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Rural Environmental Quality Evaluation Indicator System: Application in Shangluo City, Shaanxi Province

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Abstract: The evaluation of rural environmental quality plays an important role in improving farmers' quality of life and in realizing a livable, workable, and beautiful countryside. Taking Shangluo City in Shaanxi Province as the study area, 16 indicators across five systems were selected to evaluate the rural environmental quality. The following methods were used in the evaluation: the hierarchical analysis method, the expert scoring method, and the fuzzy comprehensive evaluation method. The results show the following: (1) The rural environmental quality assessment value of Shangluo City is adequate. (2) In the system layer, the toilet renovation and infrastructure scores were high; however, the household sewage treatment and the construction and management mechanisms need to be improved. (3) According to an IPA quadrant diagram, the importance and satisfaction values for each index varied significantly. The management of black, foul-smelling water bodies and action on environmental remediation emerged as key to improving rural environmental quality. This study can provide a reference for the comprehensive improvement of rural environmental quality in other areas of Shaanxi Province.

Keywords: rural environment; analytic hierarchy process; fuzzy comprehensive evaluation method; Shangluo City

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1. Introduction

The human settlement environment is a complex system, which is centered on people. It comprises villages, towns, cities, and other settlements. Human settlements also require the infrastructure necessary for survival and the natural and social environments that humans rely on for their life and production [1]. The quality of the rural environment is an issue of concern in contemporary social sciences [2]. As a key indicator for evaluating farmers' quality of life, the rural environment is directly related to the production, life, and ecological health of rural areas. Equally, it is also one of the core components in promoting the integration of urban and rural areas in China, in promoting the construction of new towns and cities, and in implementing the strategy of comprehensive rural revitalization. To date, many villages, nationwide, have gradually transitioned from "ecological poverty alleviation" to "ecological revitalization" and from "village cleanliness" to "ecological livability". Thus, they have entered a new stage in constructing livable and beautiful villages. However, some villages are at different levels in terms of their economy, infrastructure, and ecological environment, which has meant that plans to upgrade the quality of the rural environment still suffer from problems such as insufficient capital investment, difficulty in maintaining the long-term effects, limited public awareness of environmental protection, and unsound management mechanisms. These are serious impediments to rural economic development and the well-being of farmers [3]. Consequently, building an indicator evaluation system that accurately assesses rural environmental quality and for-

mulates locally relevant countermeasures for improvement is a key problem in improving rural environmental quality, and one which must be solved.

The concept of the human settlement was first proposed by Doxiadis, who divided it into urban settlements and rural settlements [4]. Other scholars have taken the lead in conducting work on rural settlements, focusing on the following [5]: rural environmental pollution [6], sustainable rural development [7], and rural human settlement environment issues [8]. The following methods are commonly adopted in the evaluation of rural environmental quality and have been widely used in subsequent research: the questionnaire method [9], the hierarchical analysis method [10], the entropy weight method [11], and other evaluation methods. Although domestic scholars' research on the rural environment started relatively late, the continuous implementation of the rural revitalization strategy has further extended and expanded the research content in this area: it has progressed from large-scale considerations, such as early disease control, house construction, and water conservancy construction, to more specific considerations, such as rural waste, sewage treatment, toilet revolution, and village appearance. This increased scope has promoted the development of practical issues related to rural environment management [12,13]. Since the implementation of the Three-Year Action Program for Rural Human Settlement Environment Improvement in 2018, rural environment-related research has received extensive attention from scholars in China. This research has mainly focused on analyzing the current situation [14,15], spatial and temporal differentiation and influencing factors [16], and remediation models and optimization paths [17,18]. At present, rural environmental quality evaluations are mainly based on statistical data and questionnaire data. These data focus on indicators such as the construction of economic development, infrastructure, and the ecological environment [19–21]. The entropy weighting method, the full-aligned polygonal composite index method, the fuzzy comprehensive evaluation method, and other quantitative methods are used to evaluate the advantages and disadvantages of the rural environmental quality in provincial areas, urban agglomerations, county areas, economic zones, and other areas [22–24].

In summary, scholars have achieved significant results in the study of the rural environment, but the following issues need to be explored further: First, most of the existing studies are concentrated in the eastern and central regions of China, and the level of China's rural environment, in general, shows a trend of decreasing from east to west; however, few studies have evaluated the rural environmental quality in Shaanxi Province. Second, the existing data sources for rural environmental improvement studies focus on cross-sectional data, and the evaluation indicator system focuses on the economic development and infrastructure of the study area, which can hardly reflect the actual situation of the area. Third, although there are more research studies on the evaluation of the rural environment, few studies have focused on evaluating the rural environmental quality based on the micro perspective. Therefore, based on the field research data, in this study, we focused on the farmers in 12 villages, across three counties in Shangluo City, as the research object. This study combined the objectives and tasks mentioned in the Five-Year Action Program for Rural Human Settlement Environment Improvement in Shaanxi Province (2021–2025), constructed the index evaluation system, and carried out an evaluation of the rural environmental quality and an analysis of the countermeasures for enhancement. This will provide useful support in the study area and for similar villages that wish to carry out rural environment improvements. It will also help to deepen the study of rural environment improvement and could provide a reference basis for solving rural environmental problems in the new period.

2. Overview of the Study Area and Data Sources

2.1. Overview of the Study Area

Shangluo (33°2′ N~34°24′ N, 108°34′ E~111°1′ E) is located at the southern foot of the Qinling Mountains in eastern Shaanxi Province, with a high terrain in the northwest and a low terrain in the southeast, bordering the provinces of Henan and Hubei, spanning

two major river basins, the Yangtze River and the Yellow River, and including Shangzhou, Luonan, Shanyang, Danfeng, Shangnan, Zhenan, and Zhashui. The study area is shown in Figure 1. According to the 2022 Shangluo City National Economic and Social Development Statistics Bulletin, the city has a total of 862,600 households, a household population of 2,479,700, a resident population of 2,020,600, and a resident population urbanization rate of 49.98%. Shaanxi Province has named provincial beautiful and livable model villages five times, and, to date, a total of 62 villages (communities) in Shangluo City have been awarded this title. In recent years, the Shangluo Human Settlement Office has issued the Rural Human Settlement Environment Improvement Initiative to promote further improvements in rural human settlements. To this end, it has explored the implementation of the rural living waste management model: "household classification, village collection, township transportation, county, and district treatment". As its focus, it selected toilet renovation, classifying and advancing the "toilet revolution" through a whole village demonstration. This precipitated a boom in the city's rural environment improvement work.

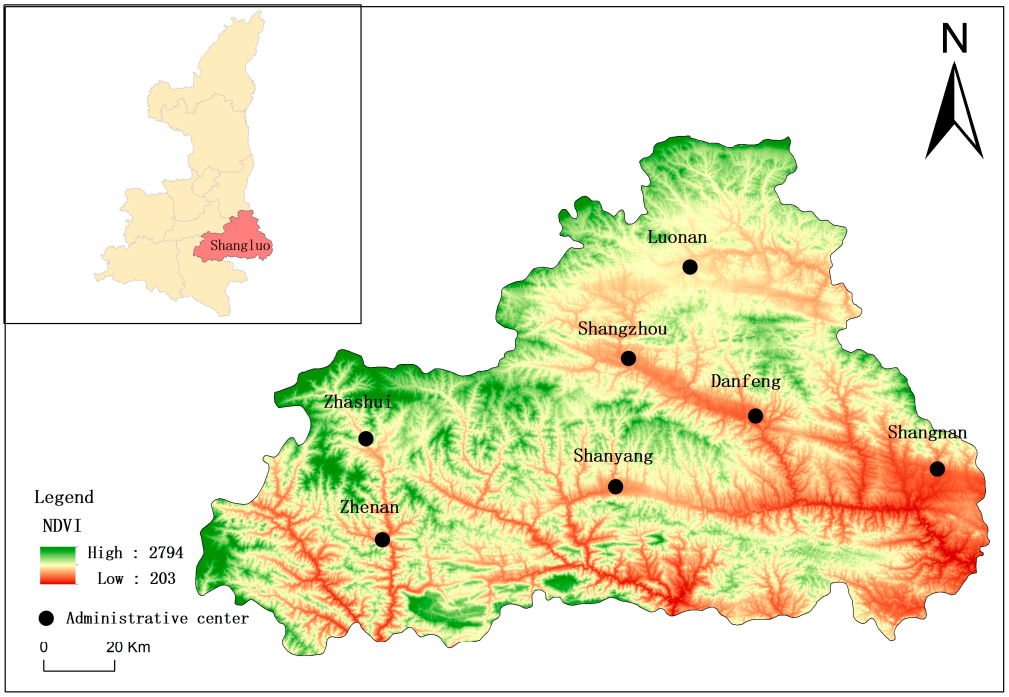

Figure 1. The study area.

2.2. Data Sources

The data were obtained from multiple rounds of field research and household interviews. These were conducted by the research group in Shangluo City in July 2022, and in January and August 2023. These data were supplemented by secondary information that was provided by the county government, the Habitat Office, and other departments. These data mainly included statistical information about counties and districts, and government statistical bulletins. To comprehensively understand the overall situation of the rural environment in Shangluo City, this study adopted a combination of stratified sampling and random sampling to determine the sample villages. The specific sampling process was as follows: three counties were randomly selected from among the seven counties of Shangluo City, two townships in each sample county were selected, two administrative villages were randomly selected in each township, and 12 sample villages were selected in total. Simple random sampling was conducted according to the list of villagers at home, which was provided by the village committee, and 10–15 households were selected for the household survey in each sample village. The survey was conducted among family members who were aware of the environment of the village: the head of the household responded to

the questionnaire and their response was recorded by the surveyor. A total of 152 questionnaires were distributed and 150 valid questionnaires were recovered, with an effective rate of 98.68%. The questionnaires included the following: (1) basic information about the farmers (gender, age, employment, education level, etc.) and (2) the status of the rural environment (infrastructure, household sewage treatment, toilet renovation, household waste treatment, and construction and management mechanisms) (Appendix A).

3. Research Methodology

3.1. Construction of Rural Environmental Quality Evaluation Index System

This study's methodology was based on the objectives and tasks referenced in the Five-Year Action Program for Improving and Upgrading Rural Human Settlement Environment in Shaanxi Province (2021–2025). It was also people-oriented and followed the basic principles of scientificity, objectivity, comprehensiveness, and ecological priority. In addition, it took into account the actual situation of the rural environment in Shangluo City through repeated field surveys, household interviews, and consultations with relevant experts in rural environments. In this way, a system of evaluation indicators for the rural environmental quality in Shangluo City was constructed, with 16 indicators across five systems finally being identified (Table 1).

Table 1. Evaluation index system for the rural environmental quality in Shangluo City.

Target Layer (A)	System Layer (B)	Indicator Layer (C)
The rural environmental quality evaluation in Shangluo City (A)	Infrastructure (B1)	Road leveling condition (C1)
		Greening of the village (C2)
		Condition of public lighting facilities (C3)
		Residential housing situation (C4)
	Household sewage treatment (B2)	Household sewage discharge pattern (C5)
		Management of black, foul-smelling water bodies (C6)
	Toilet renovation (B3)	Rural sanitary latrine penetration rate (C7)
		Satisfaction of farmers with latrine conversion (C8)
		Toilet feces disposal methods (C9)
	Household waste treatment (B4)	Household waste classification situation (C10)
		Household waste removal frequency (C11)
		Household waste disposal methods (C12)
	Construction and management mechanisms (B5)	Farmer recognition (C13)
		Farmer participation (C14)
		Publicity for environmental remediation (C15)
		Environmental remediation actions (C16)

(1) Infrastructure

Infrastructure indicators included the leveling of roads, the greening of villages, public lighting facilities, and residential housing. The leveling of roads in a village reflects the quality of transportation within it, which, thus, reflects the accessibility of travel for the villagers. The greening of a village was shown by the fruits, vegetables, flowers, and trees planted in front of and behind the farmers' houses, as well as by the reuse of wasteland, abandoned land, and marginal land. The public lighting facilities were characterized by the coverage and spacing of the streetlights within the village. The residential housing was characterized by the types of houses and their degree of dilapidation, thus reflecting the living conditions of the villagers.

(2) Household Sewage Treatment

Household sewage treatment indicators included the way that household sewage is discharged and the management of black, foul-smelling water bodies. The way that household sewage is discharged was mainly manifested in four ways: centralized treatment and discharge, discharge into sewers, discharge into nearby ditches, and random discharge.

The management of black, foul-smelling water bodies was characterized by the number of them in front of and behind houses; these included rivers, ponds, and ditches.

(3) Toilet Renovation

Toilet renovation indicators included the penetration rate of sanitary latrines in farm households, the satisfaction of farm households with their latrine renovation, and the toilet feces disposal method. The prevalence of sanitary latrines in farm households was characterized by the extent to which sanitary latrines had been installed in village households' yards or rooms; the satisfaction of farmers with their latrine conversion was characterized by the degree of their satisfaction with how sanitary this was; and how the toilet feces disposal method was handled was mainly manifested in how they were discharged into the sewage network: burying them directly in a pool of wastewater, independently transporting them to the field for use as organic fertilizer, or discharging them directly and untreated.

(4) Household Waste Treatment

Household waste treatment indicators included the classification of household waste, the frequency of household waste removal, and the method of household waste disposal. The classification of household waste was characterized by farmers' knowledge of household waste classification. The frequency of household waste removal was characterized by the speed of cleaning and transferring household waste in the village. The method of handling household waste was mainly manifested in how it is transferred to the waste disposal stations: storing it in designated places, centralized incineration, or throwing it away at random.

(5) Construction and Management Mechanisms

Construction and management mechanism indicators included the degree of recognition by farmers, the degree of farmers' participation, the publicity of environmental improvement, and the action taken on environmental improvement. Farmer recognition was characterized by the farmers' degree of satisfaction with the improvement of the rural human settlement environment in their villages, and farmer participation was characterized by their enthusiasm for these improvements. Environmental improvement publicity was characterized by the frequency of the government's environmental publicity work in their villages. Environmental improvement action was mainly manifested in the multi-dimensional co-management of the government, the community, enterprises, and the villagers.

3.2. Analytic Hierarchy Process

The analytic hierarchy process was a comprehensive and subjective judgment, which was achieved through the qualitative data and quantitative analysis of a combination of methods, and by comparing the importance of the two factors to achieve the relative importance of the indicators between the weights [25]. According to the constructed evaluation index system of the rural environmental quality in Shangluo City and using the analytic hierarchy process, 10 experts in the field were invited to score the indexes uniformly. They assigned values according to the degree of their importance.

The maximum feature root was calculated according to the constructed judgment matrix of the weight relationship among all levels of indicators. The consistency indicator (CI) value, the ratio indicator (RI) value, and the consistency ratio (CR) value were determined. The consistency test was then conducted, and the weight was calculated. Finally, the weight value of the rural environmental quality evaluation index of Shangluo City was obtained (Table 2).

Table 2. The weights and scores of the rural environmental quality evaluation index in Shangluo City.

Target Layer	System Layer	Weight	Score	Indicator Layer	Weight	Scores
The evaluation of rural environmental quality in Shangluo City (A)	Infrastructure (B1)	0.0556	2.993	Road leveling condition (C1)	0.0748	2.886
				Greening of the village (C2)	0.4705	3.013
				Condition of public lighting facilities (C3)	0.273	3.033
				Residential housing situation (C4)	0.1817	2.927
	Household sewage treatment (B2)	0.1804	2.614	Household sewage discharge pattern (C5)	0.207	2.967
	Toilet renovation (B3)	0.1034	3.038	Management of black, foul-smelling water bodies (C6)	0.793	2.521
				Rural sanitary latrine penetration rate (C7)	0.0887	3.027
				Satisfaction of farmers with latrine conversion (C8)	0.6813	3.039
				Toilet feces disposal methods (C9)	0.23	3.046
	Household waste management (B4)	0.2178	2.811	Household waste classification situation (C10)	0.6257	3.02
				Household waste removal frequency (C11)	0.281	2.333
				Household waste disposal methods (C12)	0.0933	2.828
	Construction and management mechanisms (B5)	0.4428	2.693	Farmer recognition (C13)	0.077	2.861
				Farmer participation (C14)	0.25	2.672
				Publicity for environmental remediation (C15)	0.156	2.727
				Environmental remediation actions (C16)	0.517	2.668

The formula for the maximum characteristic root (λ_{max}) is as follows:

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(BW)_i}{nW_i} \quad (1)$$

B represents the judgment matrix of each index, W represents the weight of each index, n represents the order of the judgment matrix count, and i = 1, 2, . . ., n.

The formula for the CI is as follows:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (2)$$

The formula for the CR is as follows:

$$CR = \frac{CI}{RI} \quad (3)$$

3.3. Fuzzy Comprehensive Evaluation Method

The fuzzy comprehensive evaluation method is an evaluation method that transforms the qualitative evaluation into a quantitative evaluation. It made an overall evaluation of the research object [26]. The steps for evaluating the rural environmental quality in Shangluo City are outlined in the sections below.

3.3.1. Establishing Factor Sets and Evaluation Sets

In the evaluation index system, factor set U was established first: the first layer was U1 (the rural environmental quality in Shangluo City); the second layer was U2 (infrastructure, household sewage treatment, toilet renovation, household waste treatment, and construction and management mechanisms); and the third layer was U3, which was made up of 16 evaluation factors, such as the road leveling condition. Second, evaluation set V was established, which was set into four levels: V1, V2, V3, and V4. They were assigned ranks of 1, 2, 3, and 4 points, respectively.

3.3.2. Constructing a Fuzzy Judgment Matrix

According to the ith factor of factor set U, the affiliation degree of Ui to the jth element, Vj, in the evaluation set V was Rij. The evaluation set of the ith factor was Ri = [Ri1, Ri2, Ri3,..., Rim] (i = 1, 2,..., n). For the comprehensive analysis and evaluation of the n factors,

there were n fuzzy evaluation sets: R1, R2, . . ., Rn. The matrix, R, combined by them was the fuzzy relationship matrix [27]; see Formula (4) below.

$$R = \begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_m \end{bmatrix} = \begin{bmatrix} r_{11}r_{12}\cdots r_{1n} \\ r_{21}r_{22}\cdots r_{2n} \\ \vdots\vdots\vdots \\ r_{m1}r_{m2}\cdots r_{mn} \end{bmatrix} \quad (4)$$

3.3.3. Performing Fuzzy Integrated Evaluation Operations

The evaluation matrix, R, and the weights of the indicators, W, were calculated using the following formula:

$$B = W_i \cdot R_I = W_i \cdot \begin{bmatrix} R_{11}R_{12}\cdots R_{1n} \\ R_{21}R_{22}\cdots R_{2n} \\ \vdots\vdots\vdots \\ R_{m1}R_{m2}\cdots R_{mn} \end{bmatrix} \quad (5)$$

4. Results and Analysis

4.1. Evaluation Results for Rural Environmental Quality

The weight of each index was calculated according to the analytic hierarchy process, and the score for each index was calculated using the fuzzy comprehensive evaluation method. Finally, through this, the scores of each system and index layer in the rural environment of Shangluo City were obtained (Table 2).

The comprehensive evaluation score, B, of the rural environmental quality in Shangluo City was 2.757, which is a good level. The rural environmental quality evaluation table for Shangluo City is shown in Table 3. The effect evaluation values of the infrastructure, household sewage treatment, toilet renovation, household waste treatment, and construction and management mechanisms in the system layer were 2.993, 2.614, 3.038, 2.811, and 2.693, respectively. The toilet renovation scored the highest, and the household sewage treatment and construction management mechanisms scored the lowest. Five out of sixteen items in the indicator layer were lower than the comprehensive evaluation indicators: the management of black, foul-smelling water bodies, the frequency of household waste removal, the participation of farmers, the environmental clean-up publicity, and the action on environmental remediation.

Table 3. The rural environmental quality evaluation table for Shangluo City.

Scores	(0,1)	(1,2)	(2,3)	(3,4)
Rating levels	Unqualified	Qualified	Good	Excellent

The evaluation score for the level of toilet renovation was 3.038, which was the highest evaluation score among the five components at the system layer. The evaluation values for the sanitary rural latrine penetration rate, farmers' satisfaction with latrine conversion, and latrine fecal waste treatment methods in the second-level indicators were 3.027, 3.039, and 3.046, respectively. These values were higher than those of the comprehensive evaluation indicators. According to the statistical bulletin, Shangluo City has constructed 65,500 rural household toilets and 836 rural public toilets, and the penetration rate of the sanitary rural toilets has reached 72.9%. From the actual research, we know that farmers are more satisfied with the change from "dry latrines" to "flush toilets" and pay more attention to the cleanliness and safety of the toilets and the availability of facilities. The fecal matter from the toilets in the villages is centrally discharged to the sewage network for unified treatment or is independently transported to the fields and used as organic fertilizer. These methods ensure that fecal matter from the toilets and the use of resources do not harm the

quality of the rural environment. This further confirms the positive role played by toilet renovation in promoting the improvement of rural environmental quality [28].

In terms of infrastructure, the evaluation score was 2.993, ranking second. The indicator layers of road leveling, village greening, the condition of the public facilities, and residential housing in the indicator layer were 2.886, 3.013, 3.033, and 2.927, respectively, which were all higher than the comprehensive evaluation index. In recent years, Shangluo City has focused on creating provincial-level demonstration villages for "Four Good Rural Roads". These focus on "two links" and realize the following goal: 100% of the established villages are connected to hardened roads, buses, and postal routes, forming a rural transportation network that is "safe and convenient". Village cadres have led the villagers in continuing the following actions: village cleaning and landscaping; increasing the greening efforts (in the front and back of the house and in front of the courtyards); the construction of small/micro parks and public green space, which mainly manifested as planting flowers and trees; painting a "publicity wall"; and other rectification actions. Local governments have promoted the integration of public lighting facilities and roads in the villages by strengthening the construction of street lamps on the main roads in the villages, planning the spacing of street lamps, and improving the public service facilities in rural areas. The state has taken a variety of measures to ensure the safety of rural housing, thus removing the hidden safety hazards of farmers' housing: carrying out special safety rectifications of self-built houses, carrying out the unified demolition of dangerous and abandoned houses, and reasonably resettling low-income rural groups and other key targets to migrant relocation houses.

At the level of household waste management, the evaluation score was 2.811, which was slightly higher than the comprehensive evaluation score. The evaluation scores for the secondary indicators—the classification of household waste, the frequency of household waste removal, and the household waste treatment method—were 3.02, 2.333, and 2.828, respectively. The score for the frequency of household waste removal was lower than the comprehensive evaluation score. Rural household waste management is a key project in rural environmental improvement. It is also the foundation for realizing rural revitalization and for building livable, workable, and beautiful villages. With the development of recreation and tourist facilities in villages, rural inns and lodgings have grown, meaning that household waste has gradually increased. The government has carried out special rural garbage management actions: it has explained garbage classifications and the harmless treatment of garbage to villagers, and has installed garbage classification barrels and garbage removal vehicles, etc., in villages. However, these efforts have been negatively affected by the villagers' living habits and the fact that their awareness of environmental protection is still relatively limited. This has resulted in garbage piling up and being left unattended at the treatment stations. In addition, the vast majority of villages are located in mountainous areas, where the distance between them is relatively long and the speed of waste removal is relatively slow, meaning that household waste management is still a serious issue.

At the level of construction and management mechanisms, the evaluation score was 2.693, and the evaluation scores of the secondary indicators—the recognition of farmers, farmers' participation, the publicity on environmental remediation, and action on environmental remediation—were 2.861, 2.672, 2.727, and 2.668, respectively. The scores were lower than the comprehensive evaluation scores, with the exception of the recognition of farmers. To effectively consolidate the results of rural environment improvement and to create clean, tidy, beautiful, and livable rural landscapes, Shangluo City's governments at all levels have carried out in-depth rural environment improvement work and have driven key projects forward, such as village appearance, living waste management, toilet renovation, and household sewage management. Farmers are more satisfied with the current rural environment improvements, but they still might not realize that they are participants in and the main force behind the rural environment improvement work. They are still "waiting, relying and wanting"—they tend to be overly reliant on the power of

the government or on village committees and other third parties, and they tend to have little enthusiasm for participating in the process of rural environment improvement. Due to the distance between the villages and the generally low education levels among the villagers, the government's ability to publicize environmental protection and to educate the villagers is limited to the distribution of environmental protection pamphlets, hanging banners and signboards, and publicity trucks. This is having poor results. The majority of the households interviewed in this study were headed by middle-aged people, who rely on farming at home and working outside the home to support their families' expenditures. Their initiative to consciously participate in the improvement of the rural environment is relatively limited, and they tend to rely on the government's financial support and the village committees to take the lead in the management of their environment.

The evaluation score for household sewage treatment was 2.614, which was the lowest score in the target layer, and the evaluation scores of its secondary indicators—the household sewage discharge pattern and the treatment of black, foul-smelling water bodies—were 2.967 and 2.521, respectively. The scores for the treatment of black, foul-smelling water bodies were lower than the comprehensive evaluation scores. The sewage treatment rate for rural households in Shangluo City is still only 41.07%, which makes it the biggest obstacle to improving the quality of the rural environment. To ensure that sewage treatment is effective, all levels of government in Shangluo City have built sewage treatment facilities in the villages and put them into use, which can be seen through the construction of sewage treatment stations, the laying of sewage pipe networks, the regular operational supervision of each site, guiding farmers to discharge their household sewage hygienically, and continuously improving the effectiveness of sewage treatment. Farmers in Shangluo City mainly focus on planting; therefore, they use chemical fertilizers, pesticides, and other chemical substances in agricultural production. These chemicals are then picked up in rainwater flows, meaning that they end up in rivers and ditches, which destroys the ecological balance of the water bodies. This is compounded by the industrial wastewater generated by the numerous factories in the villages, which also pollutes the water. These sources of pollution culminate in black, foul-smelling water bodies [29]. Despite continued efforts across Shangluo City to carry out river waste treatment and to comprehensively clean up the residual malodorous ditches in the river, the impact of these efforts on the management of black, foul-smelling water bodies is still not obvious.

4.2. Countermeasures to Improve Rural Environmental Quality

By analyzing the differences in the scores for importance and satisfaction among the indicators, this study can help decision makers to judge the strengths and weaknesses of each indicator. The average score for importance (0.3125) and the average score for satisfaction (2.848) among the 16 indicators were used as the dividing line to plot the IPA quadrant. The range of the importance scores was 0–0.8 and the range of the satisfaction scores was 2.3–3.1, as shown in Figure 2.

The first quadrant is the dominant area, reflecting the three indicators to which the villagers attached high importance and satisfaction: greening in the village (C2), satisfaction with the conversion of latrines in farm households (C8), and the classification of household waste (C10). In the follow-up process for rural environment improvement in Shangluo City, the village cadres encouraged the villagers to fully revitalize the unused land in the courtyard by turning it into tree gardens, orchards, gardens, or vegetable gardens; to make use of the deserted vacant land in front of and behind their houses; and to continue greening and beautification actions across the villages. The concept of "small toilet, big livelihood" was set up at a country level. It fully respects the wishes of farmers by starting from their actual needs, thus improving their satisfaction with the toilet improvements implemented. Government staff regularly carry out publicity activities on household garbage classification, explaining garbage classification to enhance farmers' awareness of environmental protection and to encourage them to develop good habits.

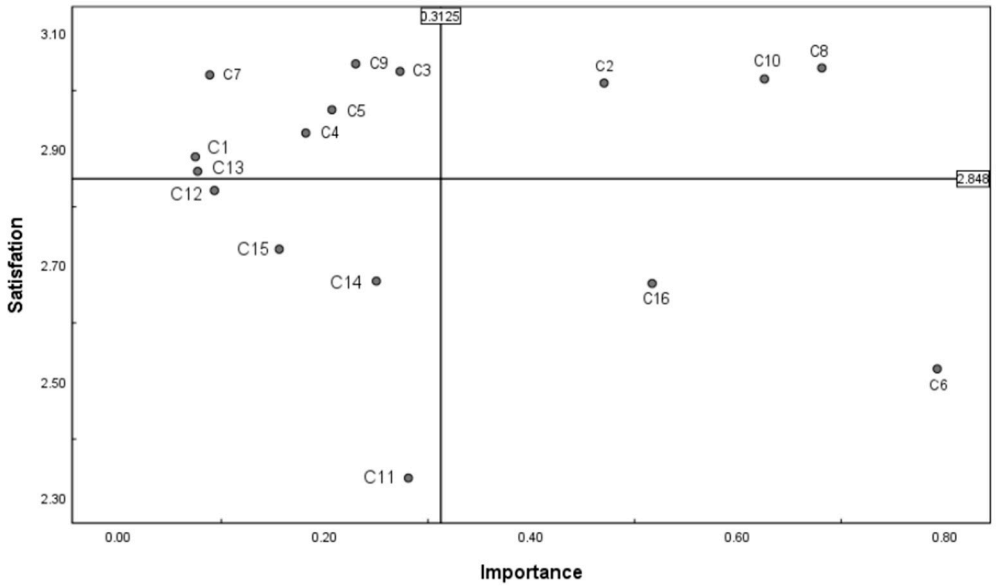

Figure 2. Importance–satisfaction IPA quadrant chart.

The second quadrant is the maintenance area, reflecting the seven indicators to which the villagers attached low importance and high satisfaction: road leveling (C1), the lighting of public facilities (C3), living houses (C4), household sewage discharge (C5), sanitary rural latrine prevalence rate (C7), toilet feces disposal methods (C9), and farmers' recognition (C13). These indicators are concentrated in the two system layers of infrastructure and toilet renovation, which represent the key projects of rural environmental quality improvement in Shangluo City. In the future, the construction of infrastructure should be continuously improved, and long-term management and protection mechanisms should be established. The government should continue to take a leading role in ensuring that the farmers are the participants, builders, and beneficiaries in toilet conversion, and they should actively listen to the views of the villagers to ensure that the toilet renovation program is in line with reality.

The third quadrant is the expansion area, reflecting the four indicators to which the villagers attached low importance and satisfaction: the frequency of household waste removal (C11), household waste disposal methods (C12), the participation of farmers (C14), and the publicity of environmental clean-up (C15). These indicators were mainly focused on the two governance levels of household waste management and construction management mechanisms and represent projects that have not yet been prioritized or have not attracted the attention of the villagers themselves. Going forward, sufficient elastic space should be left for projects such as farmers' participation and the publicity of environmental remediation, which should not be regarded as the focus of current construction. However, in the future development and construction of Shangluo City, the government should pay attention to these projects dynamically, so that, in time, the demands in the construction process can be supplemented. Projects such as household waste removal frequency and methods of household waste disposal are very important in the process of rural environment construction; however, not enough attention has been given to them due to the awareness level of the villagers. Follow-up village cadres need to strengthen publicity, education, and behavior guidance so that the villagers can actively participate in the construction and maintenance of their hometown environments.

The fourth quadrant is the repair area, which reflects the two indicators to which the villages attached high importance but low satisfaction: the management of black, foul-smelling water bodies (C6) and action on environmental remediation (C16). Villagers expressed a high degree of expectation for the indicators in this area, but the actual result has not been satisfactory. Going forward, the village cadres should organize the villagers to investigate the black and malodorous water bodies in the village, and they should regularly

count them. The government has invited experts to analyze the characteristics of different types of black, foul-smelling water bodies—such as rivers, pits, and ditches—and fully analyzed their characteristics and causes, based on the local natural environment and economic development level [30]. Going forward, the government should also classify and treat agricultural wastewater and farmers' domestic sewage, choosing reasonable physical, chemical, and biological methods [31]. Village officials should also encourage villagers to actively participate in the treatment of black, foul-smelling water bodies, and should improve the long-term supervision mechanisms to ensure the effectiveness of the treatment. Rural environmental improvement work requires the construction of a set of multi-dimensional, long-term management and care mechanisms which should be based on government investment and then supplemented by farmers' support and the active participation in social capital: First, as farmers are the direct beneficiaries of rural environmental improvement, they should play the main role in rural environmental construction. Village cadres should actively guide party members to participate in environmental governance and incorporate rural environmental remediation into village rules and regulations to enhance farmers' awareness of consciously protecting the environment [32]. Second, rural environment improvement needs national capital investment. The government should allocate reasonable funds, not only for key areas of equipment procurement or for technology research and development, but also for technical training and incentives to encourage farmers to participate in environmental governance [33]. In addition, social capital can be used to participate in rural environmental governance through corporate sponsorship, and it can also make use of advanced management means and technological advantages to improve rural environmental quality [34].

5. Discussion

Against the background of rural revitalization, this study constructed a set of rural environmental quality evaluation index systems for the environmental characteristics of Shangluo City and the laws on rural development and construction. In this study, we also put forward countermeasures to improve rural environmental quality in a targeted manner. The evaluation results of this study reflect the basic situation of the rural environment in Shangluo City, and the evaluation results were consistent with the actual situation. To a certain extent, this can provide a reference for the next phase of rural environment improvement work in Shaanxi Province. This study has expanded the research field of rural environmental evaluation and has filled the gap in the existing literature on rural environmental evaluation in Shangluo City. However, it must be recognized that the indicator system proposed in this study may have limitations and be incomplete. For example, rural ecosystem indicators, such as fertilizer use and forest cover, were not addressed [35]. Moreover, the research data are of a regional and time-dependent nature; therefore, the exploration is only relevant to some villages in Shangluo City. This may lead to the research results not being universally applicable.

Rural environmental remediation work is a long-term, systematic project, which is variable and complex. In future studies, scholars could further expand the scope of this research by combining the disciplinary knowledge of ecology, geography, and urban and rural planning [36,37]. They should also adopt emerging research tools such as 3S technology and big data analysis [38]. The evaluation index should also be further revised according to the regional characteristics through the regular evaluation method and the long-term management mechanisms that are established [39].

6. Conclusions

First, this study constructed a set of rural environmental quality evaluation index systems. Next, a hierarchical analysis was used to determine the index weight, and the index score was calculated using the fuzzy comprehensive evaluation method. Finally, based on the IPA quadrant map, targeted countermeasures to improve the rural environmental

quality of Shangluo City were proposed. This study's conclusions can be summarized as follows:

(1) In this study, sixteen indicators were selected from across five aspects to evaluate the overall rural environmental quality in Shangluo City. The results showed that the rural environmental quality of Shangluo City is adequate.
(2) According to the evaluation results, the scores for household sewage treatment and for the construction and management mechanisms in the system layer were relatively low. The scores for the treatment of black, foul-smelling water bodies, the frequency of household waste removal and transportation, the participation of farmers, the publicity on environmental remediation, and the action on environmental remediation were lower than the comprehensive evaluation scores.
(3) Based on the IPA quadrant map, the 16 indicators were divided into four quadrants according to the degree of importance and satisfaction expressed by the villagers. The results show that the villagers attached high importance to the treatment and management of black, foul-smelling water bodies and to action on environmental remediation; however, their satisfaction with these indicators was low. In the future, the Shangluo Government should prioritize the farmers' participation in the treatment of black, foul-smelling water bodies and environmental remediation in the improvement of rural environmental quality and rural environmental construction.

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Appendix A. Questionnaire on Rural Environmental Quality in Shangluo City

Part I. Basic information about the farmers.
1. What is your gender?
(1) Male
(2) Female
2. What is your age?
(1) 18–25 years old
(2) 26–35 years old
(3) 36–45 years old
(4) 46–60 years old
(5) 60 years old and above
3. What is your level of education?
(1) Elementary school and below
(2) Junior high school
(3) High school
(4) Junior college
(5) Bachelor's degree and above

4. What is your current occupation?
(1) Farming at home
(2) Farming and working
(3) Working outside the home
(4) Other
Part II. The situation of the rural environment
I. Infrastructure
5. What is your assessment of the current leveling of roads in your village?
(1) Roads are very flat
(2) Roads have less breakage
(3) Roads have lots of breakage
(4) Roads have many potholes
6. What is your assessment of the greening in your village?
(1) Very satisfied
(2) Satisfied
(3) Basically satisfied
(4) Dissatisfaction
7. What is your assessment of the public lighting facilities in your village?
(1) Roads are well-equipped with public lights.
(2) The distance between the public lights is far away.
(3) The public lights are damaged.
(4) Roads aren't well-equipped with public lights.
8. What is your assessment of your current housing situation?
(1) Very satisfied
(2) Satisfied
(3) Basically satisfied
(4) Dissatisfaction
II. Household sewage treatment
9. What is your assessment of the household sewage treatment from your home?
(1) Household sewage treatment is discharged into the sewage treatment plant for centralized treatment and unified discharge.
(2) Household sewage treatment is discharged into the sewers.
(3) Household sewage is discharged into the nearby ditches.
(4) Household sewage is discharged anywhere.
10. What is your assessment of the management of black-smelling water bodies in your village?
(1) No black-smelling water bodies
(2)A small amount of black-smelling water bodies
(3) A large amount of black-smelling water bodies
(4) Black-smelling water bodies are always in the river
III. Toilet renovation
11. What is your assessment of the penetration rate of sanitary latrines in your village?
(1) There are public toilets in the village.
(2) Villagers have flush toilets in their homes.
(3) Villagers have dry pit latrines in their homes.
(4) No toilet
12. How satisfied are you with the latrine conversion?
(1) Very satisfied
(2) Satisfied
(3) Basically satisfied
(4) Dissatisfaction

13.How do you usually do with the toilet feces?
(1) Discharge to sewerage network
(2) Direct burial of fecal lagoons
(3) Self-transported to the field for organic fertilizer
(4) Discharge without treatment
IV. Household waste management
14. How is the classification of household waste in your village?
(1) There are special staff in the village to classify the waste
(2) There are waste sorting buckets in the village
(3) Waste sorted randomly
(4) No waste classification
15. What is the frequency of household waste removal in your village?
(1) Clean once a day
(2) Clean every two days
(3) Clean once every three days or more
(4) Nobody clean
16. How is household waste disposed of in your village?
(1) Transfer Transfer waste disposal station
(2) Unified storage in the designated locations
(3) Discarded randomly
(4) Centralized burning
V. Construction and management mechanisms
17. How satisfied are you with the rural environment?
(1) Very satisfied
(2) Satisfied
(3) Basically satisfied
(4) Dissatisfaction
18. How is your enthusiasm to participate in the rural environment?
(1) Active participation
(2) Occasional participation
(3) Support but not participate
(4) Never participated
19. How does Environmental clean-up publicity work in your village?
(1) Always publicity
(2) Regular publicity
(3) Occasional publicity
(4) Never publicity
20. What actions do you think need to be taken to improve the rural environment?
(1) Government Funding
(2) Social organization manpower inputs
(3) Farmers' participation in conservation
(4) No action taken

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