in each region based on their cluster membership.*



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Denmark, for instance, has one third (34%) of its respondents favouring a multifunctional landscape, which is clearly the highest share of multifunctionalists compared to Spain (27%) and Ireland (30 %). In the other clusters, Denmark ranks between Spain and Ireland. Spain has the biggest share of people favouring agricultural uses (20 %) and the biggest cluster of people who give high values to biodiversity (31 %). The cluster favouring agroforestry is smallest in Spain (22%). In Ireland clusters are composed oppositely, here, the biggest cluster of respondents, values agroforestry (37%) and only comparatively small clusters value agriculture (9%) and biodiversity (24%).

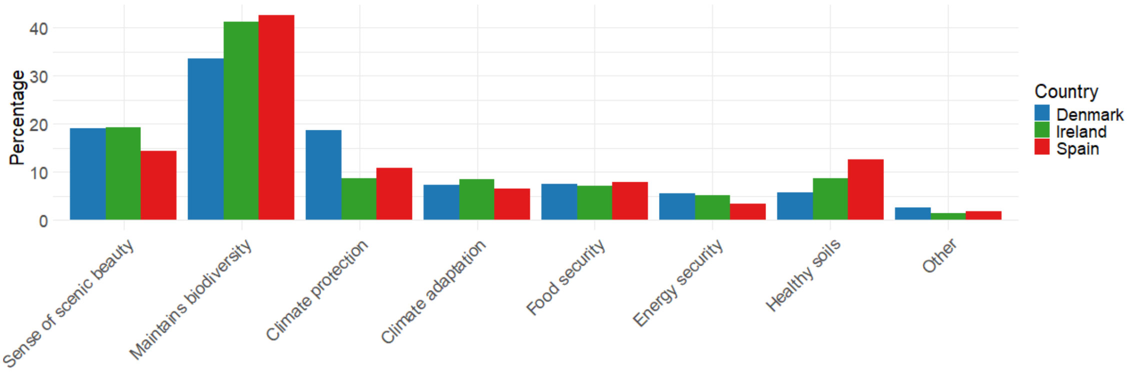


*Figure 5. Percentages of motivations indicated for the selected landscape component levels in LANDPREF.*

Reasons for the selection of landscape components were manifold and showed only small differences between countries (Figure 5). The biggest share of respondents in all countries indicated the positive effect on biodiversity as the best descriptor for their motivations followed by the personal sense of scenic beauty. Healthy soils were considered particularly important as a motivation for the choice of landscape components in Spain, whereas climate protection held greater importance in Denmark compared to the other countries.

To sum up, nuanced distinctions were revealed by the HCA. Despite general low support for renewable energy structures, Denmark stands out with the highest proportion favouring multifunctional landscapes (34%), contrasting with Spain's emphasis on biodiversity (31%) and Ireland's preference for agroforestry (37%). Variability in cluster size underscores diverse landscape perceptions within and across regions. The varied landscape preferences highlight the necessity of region-specific approaches in promoting sustainable soil management practices, which has also been observed in other contexts (Pascual *et al.*, 2017). Recognising these regional distinctions allows land managers to tailor their strategies to better address local needs and priorities, thereby enhancing the effectiveness of soil biodiversity conservation efforts.

### 3.2.6 Integration of monetary and non-monetary values

A comprehensive valuation approach is necessary to incorporate society's diverse values for various land uses and their impact on soil biodiversity into decision making. This diversity of values was emphasised in the IPBES framework (IPBES, 2022) and formed the foundation for the integrated valuation approach developed in Deliverable 4.1 and applied in this current deliverable. Although SOILGUARD evaluates solely instrumental values for SmCPs, it does so across two dimensions (i.e. economic and socio-cultural) while considering the factors that influence how the SmCPs are perceived and prioritised by people.



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The cost-based valuation prepared an informational basis for the SmCPs food and feed production, soil formation and climate regulation. This together with the direct elicitation of preferences and willingness to pay for several aspects of sustainable soil management through statement-based methods provided the economic valuation of SmCPs. Although this information is primarily relevant for policy making, farmers and landowners could profit from this information as well. Farmers and landowners may not be aware of the societal benefits of switching to different forms of agriculture that lead to sustainable soil management. Consideration of these benefits can be a daunting task given the different ways in which these benefits are expressed. Therefore, the cost-based valuation provides a unified economic approach by bringing the changes to monetary values, against which the costs can be compared. This information is also highly important for decision and policy making given that political and economic instruments to help guide farmers and landowners in land use management decisions can be based on the overall costs and benefits to society. In this way, the economic efficiency of programs and policies is promoted.

In the statement-based method, the economic valuation with discrete choice experiments complements the socio-cultural valuation of SmCPs and landscape preferences. The economic valuation allows for elicitation of the willingness to pay for a small set of sustainable soil management aspects that relate to several different SmCPs, and such values can be considered alongside associated costs of programmes and policies. However, respondents are limited in the elicitation of the preferences by the associated cost. The socio-cultural valuation complements this approach by relaxing the cost constraints and allowing respondents to express their preferences and priorities for SmCPs in relation to each other, rather than in relation to the costs. This provides a means through which the public can express their preferences and priorities for changes in soil management to be integrated into decision and policy making. The overall results can be found in Table 12.

*Table 12. Results of the integrated valuation approach including the socio-cultural valuation (frequency of SmCP in top five priorities of respondents), economic valuation (behaviour and statement-based) and landscape preferences (mean values per land use).*

| | Belgium | Denmark | Finland | Hungary | Ireland | Latvia | Spain |
|---|---|---|---|---|---|---|---|
| **Habitat creation** | | | | | | | |
| Socio-cultural valuation (%) | | 33.3 | | | 25.7 | | 25.5 |
| Landscape preference (mean) | | 1.96 | | | 1.96 | | 2 |
| **Pollination** | | | | | | | |
| Socio-cultural valuation (%) | | 19.8 | | | 31.4 | | 23.8 |
| **Regulation of air quality** | | | | | | | |
| Socio-cultural valuation (%) | | 28.0 | | | 33.4 | | 41.1 |
| **Regulation of climate** | | | | | | | |
| Socio-cultural valuation (%) | | 29.7 | | | 25.9 | | 41.1 |
| Cost-based (conventional to alternative) (€/ha) | 2,182.79 | -629.85 | -9,639.43 | 1,796.82 | -6,594.06 | 2,743.81 | 4,134.18 |
| Cost-based (higher to lower degradation)* (€/ha) | -2,797.04 | -1,325.75 | 0 | -10,925.50 | -1,315.91 | 1,380.08 | 6,235.83 |
| **Regulation of freshwater quantity** | | | | | | | |
| Socio-cultural valuation (%) | | 25.8 | | | 35.5 | | 33.6 |
| **Regulation of freshwater quality** | | | | | | | |
| Socio-cultural valuation (%) | | 30.2 | | | 34.8 | | 32.8 |
| **Soil formation and protection** | | | | | | | |
| Socio-cultural valuation (%) | | 25.4 | | | 22.0 | | 30.4 |
| Cost-based (conventional to organic), nitrogen cycling (€/ha) | -3.04 | -0.01 | 0.35 | 5.92 | -1.31 | -2.27 | -0.73 |



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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cost-based ((higher to lower degradation), nitrogen cycling (€/ha) | -3.68 | -0.32 | | -21.14 | 2.89 | 3.69 | 0.38 |
| Cost-based (conventional to organic), phosphorus cycling (€/ha) | 0.51 | 0.01 | -0.03 | 0.07 | -0.22 | 0.36 | 0.001 |
| Cost-based ((higher to lower degradation), phosphorus cycling (€/ha) | 0.27 | -0.09 | | -1.48 | -1.02 | -0.09 | 0.03 |
| Soil stability (WTP for 1% improvement in €/person/year) | | 0.77 | | | 2.4 | | 1.7 |
| **Regulation of hazards and extreme events** | | | | | | | |
| Socio-cultural valuation | | 31.2 | | | 26.6 | | 31.4 |
| **Regulation of detrimental organisms** | | | | | | | |
| Socio-cultural valuation | | 22.2 | | | 14.3 | | 23.1 |
| **Energy production** | | | | | | | |
| Socio-cultural valuation (%) | | 44.0 | | | 32.5 | | 35.3 |
| Landscape preference (mean) | | 1.7 | | | 1.59 | | 1.61 |
| **Food and feed production** | | | | | | | |
| Socio-cultural valuation (%) | | 34.3 | | | 35.2 | | 31.1 |
| Cost-based (conventional to organic) (€/ha) | -142.27 | -97.83 | 3.69 | 360.31 | 0.00 | -509.04 | -258.83 |
| Cost-based ((higher to lower degradation) (€/ha) | -101.64 | -82.54 | | -2971.19 | 0.03 | 112,90 | 129,69 |
| Landscape preference (mean) | | 1.97 | | | 2.12 | | 2.27 |
| **Production of materials** | | | | | | | |
| Socio-cultural valuation (%) | | 19.1 | | | 15.2 | | 20.2 |
| **Learning and inspiration** | | | | | | | |
| Socio-cultural valuation (%) | | 20.0 | | | 20.0 | | 22.9 |
| **Physical and psychological experiences** | | | | | | | |
| Socio-cultural valuation (%) | | 38.2 | | | 30.2 | | 38.7 |
| Woody vegetation (WTP for 1% improvement in €/person/year) | | 2.15 | | | | | 1.7 |
| Landscape heterogeneity (WTP for change in €/person/year) | | 107.53 | | | 77.03 | | 116.49 |
| Landscape preference (mean) | | 2.13 | | | 1.85 | | 1.91 |
| **Supporting identities** | | | | | | | |
| Socio-cultural valuation (%) | | 18.8 | | | 21.4 | | 22.6 |
| **Maintenance of options** | | | | | | | |
| Socio-cultural valuation (%) | | 39.1 | | | 25.4 | | 35.8 |
| **Production of medicinal resources** | | | | | | | |
| Socio-cultural valuation (%) | | 17.4 | | | 19.5 | | 28.2 |
| **Regulation of ocean acidification** | | | | | | | |
| Socio-cultural valuation (%) | | 23.4 | | | 18.0 | | 17.5 |

* values base either on a shift from high > medium degradation or from medium > low degradation level (see Table 5)

# 4 Conclusion

Soil biodiversity is crucial for various ecosystem services, and inclusive land management practices that consider diverse social values can promote equity and social justice. Current soil management often overlooks these plural values, risking soil degradation and reduced resilience, especially under climatic pressures; thus, integrating multiple valuation methods is essential for sustainable soil use. Therefore, in this deliverable the objective was to assess the integrated socio-economic values for SmCPs in selected SOILGUARD regions and explore determinants of value based on the comprehensive typology of nature's values by IPBES.

Building on the biophysical data collection and analyses in WP2 and WP5 as well as cooperation with WP1 and discussions with SOILGUARD partners, the economic values of selected SmCPs were



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estimated with both cost-based and statement-based methods and socio-cultural values were estimated with statement-based methods including landscape preferences. Overall, there is significant variation of the importance of SmCPs across the regions from a socio-economic perspective.

These values are critically important to consider in policy making and highlight the need for inclusion of such plural values in soil conservation efforts. Not only does the valuation in this deliverable aid in raising awareness, but also provides a basis for deciding on or prioritising policies and soil management schemes. For SOILGUARD, the valuation outlined here will be included in the development of the evidence chains and for the development of the SOILGUARDIANS app in WP5 as well as the policy recommendations of WP6. Specifically, evidence for the improvement of societal wellbeing through chains linking soil biodiversity indicators and SmCPs is being compiled in SOILGUARD, and the integrated valuation is part of these chains. The integrated valuation associates the biophysical changes in soil biodiversity with the changes in the provision of SmCPs. Where possible, we have provided the basis for how the economic value elicited. For example, switching from conventional to organic agriculture may lead to lower food and feed production, but the provision of SmCPs such as climate regulation or soil formation increase, which is tied to improvements in societal wellbeing. In addition to the economic valuation, socio-cultural values and landscape preferences were elicited, which can be equally important for managing soils. Although the incorporation into decision making is not always straightforward, we have provided regionally differentiated weights for the most important SmCPs. These were identified in lieu of costs so that individual can provide their preferences free of monetary constraints. Such a weighting scheme can be quantitatively integrated alongside economic values to raise awareness to changes in socio-cultural values when sustainable soil management is pursued. This provides the opportunity to weigh different management schemes in terms of the population's preferences for the outcomes. Although some of the results of the different analyses were similar between the regions (i.e. mean values of points attributed to SmCPs in the socio-cultural valuation), other results indicated regional differences (i.e. difference in selected top priorities among the SmCPs). Therefore, soil biodiversity changes that lead to the improved provision of the prioritised SmCPs of the regions would likely generate greater wellbeing. The multifunctionality indicator and evidence chains can include this information through weighting approaches in order to provide a holistic depiction of the link between soil biodiversity and wellbeing.

The survey also provides information on the acceptance of EU policies on biodiversity and sustainable land management practices as well as WTP values for specific management measures. The relevant questions regarding EU policies were aligned three of the specific policy objectives of the CAP 2023-27 (i.e. specific objectives 4, 5, and 6) and the Farm to Fork strategy, focusing on areas such as EU funding for biodiversity programs, financial incentives for transitioning from conventional to organic farming, pesticide reduction, support for sustainable soil management practices, rewards for farmers involved in climate mitigation efforts, and reducing fertilizer use. Our analyses indicate less agreement in Denmark compared to Spain and Ireland. The Discrete Choice Experiment reveals varying regional WTP for different management options. While Spain and Ireland show a preference for shifting to measures that ensure higher soil stability and greater landscape heterogeneity, respectively, Denmark exhibits the highest WTP values for transitioning to increased woody vegetation. These findings can support the contextual targeting of further sustainable policy measures, acknowledging the unique conditions that influence the agreement with policies. Furthermore, the results of the analyses underline the importance of EU policy objectives relevant for soil protection. With the Soil Strategy, the EU has raised



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awareness for the importance of healthy soils for human wellbeing and the urgent need to reduce soil degradation. According to the Soil Strategy, soils are healthy if, among other things, they provide a range of ecosystem services for which our results demonstrate a societal value. Closely linked to the Soil Strategy are policies such as the Farm-to-Fork Strategy of the Green Deal or the CAP. The results of the socio-economic valuation clearly show, for example, that an increase in organic farming and a provision of habitat is associated with societal benefits, such as a higher $CO_2$ sequestration or maintenance of biodiversity. Information on these diverse values thus provide decision-support for the political process. Next steps will include refinement of the results to be included in the evidence chains and the SOILGUARDIANS App and a further inclusion of the results in the work of WP6.

Lastly, the work outlined in this deliverable provides the grounds for the assessment of region-specific soil management, land degradation and climate change effects on environmental, economic and social values in the next task of WP4.



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# Appendix

## A.) Questionnaire of the population survey in Denmark, Ireland, Spain

**Introduction**

Welcome to our survey. We would like to examine your attitudes regarding the subject of soil. The focus is particularly on arable land used for agriculture, on which plants are cultivated for the production of food.

Soils are fundamental for human life and most ecosystems. They have the ability to provide safe and nutritious food while fulfilling other important functions such as cleaning, filtering and storing water; recycling nutrients; regulating the climate and floods; and removing carbon dioxide and other gases from the atmosphere, all while hosting about a quarter of the animal species on Earth.

At the same time, soils suffer from pressures determined by natural conditions, such as geography and climate, as well as by agricultural management. If management practices are not adequately laid out for prevalent conditions, the above-mentioned functions of soil can be at stake, for example, due to compaction (e.g. if heavy machinery is used too often) or due to inadequate inputs of nutrients. Here, sustainable land management practices aim at the protection, conservation and sustainable use of resources.

Measures for soil protection are important to maintain crucial functions, but they also create additional costs for agricultural businesses. To better understand society's preferences towards agricultural management, individual management measures and policies, we would like to ask you to answer following questions.

There are no right or wrong answers. We are interested in your individual opinions. We are pleased that you are participating!

The survey is conducted by the Institute for Ecological Economy Research, Berlin, Germany and the University of Potsdam, Germany as part of the EU-funded research project SOILGUARD ("Sustainable soil management to unleash soil biodiversity potential and increase environmental, economic and social wellbeing"). It will take about 30 minutes to answer the questions.

Your information will be kept strictly confidential. The data from this online survey will be used exclusively for research purposes and will only be evaluated in summarized form. It is not possible to draw any conclusions about you or your household from the answers.

The provided information will be treated with the safeguards established in the Regulation (EU) 2016/679 of the European Parliament and of the Council, of 27th April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC, when the treatment of personal data is made in the EU.

The data gathered and processed under the scope of this project may be subject to an international transfer (only to partners institutions).

The results from the study will be stored in the SOILGUARD database which will be archived by the overall project leader Leitat Technological Center, Institute for Ecological Economy Research and the



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University of Potsdam. The results will be available to other collaborating researchers within the SOILGUARD project.

Most participants will find the discussion interesting and thought-provoking. If, however, you feel uncomfortable in any way during the survey, you can decline to answer any question or to end the survey.

I agree to participate in this survey.

- Yes, I agree to participate in the survey.
- No, I do not agree to participate in the survey.

I am aware of the data collection privacy policy provided above and …

- I agree to the data collection privacy policy and wish to continue.
- I do not agree to the data collection privacy policy and do not wish to continue.

## I. Socio-demographic characteristics

1. Please indicate your postal code.
1. In which year were you born?
2. Please indicate the gender with which you identify. (Female, male, diverse, no response)
3. How many people permanently live in your household—children, adults and yourself included?
4. What is the average monthly net income of your household? That is, the sum of all income including regular payments such as pensions, housing allowance, parental and child benefits, alimony, unemployment benefits and after deduction of taxes and social security contributions. (Under €1,000, €1,000 to less than €2,000, €2,000 to less than €3,000, €3,000 to less than €4,000, €4,000 to less than €5,000, €5,000 or more, No response)
5. What is your level of education? (No formal education or training, Primary education, Lower secondary education, Upper secondary education, Technical or vocational, Advanced certificate / Completed, apprenticeship, Higher certificate, bachelor's degree, Postgraduate degree (i.e., master's degree), Doctorate (Ph.D.))
6. How long have you been living in this region? (Less than 5 years, 5 to less than 10 years, 10 to less than 20 years, 20 years or longer)

## II. Knowledge, attitudes and behaviour towards soil sustainability

7. Please indicate your agreement with the following statements.

| | |
|---|---|
| | 1 Strongly Disagree<br>2 Disagree<br>3 Neither agree nor disagree<br>4 Agree<br>5 Strongly agree<br>0 I don't know |



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| | |
|---|---|
| Unsustainable management of croplands and grazing lands is one of the major causes of land degradation. | |
| Land degradation is a major contributor to climate change. | |
| Soil erosion, increased risk of forest fires, invasive species, pest and pathogens will be worsened by climate change | |
| Land degradation and the resulting loss of biodiversity affects human well-being negatively. | |
| A variety of sustainable land management practices, aimed at the protection, conservation and sustainable use of resources, have been shown to be effective in avoiding, reducing and reversing land degradation. | |
| Desertification currently affects more than 1 in 3 people on earth. | |
| Soil biodiversity loss is the decline of (micro- and macro-) organisms present in a soil that provide critical functions for ecosystems. | |

8. Which of the following statements best reflect your perceptions of climate change?
    - I think that climate change is happening, and I think humans are largely causing it.
    - I think that climate change is happening, but it´s just a natural fluctuation in earth´s temperature.
    - I don´t think that climate change is happening.
    - I have no idea whether climate change is happening or not.

9. Please indicate your agreement to policies and programs of the European Union (EU) with the following statements.

| | 1 Strongly Disagree<br>2 Disagree<br>3 Neither agree nor disagree<br>4 Agree<br>5 Strongly agree<br>0 I don't know |
|---|---|
| The EU programs that promote biodiversity should be given more funding. | |
| The EU should financially support the change from conventional to organic farming. | |
| There is a need to reduce the use of pesticides by at least 50% by EU law until 2030. | |
| The EU should support a wide range of soil management practices that contribute to more sustainable farming. | |
| Farmers that engage in practices that remove $CO_2$ from the atmosphere or dedicate farmland to biodiversity should be rewarded financially from the EU. | |
| The EU should reduce the use of fertilisers by at least 20% by 2030. | |



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10. Please indicate the frequency you engage in the mentioned behaviours/actions.

| | 1 Never<br>2 Rarely<br>3 Occasionally<br>4 Often<br>5 Very often |
|---|---|
| • I donate money to support environmental protection.<br>• I sign petitions regarding environmental issues.<br>• I vote to support a policy/regulation that affects the green environment. | |
| • I recycle paper, plastic and metal.<br>• I buy environmentally friendly and/or energy efficient products.<br>• I conserve water or energy in my home. | |
| • I adjust my yard to improve conditions for wildlife.<br>• I volunteer to improve wildlife habitat in my community.<br>• I participate (or provide data) in a wildlife study. | |
| • I talk to others in my community about environmental issues.<br>• I work with others to address an environmental problem or issue.<br>• I participate as an active member in a local environmental group. | |

III. **Underlying values**

11. How important are each of these aspects in your life?

| | -1 Opposed to my values<br>1 Not important<br>2 Rather not important<br>3 Neither important nor unimportant<br>4 Important<br>5 Extremely important |
|---|---|
| • Control over others, dominance<br>• Material possessions, money<br>• The right to lead or command<br>• Having an impact on people and events | |
| • Equal opportunity for all<br>• A world free of war and conflict<br>• Correcting injustice, care for weak<br>• Working for the welfare of others | |
| • Protecting natural resources | |



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| | |
|---|---|
| • Harmony with other species<br>• Fitting into nature<br>• Preserving nature | |
| • Everything and every being have a soul<br>• Inclusion of all beings within a moral frame<br>• Taking from the ecosystem only what you need<br>• Interconnection of cultural and sacred landscapes | |

12. For each of the following statements, please rate the extent to which you agree with it.

| | 1 Strongly Disagree<br>2 Disagree<br>3 Neither agree nor disagree<br>4 Agree<br>5 Strongly agree<br>0 I don't know |
|---|---|
| My ideal holiday spot would be a remote, wilderness area. | |
| I always think about how my actions affect the environment. | |
| I take notice of wildlife wherever I am. | |
| My relationship to nature is an important part of who I am. | |
| I feel very connected to all living things and the earth. | |
| My connection to nature and the environment is part of my spirituality. | |

13. Please indicate your agreement with the following statements.

| | 1 Strongly Disagree<br>2 Disagree<br>3 Neither agree nor disagree<br>4 Agree<br>5 Strongly agree<br>0 I don't know |
|---|---|
| I feel I can personally thrive in my region.<br>My region´s natural assets allow me to lead a fulfilling and good life.<br>I want the nature in my region to be protected so that it can provide for future generations. | |
| I respect my environment and take responsibility for it.<br>Without legal supervision, the ecological status of my region will deteriorate which will have a negative impact on myself and people in my region. | |



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| | |
|---|---|
| Respect for my environment is important to me. | |
| When I spend time in my region´s landscape, I feel at home.<br>I like to spend time in my region´s nature/landscape, and I feel more balanced afterwards.<br>I enjoy going out into nature for pleasure. | |
| I feel deeply connected to my region and it is part of my identity.<br>I believe in the deep connection between nature and myself.<br>We are connected to all living and non-living beings on earth. | |

14. Please indicate your agreement with the following statements.

| | 1 Strongly Disagree<br>2 Disagree<br>3 Neither agree nor disagree<br>4 Agree<br>5 Strongly agree<br>0 I don't know |
|---|---|
| I have sufficient funds at my disposal to buy the food I want.<br>It is easy to find good housing at a reasonable price in my region.<br>It is easy to find a job in my region.<br>I am satisfied with the quality and quantity of water in my region. | |
| I feel safe in my region.<br>The presence of foreigners is good for my region.<br>Generally speaking, most people in my region can be trusted.<br>Generally speaking, the public administration of my region can be trusted. | |
| My region is committed to fight against climate change (e.g., energy efficiency, green transport).<br>The overall state of nature in my region is good.<br>I am satisfied to live in my region. | |

### IV. **Specific values**

**Socio-cultural assessment of nature's contributions to people**

15. When you think about your region and your region's landscape, how important are each of their following contributions for you personally?

| | | Not important<br>Slightly important<br>Important |
|---|---|---|



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| | | |
|---|---|---|
| | | Fairly important<br>Very important<br>I don’t know |
| Habitat creation | The ecosystem forms the ecological conditions for living beings, such as growing sites for plants, nesting sites for animals. | |
| Pollination | The ecosystem helps the movement of pollen. | |
| Regulation of air quality | The ecosystem helps to improve air quality by filtering air pollutants. | |
| Regulation of climate | The ecosystem regulates the climate by reducing emissions of greenhouse gases and by local cooling effects. | |
| Regulation of freshwater quantity | The ecosystem provides freshwater for people and natural habitats. | |
| Regulation of freshwater quality | The ecosystem improves freshwater quality by filtering sediment, nutrients and other contaminants. | |
| Soil formation and protection | The ecosystem forms and maintains soil structure and soil processes (by plants and soil organisms). | |
| Regulation of hazards and extreme events | The ecosystem reduces the impacts from extreme weather events (floods, storms, heatwaves) and hazards like high noise levels or fire. | |
| Regulation of detrimental organisms | The ecosystem reduces pests and diseases. | |
| Energy production | The ecosystem provides opportunities for renewable energy (wind, solar) and biomass which can be used for fuel (biofuel crops, animal waste, fuelwood, peat). | |
| Food and feed production | The ecosystem provides food from wild or managed organisms (fish, bushmeat, livestock, insects) and feed for domesticated animals (hay, grains, etc.). | |
| Production of materials | The ecosystem provides materials derived from organisms for construction, clothing, printing, or ornamental purposes. | |
| Production of medicinal resources | The ecosystem provides materials derived from organisms used for medicinal, veterinary, and pharmacological purposes. | |
| Learning and inspiration | The ecosystem provides opportunities for education, acquisition of knowledge, and development of skills for well-being and art. | |
| Physical and psychological experiences | The ecosystem provides opportunities for relaxation, healing, recreation, leisure, tourism and aesthetic enjoyment based on close contact with nature, for example hiking, birdwatching, fishing, or hunting. | |
| Supporting identities | The ecosystem provides the landscapes, habitats or organisms which are the basis for religious, spiritual and social-cohesion experiences (for example providing a place of belonging, connectedness, as the basis for narratives or rituals). | |
| Maintenance of options | The capacity of ecosystems to support a good quality of life also including those of future generations. | |



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16. From this list, please rank the five most important contributions of the regional landscape to human well-being and distribute a total of 100 points to indicate its importance. You may allocate the 100 points in any way you like, but your total spending may not exceed 100 points.

| | Points |
|---|---|
| Habitat creation | |
| Pollination | |
| Regulation of air quality | |
| Regulation of climate | |
| Regulation of freshwater quantity | |
| Regulation of freshwater quality | |
| Soil formation and protection | |
| Regulation of hazards and extreme events | |
| Regulation of detrimental organisms | |
| Energy production | |
| Food and feed production | |
| Production of materials | |
| Learning and inspiration | |
| Physical and psychological experiences | |
| Supporting identities | |
| Maintenance of options | |
| Total | 100 points |

**Discrete Choice Experiment**

17. Imagine you have the possibility to decide the way in which agricultural land is farmed and managed. The changes in the management of the land would bring about changes in different features that are described in the following. You can decide how these features change in accordance with an increase in your annual household expenditure which come from increases in taxes and the prices of food. Therefore, please consider your disposable income while making your choices.

**Soil stability**

Unstable soils are prone to soil erosion, which can lead to the loss of fertile land and the degradation of water bodies. Sustainable agricultural practices lead to more stable soils and prevent erosion.

- Across Spain, about 3 tons of soil is washed away from areas the size of a football field per year.
- Across Denmark, about 1/3 ton of soil is washed away from areas the size of a football field per year.
- Across Ireland, about 3/4 ton of soil is washed away from areas the size of a football field per year.


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**Woody vegetation**

Small woody vegetation (such as trees, hedges and shrubs) in and along agricultural fields promotes biodiversity and habitat connectivity.

- In Spain, small woody vegetation makes up about 4 square meters ($m^2$) for every 100 $m^2$ of land.
- In Denmark, small woody vegetation makes up about 8.5 square meters ($m^2$) for every 100 $m^2$ of land.
- In Ireland, small woody vegetation makes up about 28 square meters ($m^2$) for every 100 $m^2$ of land.

**Landscape heterogeneity**

Sustainable agricultural practices often include the cultivation of multiple crops on lands as opposed to monocultures (single crop). Such practices lead to several positive influences on biodiversity and ecosystems while providing aesthetically pleasing views.

**Cost**

Improving agriculture with sustainable soil management requires additional funds. Therefore, your household would have higher expenses in terms of taxes and food costs. Keeping the status quo does not require additional costs, but the other two options in the task below require an increase in annual household expenses to enjoy the listed features.

**Task explanation**

On the next pages, you will see two alternatives with different combinations of the features as well as the option to not change any features while incurring no additional costs. **Please decide which set of features most appeals to you**. When making your choice, please also take into account the costs you will incur and only select an alternative if you would actually be willing to pay the specified amount. In the following, you will be presented with **several similar choice tasks with different combinations of the way the features change and the corresponding costs.**

| **Attribute** | **Levels** |
|---|---|
| Soil stability | Spain:<br>• Current: 3 tons of soil per football field<br>• 5% improvement<br>• 10% improvement<br>Denmark:<br>• Current: 1/3 ton of soil per football field<br>• 5% improvement<br>• 10% improvement<br>Ireland<br>• Current: 3/4 ton of soil per football field<br>• 5% improvement<br>• 10% improvement |



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| | |
|---|---|
| Woody vegetation | Spain:<br>• Current: 4 $m^2$ for every 100 $m^2$ of land<br>• Additional 5%<br>• Additional 10%<br>Denmark:<br>• Current: 8.5 $m^2$ for every 100 $m^2$ of land<br>• 5% increase<br>• 10% increase<br>Ireland<br>• Current: 28 $m^2$ for every 100 $m^2$ of land<br>• 5% increase<br>• 10% increase |
| Landscape | Current: Primarily single crop<br>Single crop<br>Multiple crops |
| Annual increase in household expenditures (taxes + food expenditure) | • 100 €<br>• 50 €<br>• 20 €<br>• 5 €<br>• 1 € |

18. Reasons for choosing status quo
    - I do not agree with paying an additional contribution.
    - The government should finance the additional contribution.
    - I do not have the necessary financial means.
    - I do not believe there any problems with soils and current farming practices.
    - I do not think agricultural lands should be changed or managed differently.
    - The combinations offered did not appeal to me.
    - I did not understand the task.
    - I think these decisions should be made by experts.
    - Other: _______________
    - No response

V. **Landscape preferences**

Please click on the button to continue the survey on another page where you can provide your preference for landscapes and answer a few final questions.

19.

Please score the landscape components to create your preferred future landscape for your local area. Use 0 for your lowest priority/priorities and 5 for your highest priorities. Note that each level corresponds to the spatial coverage in the landscape (i.e. Level 1: 10%, Level 2: 20%, Level 3: 40%,



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Level 4: 60%, Level 5: 80%). The total spatial coverage may not exceed 100%, so some compromises or trade-offs may be necessary.

Please note that at the end of the exercise, if the selection of landscape components does not reach a total of 100%, all remaining space is going to be added to “biodiversity” as land lying fallow will inevitably provide habitat for insects, wildlife and natural vegetation.

Please note that this land use accommodates habitats for birds, insects and different plants. Biodiversity will automatically adjust to level 1 if you change any of the other land uses from 0 to a higher level.

Farmland:

Agricultural land in this scenario is managed as conventional farmland with an average input of fertilisers and pesticides. The soil management practices include tillage. The conversion of a natural land cover to farmland has a large negative impact on the soil biodiversity of a landscape because mechanical pressures and the application of agro-chemicals compromise habitats and food sources for insects, birds, and other wildlife.

Biodiversity:

Natural landscape elements such as flowering field margins, individual trees and hedgerows create habitats for farmland birds, insects and wildlife. These landscape elements provide food and shelter for plants, insects, birds and small mammals throughout the year.

Renewable Energies:

The landscape components to provide renewable energy in this scenario are represented through solar panels and wind turbines, and underneath the soil is covered by natural grassland. The provision of renewable energy has many potential benefits, such as the reduction in greenhouse gas emissions, a reduced dependency on fossil fuels, and the creation of jobs in the area. Undisturbed grassland underneath the solar panels has a positive effect on (soil) biodiversity. Renewable energy technologies and other land uses may be compatible. Here, for simplification, please indicate your preferences under the assumption of spatial exclusion.

Agroforestry:

Agroforestry here combines the growth of trees and crops on the same area of land. This land use provides various environmental benefits, as they contribute to climate change adaptation and mitigation by storing carbon in the trunk, branches and roots, and protect the soil while enhancing biodiversity by providing habitats for insects, birds and other wildlife.

[You cannot choose this level because it exceeds the spatial coverage of 100%. Please lower one of the other levels according to your preferences and within the spatial limits.]

Soils and soil biodiversity are made up of millions of microbial and animal species such as bacteria, fungi, beetles and earth worms. The intensification of different land uses has different effects on soils and soil biodiversity. For instance, in agriculture, the increasing mechanical pressures and use of fertilizers exert strong negative effects on soil biodiversity and functioning. In contrast, increasing



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(above-ground) biodiversity and associated landscape elements have been found to have positive effects.

Your choice of landscape components has a **negative/slightly positive/ positive** impact on soil biodiversity

20. Were you previously aware of the impact of your choice for the soil biodiversity?
    a. Yes, I was aware.
    b. No, I am surprised.
    c. If yes, did the impact on soil biodiversity influence your choice of landscape composition? (Yes/no)
21. Which statement best describes the motivation for your choice of landscape components? -
    - This landscape is in line with my personal sense of scenic beauty
    - This landscape maintains sites for insects, birds, and biodiversity and so creates an ecologically sound landscape
    - This landscape best protects the climate
    - This landscape best adapts to a changing climate
    - This landscape best complies with the need for food security
    - This landscape best complies with the need for energy security
    - This landscape contributes to a healthy soil and soil biodiversity
    - Other:

## VI. Conclusion

Thank you for your participation! You have successfully completed the survey and can now close it. You can find more information about the research project here: https://soilguard-h2020.eu//



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## B.) Knowledge basis of knowledge, attitudes, behaviour and value constructs used in the population survey

| Construct | Description | References |
|---|---|---|
| Knowledge | The influence of environmental knowledge on environmental behaviour has yet to be fully determined. Environmental knowledge does play a role in the complex combination of constructs like attitudes, values and motivational factors. It is proposed that environmental literate people are more likely to accept environmental policies.<br>Statements are based on the IPBES Assessment report on Land Degradation | (Gkargkavouzi, Halkos and Matsiori, 2019)<br>IPBES 2022 |
| Attitudes towards climate change | The opinion on climate change can possibly predict a certain behaviour. It also must be seen in a greater context of knowledge, values, worldviews and pro-environmental behaviour. | (De Boer and Aiking, 2021) |
| Agreement with EU policies and strategies | In this section we explore the support for measures regarding climate change mitigation and adaption (CAP, specific objective 4), water quality, soil, degradation, soil management practices (CAP, specific objective 5) and biodiversity and pesticides (CAP, specific objective 6). The statements are based on the CAP (specific objectives, Farm to Fork strategy). | https://agriculture.ec.europa.eu/cap-my-country/performance-agricultural-policy/agriculture-country/cap-specific-objectives-country_en<br><br>https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en |
| Pro-environmental behaviour | Pro-environmental behaviour is an important part in the construct of values, worldviews and policy preferences. Larson et al. suggest that PEB contains multiple domains that should be measured individually and go beyond "lifestyle behaviours" (e.g., recycling or reusing products, conserving energy and water, or picking up trash). "Social environmentalism, environmental citizenship, and land stewardship should be considered to effectively assess | (Larson et al., 2015)<br>(Sockhill et al., 2022) |



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| | | |
|---|---|---|
| | the full scope of potential conservation-oriented actions”. | |
| Worldviews | Here, we explore the value orientations of the respondents based on adapting typologies from De Groot et al (2008) and Sockhill et al. (2022) and complementing the scale by the “pluricentric” value domain as proposed by the IPBES Values Assessment. | (Sockhill et al., 2022)<br>(De Groot and Steg, 2008)<br>(Gould et al., 2019)<br>(Lucero, 2018) |
| Nature-relatedness | The nature-relatedness scale (NR-6) based on Nisbet et al. (2013) assesses respondents’ connection with nature. This concept encompasses emotions, experience and interconnectedness of humans with all other living things. The scale measures more than just the love for nature but rather an awareness and understanding of all aspects of the natural world. | (Nisbet and Zelenski, 2013) |
| Broad values and life frames | Based on the IPBES Values Assessment and O’Connor and Kenter (2019), we develop a scale to measure broad values. We selected three value statements for each life frame based on the IPBES Values Assessment. | IPBES 2022<br>(O’Connor and Kenter, 2019) |
| Quality of Life | Here we explore the perception of the quality of life based categories suggested by IPBES and statements based on a shortened list from the Eurobarometer to accommodate an added statement about the access to water. | Flash Eurobarometer 419, Quality of life in European cities (2015): https://europa.eu/eurobarometer/surveys/detail/2070 (TNS Political & Social., European Commission. Directorate General for Regional and Urban Policy., and European Commission. Directorate General for Communication., 2016) |



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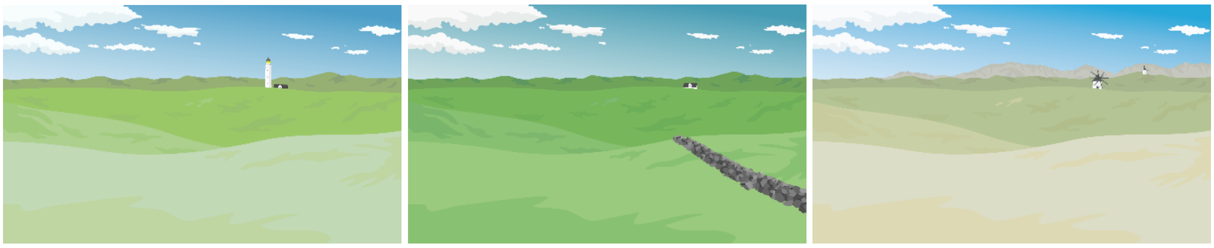
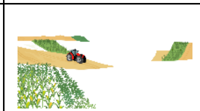
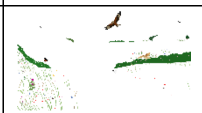
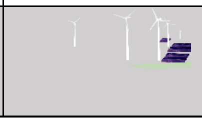
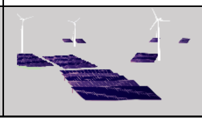
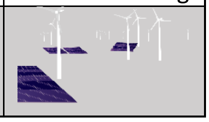
## C.) Description of LANDPREF levels for each land use

Original images with different backdrops in Denmark, Ireland, and Spain: colour schemes adapted to climatic conditions and cultural elements to signify region. These images serve as background for the additional landscape features associated with each land use (see table below).



Prompt in survey: "Please score the following landscape components to create your preferred future landscape for your local area. For this exercise, please keep in mind implications for food security, biodiversity, energy security, and climate regulation.

**Use 0 for your lowest priority/priorities and 5 for your highest priority/priorities. Note that land uses and benefits can be conflicting so some compromises or trade-offs may be necessary!"**

| Land use | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|---|
| Spatial expansion (approx.) | 10% | + 10% | + 20% | + 20% | + 20% |
| **Farmland** = spatial expansion and diversity of farmland rises with each higher level |  |  |  |  |  |
| | barley, spelt | Barley, spelt, soft wheat, oat | Barley, spelt, soft wheat, oat (60%), temporary grasses | Barley, spelt, soft wheat, oat (60%), maize (20%), temporary grasses | Barley, spelt, soft wheat, oat (60%), maize (20%), potatoes (less than 5%), temporary grasses |
| **Biodiversity** = increasing diversity in species composition and landscape elements with each higher level |  |  |  |  |  |
| | Birds, insects, grassland | Birds, insects, grassland + 1 colour | Birds, insects, grassland + 4 colours | Birds, insects, grassland + 4 colours Field margin hedges | Birds, insects, grassland + 4 colours Field margin Hedges Isolated trees with flower ring |
| **Renewable energy** = solar panels and |  |  |  |  |  |



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| | | | | | |
|---|---|---|---|---|---|
| wind turbines rise evenly with each higher level | 1 patch with solar panels, 1 wind turbine | 2 patches with solar panels, 2-3 wind turbines | 4 patches with solar panels, 4-5 wind turbines | 6 patches with solar panels, 6-7 wind turbines | 8 patches with solar panels, 8-9 wind turbines |
| **Agroforestry** = increasing spatial expansion of agroforestry with each higher level |  |  |  |  |  |
| | 1 patch with poplars or willows with cereals growing underneath | 2 patches with poplars or willows with cereals growing underneath | 4 patches with poplars or willows with cereals growing underneath | 6 patches with poplars or willows with cereals growing underneath | 8 patches with poplars or willows with cereals growing underneath |



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## D.) Discrete choice experiment methodology

For the discrete choice experiment, attributes and their levels were proposed after consulting the literature review, the results of the qualitative interviews with the stakeholders (Deliverable 4.1) and following discussions with the other institutions of the SOILGUARD project. This resulted in the set of attributes including improvements in soil stability to reduce soil erosion, increase in the coverage of woody vegetation and the conversion of agricultural lands from monocultures to more heterogeneous landscapes. Increases in woody vegetation and improving landscape heterogeneity can improve the values associated with the SmCPs learning and inspiration, supporting identities and physical and psychological experiences. The status quo (first level of each attribute) for soil stability and woody vegetation was defined according to the current average levels across each country.

| | **Denmark** | **Spain** | **Ireland** |
|---|---|---|---|
| **Attributes** | **Levels** | | |
| Soil stability | 3 Olympic stadiums of soil loss<br>2 Olympic stadiums of soil loss<br>1 Olympic stadium of soil loss | 243 Olympic stadiums of soil loss<br>170 Olympic stadiums of soil loss<br>49 Olympic stadium of soil loss | 10 Olympic stadiums of soil loss<br>2 Olympic stadiums of soil loss<br>1 Olympic stadium of soil loss |
| Woody vegetation | 8.5 $m^2$ for every 100 $m^2$<br>40% increase<br>70% increase | 4 $m^2$ for every 100 $m^2$<br>40% increase<br>70% increase | 28 $m^2$ for every 100 $m^2$<br>40% increase<br>70% increase |
| Landscape | Single crop<br>Multiple crops | Single crop<br>Multiple crops | Single crop<br>Multiple crops |
| Cost | 1€, 5€, 20€, 50€, 100€, 200€ | 1€, 5€, 20€, 50€, 100€, 200€ | 1€, 5€, 20€, 50€, 100€, 200€ |

The combination of the attribute levels for the choice sets was formed with a fractional factorial design in which 6 choice sets were randomly shown to each respondent from an orthogonal array of 18 sets. The modelling for discrete choice experiments follows the theory of demand by Lancaster (1966). This assumes that respondents make choices based on the perceived benefit from the attributes than the actual attributes themselves. Given this, the choices can be modelled as a function of the attributes which follows the theory of random utility maximisation (McFadden, 1974). A given respondent's ($n$) utility ($U_{njt}$) for an option ($j$) of the choice set ($t$) is estimable from the observable ($V_{njt}$) and the random ($\epsilon_{njt}$) components of the following equation:

$$U_{njt} = V_{njt} + \epsilon_{njt}$$

The observable component estimated through the choice model is composed of the set of attributes ($x_{nj}$), the corresponding coefficients of the attributes ($\beta$) and the error term ($\epsilon_{njt}$), as in the following equation:

$$V_{njt} = \beta x_{nj} + \epsilon_{njt}$$

Respondents are assumed to choose the option with the greatest utility such that $U_{njt} > U_{nit}$, if one option ($j$) proposes greater utility than another option ($i$). For this study, the most frequently used conditional logit model was estimated for estimating random utility maximization and provides the opportunity to quickly and efficiently investigate coefficients and their significance (Eppink, Hanley and



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Tucker, 2019). Such choice models assume that utility is not directly observed but stated and estimated based on the probability of choosing one option out of the possible options ($k$) as in the following equation:

$$P_{nj} = \frac{e^{\beta x_{nj}}}{\sum_1^k e^{\beta x_{nk}}}$$

For each country, the model was fitted with the provided choices of the respondents. The marginal willingness to pay for each of the attributes in light of the costs was estimated by dividing the coefficient of the given attribute by the coefficient of the cost (Hoyos, 2010). The data preparation, the model estimation and subsequent analyses were performed in R with the help of the gmnl package (Sarrias et al., 2018) for the conditional logit model.



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E.) Mean and standard deviation for individual items for every construct on knowledge, attitudes, behaviour, and underlying values (worldviews, life frames, quality of life)

| Latent variables | Indicators | Denmark | | Spain | | Ireland | |
|---|---|---|---|---|---|---|---|
| | | ⌀ | SD | ⌀ | SD | ⌀ | SD |
| **Level of knowledge** | prefmang_1 | 3.49 | 0.99 | 3.82 | 1.06 | 3.91 | 1.06 |
| | prefmang_2 | 3.19 | 1.01 | 3.93 | 1.00 | 3.84 | 1.22 |
| | prefmang_3 | 3.88 | 0.95 | 4.27 | 0.87 | 4.18 | 0.99 |
| | prefmang_4 | 3.74 | 1.03 | 4.28 | 0.87 | 4.15 | 0.99 |
| | prefmang_5 | 3.62 | 0.98 | 4.12 | 0.86 | 4.10 | 1.04 |
| | prefmang_6 | 3.55 | 1.05 | 3.96 | 0.92 | 4.21 | 1.27 |
| | prefmang_7 | 3.89 | 1.00 | 4.14 | 0.88 | 4.21 | 1.07 |
| **Perception of climate change** | prefclim | 1.34 | 0.65 | 1.28 | 0.60 | 1.31 | 0.58 |
| **Level of agreement to EU policies** | policy_1 | 3.71 | 1.05 | 4.00 | 0.95 | 4.06 | 1.04 |
| | policy_2 | 3.73 | 1.04 | 4.09 | 0.97 | 4.05 | 0.93 |
| | policy_3 | 3.92 | 1.04 | 4.19 | 0.90 | 4.28 | 1.02 |
| | policy_4 | 3.90 | 1.00 | 4.25 | 0.83 | 4.22 | 0.90 |
| | policy_5 | 3.79 | 1.00 | 4.19 | 0.89 | 4.09 | 0.97 |
| | policy_6 | 3.78 | 1.05 | 4.13 | 0.93 | 4.18 | 1.03 |
| **PEB: environmental citizenship** | envact_1 | 2.21 | 1.08 | 2.05 | 0.97 | 2.20 | 0.98 |
| | envact_2 | 2.38 | 1.20 | 2.77 | 1.17 | 2.55 | 1.12 |
| | envact_3 | 3.05 | 1.22 | 3.10 | 1.26 | 2.79 | 1.20 |
| **PEB: conservation lifestyle** | envact_4 | 4.00 | 1.10 | 4.36 | 0.92 | 4.48 | 0.84 |
| | envact_5 | 3.46 | 1.04 | 3.62 | 0.97 | 3.69 | 0.99 |
| | envact_6 | 4.02 | 1.05 | 4.30 | 0.77 | 3.91 | 1.03 |
| **PEB: land stewardship** | envact_7 | 3.26 | 1.30 | 3.30 | 1.33 | 3.45 | 1.23 |
| | envact_8 | 2.27 | 1.32 | 2.20 | 1.19 | 2.29 | 1.21 |
| | envact_9 | 2.30 | 1.25 | 2.11 | 1.25 | 2.22 | 1.19 |
| **PEB: social environmentalism** | envact_10 | 2.63 | 1.21 | 3.29 | 1.15 | 2.80 | 1.18 |
| | envact_11 | 2.27 | 1.25 | 2.31 | 1.21 | 2.34 | 1.14 |
| | envact_12 | 2.35 | 1.35 | 2.11 | 1.25 | 2.00 | 1.19 |
| **Worldview: Egoistic value orientation** | worldview_1 | 3.83 | 1.26 | 2.61 | 1.53 | 2.59 | 1.40 |
| | worldview_2 | 3.01 | 1.33 | 3.88 | 1.34 | 3.90 | 1.31 |
| | worldview_3 | 3.54 | 1.31 | 3.18 | 1.36 | 3.29 | 1.36 |
| | worldview_4 | 4.79 | 1.17 | 3.87 | 1.29 | 3.95 | 1.28 |
| **Worldview: Altruistic value orientation** | worldview_5 | 5.11 | 1.15 | 5.25 | 1.00 | 5.24 | 0.97 |
| | worldview_6 | 4.89 | 1.16 | 5.45 | 0.94 | 5.45 | 0.97 |
| | worldview_7 | 4.52 | 1.20 | 5.30 | 0.91 | 5.33 | 0.87 |
| | worldview_8 | 4.85 | 1.14 | 4.85 | 1.09 | 5.02 | 0.95 |
| **Worldview: Biospheric value orientation** | worldview_9 | 4.64 | 1.14 | 5.33 | 0.91 | 5.23 | 0.94 |
| | worldview_10 | 4.63 | 1.21 | 5.20 | 0.88 | 5.07 | 0.99 |
| | worldview_11 | 4.98 | 1.17 | 5.15 | 0.98 | 5.00 | 1.03 |



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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | worldview_12 | 4.37 | 1.39 | 5.37 | 0.97 | 5.23 | 0.95 |
| | worldview_13 | 4.25 | 1.22 | 4.56 | 1.34 | 4.46 | 1.45 |
| **Worldview: Pluricentric value orientation** | worldview_14 | 4.63 | 1.15 | 4.73 | 1.18 | 4.76 | 1.16 |
| | worldview_15 | 4.24 | 1.15 | 4.97 | 1.13 | 4.96 | 1.01 |
| | worldview_16 | 4.04 | 1.04 | 4.30 | 1.24 | 4.72 | 1.11 |
| **Nature relatedness** | nature_1 | 2.95 | 1.25 | 3.75 | 1.10 | 3.17 | 1.23 |
| | nature_2 | 3.44 | 1.01 | 3.99 | 0.95 | 3.68 | 0.94 |
| | nature_3 | 3.81 | 1.01 | 4.15 | 0.89 | 4.16 | 0.89 |
| | nature_4 | 3.76 | 1.08 | 4.06 | 0.93 | 3.87 | 0.98 |
| | nature_5 | 3.49 | 1.12 | 3.89 | 1.03 | 3.80 | 1.02 |
| | nature_6 | 3.16 | 1.24 | 3.70 | 1.11 | 3.54 | 1.13 |
| **Life frames: Living from nature** | broadval_1 | 4.00 | 0.97 | 3.66 | 1.04 | 3.68 | 0.92 |
| | broadval_2 | 3.81 | 1.01 | 3.82 | 0.92 | 3.71 | 0.93 |
| | broadval_3 | 4.18 | 0.87 | 4.32 | 0.83 | 4.32 | 0.81 |
| **Life frames: Living with nature** | broadval_4 | 4.03 | 0.90 | 4.25 | 0.78 | 4.20 | 0.81 |
| | broadval_5 | 3.74 | 0.95 | 4.12 | 0.89 | 4.06 | 1.01 |
| | broadval_6 | 4.15 | 0.90 | 4.38 | 0.78 | 4.35 | 0.78 |
| **Life frames: Living in nature** | broadval_7 | 3.89 | 1.00 | 4.16 | 0.90 | 4.10 | 0.88 |
| | broadval_8 | 3.87 | 1.03 | 4.17 | 0.85 | 4.11 | 0.83 |
| | broadval_9 | 4.07 | 1.01 | 4.35 | 0.83 | 4.33 | 0.79 |
| **Life frames: Living as nature** | broadval_10 | 3.61 | 1.11 | 4.00 | 0.98 | 3.92 | 0.94 |
| | broadval_11 | 3.64 | 1.11 | 3.96 | 0.98 | 3.95 | 0.95 |
| | broadval_12 | 3.51 | 1.11 | 3.91 | 1.00 | 3.98 | 1.02 |
| **Quality of life: Access to food, water, energy and livelihood security** | quallife_1 | 3.66 | 1.21 | 3.34 | 1.13 | 3.51 | 1.19 |
| | quallife_2 | 3.03 | 1.28 | 2.38 | 1.24 | 2.23 | 1.35 |
| | quallife_3 | 3.39 | 1.09 | 2.73 | 1.12 | 2.93 | 1.26 |
| | quallife_4 | 4.03 | 0.91 | 3.54 | 1.15 | 3.55 | 1.16 |
| **Quality of life: Health, good social relationship and equity, security, cultural identity and freedom of choice and actions** | quallife_5 | 4.10 | 0.92 | 3.90 | 0.92 | 3.89 | 0.93 |
| | quallife_6 | 3.37 | 1.15 | 3.56 | 1.06 | 3.57 | 1.14 |
| | quallife_7 | 3.80 | 0.95 | 3.70 | 0.95 | 3.68 | 1.02 |
| | quallife_8 | 3.63 | 1.02 | 3.29 | 1.09 | 3.47 | 1.10 |
| **Quality of life: Living in harmony with nature, living-well in balance and harmony with mother earth and human well being** | quallife_9 | 3.60 | 0.97 | 3.43 | 1.03 | 3.47 | 1.17 |
| | quallife_10 | 3.66 | 0.98 | 3.65 | 0.91 | 3.77 | 0.92 |
| | quallife_11 | 4.02 | 1.05 | 4.17 | 0.89 | 4.00 | 0.94 |



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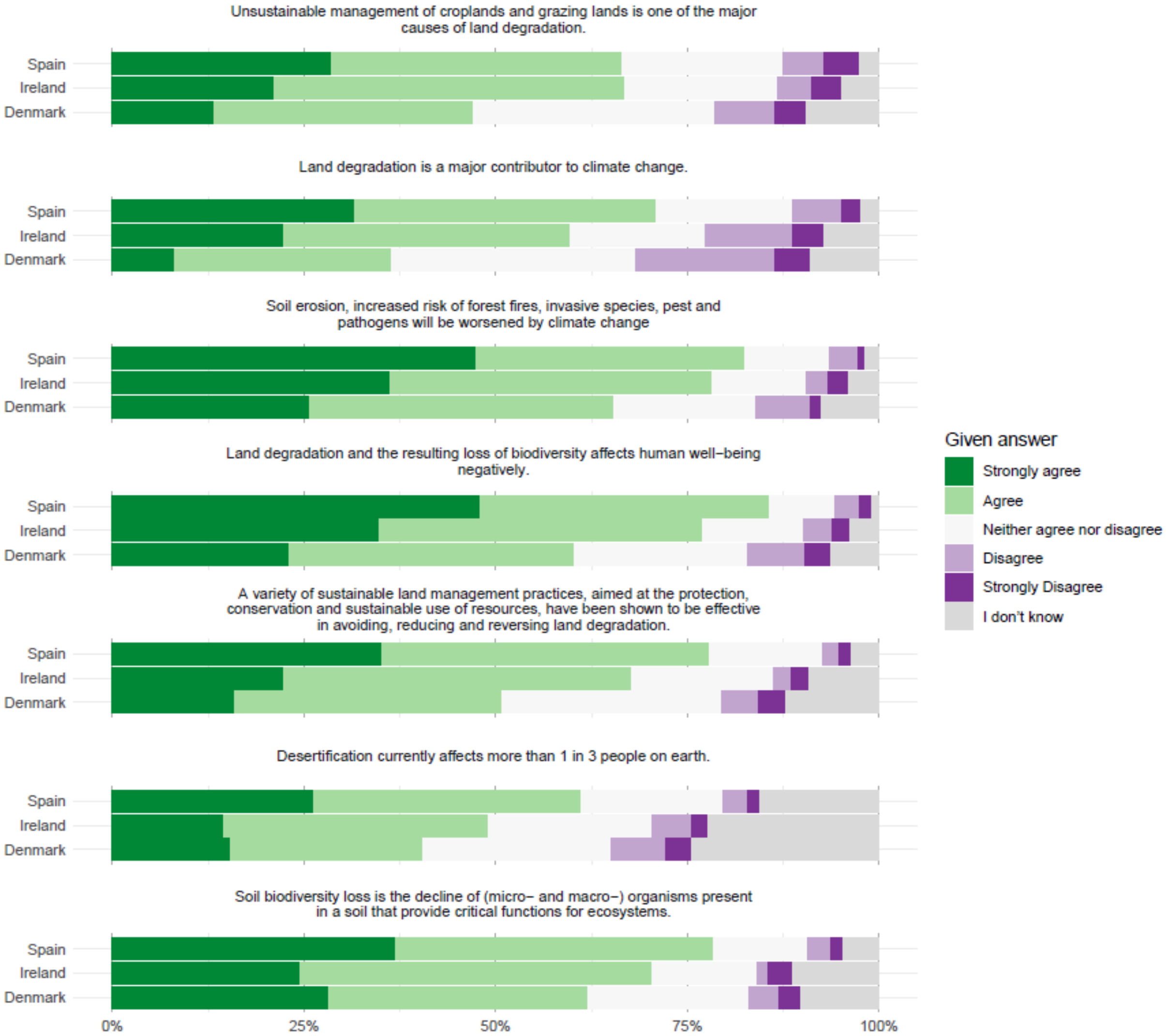
## F.) Graphic depiction of individual items for every construct on knowledge, attitudes, behaviour, and underlying values (worldviews, life frames, quality of life)

Level of knowledge



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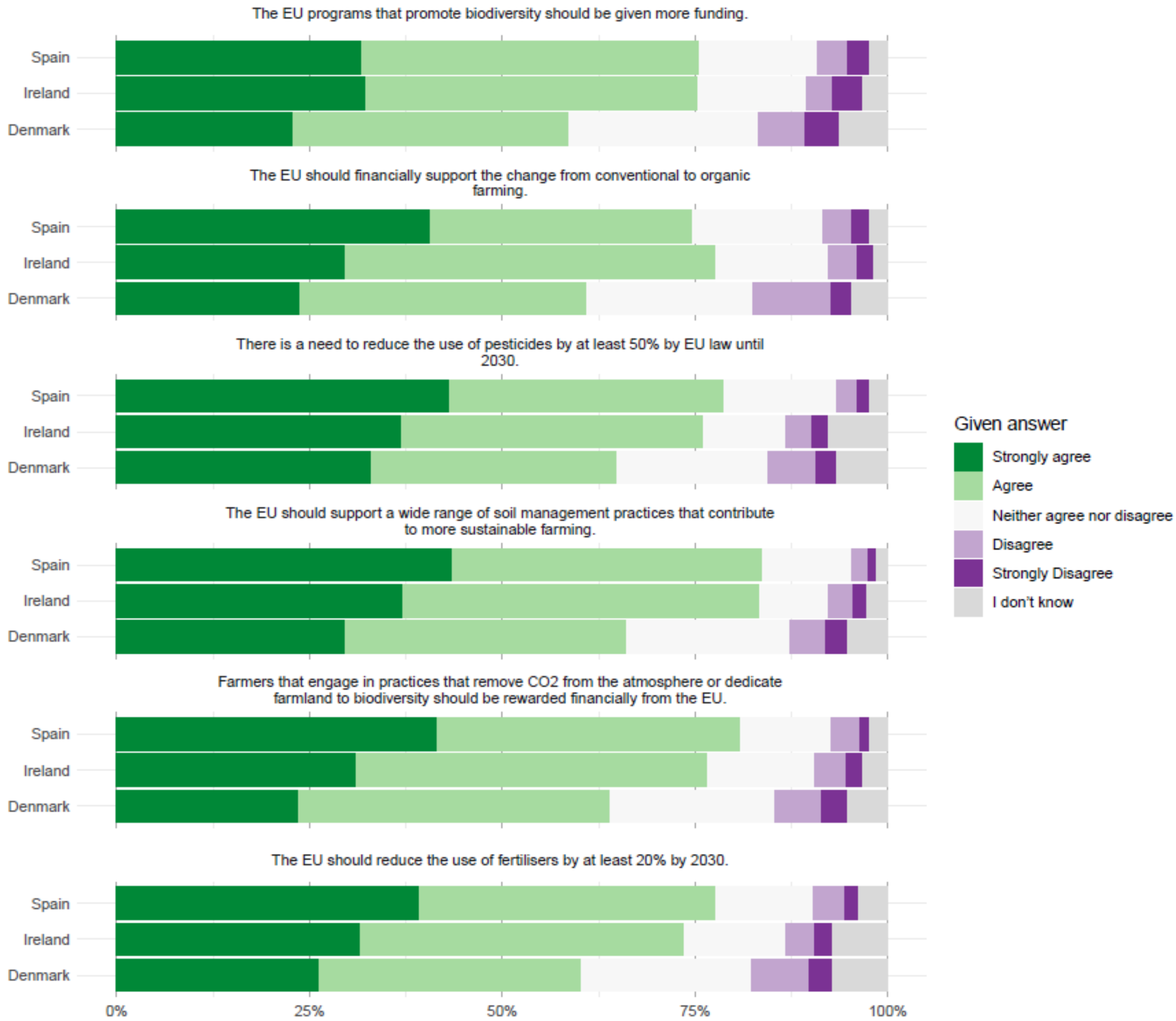
Level of agreement to EU policies



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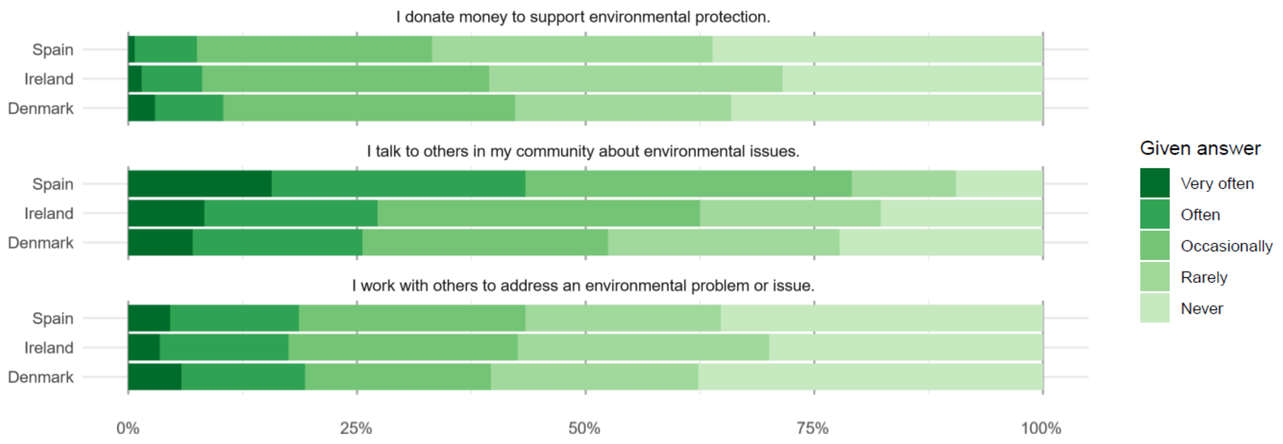
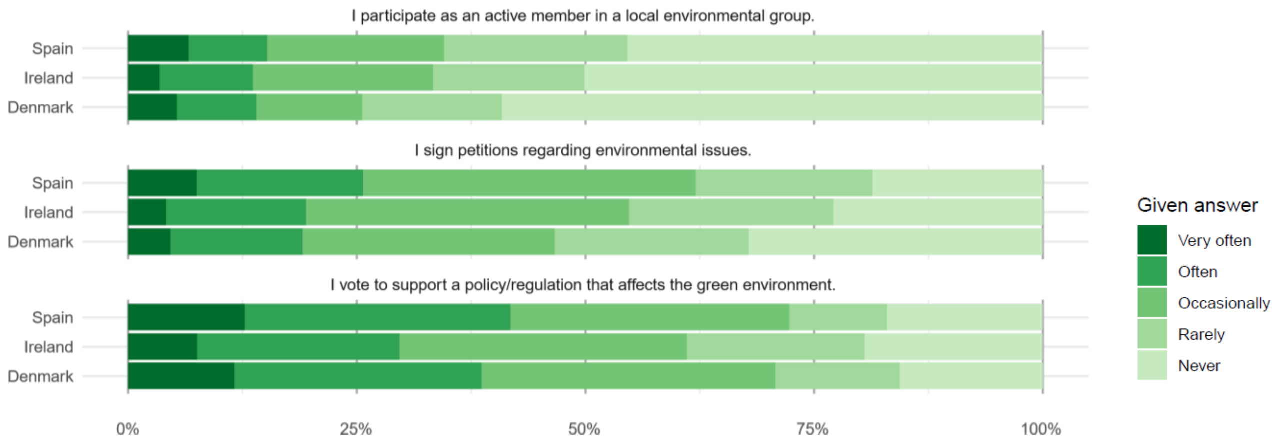
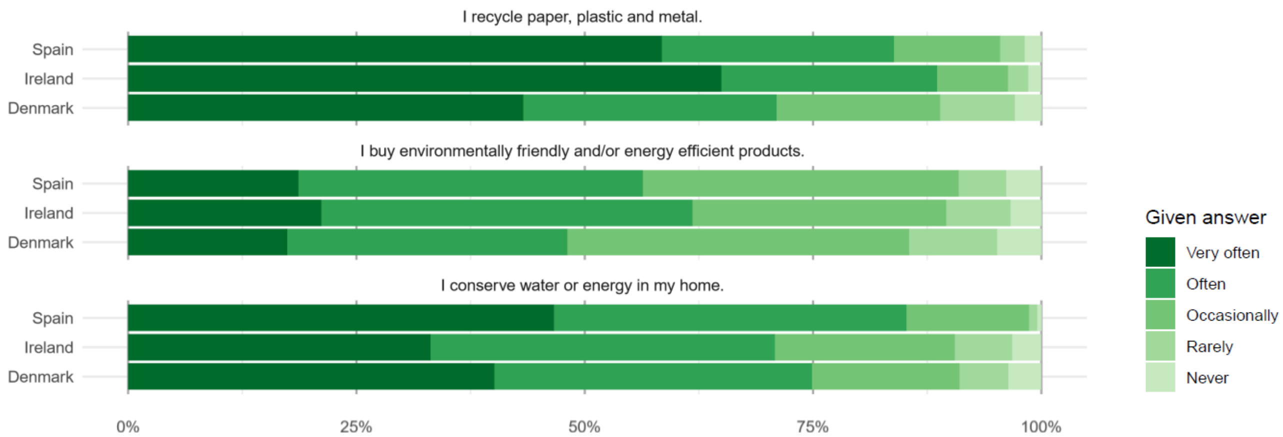
## PEB: Environmental citizenship




## PEB: Conservation lifestyle




## PEB: Land stewardship



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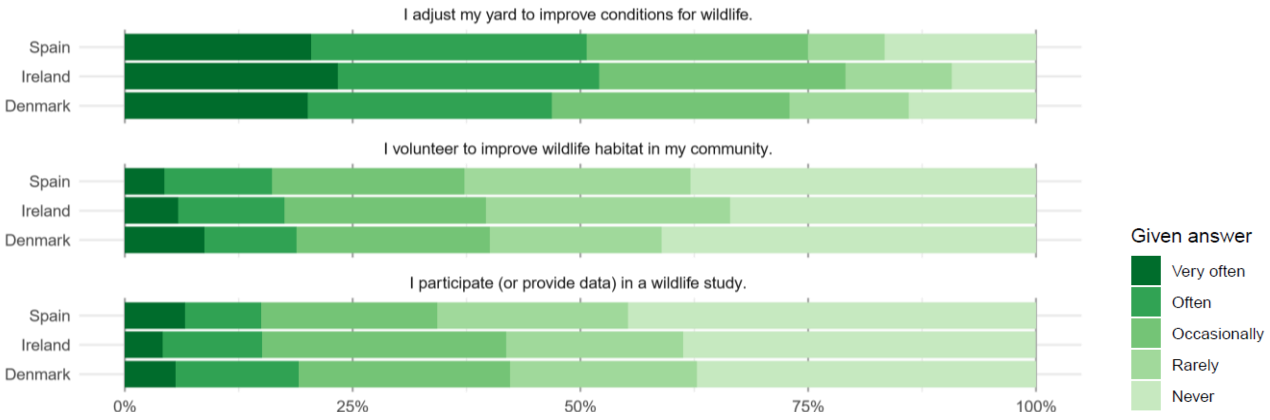
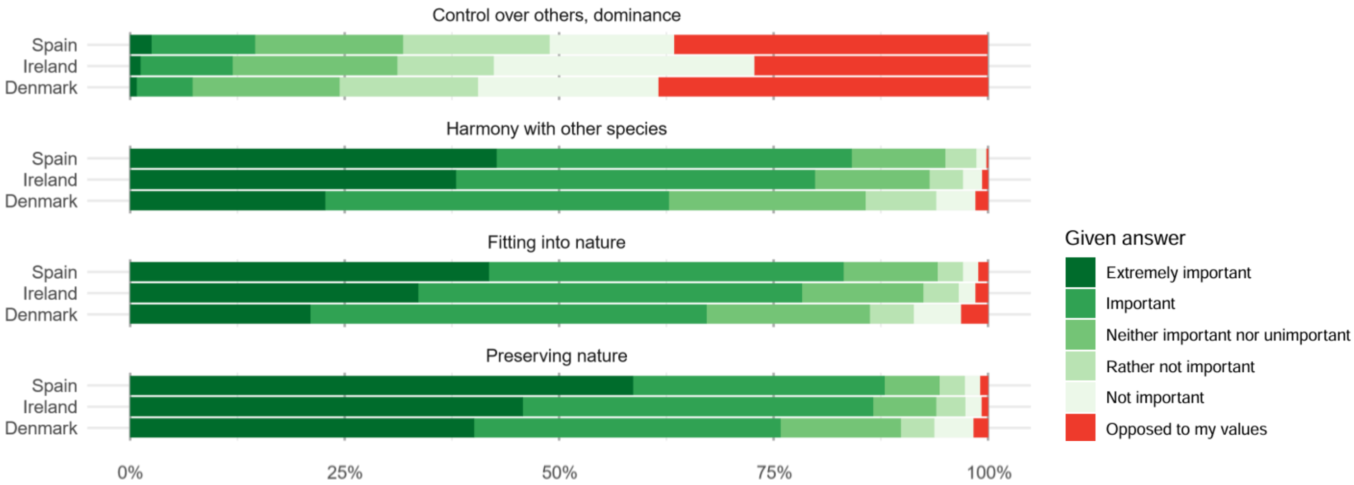
PEB: Social environmentalism




Worldview: Egoistic value orientation



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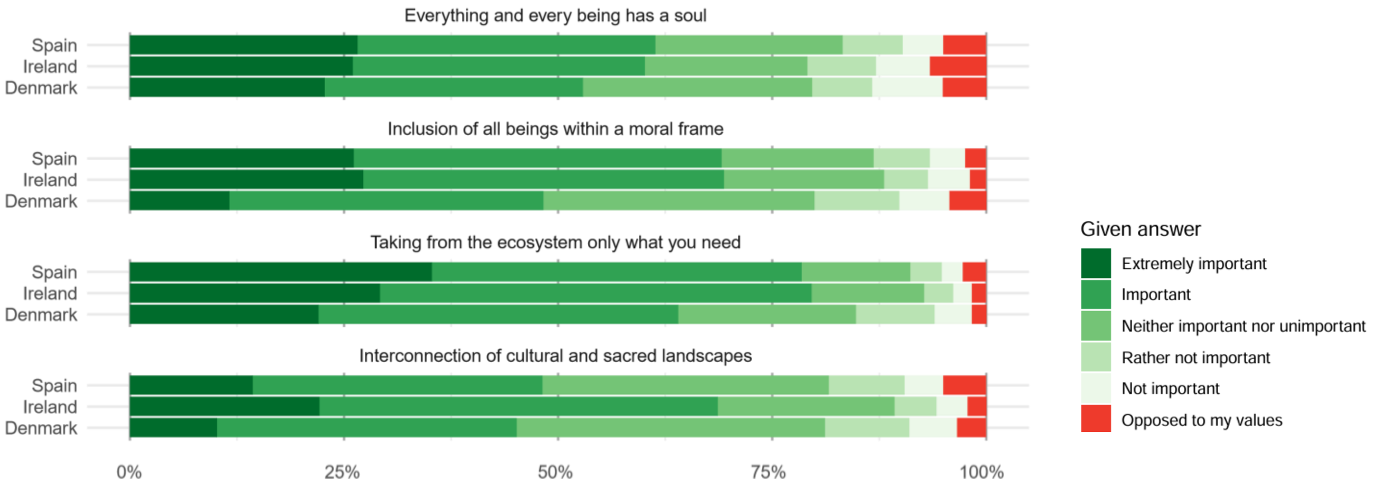
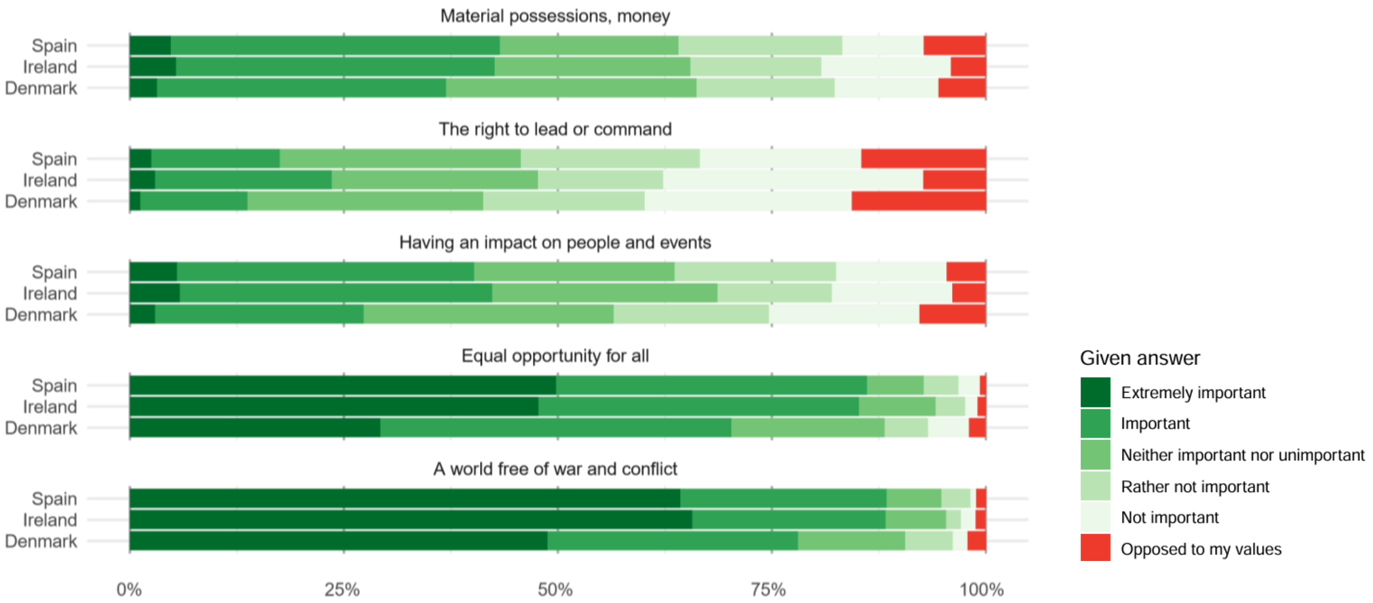
Worldview: Altruistic value orientation



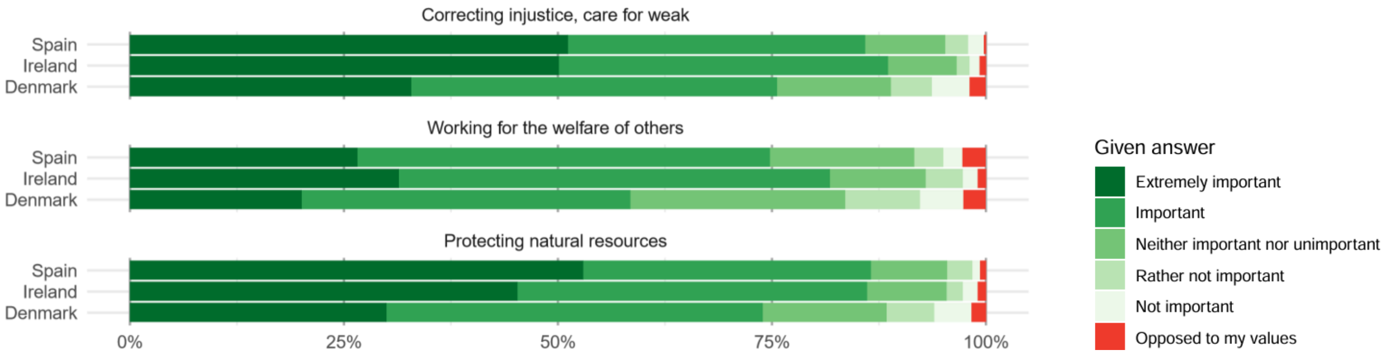

Worldview: Biospheric value orientation



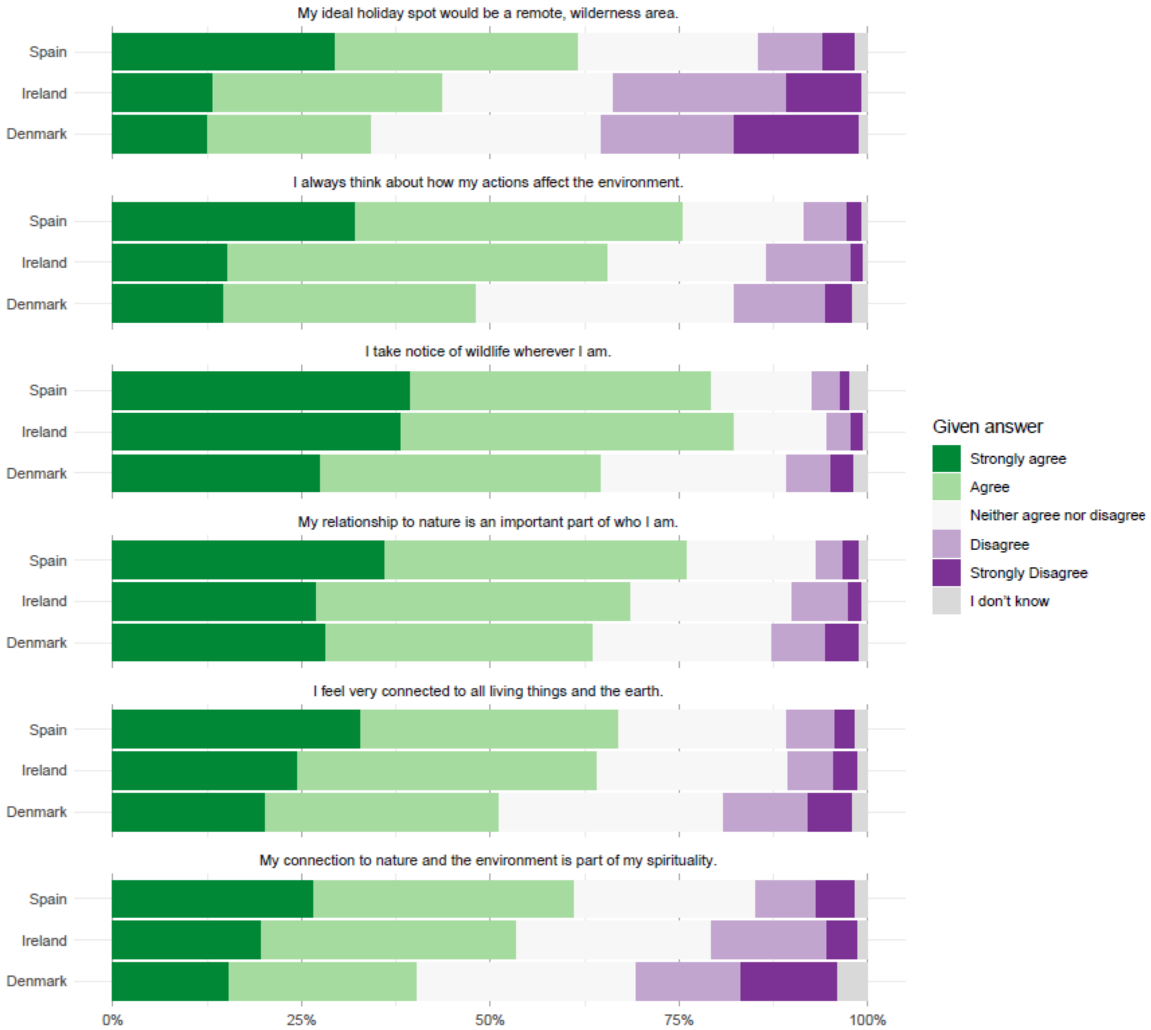



The research leading to these results has received funding from the European Union Horizon 2020 Research & Innovation programme under the Grant Agreement no. 101000371.

Worldview: Pluricentric value orientation




Nature relatedness



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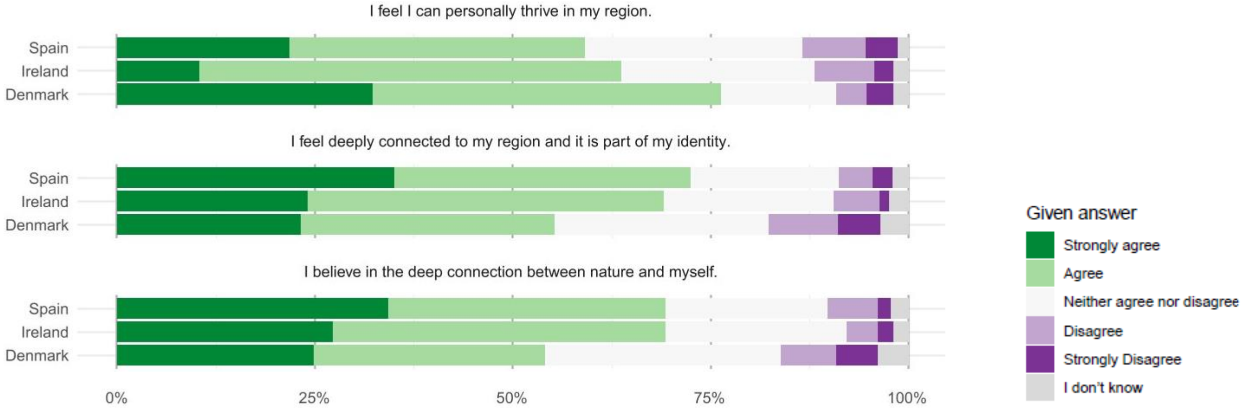
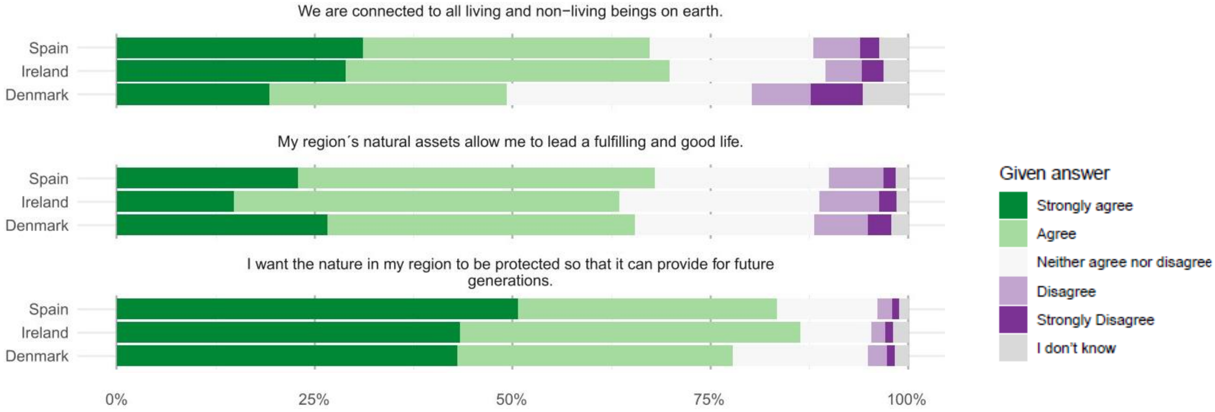
## Life frames: Living from nature




## Life frames: Living with nature



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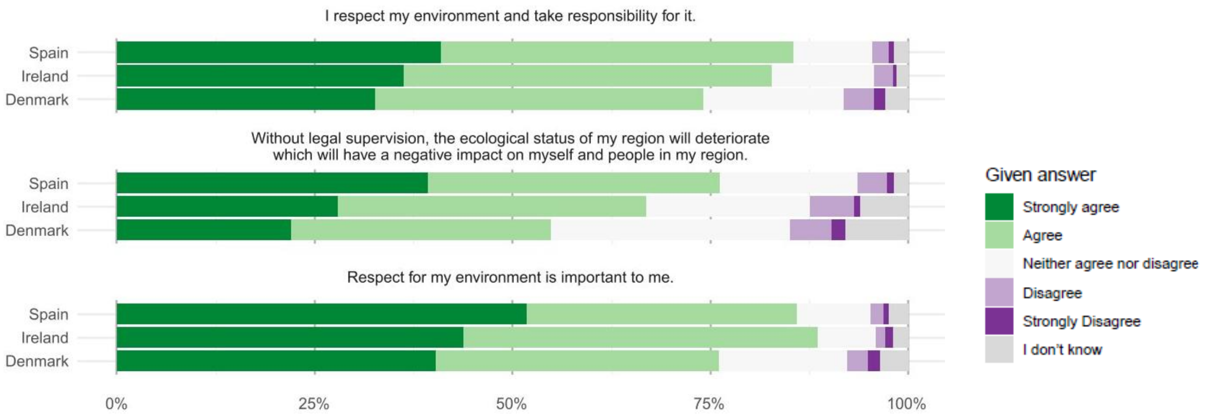
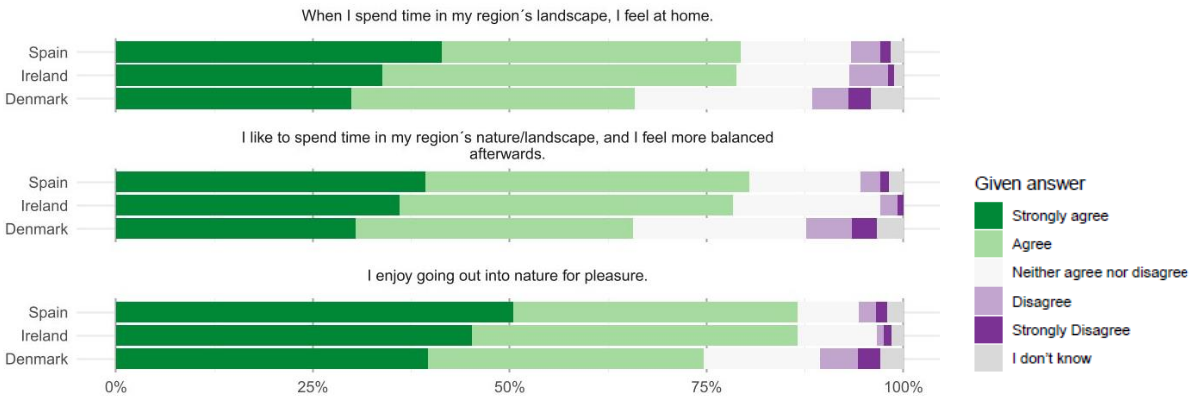
## Life frames: Living in nature




## Life frames: Living as nature



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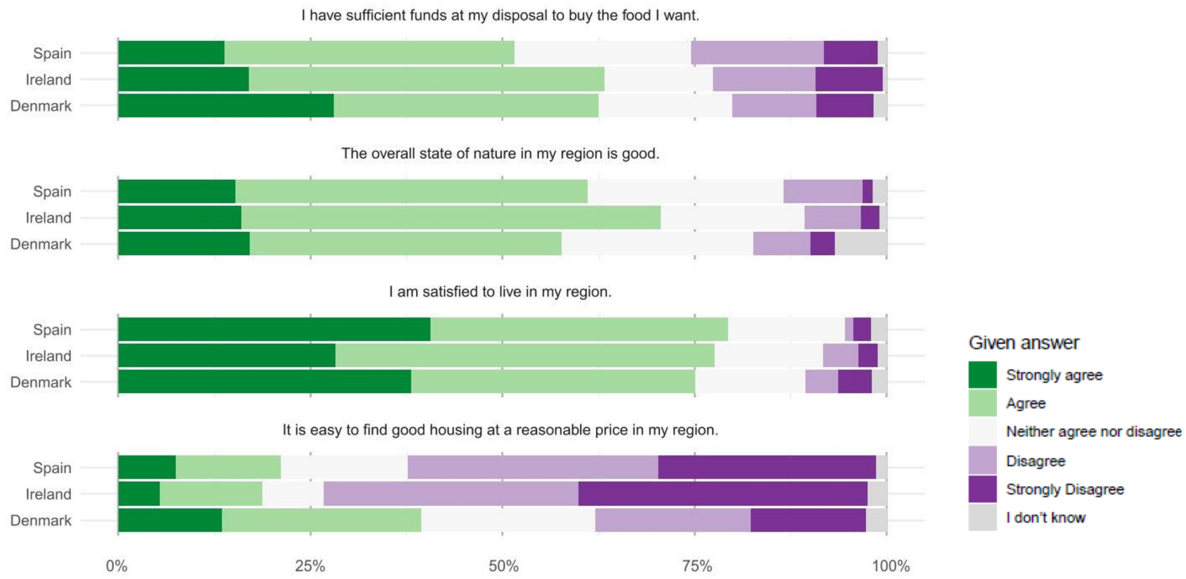
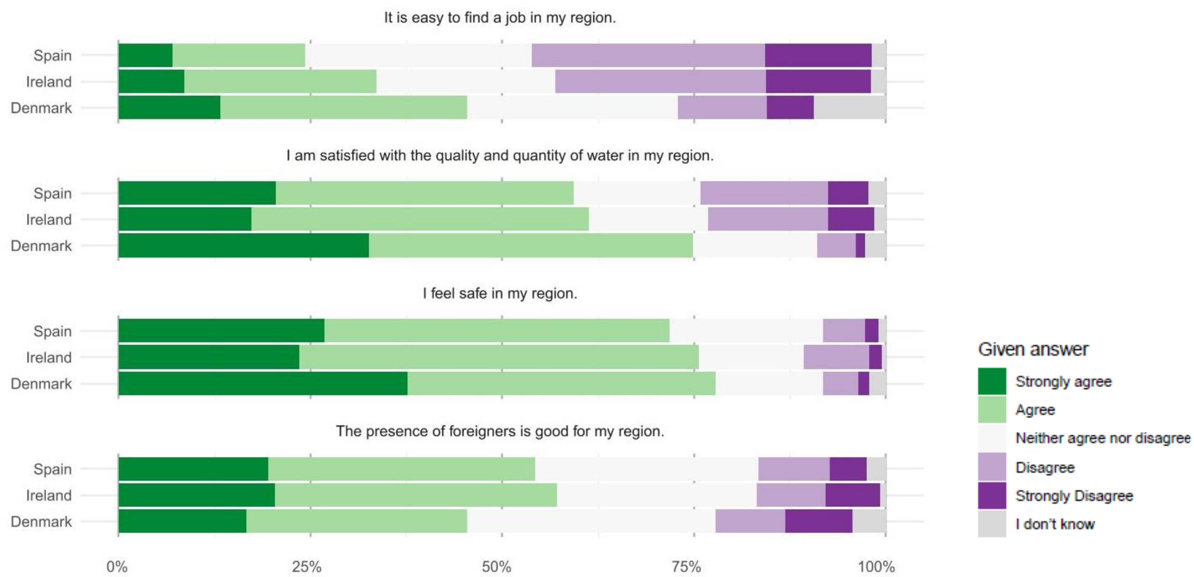
Quality of life: Access to food, water, energy and livelihood security




Quality of life: Health, good social relationship and equity, security, cultural identity and freedom of choice and actions



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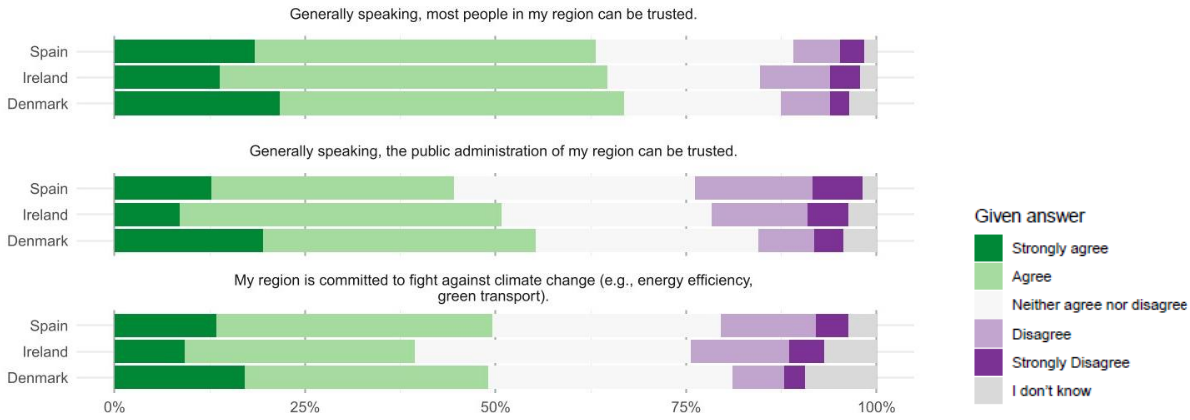
Quality of life: Living in harmony with nature, living-well in balance and harmony with mother earth and human well being



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