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# Citizens' willingness to support farmers' adoption of low crude protein diet in pig production

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A R T I C L E I N F O

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A B S T R A C T

Livestock farming has a detrimental effect on the environment since it generates a lot of gas emissions. In pig farming, the use of feed is among the substantial sources of animal farm emissions among the European Union. Nevertheless, the use of Low Dietary Crude Protein (LCP) may reduce the environmental impacts of pig farming and provide diverse ecosystem services (ESs). Concurrently, these pig diets alternatives may result more expensive than the conventional ones, which may negatively affect farmers' intention to adopt these alternatives. Citizens' payment for ESs may be a viable strategy to motivate farmers to implement more sustainable pig diets. The primary objective of this study is to assess the extent to which citizens of Catalonia (Spain) are willing to pay for the ESs generated by the implementation of a LCP diet in pig production. In pursuit of this goal, we conducted an online survey among 501 citizens, including a Discrete Choice Experiment. Participants evaluated three feed scenarios, and their choices were scrutinized using conditional logit model. Results revealed that citizens prefer the new pig diets, including both LCP and Very LCP (VLCP) diets, over the conventional pig diet. However, there is a clear preference toward the VLCP diet justified by their willingness to pay (WTP) of €67/year/adult.

## 1. Introduction

During the previous couple of decades, worldwide livestock systems have shifted from regional, small-scale, mixed crop–livestock systems to global, demand-driven supply chains, where animals are frequently separated geographically from the production of the feed they consume. These modifications, which are mostly the result of economic opportunities, have changed how livestock farming affects the environment and thereby threaten environmental and human health [1].

Livestock farming has been implicated in increasing greenhouse gas (GHG) emissions into the atmosphere [1,2]. In particular, it is asserted to significantly contribute to emissions of nitrates, Ammonia (NH3), Nitrous Oxide (N2O), and Methane (CH4). These

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emissions have been linked to air quality problems, such as atmosphere warming (CH4 and N2O); water problems, like freshwater (P) and marine (N) eutrophication; and soil quality issues, such as acidification of soils (NH3). According to the Global Livestock Environmental Assessment Model (GLEAM) developed by FAO [3], emissions from livestock farming are generated from three principal processes: Enteric fermentation (feed digestion), manure management, and feed production. Feed production represents the main contributor to several environmental impacts of livestock [4,5]. The use of feed is among the substantial sources of animal farm emissions among the European Union (EU); hence why environmentalists, ecologists, policymakers, and economists are paying attention to the execution of emission reduction strategies. To achieve these objectives, several initiatives have been considered, and many approaches and strategies have been applied. Some of these strategies aim to improve efficiency of livestock farming [6] and others focus on improving manure management or satisfying animal needs by using feed-grade amino acids to lower the amount of Crude Protein (CP) in the diet [5]. Since the 2000s, researchers in many countries, including Australia, Brazil, Canada, and Italy, have tended to use a Life Cycle Assessment (LCA) tool when investigating complex animal production systems such as pig production [7]. As well as the large amount of manure generated, pig production causes environmental damages in different stages of the production. Thus, optimizing feed formulations and making adjustments to feed composition may be an effective strategy from an environmental perspective. In pig diets, adjustments in feed formulations generally involve reduction in the amount of CP levels and supplementation of feed grade amino acids. Such adjustments are useful, since the use of imported Soybean (SOY), primarily from the American continent, as a protein source has received criticism for its significant environmental impact. These adjustments will enable the optimum use of some amino acids and therefore, lead to a well-balanced pig diet with a decreased amount of emissions [7].

Spain accounts for the largest percentage of pig production within the EU, comprising 22% of the total number of pigs [8]. Spain had the highest NH3 exceedance rates of all EU member states by 2017 (47%), which is a key contributor to fine Particulate Matter (PM) [9]. Hence, it is estimated that Spain might not be able to reach the NH3 targets that have been set, with a high possibility of finding fine Particulates (PM) emissions by 2030. The environmental damage of pig production systems may be reduced by adopting a Low Crude Protein (LCP) dietary plan. Particularly, such strategy would significantly reduce the emission of Carbon dioxide CO2, CH4, NH3, and PM. The adoption of the LCP diet would also help to significantly decrease the SOY's amount used to feed the pigs. Moreover, it would improve pig welfare by reducing antibiotic use and pigs' diarrhea. However, concerns about the possibility of higher feed costs remain a major issue [5,10]. The study's premise is that changing the formulation of pig feed (less protein from SOY) will lessen the environmental effects of pig production. Consequently, the use of LCP diet for feeding pigs will allow for ecosystem services (ESs) generation that are valued as the benefits produced by ecosystems; in other words, the connection between ecosystems and human welfare [11]. As a way of managing these ESs and achieving socially, economically, and ecologically desirable outcomes, payment for ESs is a potential approach that ensures financial support to protect and conserve the quality and sustainability of ESs [12–14].

This research seeks to assess citizens' willingness to pay (WTP) for the Ecosystem Services (ESs) resulting from the proposed low crude protein feed diet. This involves gauging the monetary value assigned by citizens to the sustainability of LCP in pig production, encompassing environmental, economic, and social aspects. We examine whether citizens agree with providing compensation via taxes to farmers in exchange for their improved quality of life.

The main research questions are as follows: Are citizens willing to support farmers' adoption of a LCP pig diet? How much are citizens prepared to pay for the ESs resulting from the adoption of a LCP diet in pig production? What is the profile of citizens who are willing to assist and support farmers' adoption of a LCP pig diet? To our knowledge, this study marks a pioneering effort as the first to estimate citizens' WTP for ESs resulting from making a significant change in the LCP diet in pig production system. This unique exploration opens new frontiers in environmental economics, shedding light on the economic valuation of production system changes and their implications for citizen preferences. Through this research, we are providing insights into WTP dynamics and contributing to the literature through:

- Proposing feed alternatives for pigs that are social and environmentally friendly.
- This study stands out by employing quantitative (precise numerical values) levels for the majority of attributes derived from life cycle analysis study to define the choice set. This marks a departure from the prevalent use of qualitative attributes in discrete choice experiments in most literature. This unique approach enhances our research, offering a more precise and quantitative perspective on citizens' preferences. By opting for numerical values, this study introduces a level of precision uncommon in similar investigations. This has the potential to provide citizens with exact information, leading to a more nuanced understanding of the choice set. The implications of this precision extend to their decision-making, allowing for a more refined and informed choice.
- In the Discrete Choice Experiment (DCE), citizens faced a set of choice tasks where they were invited to make tradeoff the three sustainability's aspects and dimensions (social, environmental, and economic) simultaneously when making their choices.

## 2. Methodology

This study aims to assess the WTP of Catalonian citizens for the ESs associated with the adoption of a LCP feed strategy in pig production. The adoption of the proposed feed formulation incurs an additional cost for farmers. Therefore, in the following study, we aim to determine whether citizens are willing to provide compensation to farmers in exchange for the benefits of ESs, including environmental, social, and economic aspects. The study focuses on the Catalonia framework because it represents the largest region with intensive pig production in Spain [15]. It is gaining significant interest in efforts to improve the environmental performance of pig production [16].

To achieve the aforementioned goals using a survey instrument that incorporates a DCE, we ensured data collection and questionnaire distribution by collaborating with the survey administration company that provides access to their own online panels, where participants are selected through a quota sampling technique—a non-probability method where specific quotas or targets are set for characteristics within the sample— For this study, we set a specific quota for age, gender, region, and education level., ensuring not only representativeness of the sample across the aforementioned demographic characteristics but also ensuring that participants receive and complete the survey till the end. Following this data collection procedure, respondents were randomly recruited, and data collection took place from the 13th to the October 18, 2022. The total number of collected responses was 693, including incomplete submissions, resulting in 501 valid responses and a response rate of 72.41%. Knowing that DCE is based on the Random Utility Theory (RUT) [17] and Lancaster's theory [18]. One of this model's key features is that each individual's choice can be deduced under the assumption of utility maximization since the decision-maker opts always for the alternative providing him the supreme satisfaction level.

### *2.1. Choice alternatives, attributes and levels*

In our experimental setting, the ESs represent the environmental (emissions reduction) and social benefits resulting from the farmer's adoption of an improved pig diet. The impacts on both environment and society considered in this research are taken from a study conducted by the Institute of Agri-food Research and Technology (IRTA) using LCA methodology in a standard pig farm in Catalonia. Attribute levels together with the cost attribute are used to model citizens' decisions when presented with alternatives feed scenarios. In this study two improved alternatives are proposed: LCP diet, and very LCP diet (VLCP), in addition to the current pig diet (status quo). The following attributes were selected to design the choice tasks assuming that there is no correlation between the attributes: CO2, CH4, NH3, PM, SOY, Animal Welfare (AW) and Cost attribute. The corresponding levels are displayed in Table 1.

All attributes were presented with three levels of impact for each except the AW and the monetary (Cost) attribute that were defined by two and six levels, respectively. The monetary attribute is expressed in euros (€) as an annual cost/individual (tax). The cost levels are in the range of costs found in several studies involving payment for ESs [12,13,19–22]. The selected attributes and levels were validated by IRTA experts who previously conducted the LCA study.

The choice tasks were thoroughly examined to enable a clear visual comprehension of the different attributes as shown in Fig. 1. A

**Table 1**
Choice attributes and corresponding levels.

| Attribute | Level descriptions | Alternative | Attribute | Level descriptions | Alternative |
|---|---|---|---|---|---|
| **CO2** (Kg CO2) | No change in the emissions of CO2 (3.73/kg LW). This is the effect of the conventional pig diet used in most farms in Catalonia. This is equivalent to the emissions of a diesel car over a distance of 31.08 km. | Baseline | **NH3** (kg of NH3) | No change in the Ammonia emissions (3351.85 Kg NH3). This is the effect of the conventional pig diet used in most farms of Catalonia. | Baseline |
| | A reduction of CO2 emissions (−2.83%) (3.62/kg LW). This is the effect of LCP pig diet. It is equivalent to the emissions of a diesel car over a distance of 30.16 km. | LCP | | A reduction of Ammonia emissions of −11.22% (2974.98 Kg NH3). This is the effect of LCP pig diet. | LCP |
| | A reduction of CO2 emissions of −3.59% (3.59/kg LW). This is the effect of VLCP pig diet. It is equivalent to the emissions of a diesel car over a distance of 29.91 km. | VLCP | | A reduction of Ammonia emissions of −21.98% (2614.85 Kg NH3). This is the effect of a VLCP diet. | VLCP |
| **CH4** (Kg CH4) | No change in the emissions of methane (9412.89 Kg CH4). This is the effect of the conventional pig diet used in most farms in Catalonia. | Baseline | **SOY** (%) | No change in the % of soybean intake included in all farm stages which is 12.63%. | Baseline |
| | A reduction of methane emissions of −2.43% (9183.81 Kg CH4). This is the effect of LCP diet. | LCP | | The % of soybean intake is 9.21%. A reduction of 27.07% in the use of soybean. This is the effect of LCP diet. This is the effect of LCP diet. | LCP |
| | A reduction of methane emissions of −1.01% (9317.67 Kg CH4). This is the effect of VLCP diet. | VLCP | | The % of soybean intake is 6.7%. A reduction of 46.99% in the use of soybean. This is the effect of a VLCP diet. | VLCP |
| **PM** | No change of PM emissions (4.17 E−07/kg LW disease incidence). This is the effect of the conventional pig diet used in most farms in Catalonia. | Baseline | **AW** | No change in animal welfare. | Baseline |
| | A reduction of PM emissions of −6.10% (3.92 E−07/kg LW) disease incidence). This is the effect of LCP diet. | LCP | | There is an improvement in animal welfare by way of a reduction in diarrhea and antibiotic use. This may be the effect of a LCP/VLCP diet. | LCP and VLCP |
| | A reduction of PM emissions of −11.48% (3.69 E−07/kg LW disease incidence). This is the effect of a VLCP diet. | VLCP | **Cost** (€) | €0/year if no change is made and farmers keep the use of the conventional pig diet | Baseline |
| | | | | 30€/year; 60€/year; 90€/year; 120€/year; 150€/year. | LCP and VLCP |

CO2: Carbon dioxide; NH3: Ammonia; N2O: Nitrous Oxide; CH4: Methane; PM: Particulate Matter; SOY: soybean; AW: animal welfare; Cost: the monetary attribute representing an annual individual cost or tax; LCP: Low Crude Protein; VLCP: Very Low Crude Protein; LW: life weight; km: kilometer; kg: kilogram; €: euros.

short cheap talk script was provided to respondents to reduce the hypothetical bias in the DCE.

This figure displays a sample choice set used in the DCE to figure out citizens' preferences for a pig diet alternative. Each column represents a hypothetical option and participants are asked to choose their preferred option from the three ones with varying attributes (CO2, CH4, NH3, SOY, AW, and Cost) and levels. Thus the experiment aims to assess the relative importance of these attributes in influencing citizens' decisions in payment for ecosystem services resulting from choosing one of the alternatives.

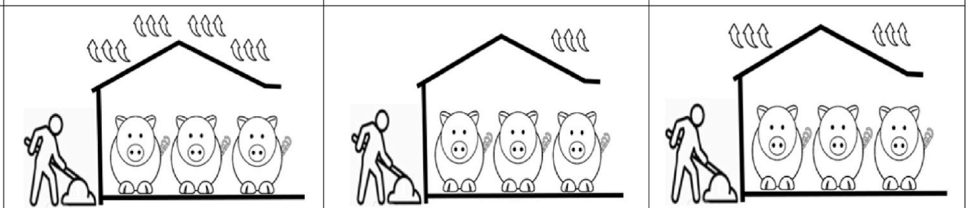
An efficient design (*D error* = 0.172) with 12 choice sets was generated using the software Ngene and displayed for each citizen. Based on the CE paradigm, citizens in a hypothetical setting were requested to make a tradeoff between the options and designate their favorite one [23].

## 2.2. Description of the survey instrument

The survey was conducted online and administered to a representative sample of 501 citizens from Catalonia. The survey consists of five sections: the first section includes questions on the buying, consumption habits and frequencies regarding pork meat. The second section includes the knowledge on pig production. The third section deals with the DCE part. The fourth section deals with questions on environmental issues, sustainability attitudes, animal welfare attitudes, and opinion on trusting policymakers. The final section includes socio-economic questions.

## 2.3. Model specification

There are various econometric frameworks to examine DCE data, knowing that the mixed logit model is the most general and standard statistical model. Similarly, the Conditional Logit Model (CLM) is also among the most commonly used random utility maximization models that assumes both Lancaster's theory and the RUT [24]. Although, in a CLM the set of options for each individual is considered a unit of analysis, so the alternatives' characteristics (levels) are the explanatory variables [25]. Furthermore, it's is grounded in the assumption of independence of irrelevant alternatives, where the probability of choosing one alternative over another

| | Actual pig diet | Pig diet 1 | Pig diet 2 |
|---|---|---|---|
| Climate change (CO2) | 3.73 / Kg live weight (equivalent to the emissions of a diesel car when it travels 31.08 km). | 3.59 Kg live weight (a reduction of -3.59% equivalent to the emissions of a diesel car when it travels 29.91 km). | 3.73 / Kg live weight (equivalent to the emissions of a diesel car when it travels 31.08 km). |
| Methane (CH4) | 9412.89 Kg CH4. | 9317.67 Kg CH4 (a reduction of -1.01%). | 9183.81 Kg CH4 (a reduction of -2.43%). |
| Ammonia (NH3) | 3351.85 Kg NH3. | 2974.98 Kg NH3 (a reduction of -11,22%). | 3351.85 Kg NH3. |
| (PM) | 4.17 E-07 disease incidence. | 3.69 E-07 disease incidence (a reduction of -11,48%). | 4.17 E-07 disease incidence. |
| % of Soybean included in the pig diet | 12.63% of the diet ingredients. | 6.7% (a reduction of the -46.99%). | 9.21% (a reduction of- 27.07%). |
| Animal welfare | No change | There is an improvement in animal welfare through a reduction of diarrhea and antibiotic use. | There is an improvement in animal welfare through a reduction of diarrhea and antibiotic use. |
| |  | | |
| Cost (€/ year) | €0 | €150 | €30 |

This figure displays a sample choice set used in the DCE to figure out citizens' preferences for a pig diet alternative. Each column represents a hypothetical option and participants are asked to choose their preferred option from the three ones with varying attributes (CO2, CH4, NH3, SOY, AW, and Cost) and levels. Thus the experiment aims to assess the relative importance of these attributes in influencing citizens' decisions in payment for ecosystem services resulting from choosing one of the alternatives.

**Fig. 1.** Example of a choice set.

is not influenced by the presence of additional alternatives. The model also assumes homoscedasticity of error terms and a linear relationship between the log-odds of choice and explanatory variables. While CLM has notable strengths, including its widespread use and value, it is not without limitations. The assumption of homogeneity of preferences within a group may not fully capture individual diversity, however in this study the CLM proves to be an adequate model. This is because our objective is to estimate the average WTP for ESs resulting from the adoption of a feed diet in pig production with lower crude proteins and the study sample size is relatively small. Additionally, CLM is primarily designed for discrete choices and may not be optimal for scenarios with numerous alternatives. Despite these limitations, we recognize the importance of understanding and addressing these aspects in our study.

In this model, the utility of individual *n* for alternative *i* at a given situation *t* is specified as follows:

$$U\ nit = \beta Xnit + \varepsilon nit \tag{1}$$

Where *Xnit* is the vector of the characteristics of pig diet *i* selected by citizen *n* on the *t*th choice card. β is the vector of parameters associated with the characteristics of pig diet and they represent the average preference weight of each attribute within the utility function. Additionally, we assume that the random disturbances ($\varepsilon$nit) are independently and identically distributed (IID) among the alternatives and throughout the population. Choice behavior can only be inferred probabilistically, since the error term is not observed. The likelihood that an individual selects option *i* from the available options within a choice set can be defined as

$$P\ (i|Cn) = P\ (Uni > Unj) = P\ (vi + \varepsilon i > vj + \varepsilon j), \forall j \epsilon Jn \tag{2}$$

Rearranging equation (2) shows that choices are made based on the variance and differences in utilities resulting from various alternatives, as illustrated in equation (3):

$$\mathrm{P}\ (\mathrm{i}|\mathrm{C_{n)}} = \mathrm{P}\ (\mathrm{v_i} - \mathrm{v_j} > \ \varepsilon_\mathrm{j} - \varepsilon_\mathrm{i}), \forall \mathrm{j} \epsilon \mathrm{J_n} \tag{3}$$

To analyze the DCE's data, citizens' responses were modeled using the CLM, in addition, to the use of a simulated maximum likelihood estimator. Applying a conditional on vector βn in equation (1), we define, as illustrated in equation (4), the probability that citizen *n* chooses alternative *i* in the *t*th choice is defined by the following formula:

$$P\ (choice_{nt} = i) = \frac{\exp\ (\beta'\ \mathrm{Xnit})}{\sum_{i=1}^{i} \exp\ (\beta'\ \mathrm{Xnit})} \tag{4}$$

The data was adjusted by applying effect coding to the different attributes' levels (except AW and cost attributes) and setting the status quo as a reference level. The AW attribute is coded as a dummy variable and the cost attribute is a continuous variable. In the initial stage of the analysis, a baseline CLM which includes only the attributes and an "status quo" Alternative specific constant (ASC) was estimated. The utility function for this analysis included the following variables: PRICE (the cost attribute), CO2LCP (carbon dioxide associated with the low crude protein diet), CO2VLCP (carbon dioxide associated with the low crude protein diet), CH4LCP (methane attribute associated with the low crude protein diet), CH4VLCP (methane attribute associated with the very low crude protein diet), PMLCP (particulate matter attribute associated with the low crude protein diet), PMVLCP (particulate matter attribute associated with the very low crude protein diet), NH3LCP (ammonia attribute associated with the low crude protein diet), NH3VLCP (ammonia attribute associated with the very low crude protein diet), SOYLCP (soybean attribute associated with the low crude protein diet), SOYVLCP (soybean attribute associated with the very low crude protein diet), AW1 (animal welfare attribute), and ASC1 (the alternative specific constant). In the second stage of the analysis, an extended CLM which includes the most relevant participants' characteristics was estimated to check the heterogeneity in the preferences. Table 2 shows the descriptive statistics of the new variables included in the model. These variables are introduced as a product of the variable and the ASC. The utility function for this analysis includes the same variables used in the first stage, plus the following variables: FEMASC1 (interaction effect of female participants' variable and the alternative specific constant), RURASC1 (interaction effect between the variable representing citizens from rural/suburban areas and the ASC), LVSTASC1 (interaction effect between the livestock impact belief variable and the ASC), HPASC1 (interaction effect of the variable representing participants motivated to pay 10% premium for eco-friendly food products with the ASC), WTPASC1 (interaction effect of between the variable representing willingness to pay for high prices and the ASC), ENVASC1 (interaction effect of participants' pro-environmental attitudes variable and the ASC), and AWASC1 (interaction effect of animal welfare variable and the ASC).

S.D: standard deviation; FEMALE: female participants; RURAL: de citizens from rural/suburban areas; LVST: people believing that

**Table 2**
Description of the variables included in the model.

| Variable | Description |
|---|---|
| FEMALE | A dummy variable. It takes the value 1 if the participant is a female, 0 otherwise. |
| RURAL | A dummy variable. It takes the value 1 if the participant is from a rural or suburban area, 0 otherwise. |
| LVST | 7-pts Likert-scale (1″Strongly Disagree' to 7″Strongly Agree"). |
| HPA | 7-pts Likert-scale (1″Strongly Disagree' to 7″Strongly Agree") |
| WTP | 7-pts Likert-scale (1″Strongly Disagree' to 7″Strongly Agree") |
| ENVATT | NEP scale. Average score. |
| AWA | Animal welfare scale. Average score. |

livestock is a major contributor to serious environmental problems; HPA: citizens motivated to pay 10% premium for food products with eco-friendly manner of production and packaging; WTP: motivated people who willing to pay more preponderant prices for products with the aim of protecting the environment; ENVATT: participant with pro-environmental attitudes; AW: participant with pro-animal welfare attitudes.

### 2.4. Marginal willingness to pay (MWTP)

Discrete Choice Models (DCM) are widely used to assess individual's WTP for ESs. In this research, two types of MWTP are calculated. The first type represents the MWTP for the attributes, and the second represents the MWTP for the improved options. The estimated coefficients (β) are used to assess the MWTP for the attributes. The estimated MWTP for an attribute *K* is the negative of the ratio of the parameter associated with the attribute *k* ($\beta_k$) and the cost parameter ($\beta_c$), all else remaining constant [26] (equation (5)).

$$\text{MWTP (Attribute K)} = -\beta_k/\beta_c \tag{5}$$

The MWTP for the improved diets (LCP/VLCP) is calculated by dividing the marginal utility of each diet ($MU_{diet}$) over the marginal utility of the cost attribute ($b_c$) (equation (6)).

$$\text{MWTP (diet)} = -(MU_{diet}) \Big/ b_c \tag{6}$$

## 3. Results and discussion

### 3.1. Descriptive statistics

The demographic part of the results is in total accordance with a Spanish representative sample. Table 3 displays a summary of the sample's characteristics. Males and females make up almost equal percentages of the sample. The 63.4% of the sample are under 55 years old and nearly two-fifths (39.4%) of the participants have a monthly household net income of between €2001 and €3500.

Most (89.8%) of the sample are pork meat consumers. Regarding to participant's knowledge on pig production systems, results suggest that on a 7-point Likert scale 86% report knowing (Extremely knowledgeable, very knowledgeable, knowledgeable, moderately knowledgeable, somewhat knowledgeable, and very slightly knowledgeable) about the pig production system. The idea that the livestock sector is an important contributor to significant environmental issues was agreed (strongly agree, agree, somewhat agree) by 45.4% of the participants.

#### 3.1.1. NEP scale

We conduct an explanatory factor analysis, and the outcomes of the Kaiser–Meyer–Olkin (KMO) test ($0.880 > 0.5$) and Bartlett's test of sphericity ($p < 0.001$) showed that the variables are adequate to run the analysis. Citizens' environmental attitudes (NEP scale of 16 items) are aggregated into two factors, and together they explain 47.37% of the overall variance (Table A1, Appendix A). The first factor comprised nine pro-environmental variables (Table A2, Appendix A). This factor is labeled "ecocentric attitudes/perspectives towards sustainable environment," since it recognizes inherent value across the entirety of nature and adopts a broader overview of the world. The second factor comprised seven anti-environmental variables (Table A2, Appendix A). This factor is labeled "an

**Table 3**
Characteristics of the sample.

| Variable | | % | Freq. | Variable | | % | Freq. |
|---|---|---|---|---|---|---|---|
| **Gender** | Men | 49 | 244 | **Income (€)** | To 600 | 3.93 | 20 |
| | Women | 51 | 256 | | 600–1000 | 4.26 | 21 |
| **Age** | 18–24 | 10.36 | 52 | | 1001–1500 | 10.33 | 52 |
| | 25–34 | 13.68 | 68 | | 1501–2000 | 13.28 | 66 |
| | 35–44 | 19.25 | 96 | | 2001–2500 | 14.59 | 73 |
| | 45–54 | 18.76 | 94 | | 2501–3000 | 14.10 | 70 |
| | 55–64 | 15.09 | 75 | | 3001–3500 | 11.48 | 57 |
| | 65–99 | 23 | 114 | | 3501–4000 | 10.16 | 51 |
| **Pork consumer** | Yes | 89.8 | 450 | | | | |
| | No | 10.2 | 51 | | | | |
| **Study level** | Student of compulsory secondary education. | 0.67 | 3 | | 4001–5000 | 9.67 | 48 |
| | Student at bachelor level. | 0.79 | 4 | | 5001–8000 | 6.72 | 34 |
| | Student of vocational training medium grade. | 3.03 | 15 | | More than 8000 | 1.64 | 8 |
| | Student of vocational training upper grade. | 8.43 | 42 | **Province** | Barcelona | 73.63 | 368 |
| | Student of the social guarantee program. | 1.01 | 5 | | Tarragona | 10.73 | 54 |
| | College student. | 22.70 | 113 | | Girona | 10 | 50 |
| | Graduate student. | 4.04 | 20 | | Lleida | 5.63 | 28 |
| | Master's student. | 15.96 | 80 | **n** | | 100 | 501 |
| | Ph.D. student. | 3.93 | 20 | | | | |
| | Other. | 39.44 | 197 | | | | |

n: sample size; €: euros; %: percentage; Freq: frequency.

anthropocentric attitude towards sustainable environment". The findings of the factor analysis are in complete accordance with those of Rahmani et al. [27].

### 3.1.2. AW scale

Similarly, for the same objectives, we used explanatory factor analysis of the AW scale, which includes 11 items; however, by means of the aforementioned analysis, two items were removed (items 4 and 11), because of their irrelevance. Then, the scale is reduced to nine items instead of 11. The results of the Kaiser–Meyer–Olkin (KMO) test (0.848) and Bartlett's test of sphericity ($p < 0.001$) confirmed that the variables were adequate to run the factor analysis. Therefore, two factors were identified, and together they explain half of the variance (52.44%) (Table A3, Appendix A). The first factor consisted of five items (2, 3, 6, 7, and 10) (Table A4, Appendix A). This factor is labeled "anthropocentric attitude towards AW." For the second factor, there were four AW items (items 1, 5, 8, 9). This factor is labeled "ecocentric attitudes towards AW".

In the DCE analysis, results on how frequently a particular alternative is selected in the DCE show that the most chosen option (44.13%) is the VLCP diet, followed by the LCP alternative (38.06%), meaning that Catalan citizens are inclined to accept the switch from the actual pig diet to the improved alternatives.

## 3.2. Conditional logit model estimation results

The CLM provides the average effect of pig diet attributes on citizens' decisions. The estimated coefficients of the CLM are reported in Table 5.

In the preliminary stage analysis, the CLM includes the diet attributes and the alternative specific constant (ASC) that takes the value 1 for improved diets, and 0 otherwise. The results revealed that all the attribute coefficients have the expected signs and most of them are statistically significant (high significance level at 1%), as shown in column 2 of Table 4, except the CO2, CH4. And SOY attributes associated with the LCP diet (CO2LCP, CH4LCP, and SOYLCP) that are not significant and for which citizens attach less importance. The respondents' preferences for reductions in CO2, CH4, PM, NH3, SOY and increasing in AW are shown by the positive sign of the coefficients in both feed scenarios (LCP and VLCP). Moreover, the high statistical significance and the positive sign demonstrate that the aforementioned attributes increase significantly the likelihood of selecting an improved option.

Generally, impacts coefficients associated with high reductions (VLCP diet) are always better in terms of magnitude and significance (high significance at 1% level). Specifically, the AW attribute have the highest coefficient, followed by the CO2 attribute (CO2VLCP), Ammonia attribute (NH3VLCP), Methane attribute (CH4VLCP), Soybean attribute (SOYVLCP), and Particulate Matter attribute (PMVLCP), all of which are associated with the VLCP diet. The great importance given to the AW and CO2 attributes may be due to the fact that citizens are more aware of AW and CO2 emissions than the other attributes. The coefficients of the PM attribute associated with both the LCP (PMLCP) and the VLCP diets (PMVLCP) are statistically significant at 1% level, with the PMVLCP coefficient being the higher. This means that higher reductions in PM emissions are highly valued by citizens. Similarly, for NH3, both parameters associated with the LCP (NH3LCP) and the VLCP (NH3VLCP) diets are statistically significant, with the NH3VLCP coefficient being the highest. This means that Catalan citizens exhibit a greater interest when the NH3 emission reductions are greater. However, the coefficient associated with the VLCP diet for SOY attribute (SOYVLCP) is highly significant while, this is not the case for the one associated with the LCP diet (SOYLCP). These findings suggest that small reduction in the amount of SOY used to feed pigs are not relevant for citizens. In contrast, greater reduction in the use of SOY is preferred, since it reduces environmental emissions.

Therefore, high benefits (associated with the VLCP diet) are more appreciated by citizens than low benefits (associated with the LCP diet). The cost attribute coefficient is negative and highly significant at 1% level. This means that cost and utility are inversely correlated, indicating that increments in the cost parameter decrease the probability of choosing the alternative in question. This is in complete accordance with the economic theory of demand. The positive sign of the ASC suggests that citizens prefer the improved alternatives (diet 1 and 2) over the actual pig diet.

**Table 4**
Descriptive statistics of the variables included in the model.

| Variable | Mean | S.D | Min | Max |
|---|---|---|---|---|
| FEMALE | 0.512 | 0.499 | 0.0 | 1.0 |
| RURAL | 0.279 | 0.448 | 0.0 | 1.0 |
| LVST | 4.243 | 1.667 | 1.0 | 7.0 |
| HPA | 3.650 | 1.783 | 1.0 | 7.0 |
| WTP | 4.297 | 1.861 | 1.0 | 7.0 |
| ENVATT | 74.784 | 12.058 | 31.0 | 100.0 |
| AWA | 39.201 | 9.930 | 7.0 | 58.0 |

S.D: standard deviation and pts denotes points; Min: minimum; Max: maximum; FEMALE: female participants; RURAL: de citizens from rural/suburban areas; LVST: people believing that livestock is a major contributor to serious environmental problems; HPA: citizens motivated to pay 10% premium for food products with eco-friendly manner of production and packaging; WTP: motivated people who willing to pay more preponderant prices for products with the aim of protecting the environment; ENVATT: participant with pro-environmental attitudes; AW: participant with pro-animal welfare attitudes.

**Table 5**
CLM estimated coefficients and WTP results (first stage of the analysis).

| Variable | Coefficient | S.E | z | Prob \|z\|>Z* | 95% C.I | |
|---|---|---|---|---|---|---|
| PRICE | −0.02863*** | 0.004 | −7.06 | 0.000 | −0.036 | −0.020 |
| CO2LCP | 0.0379 | 0.031 | 1.20 | 0.229 | −0.023 | 0.099 |
| CO2VLCP | 0.532*** | 0.078 | 6.76 | 0.000 | 0.378 | 0.687 |
| CH4LCP | 0.006 | 0.029 | 0.21 | 0.834 | −0.050 | 0.062 |
| CH4VLCP | 0.451*** | 0.082 | 5.47 | 0.000 | 0.289 | 0.613 |
| PMLCP | 0.141*** | 0.040 | 3.47 | 0.000 | 0.061 | 0.221 |
| PMVLCP | 0.312*** | 0.066 | 4.68 | 0.000 | 0.181 | 0.443 |
| NH3LCP | 0.109*** | 0.036 | 3.00 | 0.002 | 0.037 | 0.181 |
| NH3VLCP | 0.494*** | 0.090 | 5.44 | 0.000 | 0.316 | 0.672 |
| SOYLCP | 0.033 | 0.039 | 0.85 | 0.394 | −0.043 | 0.110 |
| SOYVLCP | 0.381*** | 0.062 | 6.10 | 0.000 | 0.259 | 0.504 |
| AW1 | 1.101*** | 0.108 | 10.16 | 0.000 | 0.889 | 1.314 |
| ASC1 | 0.136* | 0.072 | 1.88 | 0.059 | −0.005 | 0.278 |
| **WTP for Attributes** | | | | | | |
| (CO2LCP) | 1.325 | 1.235 | 1.07 | 0.283 | −1.095 | 3.746 |
| (CO2VLCP) | 18.609*** | 1.048 | 17.75 | 0.000 | 16.554 | 20.664 |
| (CH4LCP) | 0.211 | 1.089 | 0.19 | 0.845 | −1.923 | 2.346 |
| (CH4VLCP) | 15.778*** | 1.398 | 11.28 | 0.000 | 13.036 | 18.520 |
| (PMLCP) | 4.952*** | 1.417 | 3.49 | 0.000 | 2.174 | 7.729 |
| (PMVLCP) | 10.930*** | 1.404 | 7.78 | 0.000 | 8.178 | 13.683 |
| (NH3LCP) | 3.828*** | 1.431 | 2.67 | 0.007 | 1.023 | 6.633 |
| (NH3VLCP) | 17.258*** | 1.204 | 14.33 | 0.000 | 14.898 | 19.619 |
| (SOYLCP) | 1.168 | 1.442 | 0.81 | 0.418 | −1.659 | 3.996 |
| (SOYVLCP) | 13.333*** | 1.245 | 10.71 | 0.000 | 10.892 | 15.774 |
| (AW) | 38.489*** | 2.704 | 14.23 | 0.000 | 33.187 | 43.790 |
| **WTP for the LCP Diet** | | | | | | |
| (LCP) | €2.039 | 6.167 | 0.33 | 0.740 | −10.047 | 14.127 |
| **WTP for the VLCP Diet** | | | | | | |
| (VLCP) | €69.170 *** | 4.995 | 13.85 | 0.000 | 59.380 | 78.961 |

***, **, *: significance at the 1%, 5%, 10% level, respectively; C.I: confidence interval; S.E: the standard error; €: euros; WTP: willingness to pay; LCP: low crude protein; VLCP: very low crude protein.

### 3.3. *WTP for the attributes and proposed feed scenarios*

The final section of Table 4 presents the WTP estimates for all attributes and improved diets (LCP and VLCP). All of the WTP results for the attributes associated with the LCP and VLCP diet (CO2VLCP, CH4VLCP, PMLCP, PMVLCP, NH3LCP, NH3VLCP, SOYVLCP, and AW) are positive as expected. Most of WTP estimates are statistically significant at 1% level. However, this was not so for some attributes associated with the LCP diet, namely CO2LCP, CH4LCP, and SOYLCP meaning that the respondents are not willing to pay for

**Table 6**
CLM estimated coefficients (second stage of the analysis).

| Variable | Coefficient | S.E | z | Prob \|z\|>Z* | 95% C.I | |
|---|---|---|---|---|---|---|
| PRICE | −0.032*** | 0.004 | −7.46 | 0.000 | −0.041 | −0.023 |
| CO2LCP | 0.036 | 0.031 | 1.14 | 0.254 | −0.026 | 0.099 |
| CO2VLCP | 0.602*** | 0.083 | 7.19 | 0.000 | 0.437 | 0.766 |
| CH4LCP | −0.005 | 0.029 | −0.20 | 0.842 | −0.063 | 0.052 |
| CH4VLCP | 0.518*** | 0.087 | 5.93 | 0.000 | 0.347 | 0.690 |
| PMLCP | 0.151*** | 0.041 | 3.62 | 0.000 | 0.069 | 0.233 |
| PMVLCP | 0.360*** | 0.070 | 5.14 | 0.000 | 0.223 | 0.498 |
| NH3LCP | 0.107*** | 0.037 | 2.86 | 0.004 | 0.034 | 0.181 |
| NH3VLCP | 0.578*** | 0.097 | 5.96 | 0.000 | 0.388 | 0.768 |
| SOYLCP | 0.033 | 0.040 | 0.83 | 0.406 | −0.045 | 0.111 |
| SOYVLCP | 0.433*** | 0.066 | 6.54 | 0.000 | 0.303 | 0.563 |
| AW1 | 1.204*** | 0.115 | 10.42 | 0.000 | 0.977 | 1.431 |
| ASC1 | −4.552*** | 0.252 | −18.02 | 0.000 | −5.047 | −4.057 |
| **FEMASC1** | 0.350*** | 0.077 | 4.53 | 0.000 | 0.198 | 0.502 |
| **RURASC1** | 0.329*** | 0.087 | 3.79 | 0.000 | 0.159 | 0.500 |
| **LVSTASC1** | 0.113*** | 0.024 | 4.66 | 0.000 | 0.065 | 0.160 |
| **HPASC1** | 0.146*** | 0.030 | 4.82 | 0.000 | 0.087 | 0.206 |
| **WTPASC1** | 0.216*** | 0.027 | 7.89 | 0.000 | 0.162 | 0.269 |
| **ENVASC1** | 0.025*** | 0.003 | 7.72 | 0.000 | 0.019 | 0.032 |
| **AWASC1** | 0.019*** | 0.004 | 4.58 | 0.000 | 0.011 | 0.028 |

***, **, *: significance at the 1%, 5%, 10% level, respectively; C.I: confidence interval; S.E: standard error; LCP: low crude protein; VLCP: very low crude protein.

small reductions associated with LCP diet and place greater value on the VLCP diet, especially for those attributes. Hence, they are not willing to pay for small reductions of CO2, CH4, and SOY.

The findings revealed some differences in the WTP estimates between the different attributes included in both scenarios. For each attribute, a high difference in WTP estimates between the LCP and VLCP diets is registered, being the WTP estimates for the adoption of VLCP diet the highest ones.

The highest significant WTP corresponds to the improvement of AW attribute. In particular, citizens are willing to pay €38.48 for pigs' welfare improvement, followed by the WTP for CO2 attribute (€18.60) associated with the VLCP diet (CO2VLCP). The WTP for high reduction of 21.98% in NH3 emissions (NH3VLCP) corresponds to the following highest WTP with an amount of €17.25. Moreover, citizens are ready to pay €15.77 for high reduction of Methane (CH4VLCP) and €13.33 for high reduction in SOY (SOYVLCP). In addition, citizens are ready to pay €10.93 for high reduction of PM (PMVLCP). On average, citizens are willing to pay €69.17/year/adult for the implementation of a VLCP diet; however, their WTP for the LCP diet is not statistically significant. This means that citizens are ready to encourage the diets' implementation that lead to significant reduction of environmental emissions but are not in favor of diets with lower reductions. Therefore, WTP results of this research imply that the VLCP diet is more valued by citizens than the LCP diet even though the cost to implement it is greater. This means that they expect to gain higher level of utility and derive a more direct benefit from the VLCP diet.

Findings of the second-stage analysis are displayed in Table 6. The results showed that all coefficients associated with individual specific variables are statistically significant at 1% level with the expected signs, revealing that there are heterogeneous preferences for the improved diets according to the individual variables. Results revealed that the respondents most likely to select either of the improved diets are those related to the following variables, in order of decreasing likelihood, as follows: FEMASC1, RURASC1 WTPASC1, HPASC1 LVSTASC1, ENVASC1 AWASC1.

Specifically, female participants (FEMASC1), citizens from rural/suburban areas (RURASC1), citizens who think that the livestock is one of the significant causes to severe environmental issues (LVSTASC1), incentivized people to pay more preponderant prices for products generally with the aim of protecting the environment (WTPASC1), and citizens motivated to pay prices 10% higher than actual prices of food products produced and packaged in a less environmentally damaging way (HPASC1) are in favor of adopting an improved pig diet and making some adjustments in the current one. Similarly, participants with pro-environmental attitudes (ENVASC1) and pro-animal welfare attitudes (AWASC1) are supporting the adoption of a low CP pig diet.

DCEs are grounded in both Random Utility Theory (RUT), a foundational framework for understanding decision-maker behavior that posits individuals behave as if they are maximizing rational preferences over a given set of choices. Additionally, DCEs draw from Lancaster's theory, which suggests that consumers seek the optimal choice providing the highest utility within budget constraints.

In the context of this study, citizens served as decision-makers, thoughtfully evaluating all attributes and associated levels of the proposed low crude protein feed alternatives (LCP & VLCP). They engaged in a trade-off between the three scenarios, ultimately expressing a preference for the very low crude protein (VLCP) pig diet. This decision implies that the total utility associated with the VLCP feed diet was decomposed into separate utilities corresponding to each attribute. The result was the highest utility, indicating a willingness to contribute nearly €70/individual/year.

In general, ESs are resources that belong to a common pool and can be valued, as evidenced through WTP. Many studies have assessed consumers', citizens', and even tourists' WTP for different ESs. The study's outcomes are consistent with those of Petcharat et al. [12], who sought to estimate the non-market value of ESs in Thailand's Kachao Green Area. Bangkok citizens were prepared to spend 1.436 Baht (€38.57/year) for improved ESs in that area. Our findings are also in line with those of Jo et al. [20]. In that study, researchers aimed to determine the highest ES (soil ES) price that citizens of New South Wales, Australia, could be willing to pay based on two alternative financial resource types (taxes/donations). The findings showed that the participants' MWTP in the form of taxes is 20.126 KRW (€16.73) annually. While, participants are prepared to spend 26.518 KRW (€21.95) annually for donations. These citizens were therefore prepared to pay for ESs; however, the amount paid for ESs was higher when the financial resource type is a donation rather than a tax.

Numerous studies have considered the payment for water ESs. Khan et al. [21] aimed to evaluate residents' awareness, attitudes, and perceptions regarding environmental and water resource issues and to assess their WTP for enhancing specific attributes of the Wei river basin in northwest China. Most of the respondents showed a greater concern about water resource management issues than about socioeconomic attributes. The quality of water had the greatest WTP of 91.99 RMB (€12.67/year) for a one-unit improvement in water quality. Moreover, Ureta et al. [13] assessed the estimation of residents' WTP for ES improvement in the river basin. The findings suggested that residents are prepared to pay for enhanced ESs, although their WTP varied depending on both the region in which they lived and the ES improvement type. The mean WTP for the water quality improvement was between 0 and $3/month. A study conducted by Liu et al. [22] on the Tibetan Plateau, China, showed that ESs are valued similarly throughout cultures. It was revealed that even if people had not used ESs in that area, they are willing to contribute by 882 CNY/year (€109.49) to their management and preservation. Hjerpe and Hussain [19] aimed to measure the Tongass National Forest's conservation values so that public forest management and planning would be possible. Results revealed that Alaskan households are ready to pay $147 (€135.90) for protecting half (50%) of the ancient trees already planned to be harvested in the Tongass and $154 (€142.37) to conserve the totality (100%) of the aged growth planned to reap. Finally, our results on citizens' WTP for ESs are approximately within the range of the WTP values reported in the previous studies [12,13,19–22].

The study reveals that citizens are willingness to contribute with €70/adult annually to support the adoption of a VLCP feed alternative in pig production sector. Their motivation is rooted in the aspiration to gain advantages of ESs resulting from this new feed by introducing differentiations in citizens' livelihoods. Beyond individual preferences, this finding has profound implications for ESs, as citizens' financial contributions become a crucial tool for fostering diverse ecosystems and ensuring a continuous flow of high-quality services. This approach has a positive environmental impact, leading to significant advantages such as better air quality, decreased deforestation, enhanced forest cover, improved soil and landscape quality, and healthier aquatic ecosystems all in perfect alignment with sustainability principles. At the regional level, the adoption of VLCP diet for pig production can be regarded as a supportive instrument for the conservation of ecosystem services.

## 4. Conclusion

This study sought to evaluate citizens' WTP for ESs generated by the adoption of a low crude protein pig diets (LCP and VLCP). The preferences and WTP of a representative sample of Catalan citizens were assessed using the DCE approach. Findings of DCE revealed that most of the citizens (82.19%) support the adoption of improved diets (LCP/VLCP) to lessen the environmental impacts of currently used diets, while only a small segment (17.81%) prefer to keep the diet currently used in most farms.

The CLM findings on diet selection and the MWTP for it allow us to conclude that, in general, citizens evaluate the VLCP diet higher than the LCP diet. In other words, the benefits associated with the VLCP diet are more appreciated by citizens than the benefits associated with the LCP diet; and, consequently, they are more willing to pay for this pig diet, since it does not only reduce environmental emissions such as CO2, CH4, NH3, and PM, but also reduces the amount of SOY included in the diet. In particular, citizens attach greater importance to AW attribute, followed by CO2, NH3, and CH4 attributes, then to SOY and PM attributes. This is demonstrated by the amount of money they are ready to pay for each attribute. The residents of Catalonia are willing to pay a premium price of €38.48 to improve the welfare of pigs. They are ready to pay, respectively, €18.60, €17.25, €15.77, €13.33, and €10.93 for high reductions of CO2, NH3, CH4 emissions, SOY, and PM associated with the VLCP diet. In total, the valorization of the VLCP diet was higher, which is in accordance with our expectations. Citizens of Catalonia are prepared to pay about €69/year/adult for the VLCP diet, while compared to the LCP diet, citizens' willingness to pay is not significant. This allows to conclude that citizens are willing to pay only for significant reductions of environmental emissions. The adoption of the VLCP pig diet therefore generates significant environmental benefits and reduces CO2 emissions by 3.59%, NH3 emissions by 21.98%, CH4 emissions by 1.01%, PM by 11.48%, and the amount of SOY used in the feed by 46.99%. The execution of VLCP diet will not only lead to better air quality and better livelihoods, but also decrease global warming and the reliance on imported SOY meal, since the quantity of SOY used to feed the pig will be lower.

Controlling for sociodemographic characteristics of citizens, leads to the conclusion that citizens' preferences for the implementation of LCP diets in pig production are heterogeneous. The female participants and citizens in rustic, rural, or suburban areas attach the greatest importance and have the most interest in adopting a new diet for pigs that reduces environmental emissions, followed by those who are motivated to pay greater rates for products generally with the aim of protecting the environment and those who are motivated to pay prices 10% higher than actual ones for food products produced and packaged in a less environmentally damaging manner. Given to the benefits associated with the VLCP diet implementation and its beneficial effects on the environment. Thus, the adoption of such diets in pig production is of a great interest and should be taken into consideration.

The study's outcomes may encourage farmers to adopt a low crude protein feed and at the same time help policy makers to develop some strategies like subsidies for farmers. As a further step, an Extended Cost–Benefit (ECB) analysis could be of a great interest, since it would allow for a feasibility analysis and implementation of the proposed pig diet alternative at production gate level. Moreover, policymakers may find these results to be very compelling, attractive and helpful in implementing policies for supporting farmers, such as giving them subsidies that lower their cost of production.

The study's limitations are evident in its reliance on specific outcomes, particularly the estimated WTP values, which only represent the preferences observed among Catalonia residents. Consequently, these findings may lack generalizability to the wider population of Spanish residents. Given that the population of Catalonia is known for its affinity towards local products and strong regional ties, future research could explore the replication of the study in other regions within Spain. Investigating citizens' preferences in different cities across Spain would offer a more comprehensive understanding of the nuanced variations in preferences across various regions.

### Data availability statement

There is no data associated with this study been deposited into a publicly available repository and data will be made available on request.

### CRediT authorship contribution statement

**Kenza Goumeida:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Data curation, Conceptualization. **Djamel Rahmani:** Writing – review & editing, Visualization, Software, Methodology. **Josselin Le Cour Grandmaison:** Writing – review & editing, Project administration, Funding acquisition. **José María Gil Roig:** Writing – review & editing, Validation, Project administration.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix

### *Appendix A*

**Table A.1**
Total Variance Explained.

| Component | Initial eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of variance | Cumulative % | Total | % of variance | Cumulative % | Total | % of variance | Cumulative % |
| 1 | 5.216 | 32.602 | 32.602 | 5.216 | 32.602 | 32.602 | 4.351 | 27.192 | **27.192** |
| 2 | 2.363 | 14.770 | 47.372 | 2.363 | 4.770 | 47.372 | 3.229 | 20.181 | **47.372** |
| 3 | 1.210 | 7.560 | 54.932 | | | | | | |
| 4 | 0.878 | 5.486 | 60.418 | | | | | | |
| 5 | 0.804 | 5.025 | 65.443 | | | | | | |
| 6 | 0.739 | 4.620 | 70.063 | | | | | | |
| 7 | 0.683 | 4.271 | 74.333 | | | | | | |
| 8 | 0.645 | 4.030 | 78.363 | | | | | | |
| 9 | 0.580 | 3.627 | 81.990 | | | | | | |
| 10 | 0.533 | 3.334 | 85.325 | | | | | | |
| 11 | 0.512 | 3.200 | 88.525 | | | | | | |
| 12 | 0.446 | 2.789 | 91.314 | | | | | | |
| 13 | 0.431 | 2.693 | 94.007 | | | | | | |
| 14 | 0.345 | 2.154 | 96.161 | | | | | | |
| 15 | 0.330 | 2.062 | 98.223 | | | | | | |
| 16 | 0.284 | 1.777 | 100.000 | | | | | | |

**Table A.2**
Rotated Component Matrix.

| | Components | |
|---|---|---|
| | 1 | 2 |
| Human ingenuity will ensure that we do not make the earth a place uninhabitable. | 0.140 | **0.597** |
| We are approaching the maximum number of people that earth can tolerate. | **0.508** | −0.094 |
| Earth has natural resources in abundance. We just have to learn how to exploit them. | 0.038 | **0.537** |
| Earth is like a spatial nave, with limited resources and space. | **0.468** | 0.134 |
| Despite our special skills, human beings are still subject to nature's laws. | **0.648** | 0.016 |
| Plants and animals have as many rights as human beings to exist | **0.681** | −0.094 |
| Human beings have the right to modify the environment so as to suit their needs. | −0.261 | **0.657** |
| Eventually, humans will learn how nature works, in order to be able to control it. | 0.042 | **0.711** |
| Humans severely abuse the environment. | **0.744** | −0.194 |
| When humans interfere with nature's balance, the consequences are usually disastrous. | **0.770** | −0.253 |
| Humans were created to dominate the rest of nature. | −0.271 | **0.659** |
| If nothing changes, we are soon going to experience a severe ecological disaster. | **0.722** | −0.263 |
| Nature's balance is very delicate and easily alterable. | **0.740** | −0.091 |
| The idea of humanity facing a global ecological crisis has been greatly exaggerated. | −0.288 | **0.716** |
| Nature's balance can tolerate the impact of industrialized countries. | −0.278 | **0.691** |
| In order to achieve sustainable development, a more balanced economy is required, accompanied by more controlled industrial growth in it. | **0.671** | −0.092 |

**Table A.3**
Total Variance Explained for AW concerns.

| Component | Initial eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | Total | % of Variance | Cumulative % | % of Variance | Total |
| 1 | 3.403 | 37.815 | 37.815 | 3.403 | 37.815 | 37.815 | 2.521 | 28.011 | **28.011** |
| 2 | 1.317 | 14.629 | 52.443 | 1.317 | 14.629 | 52.443 | 2.199 | 24.432 | **52.443** |
| 3 | 0.860 | 9.551 | 61.994 | | | | | | |
| 4 | 0.694 | 7.709 | 69.702 | | | | | | |
| 5 | 0.638 | 7.089 | 76.791 | | | | | | |
| 6 | 0.583 | 6.473 | 83.264 | | | | | | |
| 7 | 0.552 | 6.132 | 89.396 | | | | | | |

(*continued on next page*)

**Table A.3** (*continued*)

| Component | Initial eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | Total | % of Variance | Cumulative % | % of Variance | Total |
| 8 | 0.490 | 5.442 | 94.838 | | | | | | |
| 9 | 0.465 | 5.162 | 100.00 | | | | | | |

**Table A.4**
Rotated Component Matrix.

| | Components | |
|---|---|---|
| | 1 | 2 |
| It is totally wrong to hunt wild animals just for sport. | −0.085 | **0.727** |
| I do not think there is anything wrong with using animals in medical research. | **0.739** | −0.267 |
| I think it is perfectly acceptable that cattle and pigs are raised for human consumption. | **0.763** | −0.040 |
| Sometimes I get upset when I see animals in cages at zoos. | −0.211 | **0.678** |
| Breeding animals for fur is a legitimate use of animals. | **0.428** | −0.285 |
| Some aspects of animals can only be learned through dissecting preserved animals like cats. | **0.723** | −0.109 |
| It does not seem right that animals are used in cultural festivals. | −0.103 | **0.736** |
| The use of animals like rabbits in testing the safety of cosmetics and household products is unnecessary and it has to be stopped. | −0.255 | **0.681** |
| I agree with the use of animals for work. | **0.747** | −0.200 |

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