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Attitudes and Preferences towards Soil-Based Ecosystem Services: How Do They Vary across Space?

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Abstract: Soil ecosystem services (ES) provide multiple benefits to human well-being, but the failure to appreciate them has led to soil degradation issues across the globe. Despite an increasing interest in the threats to soil resources, economic valuation in this context is limited. Importantly, most of the existing valuation studies do not account for the spatial distribution of benefits that soil ES provide to the population. In this study, we present the results of a choice experiment (CE) aimed at investigating spatial heterogeneity of attitudes and preferences towards soil conservation and soil ES. We explored spatial heterogeneity of both attitudes and welfare measures via GIS techniques. We found that citizens of the Veneto Region (Northeast Italy) generally have positive attitudes towards soil conservation. We also find positive willingness-to-pay (WTP) values for soil ES in most of the study area and a considerable degree of heterogeneity in the spatial taste distribution. Finally, our results suggest that respondents with pro-environmental attitudes display a higher WTP based on the geographic pattern of the distribution of WTP values and attitudinal scores across the area.

Keywords: soil ES; choice experiment; preference heterogeneity

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1. Introduction

The adoption of an ecosystem service (ES) approach to land and resource management has gained considerable traction globally in the last decade, due to the increased awareness of the importance of ES for human well-being [1,2]. However, the attention given to the importance of soils in this context is still limited. The failure to fully appreciate the contributions of soils to human well-being beyond food production has led to soil degradation issues at a global scale [3,4]. Despite the increasing importance of these issues, there is still a lack of information about the economic value of soil ES, as highlighted in a recent review [5]. Furthermore, most of the existing studies adopt cost-based market valuation methods, thus disregarding the non-use component of soil ES values and failing in fully capturing the benefits that soil ES provide to society. This also affects the number of ES evaluated, which is still quite limited. Studies have pre-eminently focused on ES, the value of which can be estimated relatively straightforwardly [5] from market values, such as carbon sequestration and water quality. Some studies have considered the loss or degradation of topsoil, the replacement of this soil or the loss of productivity as a surrogate to measure the value provided by soil [6,7]. Proxies such as gross margins have been used to demonstrate the value that soil has supported [8], and more comprehensive studies have focused on replacement costs to overcome soil nutrient loss and repair physical degradation [9]. Focusing only on a few ES limits the capability of valuation studies to explore trade-offs among different services. Accounting for such trade-offs is crucial as

soils are multifunctional and it is not possible to simultaneously maximize the provision of all ecosystem services at one location. For example, increasing the food provisioning service may result in a low provision of habitats for farmland species [10].

Only a few studies have used non-market valuation methods to elicit the benefits provided by soil ES. Among these, refs. [6,11] investigated preferences towards soil erosion prevention programs in Spain. In both cases, the authors found citizens to be willing to financially support such programs. Reference [12] elicited preferences for a soil carbon program in Scotland. Reference [13] also analyzed the benefits associated with carbon sequestration in Australia, jointly with soil erosion prevention. They found citizens to be willing to pay to support carbon sequestration programs, but not preventative soil erosion ones.

The above non-market valuation literature has the main limitation of not accounting for the spatial distribution of the benefits that soil ES provide to the population. This is important because welfare estimates might vary across space due to the influence of several factors (socio-demographic, geographic, psychological traits, etc.). Measuring taste heterogeneity (i.e., how preferences for soil ES vary across the population) can have direct relevance to the design and application of public policies and provide insight into public preferences.

In the analysis of the spatial component in the study of environmental resources using discrete choice experiment (DCE) applications, two main approaches have been recognized in the literature to investigate consumer preferences: (i) spatial econometrics and (ii) spatial statistics. Spatial econometrics is a common approach that directly includes spatial variables in regression models, referring to characteristics of the goods to be valued, the geographical context or respondents' features [14,15]. Meanwhile, spatial statistics allows a comprehensive and exploratory analysis of taste patterns. This exploratory spatial data analysis can be helpful in detecting spatial heterogeneity in resident preferences for non-market valuation.

For instance, ref. [16] included geographical variables (altitude) and socio-demographic characteristics (population size and income) in the choice model to control for preference heterogeneity towards key features of heating systems in an Italian study. The findings suggest how the benefits from reducing carbon emissions can vary spatially across the study area, evidencing a wider range of preferences from respondents living in mountain areas than those from the plains. Simiilarly, ref. [17] included a variable representing the distance from respondents' location data to a recreational site with the presence of forest attributes in France (dominant tree species, recreational facilities, absence or presence of water bodies). Results provided evidence of spatial taste heterogeneity and suggested unsurprisingly how respondents prefer forests close to their residence.

Through the use of spatial statistics, ref. [18] mapped the distribution of welfare measures towards peatland restoration in Scotland and found the presence of specific patterns related to environmental attitudes, place identity beliefs and socio-demographic features. The authors found that people with more aspirational environmental attitudes and more informed place identity show higher WTP values. Furthermore, spatial statistics also allow for applying multiple analysis types for individual-specific WTP estimates, as [19] demonstrated in their seminal study. The authors provided evidence of spatial dependence of welfare estimates obtained from DCE. Using Moran's I statistic, they observed positive spatial autocorrelation among WTP values for rural landscape improvements in Ireland.

In this study we contributed, at least partially, to filling the above gaps by investigating the spatial heterogeneity of attitudes and preferences towards improving soil condition and soil ES. We used data generated via a specifically designed survey addressed to a sample of householders of the Veneto Region (Northeast Italy). The survey included several sets of attitudinal questions on soil-ES-related aspects and elicited willingness-to-pay values of several soil ES via a choice experiment approach. More specifically, the attitudinal questions aimed at measuring the degree to which citizens are aware of the need to maintain soil condition, feel a moral obligation to contribute to its conservation

and—more generally—are concerned about environmental issues. We note that such traits can be seen as indicators for the "connectivity" dimension of the soil security framework proposed by [4], which refers to the degree to which people feel connected to soil.

We investigated the spatial heterogeneity of both attitudes and welfare measures via GIS techniques. This approach allowed us to explore whether there is a link between the geographical distribution of WTP values and the distribution of attitudinal scores across municipalities. We note that the attitudinal traits do not directly refer to any specific action that citizens could perform in order to contribute to soil conservation but only measure the degree to which they feel they should act (regardless of how) in favor of preserving soil ES. On the other hand, WTP values directly measure citizens' willingness to dedicate part of their income to support policies aimed at increasing the provisioning of soil ES. Our hypothesis is that people with positive attitudes towards soil security (and are hence highly connected to it and inclined to act to maintain or improve soil condition) show positive WTP values for soil ES, i.e., that connection is one of the drivers of individuals' willingness to pay for soil conservation. High connection to soil and positive WTP values, in turn, would suggest how high attention should be afforded to preserve soil capability to generate well-being for societies.

The remainder of the paper is structured as follows: Section 2 describes the methods used in the study, and Section 3 reports our results. Finally, Section 4 discusses the results of the study, and in Section 5 we present the conclusions.

2. Materials and Methods

2.1. Study Area

Our study focuses on the valuation of benefits provided by soil ES in the Veneto Region. The region has a total area of 18,399 km^2. The Venetian plain, where most agricultural production is concentrated, covers 55% of the area. The municipalities located inside the plain are covered from 30% to 94% by agricultural areas. Figure 1 provides a characterization of the features of the study areas and depicts two maps illustrating land use and population density of each municipality of the region. According to the CORINE land cover classification, they are represented for the most part by arable land, permanent crops, pastures and heterogeneous agricultural areas (Figure 1a). The plain is also an area characterized by high population density (Figure 1b), with municipalities with more than 120 inhabitants per km^2 and 4 out of the 6 provincial administrative centers with a population density of more than 1000. More sparsely populated municipalities are found in the more mountainous northern part of the region, where the elevation can reach up to 3200 m above sea level and the presence of forest is dominant.

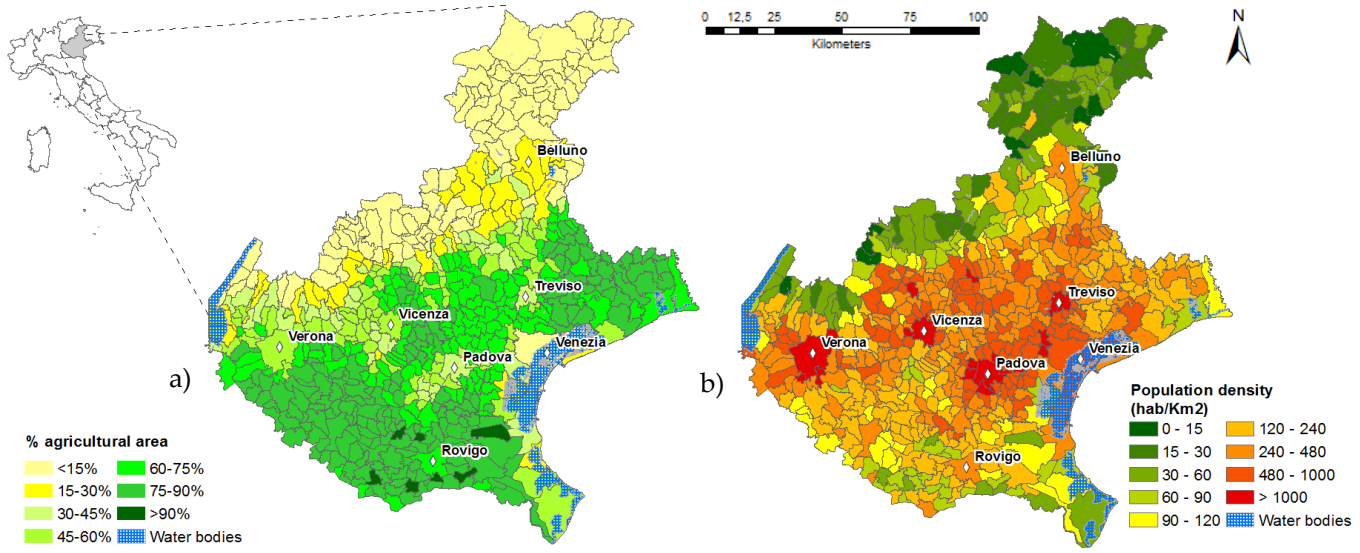

Figure 1. Localization of the Veneto Region study area and description of: (**a**) agricultural area; (**b**) population density with the denotation of the presence of water bodies. Source: [20,21].

2.2. Data Collection

Data were collected via a web-based survey addressing a sample of around 1500 householders (one individual for each family) within the Veneto region. The sample was randomly drawn from a panel provided by a market research company and was stratified according to the main socio-demographic variables (age, gender, education and income) to ensure that all the parts of the population were properly represented. The descriptive statistics of the sample that detail its stratification are reported in Table 1. Given our available budget and to ensure adequate coverage of the sampled region, we collected information from householders living in 324 out the 581 municipalities of the region. The Section 1 of the survey included a series of attitudinal questions concerning attitudes towards environmental issues and soil security. The Section 2 included the choice experiment. Finally, the Section 3 collected information about respondents' demographic and socio-economic characteristics. The two subsections below describe in detail the attitudinal questions included in the survey and the choice experiment.

Table 1. Socio-economic characteristics of respondents.

Variable	Percentage
Gender	
Man	50.4
Woman	49.6
Age (years)	
<20	3.5
20–39	29.5
40–59	44.8
>60	22.1
Education	
Primary school	12.1
Secondary school	53.1
High school	29.6
Degree	4.3
Postgraduate	0.2

Table 1. *Cont.*

Variable	Percentage
Annual net income (EUR)	
<15,000	12.6
15,001–25,000	27.7
25,001–35,000	20.6
35,001–45,000	12.4
45,000–55,000	5.3
>55,000	4.7
No answer	16.8
Province of residence	
Belluno	3.6
Padua	21.4
Rovigo	4.8
Treviso	16.2
Venice	18.7
Verona	18.0
Vicenza	17.4

2.2.1. Elicitation of Attitudes towards Soil Conversation and Environmental Issues

Attitudes towards maintaining soil condition were measured by a set of attitudinal questions referring to the norm activation model [22], a psychological theory which aims at explaining altruistic and environmentally friendly behavior (in our case contributing to soil conservation). According to the theory, the decision to perform a given pro-social behavior is driven by three factors: (i) awareness of consequences; (ii) ascription of responsibility; (iii) personal norms. In this paper we focus specifically on awareness of consequences and personal norms. Awareness of consequences refers to whether someone is aware of the negative consequences for others of not performing a pro-social behavior (in our case not contributing to conserving soil). Personal norms refer to the moral obligation to perform or refrain from specific actions (in our case acting to preserve soil ES). We note that the above traits describe an innate propensity to feel connected to soil and to believe it is right to contribute to its conservation, without being directly linked to any specific action that could achieve this purpose. We measured such traits via attitudinal questions retrieved from the literature [23–25] and adapted to our study. The attitudinal questions were formatted as a Likert scale and respondents were asked to express their agreement with a series of statements, reported in Table A1 (Appendix A). The survey included four questions designed to elicit the respondents' level of awareness concerning soil conservation and four questions aimed at investigating their moral obligation to secure soils.

Next to attitudes towards conserving soil condition, we more generally investigated environmental concerns via the New Environmental Paradigm (NEP) scale [26]. The scale includes 15 statements related to fundamental beliefs and attitudes concerning environmental issues. Respondents were asked to indicate their degree of agreement or disagreement with each question, based on a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree and 5 = strongly agree).

2.2.2. Choice Experiment

The choice experiment focused on eliciting preferences for soil conservation programs aimed at achieving different levels of provisioning of soil ES. Attributes and levels were defined according to the existing literature and after in-depth discussion with soil scientists. The full list of attributes and levels is reported in Table 2.

To ensure that respondents could make informed choices, the survey included a detailed description of the attributes, which also reported the benefits for human well-being of increasing the level of each service. Furthermore, to increase the realism of the attributes and their levels, the description explicitly stated which agricultural practices might be adopted to increase the level of each service.

Table 2. Attributes and levels of the choice experiment.

Attribute	Unit	Level
Carbon sequestration	t/ha/year	0.20 (baseline) 0.80 1.40 2.00
Earthworm density	individuals/m^2	15 (baseline) 25 4 60
Rainfall water infiltration	rainfall	23% (baseline) 28% 34% 40%
Nitrogen in groundwater	mg/L	11.9 (baseline) 8.3 4.8 1.8
Household tax	EUR	5 10 25 50 100 180

The first attribute is soil carbon sequestration, which refers to the soil's functionality to capture and store atmospheric carbon dioxide. It was explained to respondents that increasing soil carbon sequestration has two major benefits, namely mitigating climate change effects and increasing soil nutrient cycling and water holding. The second attribute refers to the density of earthworms living in the soil. Respondents were told that earthworms have a crucial ecological role, as they influence the hydraulic and nutrient cycling properties of soil. The third attribute (rainfall water infiltration) measured soil ability to absorb water at the land surface and either store it for use by plants or slowly release it into groundwater. The fourth attribute describes the amount of nitrogen in groundwater. Respondents were informed that nitrogen pollution in groundwater can cause environmental and health issues. The last attribute was the payment vehicle, described as a household tax (to be paid annually for the next 5 years). Respondents were told that the tax would be used to support land management plans aimed at increasing the ES provisioning at regional level. It was also explained to them that the above management plans would be centered around fostering the diffusion of agricultural practices having direct benefits for ES levels (e.g., cover crops to increase rainfall water infiltration and organic farming to increase earthworm density). As such, the estimated WTP values measure the amount of their own money that citizens are willing to pay to support policies aimed at increasing the provisioning of the soil ES by fostering more sustainable agricultural practices.

Attributes and level were combined to create the choice set alternatives via a d-efficient design. Each respondent faced 12 choice sets, which included two experimental alternatives and the status quo option (i.e., no payment and no improvement of soil ES provisioning).

2.3. Data Analysis

This section describes the approaches we used to analyze the above data. We first describe the attitudinal scores analysis and the econometric model used to estimate willingness-to-pay values from choice data, and then we outline the framework adopted for the spatial analysis.

2.3.1. Analysis of Attitudinal Scores

Individuals' responses to the questions on their environmental attitudes, soil conservation awareness and moral obligation values were used to create an individual score for

each of the traits measured. These individual scores were derived from the mean of the respondents' answers to the statements reported in Tables A1 and A2 (Appendix A).

When necessary, we reverse coded the statements from the norm activation model (items 1, 2 and 4 in Table A1) so that for each of them a high score indicates a high level of the traits (i.e., high awareness and high moral obligation). For some of the NEP scale statements, a high level of agreement corresponds to a high environmental concern. In contrast, for other statements a high score indicates an anti-environmental attitude. Therefore, we reverse coded the latter statements (item 2, 4, 6, 8, 10, 12, 14 in Table A2) such that agreement indicates a pro-environmental attitude.

2.3.2. Choice Model

We analyzed choice data via a mixed logit model (MXL, [27]). The model is based on the random utility theory [28], according to which a respondent n facing a set of J mutually exclusive alternatives has utility U_i for alternative i as a function of attributes X_i, so that:

$$U_{ni} = \beta'_n x_{ni} + \varepsilon_{ni} \quad (1)$$

where β'_n is a vector of coefficients and ε_{ni} is the unobserved error assumed to be i.i.d. extreme value type I. In the MXL model, the coefficients are assumed to vary across the population according to a distribution specified a priori by the researcher and described by its parameters θ (e.g., mean and standard deviation).

Conditional on β'_n, the probability that respondent n chooses alternative i is given by the standard logit formula:

$$\pi_{ni} = \frac{\exp(\beta'_n x_i)}{\sum_{j=1}^{j=J} \exp(\beta'_n x_j)} \quad (2)$$

The unconditional choice probability is the integral of this logit formula over the density of β'_n :

$$P_{ni} = \int \pi_{ni}(\beta) f(\beta|\theta) d\beta \quad (3)$$

The model was estimated by simulated maximum likelihood with the R package Apollo [29]. Choice probabilities were simulated in the sample log-likelihood with 1000 Sobol draws. All the coefficients for the non-monetary attributes were assumed to follow a normal distribution, whereas a log-normal one was assumed for the cost coefficient.

The model estimates were used to derive marginal willingness-to-pay values (mWTP) at an individual level. To obtain such values, we generated 10,000 pseudo-random draws from the unconditional distribution of the estimated parameters, and then we calculated the individual-specific estimates for each draw as explained in the seminal literature of panel choice models [27].

2.3.3. Spatial Analysis

To analyze the spatial distribution of attitudes towards soil conservation and environmental issues, we computed an average attitudinal score for each municipality. The score was obtained by averaging the respondent's individual score for the traits measured in each municipality (i.e., environmental concern, soil conservation awareness and moral obligation values). We then used ArcGIS 10.8.1 (ESRI, Redlands, CA, USA, 2020) to create thematic maps.

As it concerns the distribution of welfare measure, we mapped the mean WTP score by municipality as well. The average WTP value for municipality was computed by averaging the individual level estimates across residents in each municipality for each of the CE attributes.

We tested the presence of spatial autocorrelation in the averaged WTP values for administrative areas using Moran's I statistic [30]. Moran's I values range from -1 to 1. A positive value denotes that WTP values in one municipality and surrounding municipalities exhibit a similar trend. A negative value implies that in one municipality and surrounding municipalities an opposite trend exists. Moran's I values close to zero indicate that WTP

values are randomly distributed across space, a sign of a weak spatial autocorrelation. The test was also applied to the soil conservation attitudinal scores (environmental concern, awareness and moral obligation) using the average attitudinal score for each municipality.

We also investigated the degree of correspondence between the geographical distribution of WTP and the distribution of attitudinal scores across municipalities. We checked if respondents that show environmental attitudes, soil conservation awareness and moral obligation values above (below) the average of the sample also have a WTP above (below) the sample average, displaying a low to strong positive relationship. Furthermore, we identified if respondents with environmental attitudes, soil conservation awareness and moral obligation values below (above) the average of the target population are associated with a WTP above (below) the average, displaying a low to strong inverse relation.

3. Results

This section is structured as follows: Section 3.1 reports the descriptive statistics; Section 3.2 reports maps illustrating the spatial distribution of attitudes towards soil conservation and welfare measure and attempts to explore whether there is a relation between the two. Finally, Section 4 discusses the results.

3.1. Test Descriptive Statistics

The sample covered 324 municipalities, and a total of 1526 questionnaires were collected. Table 1 reports descriptive statistics of the main demographic and socio-economic characteristics of the sample. On average, respondents are 46 years old, and the most represented class is the one of age between 40 and 59 years. The sample is balanced in terms of gender. Regarding education, most of the sample is characterized by a secondary school level (53.1%), whereas for income the low–mid level classes are the most represented. Finally, respondents are rather evenly distributed across the provinces of the region, with the exception of Belluno and Rovigo, which are the two least populated ones.

3.2. Spatial Distribution of Attitudes towards Soil Conservation and Welfare Measures

The distribution of the attitudinal scores related to the importance of conserving soil and moral obligation is shown in Figure A1 (Appendix A). Overall, 39% of the respondents strongly agree that the region needs to improve soil condition measures. Meanwhile, 30% of the respondents feel neutral towards soil conservation as a high priority. The individual average score for soil conservation awareness is 3.5 (Figure A1a). In general, respondents strongly agree with the statements related to their moral obligation to secure soil, displaying an average score of 3.8 (Figure A1b). Respondents' attitudes related to environmental concerns, measured by the 15 statements from the NEP scale, are reported in Table A2. Generally, respondents agree with most of the NEP statements, suggesting positive attitudes towards the environment and its protection. The individual average score for environmental concern is 3.7.

The average scores of the attitudinal questions and their spatial distribution are shown in Figure A2 (Appendix B), where dark blue colors indicate a higher score and light red colors indicate a lower score. The municipalities with a crisscross pattern correspond to locations for which no data were available from the survey. Overall, there is a pattern of high score values across the three attitudinal questions. For instance, 68% of the municipalities sampled display scores between 3.5 and 5 in environmental attitudes, indicating a concerned environmental behavior. Meanwhile, 49% of the municipalities show awareness regarding soil conservation issues, and 70% display high moral obligation values to conserve the soil. Overall—albeit indirectly—such results suggest how in most of the study area individuals feel a high degree of connection with soil.

To represent the geographical pattern of WTP, the individual-specific WTP estimates are averaged for each municipality. Table 3 reports summary statistics from this analysis for each of the CE attributes.

Table 3. Summary statistics of individual-specific WTP estimates for soil-based ecosystem services.

Attributes	Mean (Euro/Year)	Standard Deviation (Euro/Year)	Coefficient of Variation (Percent)
Carbon sequestration	13.36	13.14	0.98
Earthworms density	1.59	1.55	0.97
Rainfall water infiltration	3.11	5.80	1.87
Avoid nitrates in groundwater	10.40	9.94	0.96

Figure A3 (Appendix B) describes the geographical distribution of the benefits of increased provisioning of soil ES, measured by the mWTP values. The maps suggest how in most sampled municipalities, respondents benefit from all soil ES included in the study and are willing to dedicate their financial resources to support policies aimed at increasing ES provisioning (via fostering the adoption of sustainable agricultural practices). Only in a few locations are the WTP values negative, thus indicating a low interest in financially contributing to soil conservation. Depending on the attribute considered, the percentage of municipalities with negative values range from 10 to 23% of the total sampled. The maps also provide strong evidence of spatial preference heterogeneity since values change in different areas of the region. Even though no clear taste patterns are visible, most of the municipalities showing the highest marginal WTP value are located on the Venetian plain, where agricultural activities are dominant (see Figure 1a). This may be linked to a higher sensitivity to soil conservation of citizens living in areas with a developed agricultural sector, given the strong connection between agricultural practices and soil condition (also emphasized in the hypothetical scenario of our CE and the attributes' descriptions).

Moran's I statistics calculated for the averaged WTP values and for attitudinal scores towards soil conservation are presented in Table A3 (Appendix B). The results of the test for spatial autocorrelation for WTP values showed the absence of global patterns of spatial significance. We found that Moran's I value is close to zero for all attributes, indicating a random distribution across space. Similarly, no spatial patterns were detected for the attitudinal scores. These results suggest how the averaged WTP values and attitudinal scores are a result of apparently random spatial processes.

To determine if respondents' attitudes towards environmental issues and soil conservation could in part explain the spatial heterogeneity of preferences, we created correspondence maps. Figure 2 summarizes this exercise, in which we explored the relationship between the geographical distribution of WTP values and the distribution of environmental attitudes, soil conservation awareness and moral obligation scores across municipalities. We identified a mix of areas where the mean WTP values and attitudinal scores moved in the same direction and others with an inverse relationship. Specifically, more than half of the sampled municipalities (around 180) exhibited a strong to low positive relationship for all the CE attributes analyzed, i.e., the mean WTP values and mean attitudinal scores move in the same direction. This result suggests how most respondents who display a high (low) WTP value are associated with high (low) environmental attitudes. This supports our hypothesis that connectivity to soil is linked to WTP for soil conservation, i.e., that individuals that feel a moral obligation to preserve soil tend to be willing to dedicate their financial resources to support policies aimed at increasing the provisioning of soil ES. Additionally, these results shed light on the complexity of the heterogeneity of people's preferences and the influence of physiological traits (attitudes towards environmental, in our case) on welfare changes.

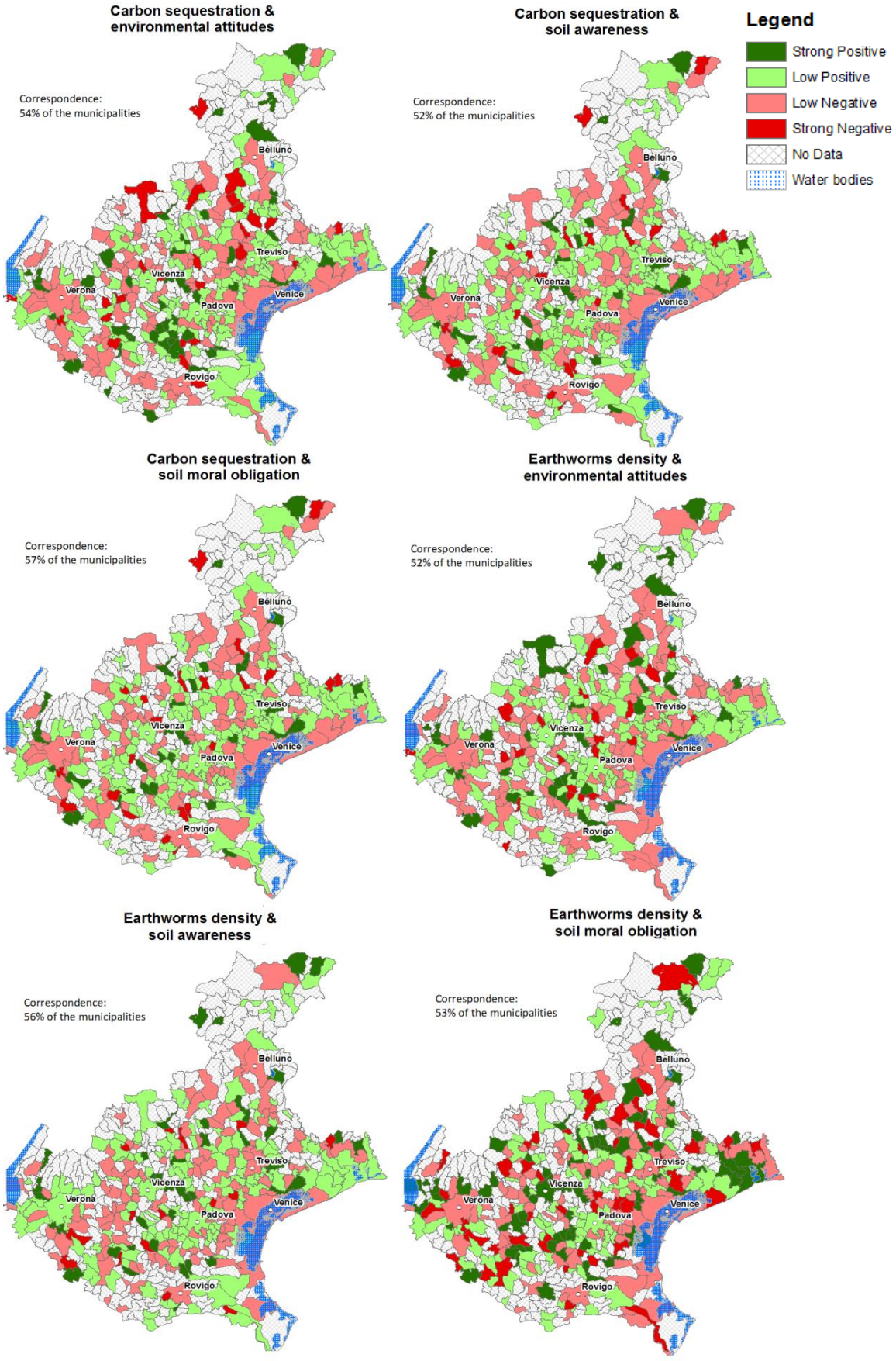

Figure 2. *Cont.*

Figure 2. Degree of correspondence between the geographical distribution of WTP and environmental attitudes, soil conservation

awareness and moral obligation scores. Note: Areas marked in light to dark green indicate municipalities with a low to a strong positive degree of correspondence between WTP and environmental attitudes, soil conservation awareness or soil moral obligation scores. Areas colored in light to dark red indicate locations where there is a low to a strong inverse relationship between WTP and environmental attitudes, soil conservation awareness or soil moral obligation scores. The municipalities with a crisscross pattern correspond to locations for which no data were available from the survey. Municipalities where a blue polygon is overlapping denote the presence of a water body.

4. Discussion

The maps presented in this study provided evidence of generally positive attitudes towards conserving and improving soil condition and associated ecosystem services across the sampled municipalities (Figure A2). The individuals' attitudes towards environmental issues, soil conservation and moral obligation to protect soil generally appeared to be positive, indicating a high level of concern, awareness and involvement, respectively. This suggests high connectivity between citizens and soil; however, this may have been influenced by the detailed information provided in the survey about the role of soil in providing ES, as connectivity is strictly linked to knowledge and information about soil [4]. The positive attitudes seem to be corroborated by the positive average WTP values retrieved in most municipalities, which suggest how householders would generally benefit from an improvement of the current level of the ecosystem services provided by soil (Figure A3). The results showed a majority of areas among those included in the survey with positive values and only a few locations with negative WTP, evidencing a considerable degree of heterogeneity in the spatial taste distribution.

The results regarding spatial autocorrelation show weak global clustering of the averaged WTP estimates. The low level of spatial autocorrelation might be influenced by the sampling procedure, as the survey targeted a representative and not homogenously distributed sample in space, with a concentration of observations in densely populated areas and a lower number of respondents in the northern part of the region (i.e., mountainous areas). In this light, it would be advisable for further studies to explore the influence of spatial features on preferences towards soil ES to acquire spatially balanced data for clearer insights into the spatial patterns.

Concerning the link between connectivity (i.e., innate propensity to feel it is right to preserve soil ES) and WTP values (i.e., concretely act to protect soil by dedicating financial resources to this purpose), we found that more than 50% of the sampled municipalities display a positive relationship between all CE attributes and the attitudinal scores (Figure 2). This finding suggests that spatial and psychological determinants such as motivations, beliefs, attitudes and perceptions might contribute to explaining the taste heterogeneity evidenced in our results. This also seems to imply a link between connectivity to soil and willingness to financially contribute to its conservation in most of the sampled area. This suggests how it would be beneficial to increase the awareness of the importance of soil conservation among the population to increase public acceptance of soil conservation policies and citizens' willingness to dedicate financial resources to support them.

As [5] pointed out in their review of economic valuation of soil ES, information about people's preferences based on stated preference methods is scarce. Our results provide an overview of the preferences of the residents of the Veneto region with respect to soil management—an essential aspect to guide political decisions—and of their spatial distribution. Nevertheless, our results are mainly descriptive and have, due to the nature of collected data, limited predictive power restricting generalization to other regions. Given the promising results of our study, however, future investigations into predicting soil preferences for other regions around the world should account for spatial characteristics when drawing the sample. This way, they might increase the predictive power of their results.

5. Conclusions

Despite the global threat to soil and its capability to provide ecosystem services, there is still a paucity of information about the value that people attach to soil conservation. The few existing valuation studies focused in most cases on a limited number of soil ES and did not account for the public component of ES values. Furthermore, there is a lack of knowledge about the spatial heterogeneity of attitudes and preferences towards soil conservation. In this study, we tackled such issues by collecting survey data on attitudes and preferences towards soil ES and by estimating their economic value. Attitudes were investigated via specific questions retrieved from well-established psychological theories, while the valuation was performed via a choice experiment focusing on several soil ES. Spatial heterogeneity of both attitudes and values was explored via GIS techniques.

Our results highlight how individuals generally have positive attitudes towards soil conservation. More specifically, we found that citizens of most municipalities of the study area (the Veneto Region in Italy) are aware of the importance of preserving soil and feel a moral obligation towards contributing to it. This indirectly suggests how citizens are highly connected to soil. This generally positive view towards soil conservation and high connection is corroborated by the positive willingness-to-pay values for soil ES estimated in most of the study area. Both attitudes and welfare measures are highly heterogeneous across space, although no specific patterns were detected, and heterogeneity seems driven by random spatial processes, as suggested by non-significant Moran's I values. We also found some evidence for the spatial correspondence between the distribution of attitudes and welfare measure, validating individual responses to WTP questions and providing evidence that respondents with pro-environmental attitudes display a higher WTP. However, this will need to be corroborated in future research via statistical tests.

From a policy perspective, our results suggest how it is important to preserve soil capability to generate well-being for societies and how being able to account for spatial distribution of the perception of soil ES benefits can be useful to design soil conservation programs that are coherent with public preferences. Given the link between connectivity to soil and willingness to pay for its conservation highlighted by the correspondence maps, it also seems that increasing the awareness of soil importance among the population would be beneficial to increasing the public acceptance of soil conservation policies, which requires financial support from citizens.

Overall, our study highlights the importance of accounting for spatial heterogeneity in valuation studies focusing on soil ES. Future research on this topic may concern the estimation of more formal spatial econometric models to further explore how spatial factors affect the perception of benefits provided by soil. It would be also of interest to measure more specifically the connectivity with soil, its effect on WTP values (for example by eliciting such value before and after provisioning of information about soil) and how it is distributed spatially.

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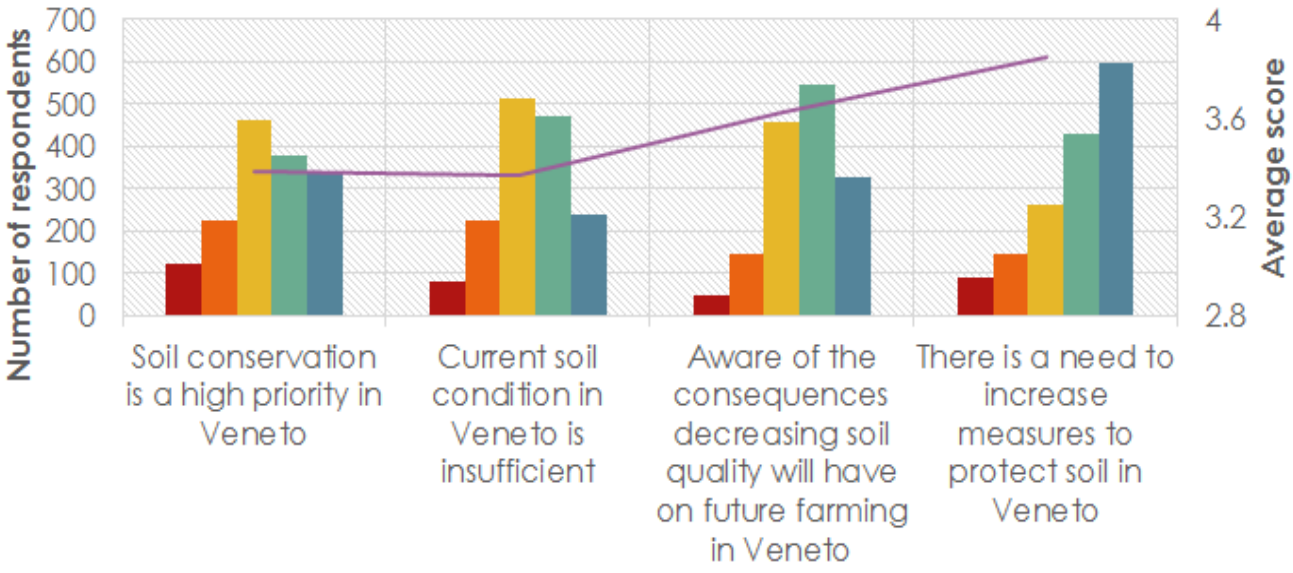
Appendix A

Table A1. Descriptive statistics of the responses to awareness and moral obligation to protect soils statements.

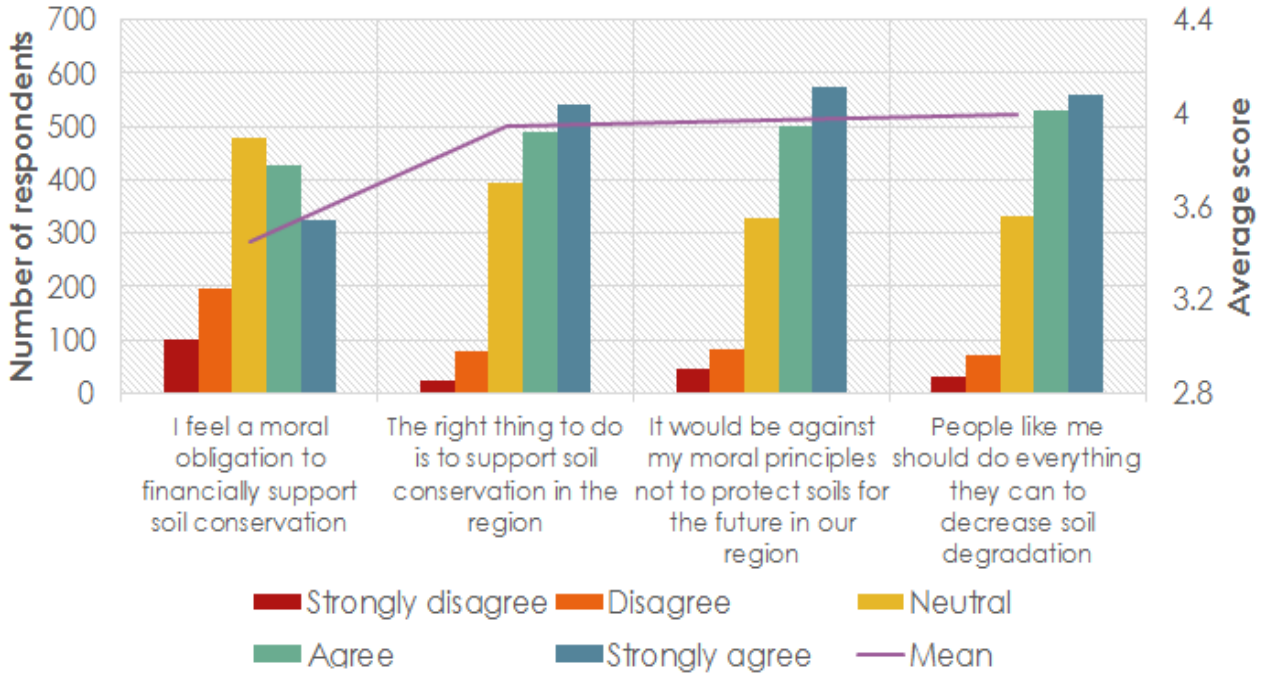
	Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	Compared to other environmental issues of the Veneto region, soil conservation is a high priority (reverse coded)	8.1%	14.7%	30.2%	24.8%	22.2%
2	The current soil condition in the Veneto region is insufficient (reverse coded)	5.2%	14.8%	33.6%	30.8%	15.6%
3	I am aware of the consequences decreasing soil quality will have on future farming in the Veneto region	3.2%	9.5%	30.1%	35.7%	21.4%
4	There is a need to increase measures to protect soil in the Veneto region (reverse coded)	6.0%	9.5%	17.2%	28.2%	39.1%
5	I feel a moral obligation to financially support conservation of our soils no matter what other people do	6.5%	12.9%	31.3%	28.0%	21.2%
6	According to my values, the right thing to do is to support soil conservation in the Veneto region	1.6%	5.2%	25.9%	32.0%	35.3%
7	It would be against my moral principles not to protect soils for the future in the Veneto region	2.9%	5.4%	21.5%	32.7%	37.5%
8	People like me should do everything they can to decrease degradation of our soils	2.0%	4.8%	21.8%	34.8%	36.6%

Table A2. Descriptive statistics of the responses provided to the New Ecological Paradigm (NEP) scale.

	NEP Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	We are approaching the limit of the number of people the earth can support	3.4%	9.0%	30.8%	29.1%	27.7%
2	Humans have the right to modify the natural environment to suit their needs (reverse coded)	6.4%	10.1%	22.0%	26.3%	35.3%
3	When humans interfere with nature it often produces disastrous consequences	1.4%	4.5%	15.6%	30.9%	47.7%
4	Human ingenuity will ensure that we do not make the Earth unlivable (reverse coded)	16.3%	16.3%	30.1%	17.7%	19.5%
5	Humans are seriously abusing the environment	1.4%	2.2%	10.2%	23.1%	63.0%
6	The Earth has plenty of natural resources if we just learn how to develop them (reverse coded)	41.5%	31.2%	19.6%	5.5%	2.2%
7	Plants and animals have as much right as humans to exist	1.6%	5.4%	17.9%	23.3%	51.8%
8	The balance of nature is strong enough to cope with the impacts of modern industrial nations (reverse coded)	8.4%	14.6%	23.6%	28.6%	24.8%
9	Despite our special abilities, humans are still subject to the laws of nature	1.9%	4.2%	19.2%	30.4%	44.3%
10	The so-called "ecological crisis" facing humankind has been greatly exaggerated (reverse coded)	8.5%	11.9%	18.5%	26.0%	35.1%
11	The Earth is like a spaceship with very limited room and resources	4.6%	5.6%	17.8%	30.6%	41.4%
12	Humans were meant to rule over the rest of nature (reverse coded)	8.8%	14.9%	25.0%	23.3%	27.9%
13	The balance of nature is very delicate and easily upset	1.2%	3.1%	15.3%	34.3%	45.9%
14	Humans will eventually learn enough about now nature works to be able to control it (reverse coded)	8.3%	16.5%	37.0%	22.2%	16.0%
15	If things continue on their present course we will soon experience a major ecological catastrophe	1.2%	5.3%	17.1%	30.4%	45.9%



(**a**)



(**b**)

Figure A1. Chart showing the survey results asking the respondents to gauge the level of importance of: (**a**) soil conservation statements; (**b**) moral obligation statements.

Appendix B

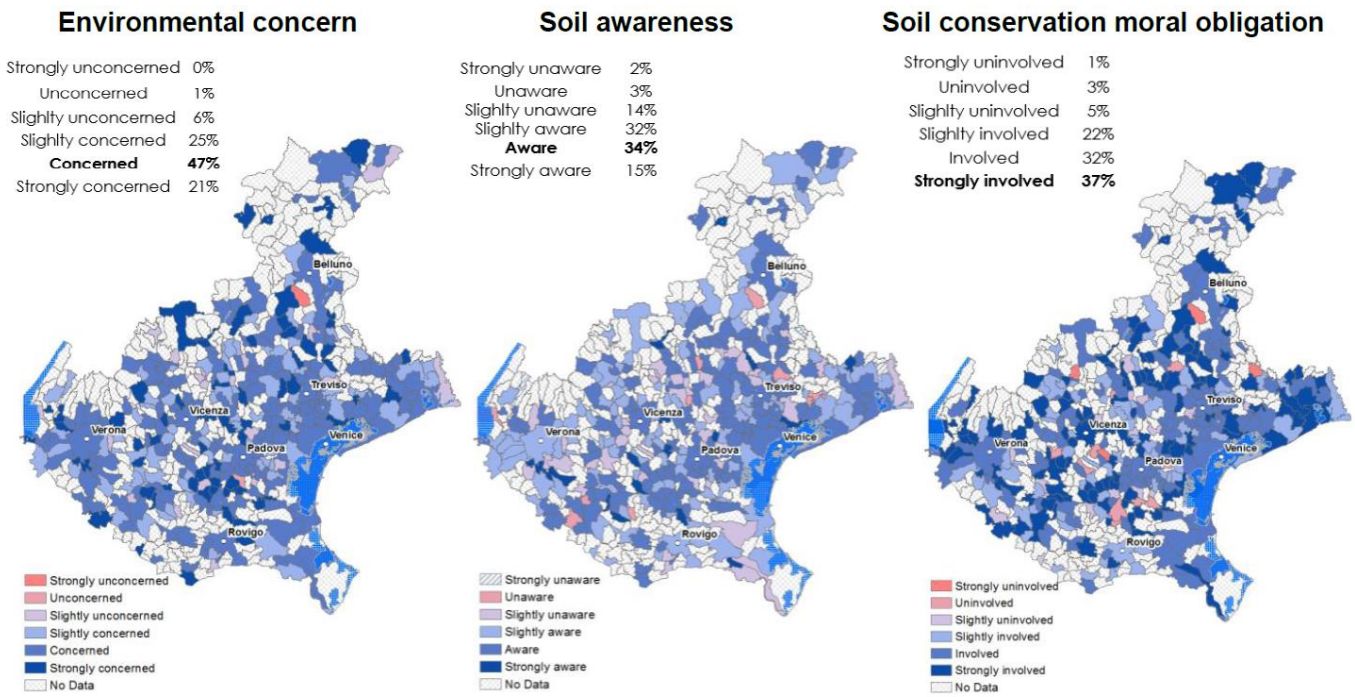


Figure A2. Maps of the distribution of: (**i**) environmental attitude scores, (**ii**) soil awareness scores and (**iii**) soil conservation moral obligation.

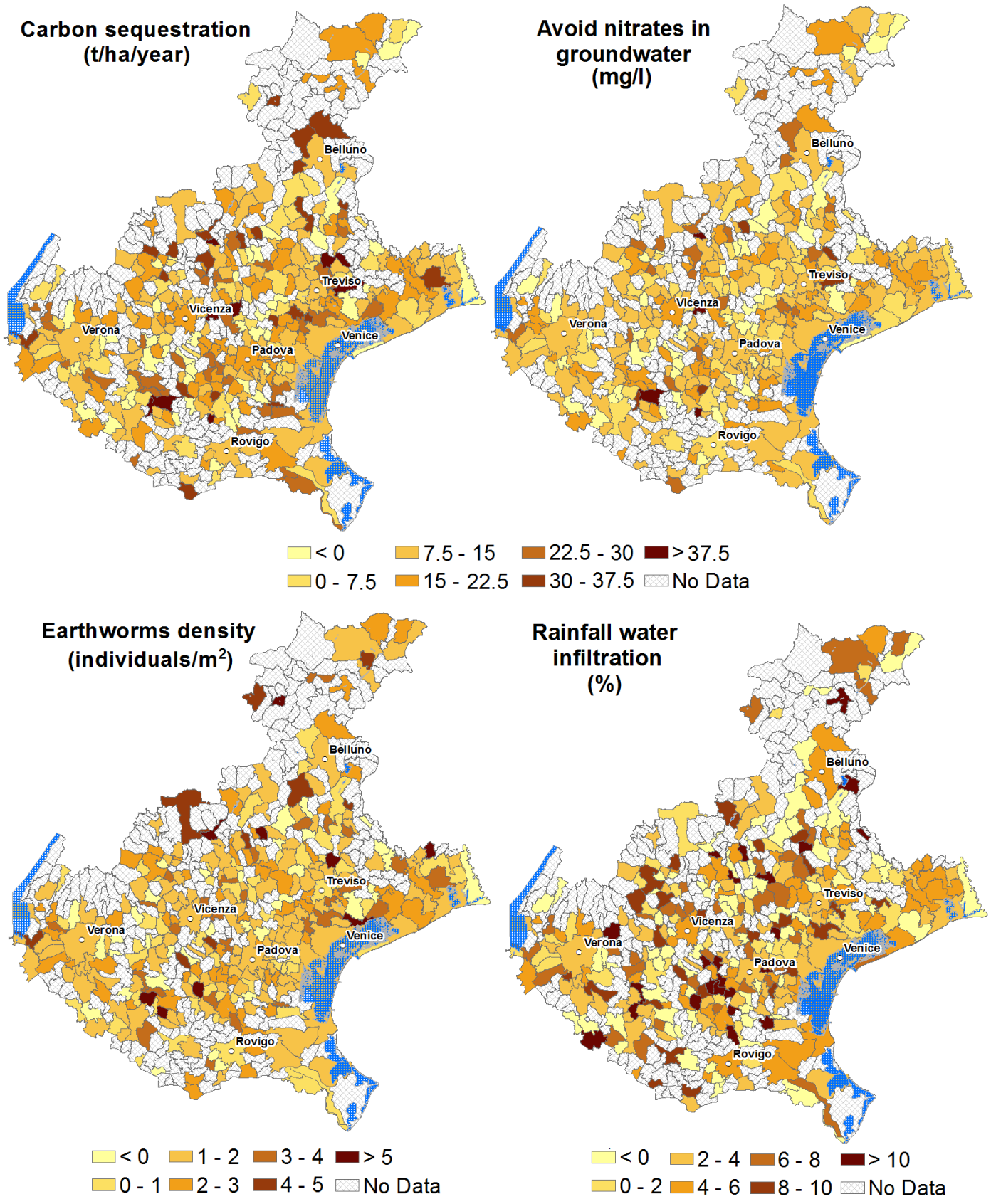


Figure A3. Maps of willingness-to-pay (WTP) distribution (average by municipality, in EUR) with the denotation of presence of water bodies.

Table A3. Spatial autocorrelation in averaged WTP for the benefits of increased provisioning of soil ES and attitudinal scores.

Attributes	Moran's I	*z*-Value
Carbon sequestration	0.011	0.61
Earthworms density	−0.022	−0.79
Rainfall water infiltration	−0.013	−0.45
Salinity in groundwater	0.015	0.77
Environmental concern	0.004	0.29
Soil awareness	−0.009	−0.26
Soil moral obligation	0.018	0.91

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