

Article

Rural Residents' Perceptions of Ecosystem Services: A Study from Three Topographic Areas in Shandong Province, China

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Abstract: Rural residents' perception is an important way of evaluating rural ecosystem services. Different topographies affect the level of ecosystem services, thus affecting residents' perceived preferences. This study conducted a questionnaire survey of 1176 rural residents in mountainous, hilly, and plain areas of Shandong Province. It analyzed respondents' satisfaction with ecosystem services and landscape preferences in different topographical areas. The results showed that the perception of ecosystem services was higher than average in all three topographic areas. The perceptions from high to low were cultural services, provisioning services, and regulating services. The perception of ecosystem services was significantly affected by topography, with significant differences between mountainous and plain areas in particular. Rural residents' perceptions of cultural services varied widely and there were diverse preferences. This study believes that the important concerns in enhancing the perception of ecosystem services among rural residents are to raise villagers' ecological awareness by meeting their growing spiritual needs and the high sensitivity of older people.



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Keywords: rural area; residents' perception; ecosystem services; topographic areas; questionnaire survey

1. Introduction

Ecosystems play a crucial role in supporting human societies [1,2]. The traditional methods for evaluating ecosystem services have typically been based on objective data, such as biophysical methods and monetary values [3–5]. In the process of analysis, the ecosystem was scored by corresponding algorithms, and then the research was conducted [6–8]. Later, researchers introduced methods to assess the values of various ecosystem services by spatial data such as remote sensing [9–11]. However, few studies have focused on the perceptions of individuals, as related to their surroundings, and their value of ecosystem services [12]. Therefore, as another analysis method, residents' perceptions of ecosystem services can effectively combine the relationship between the environment and individuals. People are the end-users of ecosystem services [13], and their perceived satisfaction should not be overlooked [14–16]. Studies of ecosystem perceptions have provided deeper insights into stakeholders' perceptions and satisfaction, thereby effectively enhancing their participation and initiative [17], as well as supporting sustainable improvements for ecosystem services [18–20]. Research on perceptual valuation has contributed to the development of comprehensive approaches to ecosystem service assessment [21,22]. As in real-world decision-making, a single tool is rarely sufficient, and methods must be combined to meet practitioner needs [22]. Public perception has also been used to evaluate people's attitudes toward the effectiveness of the practical implementation of ecological engineering and management policies, which could effectively enhance public participation and collaboration as well as increase concept awareness and communication [23].

At regional and global scales, ecosystem services have varied spatially in terms of their availability, distribution, and service capacity [13]. Differences in the natural environment

and the resource endowments of different regions [24] have resulted in different levels of ecosystem services, which in turn have influenced the perception of ecosystem services by local residents [25]. Studies have shown that the characteristics of ecosystem services are closely related to topography [26–28]. For example, topography has affected vegetation types and had a significant impact on the areas of natural forests and cultivated lands [29], which then affected the level of ecosystem services. Along with topographic gradients, topography also affects water yield, soil water storage, carbon storage, soil conservation, and water purification [30], which are important indicators for evaluating ecosystem services. Different topographic areas such as basins [31], plains [32], mountains [33], and hills [34] have varied dominant ecosystem services, resulting in different needs and perceptions in different regions. It is necessary to understand and compare the differences in people's perceptions of ecosystem services in different areas to provide efficient strategies for ecological restoration and management practices. Working with the natural environment has shown to be more effective than “fighting the site” [35].

The diversity in the perceptions of ecosystem services in different populations [36] should be explored for effective, equitable, and sustainable ecosystem governance and management [37]. Only by understanding and satisfying various needs in diverse populations can we better promote the participation of all people and effectively improve the ecosystem services. Individual characteristics of populations, such as age, education, and number of social contacts contribute to differences in perceptions and preferences for ecosystem services [38,39]. Linking the sociodemographic background of different groups with perception evaluations has improved environmental awareness [40] and provided better guidance for future landscape planning. Survey data from different populations has been incorporated into ecosystem management plans to identify efficient, equitable, and environmentally sustainable developmental strategies [41]. For example, ecological reserves have been easier to regulate [42], enabling people to make informed decisions regarding ecological responsibilities [43]. Satisfying farmers' needs and influencing their behavior has been effective to achieve farmland biodiversity conservation [44]. In forest management, identifying the various benefits to residents in a community provided insight for public outreach and increased awareness concerning the value of forests [45].

China is an ideal case for studying ecological perception and its variability. China has a complex and diverse topography, including mountains, plateaus, plains, hills, and basins, of which the mountainous areas are the most extensive, accounting for 70% [46]. Villages in China are distributed in almost all topographic areas [47]. In regions such as plains and transition zone between hills and mountains, the spatial distribution of settlements is denser; in regions such as cold alpine areas and desert fringes, the rural settlement density is low and clustered. However, due to the wide variation in geographical and natural resource conditions, the ecosystem services in rural areas vary greatly. The rapid urbanization process in China in the past decade has driven changes in land use, resulting in a decline in ecosystem services in many rural areas and causing serious environmental problems [48,49], such as water scarcity, air pollution, soil contamination, and other ecological risks [50]. However, there are relatively few studies on ecosystem services in rural areas at this stage. Obtaining evaluation data of ecosystem services in rural areas may support the harmonious development between cities and villages and their environmental impact.

Based on the analysis of perception survey data, the main purpose of this study was to identify differences in the perceptions and preferences of ecosystem services among residents in different topographic areas and to explore the reasons behind them. We targeted permanent residents of the study area (those who lived there more than 10 months per year), as our interest lied in exploring local perceptions. Along this line, the objective of this study was to address the following questions: how do rural people, as the most direct stakeholders, perceive various ecosystem services? How do people's perceptions differ between areas in different topographical ecosystem settings, such as mountains, hills, and plains? Are there differences in perceptions and preferences among different groups?

Finally, we discussed the perceived preferences of people in different topographic areas and how to improve the perception of ecosystem services among the population.

2. Materials and Methods

2.1. Study Areas

Shandong is a province with a large number of villages and a high proportion of the population in China, with a high output of agricultural products. As of 31 December 2019, Shandong Province had arable land of 64,618.68 km² (accounting for 5.05% of the country's arable land) and a total population of 101.65 million, including a total rural resident population of 37.56 million, and more than one-third of rural residents relied on agricultural production as their main source of income [51]. Ecosystem services have a significant impact on the production and livelihood of rural residents in this region.

The average altitude of Shandong Province is low, but the topography varies significantly. The central part is headed by the Taishan Mountains, which provide a mountainous terrain with large, complex undulations. The eastern region comprises rolling, shallow hills with a slope less than 15°, and this area is an important producer of fruits and vegetables in China. The northwest and southwest areas are plains, low-lying and flat, which are part of the Great North China Plain and are important grain production bases in the country. Shandong Province is also rich in biodiversity. There are 9 vegetation types (coniferous forest, deciduous forest, bamboo forest, etc.) and 80 group types (red pine forest, fir forest, *Phyllostachys pubescens* forest, etc.). The flora is distributed in the mountains and hills, and there are only a few types in the plains. A total of 602 species of wild vertebrates are distributed across the province, which have the highest variations in the hilly areas, followed by the mountainous areas, and the lowest in the plains area. There is no significant difference in insect distribution. See Appendix A for relevant ecological data (Table A1) [52].

The survey data for this study were obtained from 46 villages in these three topographic regions (Figure 1).

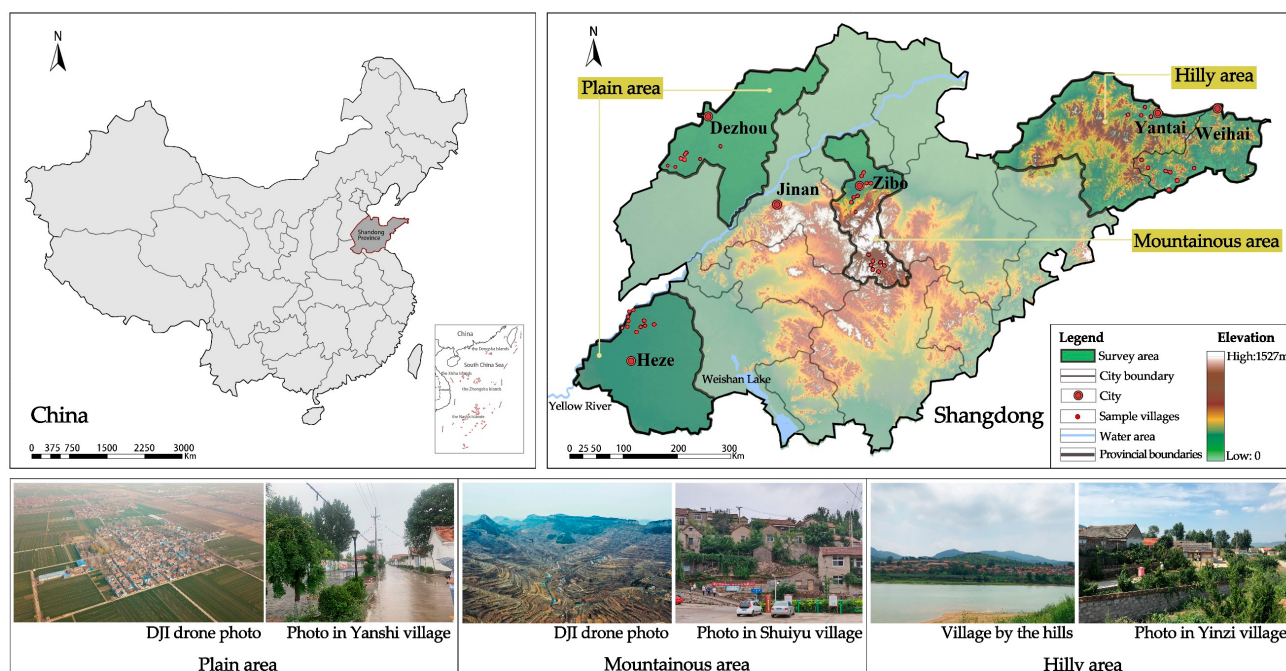


Figure 1. Location, topographic map, and photos of the study areas.

2.2. Data

In August 2020, the research team conducted two rounds of pre-surveys in the study area and collected statistical data on resources, environment, and social economy from relevant departments. After modifying and further improving the questionnaire according

to the pre-investigation, a formal survey was conducted from November 2021 to December 2021. In addition to questionnaires, participatory rural appraisal (PRA) methods such as semi-structured interviews were also used to obtain the data required for the study. The research team selected a number of villages in the districts and counties covered by the three major topographic areas for the sample survey, which was approximately 40 min long. A total of 1255 households were surveyed, and 1176 valid questionnaires were returned, yielding an effective rate of 93.71% (Table 1).

Table 1. Statistics of the surveyed villages.

Topographic Areas	City	County or District	Number of Research Villages	Number of Rural Households Surveyed
Hilly area	Yantai Weihai	Fushan District	6	174
		Rushan District	9	185
Mountainous area	Zibo	Zhangdian District	3	69
		Zichuan District	4	93
		Yiyuan District	8	235
Plain area	Dezhou Heze	Xiajin County	7	145
		Juancheng County	9	275
Total	5	7	46	1176

The questionnaire consisted of 4 parts: (1) The characteristics of the respondents, including gender, age, education level, length of time in the village per year, annual household income, number of household members, and proportion of agricultural income. (2) Satisfaction with ecosystem services. Based on existing studies, the research group divided ecological function services into four categories, including provision services, regulation services, support services, and cultural services [53,54]. According to the previous two rounds of pre-investigation and the literature review, it was found that support services were difficult to perceive by villagers [12] and, therefore, were not included in the questionnaire. The indicators of the other three types were further screened, including the source of food, vegetables and fruits, fresh water, the quality of soil, water and air, the level of temperature and humidity regulation, and the number of common wild animal species. Respondents were asked to rate the above indicators on a five-point Likert scale with multiple choices for landscape preference (Appendix A, Tables A2–A4). (3) Ecological resources owned by households and ecological behavior included the areas of arable land and economic forest; the number of livestock and poultry; the area of home garden and vegetation planting preference in courtyards [55]; the frequency of crop waste removal; the amount of fertilizer and pesticides applied during farming, and the degree of support for ecological policies. (4) The preference of rural residents for distance to cultural services included cultural and ecological spaces, fitness plazas, walking trails, historical and cultural spaces, and orchards and nurseries, as well as the reasons, the visiting frequency, and the length of stay.

The characteristics of the 1176 respondents who responded to the valid questionnaire are shown in Table 2. The average age of the respondents was 46.8 years old, and the ratio of male-to-female respondents was 3:2. A total of 88.92% of the respondents were permanent residents (more than 10 months in the village per year), 42.31% had a junior high school education, and 28.76% had a high school education. A total of 60.79% of respondents had an annual household income of less than USD 4539 (RMB 30,000). Due to the low income from farm work, one or two people in each household were farmers at most, and 37.61% of households did not have farmers, and many people relied on part-time jobs to increase their income.

Table 2. Respondents’ personal and household characteristics.

Personal Characteristics				Household Characteristics				
	Options	Number	Percentage		Options	Number	Percentage	
Personal	Age	Under 29 years old	116	9.32%	Number of household members	Living alone	37	2.95%
		30–39 years	250	20.08%		1–2 people	447	35.62%
		40–49 years	337	27.07%		3–6 people	737	58.73%
		50 years and above	542	43.53%		7 and above	34	2.71%
	Sex	Male	747	59.52%	Household member occupation (multiple choice)	No job or student	407	32.43%
		Female	508	40.48%		Planting, farming	552	43.98%
	Education	Primary school and below	187	14.90%		Working	392	31.23%
		Junior high school	531	42.31%		Part-time	363	28.92%
		Senior high school	361	28.76%		Individual business	147	11.71%
		Bachelor degree and above	176	14.03%		Others	110	8.76%
	length of time in the village per year	Always in the village	970	77.9%	Annual household income	RMB 5000 and below (USD 775 and below)	190	15.14%
		9–11 months	90	7.17%		RMB 5001–10,000 (USD 775–1550)	243	19.36%
		5–8 months	49	3.9%		RMB 10,001–30,000 (USD 1550–4650)	330	26.29%
		1–4 months	146	11.63%		RMB 30,001–50,000 (USD 4650–7750)	241	19.2%
	Respondent’s occupation	No job or student	252	20.08%		Over RMB 50,000 (Over USD 7750)	251	20.00%
		Planting, farming	406	32.35%	Agricultural income as a proportion of annual household income	20% and below	636	50.68%
Working, part-time		375	29.88%	21–40%		185	14.74%	
Individual business		106	8.45%	41–60%		125	9.96%	
Others	116	9.24%	61–80%	135		10.76%		
Number of people with social contacts in the village	Nobody	210	16.73%		Over 80%	174	13.86%	
	1–4	379	30.20%	Number of farmers in the household	Nobody	472	37.61%	
	5–9	286	22.79%		1–2	704	56.1%	
	10–19	104	8.29%		3–4	76	6.06%	
	≥20	276	21.99%		5 or more	3	0.24%	

Reliability analysis refers to testing the internal consistency and stability of the data obtained from the scale in the questionnaire to ensure reliability. Cronbach’s alpha coefficient method (Cronbach α) is suitable for the reliability analysis of subjective consciousness and cognitive questionnaires. Therefore, this paper used the Cronbach α coefficient to analyze the reliability of the questionnaires. Usually, the value of the alpha coefficient is between 0 and 1. If the Cronbach α does not exceed 0.6, it is generally considered that the internal consistency reliability is insufficient; when it reaches 0.7–0.8, it means that the scale has considerable reliability, and when it reaches 0.8–0.9, the scale has very good reliability. After inspection, the Cronbach’s α of the data in each region was greater than 0.7, indicating that the reliability of the questionnaire was high. The reliability of the questionnaire met the research needs and could be further analyzed (Appendix A, Table A5).

2.3. Methodology

2.3.1. Descriptive Analysis

Descriptive analysis is a research method that analyzes the collected data and obtains various quantitative characteristics reflecting objective phenomena to determine the inherent concentration or dispersion of data [56]. It is the first step in the statistical analysis of social surveys and usually describes the characteristics of a certain population, to determine the preference, support, and satisfaction of a population for a variable, to determine the relationship between different variables, and to predict the subsequent results. By descriptive analysis to calculate the centrality and volatility characteristics of the questionnaire data, the villagers’ perception of ecosystem services could be observed.

The calculation formula of provisioning service perception index was as follows:

$$P_{mj} = \sum_{i=1}^n P_{mij} \quad (1)$$

where P_{mij} denotes the perceived intensity assignment of respondent i in j area to m type of supply services, n denotes the number of respondents in region j , and P_{mj} denotes the perception index of m type of supply service by respondents in j area.

The map of the rural ecosystem service indicators were applied to the questionnaire options. The options were assigned sequentially according to the distance of the supply source (Appendix A, Table A2). The closer the food source was, the greater the supply capacity to the village. Similarly, the options were sequentially assigned according to residents' perceptions of regulating services (Appendix A, Table A3). The higher the perception index, the more satisfied the rural residents in the area were with the ecosystem regulating services.

2.3.2. Chi-Squared Test

The Chi-squared test is a widely used hypothesis testing method, which can count the degree of deviation between the actual observed value of a sample and the theoretically inferred value [57]. The degree of deviation determines the size of the Chi-squared value. The larger the Chi-squared value, the greater the degree of deviation between the two; conversely, the smaller the deviation between the two.

This paper used the Chi-squared test to analyze the factors that affected resident preferences, with variables including gender, age, education level, and the number of social contacts. The results of the test were used to analyze and determine the correlation between the individual characteristics of rural residents and the ecological perception results. Cramé's V coefficient formula is as follows:

$$\chi^2 = \sum_{i=1}^k \frac{(f_i - np_i)^2}{np_i} \quad (2)$$

where p_i denotes the probability that the value of x falls into the i -th interval, k denotes the value range of the overall x , n denotes the number of samples, and f_i denotes the number of sample values that fall into the i -th interval.

In this study, Cramé's V coefficient characterized the strength of the correlation between each variable and the perceived outcome. The Cramé's V coefficient ranges from 0 to 1, with higher values indicating a stronger correlation. When the value is below 0.1, the correlation between the two elements is weak; between 0.1 and 0.3, the correlation is moderate; between 0.3 and 0.5, the correlation is strong, and above 0.5, the correlation is extremely strong.

2.3.3. Analysis of Variance

Analysis of variance (hereinafter referred to as ANOVA) is often used to test the significance of the difference between the means of two or more samples. It determines the influence of controllable factors on the research results by analyzing the contribution of variation from different sources to the total variation. This paper used ANOVA to examine whether perceptions of provisioning services, regulating services, and cultural services differ among three topographic areas.

$$s^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1} \quad (3)$$

n represents the number of samples, x_i represents the i -th sample value, and $\bar{x}$ represents the mean value of all sample values.

In the research results, when the p value is used for indicating the significances of the difference between the two or more groups, p is usually divided into 0.1/0.05/0.01 segments. $p < 0.1$ means that there is a difference between the two groups of data. $p < 0.01$ indicates that the difference between the data is very significant.

3. Results and Analysis

3.1. Overview of Ecosystem Service Perception Results

The overall perception of ecosystem services was high, and the differences in perception among various services were small. Only the one indicator of common wild small animals was significantly low (1.72), below the median of the mean 2.5. From the overall results of the data analysis, the perception measures of rural residents in the studied regions were relatively high for supply, regulation, and cultural services, with mean perceptions of 3.34, 3.13, and 3.36, respectively, all greater than the median of 2.5 (Table 3). Among them, the perceptions of the supply and cultural services were the highest and relatively close.

Table 3. Perception measures of rural residents on ecosystem services.

Ecosystem Services	Medium Category	Perception Indicators	Mean *	Standard Deviation
Provisioning service	Food	Grain	3.83	0.89
		Vegetables and Fruits	3.74	0.83
	Fresh water	Drinking water	2.69	0.83
		Water for domestic production	3.26	0.94
	Raw materials	Construction timber	3.19	0.73
Regulating service	Biodiversity	Insect population change	2.93	1.28
		Common wild small animals (natural fish, sparrows, hedgehogs, etc.)	1.72	1.12
	Water regulation	Water storage capacity	2.97	0.93
		Water quality	3.25	0.99
	Air conditioning	Air quality	3.83	0.91
		Air temperature comfort	3.61	0.86
	Humidity regulation	Humidity comfort	3.60	0.84
Cultural service	Leisure and aesthetic value	Satisfaction with public spaces such as squares and trails	3.64	1.50
		Satisfaction with street greening	3.71	1.35
		Landscape construction expectations	2.74	1.86

* Note: the median of the mean is 2.5.

In the analysis of the reasons for the higher ecosystem service perception results, the perception results of provision services were consistent with the strong provisioning capacity of the local ecosystems. Shandong Province is an important producer of food, vegetables, and fruits. Rural residents can be self-sufficient or buy from local markets to meet their needs. They were less likely to travel to urban shopping markets or purchase supplies shipped from other places via the internet. Regulation services were the least perceived of the three, but were also greater than average. This was related to Shandong Province being located in the warm temperate monsoon climate zone. It has hot summers and cold winters, but with moderately average temperatures and humidity and rare extremes, so the regulation services of the ecosystem are relatively stable. The perception of cultural services was the highest, indicating that villagers were very concerned and satisfied with cultural services. However, the standard deviation was greater than 1, indicating that the perception of cultural services varied widely among rural residents and that there were diversified preferences.

In the perception index result analysis, among the 15 specific perception indicators, the top 5 highest perceptions were food supply (3.83), air quality regulation (3.83), vegetable and fruit supply (3.74), greening of the village roads (3.71), and artificial landscapes such as village squares (3.64). The last 5 items with the lowest perception were water regulation (2.97), insects increasing (2.93), expectation of new landscape in the village (2.74), drinking water supply (2.69), and common wild animal species (1.72). The low perceptions of water regulation and drinking water supply could have been related to the reality of the freshwater shortage in Shandong Province. As compared to drinking water, the perception of domestic water was higher (3.26), with interviews revealing that wells, reservoirs, and

groundwater could provide more water sources for domestic and agricultural farming, but that these sources could not be used directly as drinking water. The perception of water quality was good, which was related to the ecological project of water purification and the management system of chemical enterprise discharges in recent years. Wild animals were low, which was related to the high population density, high urbanization rates, and less natural environment available in Shandong province. However, the number of insects had increased (2.93), indicating that the ecological environment policies may have been effective in improving the ecological environment. As compared to wild animals, the insects at the bottom of the biological chain were more sensitive, and the number of insects had changed first [58]. The low level of expectation for the construction of new landscapes suggested that the existing landscape spaces had met the needs of village residents, or that villagers were not well informed and were unaware of the potential for upgrading landscape spaces within the village.

3.2. Analysis of the Influence of Topography on Perception

The perceptions of most indicators were significantly influenced by topography, especially between mountainous and plains areas, where the perceptions of the same indicators contrasted significantly. Among them, supply services, biodiversity perception in regulation services, and the preference of places for cultural services were greatly affected by topography.

We used ANOVA to test whether there were differences in the perception of provisioning services in different areas. The homogeneity of variance test showed that $p = 0.053 < 0.1$, indicating that the variance was homogeneous, and the analysis of variance method can be performed. In the ANOVA test, $p = 0.049 < 0.05$, indicating that there was a significant difference between the data, which meant different topography had an impact on rural residents' provisioning perception.

In the multiple comparison test, the smaller the p -value was, the greater the significance of the difference between the topographic was. Therefore, the difference between the plain areas and the mountainous areas was the most significant, followed by that between the mountainous areas and the hilly areas. The difference between the plain areas and the hilly areas was relatively smaller (Table 4).

Table 4. Significance of multiple comparisons (by ANOVA) for provisioning service perceptions in three topographic areas.

Multiple Comparisons	Areas	p -Value *
Hilly area	Mountainous area	0.036
Mountainous area	Plain area	0.017
Plain area	Hilly area	0.064

* Note: p -value is the variance test result of the significance of perceived difference between different topographic areas.

The analysis of the reasons why the perceptions of supply service (Table 5) were greatly affected by topography. Although food supply perceptions were the strongest in all three topography areas, as compared to other indicators, the results were highest in the plains and lowest in the mountains. While the plains had plenty of cultivated land, the mountains were not suitable for large-scale cultivation due to their slope. The hilly areas had the median perception of food supply, but the perception of vegetable and fruit supply was higher than the others, indicating that although the hilly topography was not conducive to the large-scale cultivation of food crops, fruit and vegetables could still be grown in large quantities. The perception of the fresh water supply varied little among the three areas and was lowest in the mountainous areas. Interviews with the villagers revealed that water storage was a difficult problem in mountainous areas due to the large slopes. The perception of timber supply was relatively low in all three topographic regions, related to the forest coverage rate of Shandong Province being only 18.2% [59], with the

highest in the plains and the lowest in the mountains. During the survey, it was observed that some rural residents in the plains used timber to build houses, while the villagers in the mountains tended to build their houses with local mountain stones.

Table 5. Perception measures of provisioning service in three topographic areas.

Provisioning Service		Hilly Area		Mountainous Area		Plain Area	
		Mean *	Standard Deviation	Mean *	Standard Deviation	Mean *	Standard Deviation
Food	Grain	2.95	0.93	2.54	0.74	3.36	0.85
	Vegetables and fruits	3.09	0.86	2.65	0.76	3.01	0.87
Fresh water	Drinking water	2.20	0.95	1.86	0.72	2.13	0.72
	Water for domestic production	2.67	0.94	2.36	0.97	2.65	0.92
Raw materials	Construction timber	2.30	0.64	1.81	0.29	2.65	0.74

* Note: the median of the mean is 2.5.

In the significance test of topography differences in regulating perception, the homogeneity of variance test showed that $p = 0.053 < 0.1$, so an analysis of variance can be performed. In the ANOVA test, $p = 0.053 < 0.1$, indicating that there were differences between the data, that is, different topography will affect the adjustment perception of rural residents. The multiple comparison test proved that the difference in perception of ecosystem provision services between hilly and mountainous areas was the most significant (Table 6).

Table 6. Significance of multiple comparisons (by ANOVA) for regulating service perceptions in three topographic areas.

Multiple Comparisons	Area	<i>p</i> -Value *
Hilly area	Mountainous area	0.046
Mountainous area	Plain area	0.096
Plain area	Hilly area	0.384

* Note: *p*-value is the variance test result of the significance of perceived differences between different topographic areas.

The regulating service perceptions were high and close in all three topography regions (Table 7). It showed that in areas with close geographical locations and the same climate zone, the regulation services were not significantly affected by topography. However, there were obvious differences in the perception of common wild animal species, with very high perceptions in the hills (4.23), as compared to 1.56 in the mountains and 2.40 in the plains. This difference may have been the result of the different topography. Hills have undulating terrain with small slopes, forming a variety of microclimates that can be conducive to wild animals' survival, shelter, and breeding [60]. Mountainous areas with steep slopes may have little impact on wild animals, but they were not conducive to residential travel. Most residents had relatively few daily walks and recreational activities, resulting in a lower chance of seeing wild animals. The plains had more settlements, which had likely affected the number and diversity of organisms. Moreover, the standard deviations of biodiversity perceptions in all three topographical areas were all greater than 1, indicating that people's perception of this indicator was quite different and was related to people's travel preferences and the length of their daily trips.

Table 7. Perception measures of regulating service in three topographic areas.

Regulating Service		Hilly Area		Mountainous Area		Plain Area	
		Mean *	Standard Deviation	Mean *	Standard Deviation	Mean *	Standard Deviation
Biodiversity	Change in insect population	2.91	1.30	3.43	1.47	2.86	1.87
	Common wild small animals (natural fish, sparrows, hedgehogs, etc.)	4.23	1.20	1.56	1.08	2.40	1.59
Water regulation	Water storage capacity	2.91	1.05	3.12	0.83	2.81	0.84
	Water quality	3.28	1.03	3.39	1.01	3.09	0.98
Air conditioning	Air quality	3.89	0.93	4.03	0.97	3.64	0.82
Temperature regulation	Air temperature comfort	3.69	0.91	3.85	0.94	3.37	0.72
Humidity regulation	Humidity comfort	3.38	0.88	3.84	0.95	3.35	0.70

* Note: the median of the mean is 2.5.

In the test of the significance of regional differences in cultural perception, $p = 0.083 < 0.1$, an analysis of variance can be performed. In the ANOVA test, $p = 0.057 < 0.1$, which proved that different topography had an impact on the cultural perception of rural residents, but compared with the provisioning perception, the topographic difference in cultural perception was not significant. The multiple comparison test proved that the difference in the perception of ecosystem services provided by the mountainous area and the plain areas was relatively significant, and there was no significant difference between the hilly areas and the mountainous areas (Table 8).

Table 8. Significance of multiple comparisons (by ANOVA) for regulating cultural perceptions in three topographic areas.

Multiple Comparisons	Area	<i>p</i> -Value *
Hilly area	Mountainous area	0.484
Mountainous area	Plain area	0.056
Plain area	Hilly area	0.098

* Note: *p*-value is the variance test result of the significance of perceived differences between different topographic areas.

The perceptions of the ecosystem cultural services were high and not significantly different in all three topographical areas (Table 9), indicating that these services were not significantly affected by topography. However, the standard deviations were almost greater than 1, indicating that there were significant differences in villagers' preferences. In order to further understand the differences, the questionnaire had included preference questions for ecological landscape sites for respondents to choose. As shown in Figure 2, there were similarities but also differences in the villager' preferences for ecological and landscape locations in the three topographical zones, with a marked contrast in ecological preferences between villagers in the mountainous and plains areas, in particular. The top four most popular landscape spaces in the three topographic areas were home gardens, public spaces such as village squares, artificial fields, and natural water bodies, but the popularity sequence of the spaces in the three topographic areas was different. The villagers in the plains areas preferred their own home gardens, with a selection rate of 26%. As the yard area of each household in the plains areas was relatively large (about 200 m²), the villagers could design their own yards and provide for their own leisure needs. In contrast, the villagers in mountainous areas had a significantly lower preference for their own yards, with a selection rate of only 8.9%. During the on-site investigation, we noted that the villagers in this area had small family yards (less than 80 m²) due to the slope limitation, which made it difficult to provide better leisure functions. The choice rate of villagers in the low hill areas for their home yards (20.24%) was also high due to the small topographical constraints and relatively large yard areas (between 100–200 m²). Villagers' own yards in mountainous areas provided little leisure function, so public spaces such as village squares

were preferred by villagers in this topographic area, and the selection rate was significantly higher than that of the other two topographic areas. In addition, due to topographical reasons, artificial fields such as farmlands, orchards, and nurseries were large in the plains and small in mountainous areas. Therefore, the villagers in plains areas had a much higher preference for such ecological spaces, as compared to villagers in mountainous areas. As for the spaces around natural water bodies, since there were few of these landscapes in mountainous areas, the villagers were full of interest and yearning for such landscapes, and the selection rate was much higher than in the other two topographic areas.

Table 9. Perception measures of cultural service in three topographic areas.

Cultural Service		Hilly Area		Mountainous Area		Plain Area	
		Mean *	Standard Deviation	Mean *	Standard Deviation	Mean *	Standard Deviation
Leisure and aesthetic value	Satisfaction with public spaces such as squares and trails	4.14	1.27	4.32	1.17	3.63	1.29
	Satisfaction with street greening	4.06	1.35	4.47	0.99	3.51	1.61
	Landscape construction expectations	2.69	1.54	3.18	1.58	2.79	1.02

* Note: the median of the mean is 3.0.

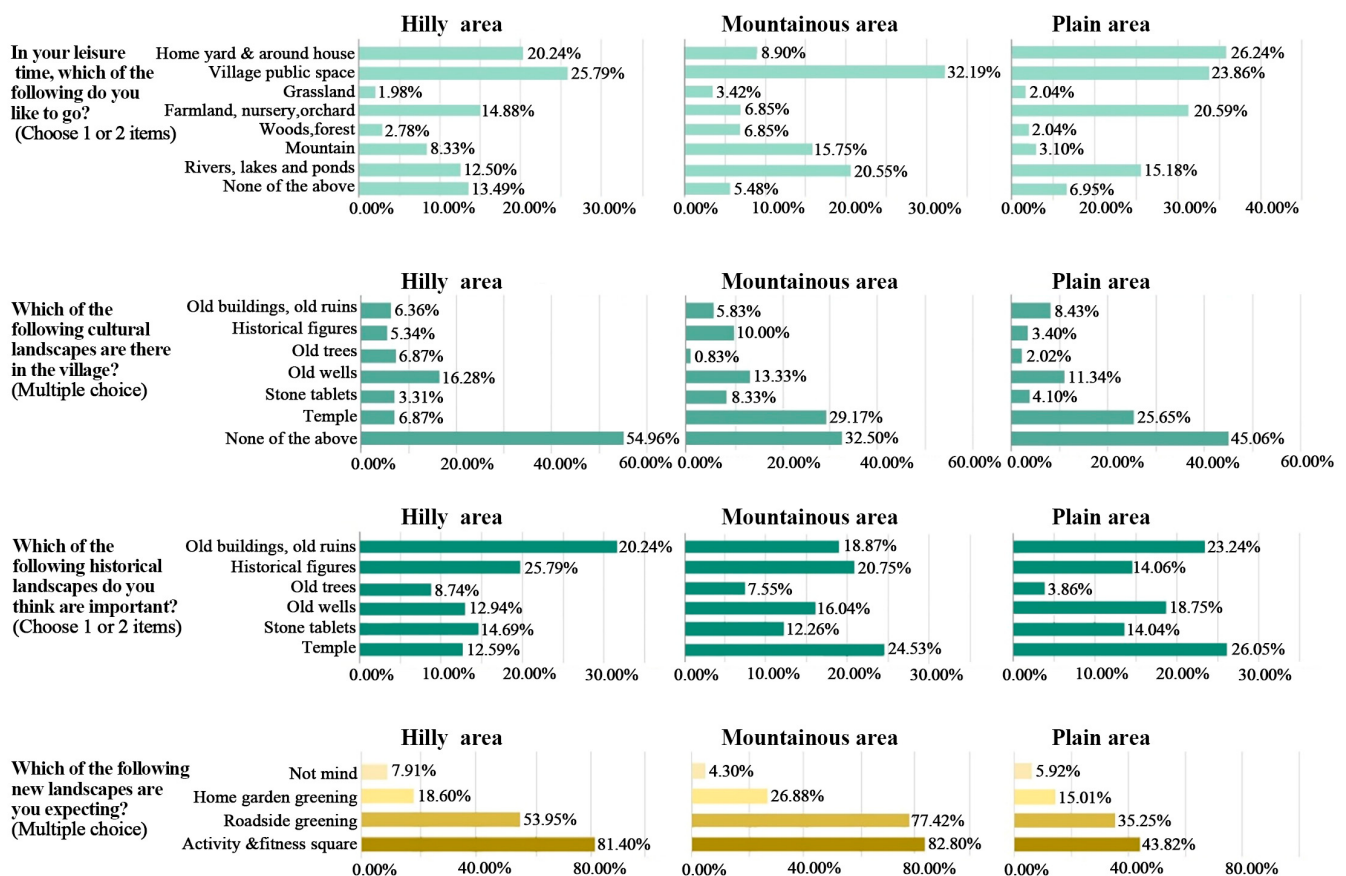


Figure 2. Cultural Service Preference Statistics Chart.

3.3. Cultural Service Preference Analysis

Rural residents had relatively similar perceptions of historical landscapes in cultural services. They rated the importance of such landscapes from highest to lowest as temples, ancient trees, ancient buildings, historical celebrities, and inscriptions. At the same time, the survey found that 32.50% of villagers (117 people) in hilly areas, 54.96% of villagers (218 people) in mountainous areas, and 45.06% of villagers (189 people) in plain areas

believed that their villages did not have any historical landscapes, but this did not affect residents' perception of the importance of historical landscapes.

Villagers in mountainous areas had significantly high expectations for new landscapes (3.18) (Table 9). This could have been related to the large slope, the small size of the home yards, and the insufficient number of public spaces, which could not meet the outdoor leisure needs of the villagers. Further analysis of villagers' preferences for new landscape types revealed that (Figure 2) the most desirable types among all three geomorphic areas were public spaces such as fitness squares, followed by the greening along the roads. The former was beneficial for sports and leisure activities, while the latter could provide aesthetic value. Villagers had the lowest willingness to participate in government initiatives for their home gardens and were more inclined to design and build their own private areas. There were also a few villagers who held indifferent attitudes towards the new landscape.

3.4. Perception Differences among Different Groups

The relationship between villagers' individual characteristics and perceptions was analyzed by a Chi-squared test. We selected the age, gender, education level, and annual family income data of the respondents to analyze the differences in perceptions of supply, regulation, and cultural services among different groups of people.

Groups with lower household income, older, and with lower education levels had the greatest perceptions of the provision of services. A correlation analysis was conducted between the 5 supply service indicators and the 4 respondent characteristics, and it was concluded that the 20 correlation *p*-values were all less than 0.01, indicating that all were correlated. Therefore, the Chi-squared test was performed, and the 20-item Cramer's *V* values are shown in Table 10: the larger the value, the stronger the correlation. The annual household income had the strongest correlation with the perception of service provision, followed by the level of education, and the weakest, by age and gender. According to the standardized residual data, it was found that villagers' perception of provision service decreased with the increase in household annual income (Appendix A, Figure A1). Low-income households with an annual household income of RMB 5000–10,000 (USD 775–1550) had the highest perception of provisions. The reason may be similar to the Engel coefficient theory [61]: the lower the income of a family, the higher the proportion of expenditures used to buy food in the home. As household income increases, the proportion of household spending on food decreases. Combined with several other Cramer's *V* values, we concluded that a higher proportion of rural residents included older people (43.67% over the age of 50), those with low annual family income (57.21% under USD 1541), and those with low education (34.50% finished high school and below). These subpopulations in the groups preferred the more traditional methods of "planting by themselves", "buying at the market", "well water", and "tap water" for providing services.

Table 10. Cramer's *V* value of the correlation between perception of provisioning service and individual characteristics.

Provisioning Services		Age	Gender	Educational Level	Annual Household Income
Food	Grain	0.092	0.201	0.366	0.519
	Vegetables and fruits	0.086	0.156	0.224	0.508
Fresh water	Drinking water	0.246	0.035	0.499	0.507
	Water for domestic production	0.109	0.068	0.423	0.502
Raw materials	Construction timber	0.069	0.054	0.129	0.487

Females, young people, and the elderly had higher perceptions of regulation services. The *p*-values for the association of five regulation service indicators with four respondent characteristics were less than 0.001, indicating that all were correlated. Two other biodiversity indicators were not correlated. The Cramer's *V* values for the Chi-squared test are

shown in Table 11. However, in contrast to the correlation characteristics of supply services, the correlation between annual household income and perceptions of regulation service was the lowest, which were 0.057, 0.068, 0.105, 0.123, and 0.110. Gender had the highest correlation with perceptions of regulation services, and each Cramer's V value was also extremely close, which were 0.398, 0.397, 0.396, 0.396, and 0.397. Further analysis revealed that the female group was more likely to perceive regulation services than the male group. The standardized residuals showed that the majority of the female group chose "relatively satisfied" (4 points) or "moderate" (3 points), while the majority of males chose "very satisfied" (5 points). This could have been related to the female group having a higher threshold for satisfaction [62,63]. Age was the second most correlated with regulation services. Our analysis revealed that younger people, under the age of 29, and older people, over the age of 50, were more sensitive to regulation services. The perception of those in the middle, aged 30–49, was relatively weak. Participants under the age of 29 were more sensitive to the regulation of water quantity and quality, and those over 50 were more sensitive to temperature and air regulation. Combined with educational attainment, we found that younger participants were more educated. Water bodies, which had a greater impact on human health, were of more concern to those under 29 years of age. The older participants were more prone to diseases such as chronic bronchitis, emphysema, and osteoarthritis, which likely made them more sensitive to air quality and temperature.

Table 11. Cramer's V value of the correlation between perception of regulating service and individual characteristics.

Regulating Services		Age	Gender	Educational Level	Annual Household Income
Water regulation	Water storage capacity	0.229	0.398	0.128	0.057
	Water quality	0.231	0.397	0.114	0.068
Air conditioning	Air quality	0.176	0.396	0.139	0.105
Temperature regulation	Air temperature comfort	0.132	0.396	0.103	0.123
Humidity regulation	Humidity comfort	0.112	0.397	0.122	0.110

A correlation between the number of friends and leisure space preferences was found to be highest in cultural services. We also analyzed the correlation between cultural services and individual resident characteristics. Due to the different topography, there were some differences in natural resources and landscape spaces, so the topography was distinguished in this part of the analysis. We also adjusted the indicators of the villager characteristics. In addition to age, gender, education level, and annual family income, we added the number of friends with whom participants had daily socialization and their travel habits (e.g., whether they had been to cities). However, the *p*-values between gender and each data group were greater than 0.001; there was no correlation. The same was found for annual household income. Therefore, no further analysis was conducted for these two items. The Cramer's V values of the other four items are shown in Table 12. The results in the plains areas had the highest correlation with individual characteristics, followed by the mountainous areas, and the lowest in the low hilly areas. The choice of leisure spaces in all three geomorphic areas had the strongest correlation with the number of friends, and the weakest correlation with age. The Chi-squared analysis also verified that villagers with more than 20 social contacts were the most active groups in the villages. They were more willing to go to the village square for activities, and their frequency was the highest. The group with no social contacts was more inclined to stay at home rather than visit outdoor public spaces. Resident groups whose social contacts were in the ranges of 1–4, 5–9, and 10–19 had a stronger tendency to go to various spaces for leisure activities as the numbers of contacts increased, and a greater perception of the natural landscape. In other words, as the number of social interactions increased, their preference for leisure spaces gradually changed from

more personal places such as homes and farmlands, to natural ecological spaces such as mountains, forests, rivers and lakes, and finally, to public spaces where people tend to gather. In terms of the villagers' travel experience, the respondents' experience of visiting urban parks may have influenced their attitudes toward rural landscapes. Therefore, the respondents' preferences were compared to whether they had visited an urban park, as a reference. The results showed that the rural residents that had not visited an urban park preferred to stay in their own yards, while the residents who had this experience were more interested in outdoor landscapes (both artificial and natural landscapes).

Table 12. Cramer's V value of the correlation between residents' leisure space preference and individual characteristics in three topographic areas.

	Age	Breadth of Vision	Educational Level	Number of Residents Daily Socialized
Hill area	0.174	0.261	0.229	0.365
Mountainous area	0.246	0.238	0.286	0.338
Plain area	0.329	0.359	0.280	0.384

4. Discussion

4.1. Differences in the Perceptions of Residents in Different Topographic Zones Are of Concern

Shandong belongs to the temperate monsoon climate zone. The government data showed that there were no significant differences in climate, wind direction, annual rainfall, and other data between regions [64]. However, affected by topography, there were differences in slope, water storage, and microclimate (temperature, humidity, wind speed, wind direction), thus affecting vegetation types and biodiversity. This also leads to different levels of provisioning, regulating, and cultural services of ecosystems in different topographic regions. The above aspects further influence the villagers' lifestyles and preferences in different habitats, resulting in different ecological perceptions. In particular, the differences in perception between mountains and plains were significant. These results reflect the subjective feelings of rural residents in different ecological environments in three topographic areas. During the interviews, it was found that villagers were more concerned with realistic issues such as income, education and pension, and tend to involuntarily neglect the natural environment in which they live. They thought these were common, and they did not cherish what they obtained easily. However, with the deepening of exchanges, we felt that a large number of villagers still were full of a sense of belonging to the surrounding ecological environment. Therefore, in order to improve and enhance ecosystem services in rural areas, the participation of local people is required [65,66]. Only by understanding their awareness and perception of these services can their participation and initiative be more effectively enhanced, and the sustainability of ecosystem service improvement can be guaranteed. The provincial government needs to consider the characteristics of ecosystem services and people's perception in different topographical areas, and adopt different policies and methods for different ecological indicators.

4.2. Growing Spiritual Needs of Rural Residents

The interview process revealed that materially supplied services could satisfy villagers' long-term needs, and villagers placed more emphasis on spiritual needs. This was in line with Maslow's hierarchy-of-needs theory [67]. Urban residents preferred wild landscapes with natural attributes [68], such as mountains and rivers. However, data analysis and interviews revealed that rural residents preferred landscapes with practical attributes, such as squares where they could exercise and socialize. Here, they could play chess, dance, and socialize with friends. They also enjoyed farm fields, nurseries, and orchards, places where they could feel the joy of labor and the satisfaction of harvesting. Many villagers were also accustomed to planting fruit trees and crops in their own yards as well as beside the roads outside their courtyards, which was their own territory. This feeling went beyond financial gain as an important factor, with satisfaction, years of habit, and

being able to share with friends as important reasons [69,70]. Most of the villagers were looking forward to the landscape projects in the village, such as squares, trails along the river, and greenery along the roads. There were also some villagers who did not want the greening along the road unified by the government. They preferred to landscape the sides of the road outside of their yards themselves. Therefore, in some villages, after the government planted flowers and other greenery on roadsides every year, it was destroyed by the villagers and replanted with their favorite crops. One village chief told the research team that this situation had continued for five years, resulting in a huge waste of funds. However, there has not been an effective solution to such vandalism by the villagers. Many scholars have proposed the concept of co-creation [65,66,71–73], by providing some broad requirements to allow rural residents to participate in the formation of low-maintenance and sustainable rural landscapes. For example, placing restrictions on the height, type, and shape of plants while allowing residents to plant their favorite crops on the sides of roads next to their homes. Interviews revealed that residents' favorite fruit trees to plant in their yards and along the roadside included apple, peach, fig, date, pomegranate, and persimmon trees, and their favorite crops include aubergines, tomatoes, peppers, loofahs, radishes, cabbages, leeks, spring onions, and corn. Selecting some of these for villagers to plant along the roadside [74], with the government only controlling the spacing to form an orderly agricultural landscape, could provide a solution.

For the old buildings and temples in the village, many villagers over the age of 40 valued them as a continuation of a certain culture. These things also provided a sense of belonging in their hometown [75–77]. However, in the opinion of historians [78,79], planners, and architects, some old buildings may not have a high preservation value. Therefore, in the process of rural landscape construction, it was often not possible to preserve the entire landscape [80]. This could result in fewer and fewer landscapes with important elements of rural identity. Some studies have explored how to retain what villagers perceived as unique landscapes [81,82]. They found that it was more meaningful to record and retain the daily landscapes that residents considered valuable than the opinion of experts [83]. The advantage was that the rural landscape characteristics of different regions could be preserved, and resident-led management could be implemented.

4.3. The Perception of Older Villagers Needs Attention

Among personal attributes, gender, age, and number of social contacts had a greater impact on the perception of cultural services [84]. For example, we found that male respondents were more willing to participate, which may have been related to the different gendered expectations in the culture. Males tended to have experience working in the county or city, which may have been conducive to enhanced information exchange. Therefore, males were more concerned with information regarding cultural services than females [85]. Participants over 50 years old were more sensitive to temperature and humidity regulation, which could have been related to their increased susceptibility to chronic bronchitis, emphysema, and osteoarthritis. Unsuitable temperature and humidity were more likely to cause them physical discomfort [86].

During the interviews, we met a few elderly people over the age of 70 who were in poor health and walking slowly. They lacked the confidence to take long walks and seldomly left their residential yard. Relevant evidence [87] has suggested that poor pedestrian infrastructures could hinder older people from walking. Pavement conditions and lack of appropriate light at night in most rural areas increased the risk of falls and injuries among the elderly. Due to the aging of rural areas in the region, pedestrian infrastructure should be an important consideration for future construction.

5. Conclusions

This study investigated the ecological perceptions of rural residents in different topographical areas through semi-structured interviews and questionnaires. The results showed that topography had a significant impact on residents' perception of ecosystem

services, especially provisioning and cultural services. In addition, residents generally had a sense of hometown belonging and identification in the rural ecological environment. The most preferred ecological landscape spaces included public spaces, farmland, and their residential yards. As compared to cities, this sense of familiarity and belonging in their hometown increased their willingness to live in the countryside for the long term. They had a more obvious preference for artificially constructed village squares and fitness and leisure spaces. This indicated that the rural residents in the study area had achieved certain material satisfaction and had begun to pursue health and spirituality to varying degrees. They had a strong sense of ownership of the vegetation along the road outside their home. In terms of cultural landscapes, old buildings, temples, and old trees were considered very important. At the same time, there were differences in the perceived outcomes of different groups, and the older participants should be considered in future planning and construction.

This study enhanced our understanding of the villagers' ecological perception, and some of the main findings can provide valuable references for the development and management of rural ecological policies. For example, ecological landscape spaces preferred by village residents could be constructed and planted with their preferred fruit trees. Providing villagers with the rights to plant and manage the open spaces around their yards, with broad specifications, could be effective in stimulating their enthusiasm for co-creation and maintenance while promoting public participation. It also could improve the ecological and ornamental properties of such planting. In the construction of infrastructure, such as road surfaces and lighting, it will be necessary to consider the travel convenience of all, particularly those who are older. These findings could reduce the management pressure on rural governments, and the economic and labor costs of construction and management.

There were several limitations in our study. Our lack of in-depth research on rural culture and society led to different views regarding some questions in the questionnaire. Therefore, in the future, further research should be conducted into the rural cultural identity and social attachment, and clear measurement indicators and questionnaires should be proposed to improve the results of this research.

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Appendix A

Table A1. Main animal and plant diversity data of the three topographic areas.

Category	Middle Class	Hilly Area (Species)	Mountainous Area (Species)	Plain Area (Species)
Main plant	Woody and lianas	457	421	239
	herb	742	778	698
	Cultivated plants (excluding ornamental plants)	150	102	126
	Total	1349	1301	1063
Main wild vertebrates (excluding freshwater fish) *	Mammal	30	28	21
	Bird	377	256	204
	Reptile	15	22	13
	Amphibian	8	7	7
	Total	430	313	245

* Note: Shandong Province has 602 species of wild vertebrates, including 39 species of mammals, 399 species of birds, 22 species of reptiles, 9 species of amphibians, and 133 species of freshwater fish. According to statistics, the number of wild vertebrate species in Shandong Province varies from 269 to 437. The number of wild vertebrate species in 38.3% of the counties varied from 269 to 290, 36.7% from 310 to 373, and 25% from 405 to 437. The number of freshwater fish species in three topographic areas has not been identified.

Table A2. Provisioning service perception questionnaire and assignment.

Provisioning Service	Perception Indicators	Options and Assignments			
		4 (Nearest)	3	2	1 (Farthest)
Food	Grain	Self-planted	Buy from village market or mobile vendors	Buy from stores in city and town	On-line shopping
	Vegetables and fruits	Self-planted	Buy from village market or mobile vendors	Buy from stores in city and town	On-line shopping
Fresh water	Drinking water	Well water, groundwater	Nearby reservoir	Tap water	Bottled water
	Water for domestic production	Well water, groundwater	Surface water (rivers, lakes, springs, reservoirs)	Tap water	Artificial canals and rainwater
Raw materials	Construction timber	Own village	Nearby villages	Buy in province	Buy outside province
		Not need (Do not calculate)			

Table A3. Regulating service perception indicators, options, and values.

Regulating Service	Perception Indicator	Options and Values				
		5	4	3	2	1
Biodiversity	Insect population change	Significant increased	Increased	The same as before	Decreased	Significant decreased
	Common wild small animals (natural fish, sparrows, hedgehogs, etc.)	10–15 species	-	6–9 species	-	0–5 species
Water regulation	Water storage capacity	Plenty	A bit more	Moderate	Lower	Few
	Water quality	Plenty	A bit more	Moderate	Lower	Few
Air conditioning	Air quality	Plenty	A bit more	Moderate	Lower	Few
Temperature regulation	Air temperature comfort	Plenty	A bit more	Moderate	Lower	Few
Humidity regulation	Humidity comfort	Plenty	A bit more	Moderate	Lower	Few

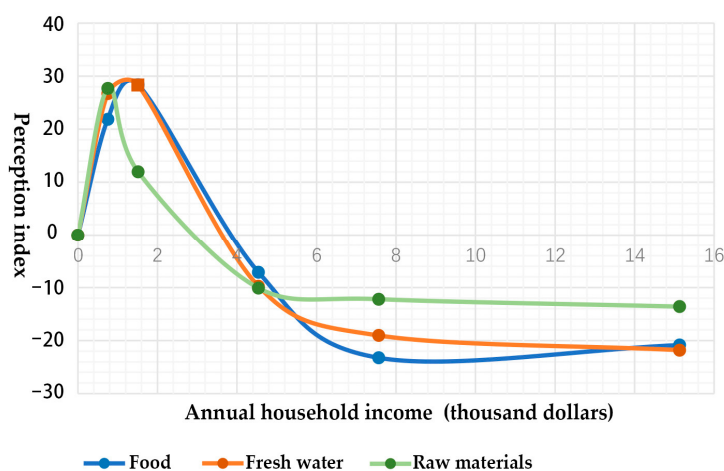
Table A4. Culture service perception indicators, options, and values.

Culture Service	Perception Indicators	Options and Assignments					
		5	4	3	2	1	0
Leisure and aesthetic value	Satisfaction with public spaces such as squares and trails	Very satisfied	Satisfied	Moderate or indifferent	Dissatisfied	Very dissatisfied	No such place
	Satisfaction with street greening	Very satisfied	Satisfied	Moderate or not mind	Dissatisfied	Very dissatisfied	No street greening
	Landscape construction expectations	Strong wish	Wish	Not mind	Not wish	Strong unwish	-

Table A5. Culture service perception indicators, options, and values. Statistical Results of Questionnaire Data Reliability.

Perceptual Variable	Cronbach Coefficient (α Coefficient)			
	Hilly Area	Mountainous Area	Plain Area	Total Reliability
Provisioning service perception	0.787	0.856	0.733	0.828
Regulating service perception	0.751	0.861	0.727	0.826
Culture service perception	0.777	0.776	0.739	0.752

Note: α reliability coefficient refers to the average value of the reliability coefficients obtained by all possible item division methods of the scale.

**Figure A1.** Correlation between perception of provisioning service and household income change.

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