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Developing a Method to Evaluate Public Space Perception in River Valley Plain Villages of the Loess Gully Area Based on Villagers' Perspectives

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Abstract: The natural conditions in the loess gully area are harsh, and the construction of rural public spaces often lacks scientific guidance. It is essential to develop an optimization method for public spaces that is oriented toward the needs of villagers. For this study, the numerous river valley plain villages in Northern Shaanxi were selected as typical examples, with a focus on Liangqu Village as a case study. First, a public space perception evaluation system was established using the semantic differential method, which comprised four criterion-layer factors and nineteen indicator-layer factors. Perception evaluations were conducted for two types of public spaces: nodes and lanes. The results indicate that "facility completeness", "accessibility", and "activity diversity" were the most significant factors affecting villagers' perceptions of node spaces. In contrast, "safety", "landscape richness", and "facility completeness" were the most critical factors influencing villagers' perceptions of road spaces. Based on the evaluation results, the optimization needs of public spaces were categorized into four levels, and factors that urgently require improvement such as "facility completeness" and "safety" were identified. This study analyzed villagers' perceptions and needs related to public spaces, providing scientific guidance for establishing a bottom-up design method for optimizing public spaces.

Keywords: loess gully area; river valley plain-type villages; public spaces; perception evaluation

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1. Introduction

The dilemma of rural community development is a common topic of sustainable development around the world [1]. Rural living conditions are critical factors in the sustainable development of rural areas [2,3]. Rural habitats may often be exacerbated by poverty or lack of infrastructure and services compared to urban areas [4]. In recent years, China has placed importance on rural construction and development by introducing policies like "New Rural Construction", "Beautiful Countryside Construction", and "Rural Revitalization" to address the urban–rural development imbalance [5]. Public space, as the spatial framework for villagers' daily production and lives, constitutes a central element of rural space [6]. It not only serves the functional needs of villagers for production and daily life [7] but also acts as a crucial link that maintains the social relationships within a village [8]. Additionally, public space plays a key role in the preservation and transmission of rural history and culture [9,10]. However, under the past model of rapid urbanization, the international research on rural public space was insufficient [11], and commonly faced issues such as mismatches between supply and demand, functional decline, and homogenized construction [12]. More critically, the current planning and construction of rural public

spaces often prioritizes efficiency over the actual needs of villagers. As a result, various spaces end up underutilized or even abandoned, reflecting gaps between their designs and villagers' real demands. Thus, evaluating villagers' perceptions and demands regarding rural public space and using these insights to guide its construction has become an urgent issue in the context of contemporary rural development.

The Loess Plateau, which covers 6.67% of China's land area, is a vast arid inland region [13]. Characterized by loess hills and gorges, this region faces severe soil erosion and a fragile environment, which significantly constrains the development of rural living conditions. Additionally, the process of homogenized construction under China's rapid urbanization has consumed much of this region's scarce buildable land [14]. This development process has often insufficiently considered the unique topography and ecological constraints of this area, leading to designs that do not fully accommodate the landscape or villagers' cultural practices. Consequently, much of the public space remains underutilized or idle in this region. Therefore, it is essential to conduct a scientific analysis of rural public spaces and assess villagers' perceived needs based on the typical village types and their unique requirements in this region. This study aimed to (1) develop a perceptual evaluation system for public spaces in river valley plain-type villages within the loess gully region from the villagers' perspective and (2) establish an importance–satisfaction model for optimizing rural public spaces, identifying priority levels for the optimization needs of different types of public spaces from the villagers' point of view. This model will help highlight specific areas where villagers feel most dissatisfied, providing clear priorities for intervention. By analyzing the villagers' perceptions and evaluations of public spaces, this study provides an effective foundation for developing a bottom-up (villager-demand-based) approach to the optimization and design of rural public spaces.

2. Literature Review

2.1. Conceptualization and Classification of Rural Public Space

Previous studies suggested that the conceptualization of rural public space should consider both physical spaces and cultural elements [10,15]. Rural public space not only is a material entity, encompassing indoor and outdoor spaces such as temples and marketplaces, but also includes non-material elements, such as religious and folkloric activities [15,16]. Based on this concept, scholars have proposed various classification methods for rural public space. Chen Jianhua et al. categorized the public spaces of traditional villages and towns into two types: nodal and linear spaces [12,17]. Tang Shanshan, on the other hand, classified rural public spaces in traditional villages into three types—nodes, linear spaces, and surface spaces—according to their geometric characteristics [18,19]. Nodes primarily include road intersections, spatial junctions, and specific functional nodes; linear public spaces refers to roads, alleys, and water systems, while surface public spaces mainly encompass open areas such as plazas and farmland. Yu Xujiao further classified rural public spaces into three categories—organizational, event-based, and place-based—according to their functional attributes [14,20]. In summary, different research perspectives and objectives have led to varied approaches to the classification of rural public space.

2.2. Evaluation and Perception of Rural Public Space

The evaluation of public space perception originated in studies on urban environments that focused on the relationship between individual perception and urban public spaces. Since the village construction movements that began in the 1950s across various countries, research on the evaluation and perception of rural public spaces has yielded a substantial body of theoretical work [11,16,17,21–23]. In recent years, scholars have increasingly recognized the central role of villagers in rural renewal and public space development and have adopted a bottom-up approach to evaluating rural public spaces.

Currently, the evaluation methods for public spaces in academic research can be broadly categorized into qualitative and quantitative approaches. Qualitative evaluation methods primarily include the cognitive mapping technique [20,24] and the 'public space–

public life' survey method [25,26], focusing on villagers' perceptions and patterns of public space usage. Agboola [22] conducted a qualitative study of Nigerian village marketplaces through interviews, group discussions, and questionnaires, analyzing differences in marketplace space perception from the perspectives of villagers belonging to different ethnic groups. Based on these insights, he proposed recommendations for optimizing spatial design and operational management. Dawid [11], through expert interviews and field surveys in four Polish villages, concluded that a bottom-up development model contributes to the vitality of rural public spaces. Similarly, Navarro [23] revisited the impact of the European LEADER initiative (Liaison Action for Rural Economic Development) on rural areas. Their study of two case regions in Spain and the United Kingdom affirmed that this bottom-up strategy has generated both social and economic benefits in rural public space development and governance.

Quantitative evaluation methods primarily include the semantic differential (SD) method [24], the environmental simulation method [26], and the big data analysis method [27]. Additionally, recent studies have utilized new technologies such as GPS and mobile devices to analyze rural public spaces. A study in Handan, Hebei Province, utilized eye-tracking devices to evaluate rural public spaces [28]. In Jiangxi Province [29] and Zhejiang Province [30], studies used mobile Wi-Fi devices and GPS to measure the characteristics of villagers' and tourists' use of tourist-oriented rural public spaces. In Malaysia, there is a study on mapping and spatial analysis of rural habitats using drones [31]. These methods have significant advantages in terms of objective spatial and temporal characterization and evaluation of the use of public space, but they have some limitations in quantifying the subjective needs of local villagers.

The environmental elements of rural public spaces are complex and difficult to replicate using virtual platforms. Moreover, obtaining rural data via the internet presents significant challenges. As a result, the SD method was introduced into the field of architecture and has been widely applied to quantitatively evaluate rural public spaces [32]. This method employs language as a scale, comparing a series of symmetrical adjective pairs to the evaluated object to quantitatively assess individuals' attitudes, impressions, or feelings. It provides a scientific approach for perceptual evaluation of rural public spaces [33]. Michal Micek and colleagues applied the SD method to compare the quality of urban and rural public spaces in Poland, demonstrating its effectiveness in the quantitative evaluation of public spaces [34]. In recent years, as rural areas in China have developed rapidly, the SD method has also been used in studies of rural space perception [35]. These studies have enriched the body of research on rural public spaces across diverse natural environments. However, most of these studies have focused on rural areas in economically developed regions, such as coastal areas [30], offering limited guidance for the development of rural spaces in the harsh environment of the Loess Plateau.

2.3. Studies Related to Loess Gully Areas

At present, research on rural areas in the loess gully regions of China primarily focuses on analyzing the overall spatial structures and morphological characteristics of settlements. In recent years, some scholars have gradually recognized the significant value of public space in rural construction and development, conducting studies at various levels. Macro-level research primarily addresses the overall configurations and layouts of rural public spaces and public service facilities [36]. Meso-level studies focus on the internal layouts and usage characteristics of public spaces within villages, analyzing the differences in satisfaction levels among different groups of villagers regarding the public spaces in traditional villages in loess gully areas [37]. Micro-level research is centered on practical methods for renovating specific public spaces [36]. In the context of the loess gully region, previous studies have generally agreed that river valleys and plain areas in Sichuan have a clustering effect on the evolution and development of villages, serving as the core areas for rural human habitat formation [38]. These studies explored the structural characteristics of public spaces within the spatial organization of river valley plain-type

villages. However, research on the perceptual evaluation of public spaces in such villages remains scarce, resulting in limited guidance for optimizing public space design in the Loess Plateau region.

China's villages are broadly categorized into agricultural, industrial, tourist with tourism resources and traditional villages with geographical historical and cultural resources. The latter three types have a higher level of economic development and a larger population compared to the first type. Previous research on the perceptual evaluation of rural public spaces has primarily focused on traditional and tourist-oriented villages with better resource endowments, while studies on villages in underdeveloped regions, such as the loess gully areas, remain insufficient. Villages in relatively underdeveloped areas, such as loess gully areas, have insufficient infrastructure, are sparsely populated and have a high degree of population aging. This leads to difficulties in the application of smart devices such as GPS or Wi-Fi tracking. Due to the difficulty of obtaining research data, the evaluation of the perception of rural public space in this region is not sufficient, and there is a lack of guidance for the design method of rural public space. With the ongoing and deepening implementation of rural revitalization, increasing attention is being paid to the central role of villagers and their needs in the construction and development of rural public spaces. Therefore, it is essential to conduct a perceptual evaluation of public spaces from the perspective of villagers, which means that it is necessary to develop a method for evaluating the perception of public space based on the villagers' perspective for areas where data collection is limited. This study focused on the widely distributed river valley plain-type villages in the loess gully region, analyzing the characteristics of rural public spaces and quantifying villagers' perceptual evaluations of these spaces. Based on these findings, this study summarized the actual needs of villagers, providing a scientific basis and a reference for designing optimal public spaces in villages within the loess gully areas.

3. Materials and Methods

3.1. Selection of Study Area and Typical Villages

The Loess Plateau is located between 32° and 41° N latitude and between 107° and 114° E longitude, covering a total area of 648,700 km^2. The Loess Hills and Gullies Area is one of the most characteristic geomorphological units within the plateau, spanning 140,000 km^2 [13]. It is predominantly composed of ridge-shaped hills with a fragmented topography and extensive gullies. Rural settlements in the loess gully region can be classified into four types based on their geographical locations, surrounding environments, and distribution characteristics [39]. River valley plain-type villages, which are located near rivers, represent the predominant settlement type. Consequently, this study focused on river valley plain-type villages, as optimizing and improving their living conditions holds significant relevance for other villages in this region. Field investigations revealed that these villages are primarily concentrated in Zizhou County. As shown in Figure 1, seven villages in this category have relatively well-developed public spaces. Liangqu Village, in particular, was noted for having the best construction conditions, with various kinds of well-developed public spaces; however, it faces typical challenges, such as low usage rates and poor landscape esthetics. Thus, Liangqu Village was selected as the primary case study for this research. This village currently has a population of 1058 across 262 households, with over 30% of the population aged 60 or above, indicating that population aging is a severe issue.

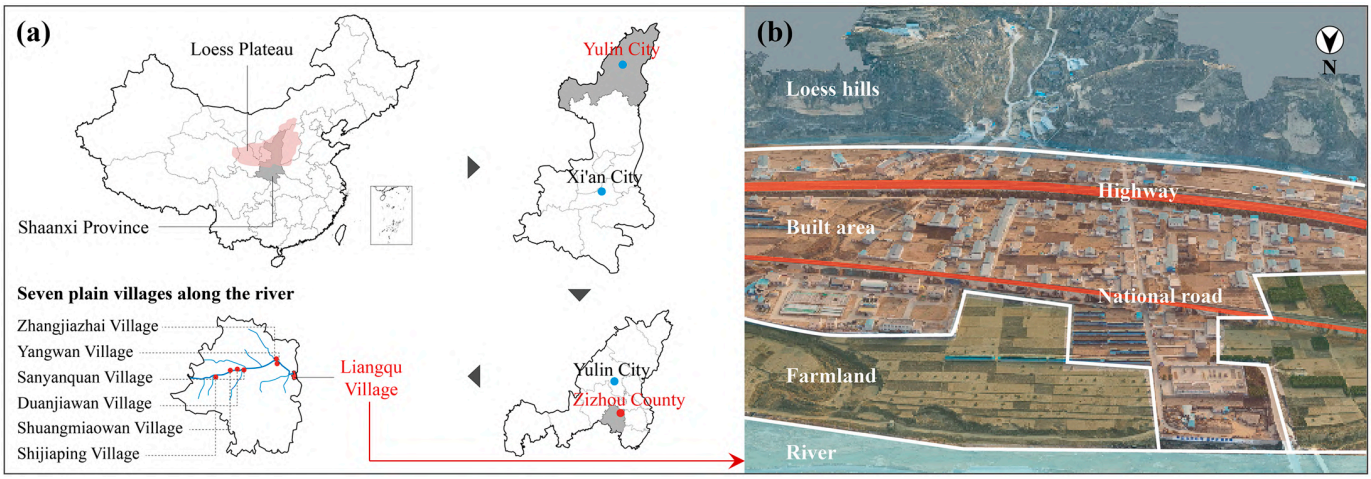


Figure 1. (**a**) Typical village locations. (**b**) Typical functional layout of a village.

3.2. Field Survey and Data on Public Space in Typical Villages

3.2.1. General Distribution of Public Space in the Village

First, a field survey was carried out on the public space in Liangqu Village to determine the characteristics of public space distribution. This research was carried out in November 2021 and August 2022. Figure 2 shows the general distribution of the public space in the village, most of which was in the Dali River valley. Because of the land constraints in the loess gully area, the public space mostly had a small scale and a decentralized layout, and there were few large-scale "surface" public spaces. Therefore, the public space in the village was divided into two categories: node space and lane space.

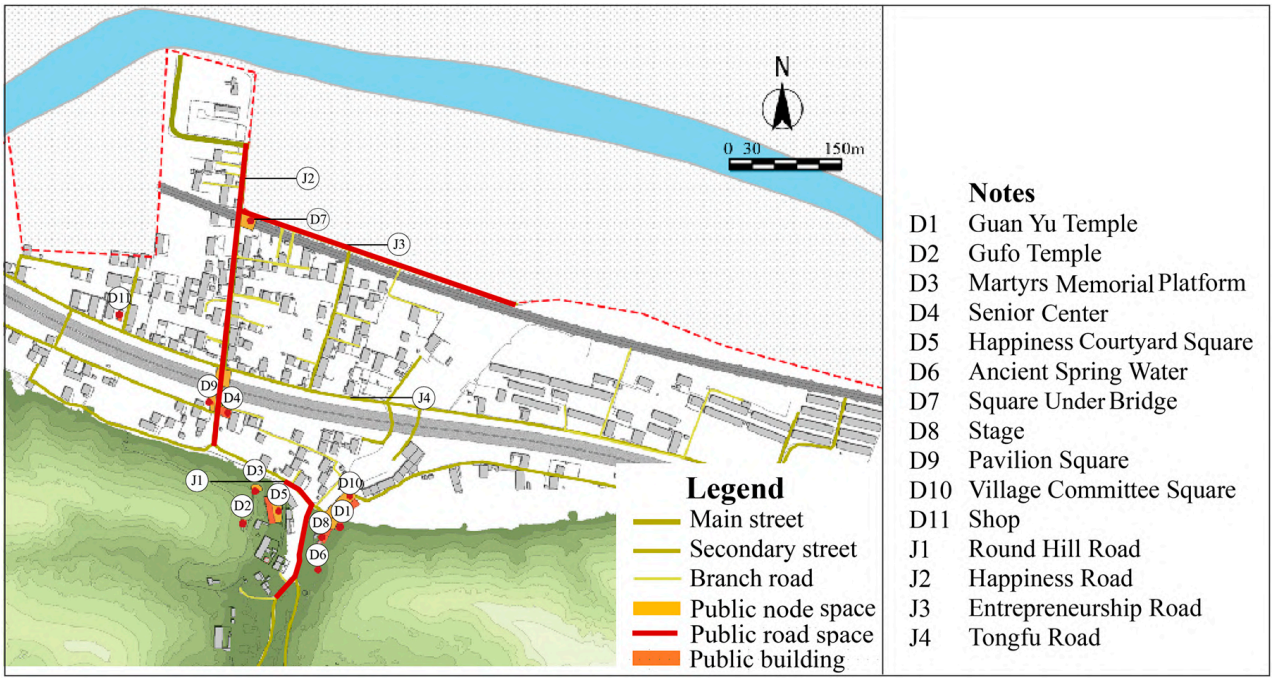


Figure 2. The distribution plan of the major public spaces in Liangqu Village.

3.2.2. Public Node Spaces

Based on the field research, the public node spaces in Liangqu Village were classified into three categories: pre-house space, general node space, and important node space. Figure A1 shows the construction statuses of the public node spaces in the village. Pre-house space refers to open space next to a house or residential compound that is accessible from a road. General node spaces include small-scale activity sites such as springs, the square under the bridge, and the elderly activity center, which were mostly constructed by villagers on their own initiative. These spaces serve as the main venues for villagers' daily interactions and public life in Liangqu Village. Important node spaces are mainly concentrated together in the village, and they include political and religious spaces such as the village committee square, stage, and Guandi Temple, which were mostly built from the top down. These spaces were originally the main locations where villagers conducted collective activities; however, under the impact of urbanization, the sense of village customs has gradually faded, and they are now mostly unused.

3.2.3. Public Road Space

The road space in Liangqu Village was divided into main roads and secondary roads, and Figure A1 shows their construction statuses. The main road is Happiness Road, which runs from north to south and connects with National Highway 307 at the northern end, serving as the main internal and external traffic route for the village. The main road is approximately seven meters wide and is in good condition. It connects most of the node spaces in the village, carrying relatively rich public activity. The secondary roads are mainly used for internal traffic, with widths of 3–5 m, and they divide the village into several groups. Roadside facilities such as streetlights and seats are often provided, making these roads places for villagers to engage in neighborhood interactions and other activities.

3.3. Constructing the Village Public Space Perception Evaluation System

The semantic differential (SD) method selects common adjectives to measure respondents' psychological responses to various environmental elements in a target space. This method can transform ambiguous perceptual descriptions into quantitative evaluation results [40]. Using the semantic differential method and field research, a system for evaluating public space perception in river valley plain-type villages was constructed based on four aspects: function, landscape, spatial form, and environmental sensation. Additionally, to coordinate the hierarchical relationship between the evaluation factors, the Analytic Hierarchy Process (AHP) was adopted to construct a quantifiable, multi-level evaluation index system. The weights obtained using the AHP were combined with scores derived using the SD method to yield quantitative perception evaluation results related to village public space from the perspective of the villagers.

3.3.1. Semantic Differential Method for Selecting Evaluation Factors

To ensure a scientific, comprehensive, and regional selection of evaluation factors, the CNKI China Knowledge Network data platform was used to search the literature for the keywords "village public space", "public space perception", and "village public space evaluation". A total of 103 articles in Chinese and foreign journals met the criteria for evaluation. Further, using the "article journal level" and the "number of citations" as evaluation criteria, 19 authoritative articles were selected as references [12,41–59]. Finally, 4 criterion factors, 17 indicator factors for "public node space", and 19 indicator factors for "public road space" were determined. The perceptual evaluation factor systems of the two types of public spaces are shown in Tables 1 and 2.

Table 1. The weight distribution of the public space perception evaluation system for nodes.

Objective Layer	Criterion Layer	Weight Value	Indicator Layer	Single-Layer Weight Value	Comprehensive Weight Value	Adjective Pairs
Public Node Space Perception Evaluation System (A)	B_1 Functional Services	0.399	C_{11} Accessibility	0.226	0.090	Convenient–Inconvenient
			C_{12} Publicness	0.212	0.085	Public–Private
			C_{13} Activity Diversity	0.176	0.070	Diverse Activities–Monotonous Activities
			C_{14} Functionality	0.147	0.059	Functionally Sound–Functionally Poor
			C_{15} Facility Completeness	0.240	0.096	Fully Equipped–Lacking Facilities
	B_2 Characteristic Features	0.226	C_{21} Esthetics	0.249	0.056	Beautiful–Ugly
			C_{22} Liveliness	0.186	0.042	Lively–Dull
			C_{23} Regional Identity	0.294	0.066	Distinctive–Nondescript
			C_{24} Pavement	0.271	0.061	Exquisite Pavement–Coarse Pavement
	B_3 Spatial Form	0.067	C_{31} Openness	0.505	0.034	Open–Enclosed
			C_{32} Size Scale	0.495	0.033	Spacious–Cramped
	B_4 Environmental Perception	0.308	C_{41} Cleanliness	0.151	0.047	Clean–Messy
			C_{42} Comfort	0.195	0.060	Pleasant–Uncomfortable
			C_{43} Tranquility	0.162	0.050	Quiet–Noisy
			C_{44} Greenery Configuration	0.188	0.058	Abundant Greenery–Sparse Greenery
			C_{45} Safety	0.128	0.039	Safe–Dangerous
			C_{46} Landscape Richness	0.176	0.054	Rich Landscape–Monotonous Landscape

Table 2. The weight distribution of the public space perception evaluation system for lanes.

Objective Layer	Criterion Layer	Weight Value	Indicator Layer	Single-Layer Weight Value	Comprehensive Weight Value	Adjective Pairs
Public Road Space Perception Evaluation System (A)	B_1 Functional Services	0.301	C_{11} Accessibility	0.199	0.060	Convenient–Inconvenient
			C_{12} Publicness	0.165	0.050	Public–Private
			C_{13} Activity Diversity	0.150	0.045	Diverse Activities–Monotonous Activities
			C_{14} Functionality	0.233	0.070	Functionally Sound–Functionally Poor
			C_{15} Facility Completeness	0.254	0.076	Fully Equipped–Lacking Facilities
	B_2 Characteristic Features	0.234	C_{21} Esthetics	0.224	0.052	Beautiful–Ugly
			C_{22} Liveliness	0.201	0.047	Lively–Dull
			C_{23} Regional Identity	0.172	0.040	Distinctive–Nondescript
			C_{24} Pavement	0.173	0.040	Diverse Interfaces–Monotonous Interfaces
			C_{25} Interface Variation	0.230	0.054	Exquisite Pavement–Coarse Pavement
	B_3 Spatial Form	0.067	C_{31} Openness	0.272	0.018	Open–Enclosed
			C_{32} Size Scale	0.478	0.032	Spacious–Cramped
			C_{33} Sense of Direction	0.251	0.017	Strong Sense of Direction–Weak Sense of Direction
	B_4 Environmental Perception	0.398	C_{41} Cleanliness	0.123	0.049	Clean–Messy
			C_{42} Comfort	0.153	0.061	Pleasant–Uncomfortable
			C_{43} Tranquility	0.131	0.052	Quiet–Noisy
			C_{44} Greenery Shade Provision	0.183	0.073	Abundant Greenery–Sparse Greenery
			C_{45} Safety	0.212	0.084	Safe–Dangerous
			C_{46} Landscape Richness	0.198	0.079	Rich Landscape–Monotonous Landscape

3.3.2. Quantitative Factor Weights

In current research related to evaluation using hierarchical analysis, the expert scoring method is often used to determine the weight of each evaluation factor in a top-down manner. To accurately reflect villagers' perceptions and needs, this study allowed villagers to evaluate and assign values to each evaluation factor.

- Determination of weights in the criterion layer

First, through a questionnaire survey, villagers were invited to score the four evaluation factors of the criterion layer (with the scores ranging from 1 for the least important factor to 4 for the most important factor), which allowed us to obtain the importance weight of each factor. In total, 61 questionnaires related to public node space and 55 questionnaires related to public road space were collected. The test results of the node ($\lambda max = 4.023$, $CI = 0.008$, $RI = 0.882$, $CR = 0.009 < 0.1$) and road space ($\lambda max = 4.021$, $CI = 0.007$, $RI = 0.882$, $CR = 0.008 < 0.1$) satisfy the consistency condition, indicating that the weighting results are accurate and reliable. Tables 1 and 2 demonstrate the factor weighting results of the node and road indicator layers.

- Determination of weights in the indicator layer

Due to the large number of indicator-layer factors, employing two-by-two comparisons between factors or importance rankings would have increased the workload for the interviewed villagers, thereby affecting the effective recovery rate and the credibility of the questionnaire.

In this study, the average of the importance scores of each indicator-layer factor was used as a basis to determine the influence of each factor on the perception of public node space and public road space. First, the average importance scores of the two types of public space were calculated. Second, a two-by-two comparison judgment matrix of the evaluation factors of each indicator layer was constructed, and the maximum eigenroot value of the judgment matrix and its corresponding eigenvector were calculated. Table 3 presents the statistical validation results for the indicator layer factors. The results show that the CR value of the single-layer factor weights of the four criterion layers of the public node space is less than 0.1, which meets the requirement of the consistency condition and indicates that the weighting results are accurate and credible. Tables 1 and 2 demonstrate the factor weighting results of the node and road indicator layers.

Table 3. Statistical validation of the indicator layer for public node spaces and road spaces.

Type	Statistical Parameter	Functional Services	Characteristic Features	Spatial Form	Environmental Perception
Node	λmax	5	4	Null *	6
	CI	0	0	Null *	0
	RI	1.11	0.882	Null *	1.25
	CR	0	0	Null *	0
Road	λmax	5	5	3	6
	CI	0	0	0	0
	RI	1.11	1.11	0.525	1.25
	CR	0	0	0	0

Note: * second-order matrices require no judgment.

3.3.3. Selection of Evaluation Objects

Based on the public space perception evaluation system, the SD method was used to conduct a questionnaire survey to evaluate villagers' perceptions of typical node and road spaces. Four public node spaces and three road spaces with rich concentrations of public activities and the most typical spatial designs in the village were selected as samples. The status of the construction in each node and road space is shown in Figure 3.

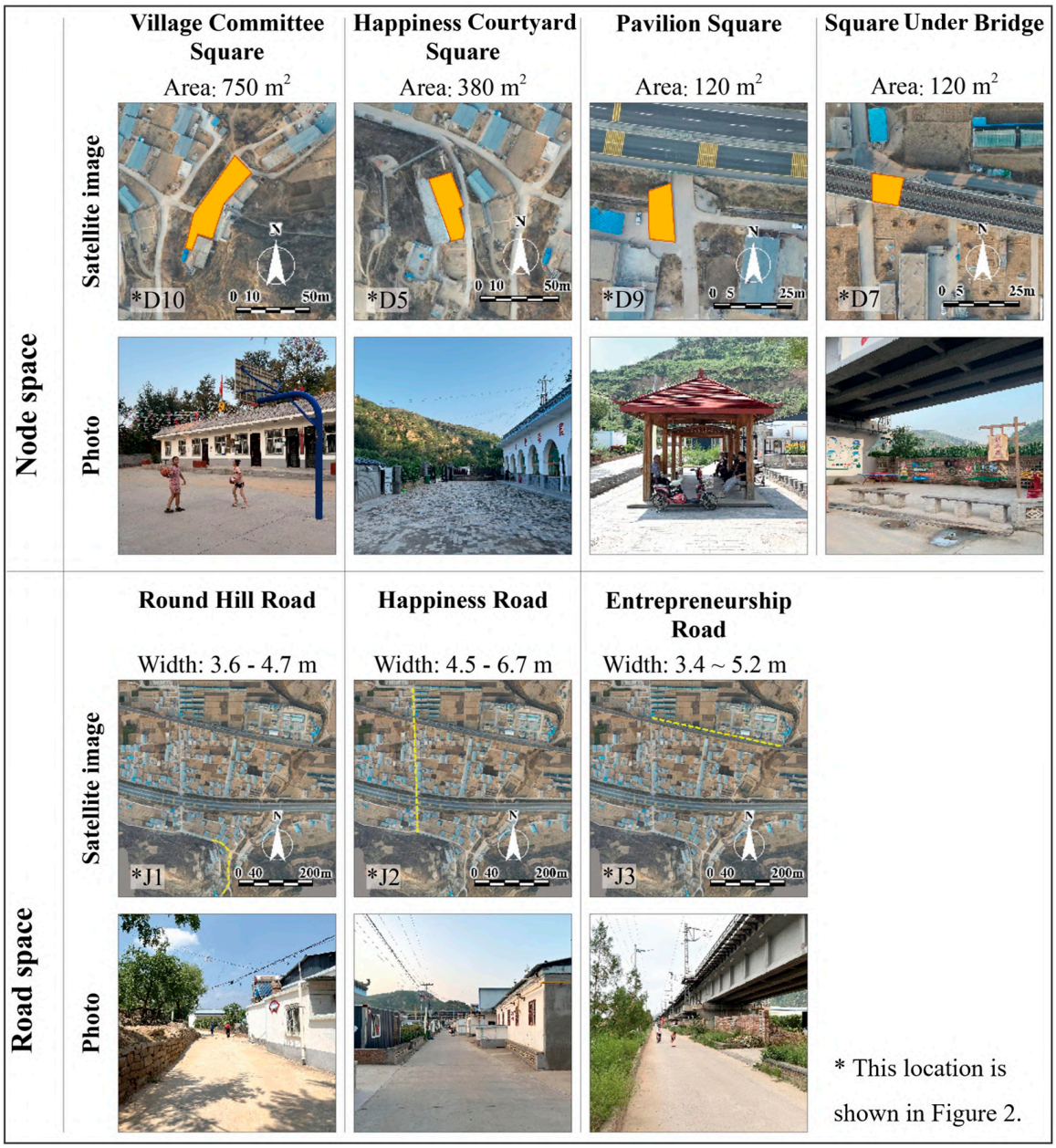


Figure 3. Characteristics of four typical public node spaces and three typical public road spaces in Liangqu Village.

3.3.4. Questionnaire Survey on Villagers' Perception Evaluation and Data Validation

The scale of the evaluation using the SD method used five segments, i.e., very, slightly, neither, slightly, and very, which were assigned the values −2, −1, 0, 1, and 2, respectively. The positive and negative words of the corresponding adjective pairs were placed at the two ends of the evaluation scale axis, and the respondents judged the descriptions according to their own feelings (see Figure A2). During a pre-survey, it was found that Liangqu Village is located in a cold area. The villagers mainly focus on home activities in the winter and spring seasons, and the usage rate of public space is extremely low. Usage is mainly concentrated in summer and autumn. Therefore, the questionnaire survey was conducted in August 2022 on one day of the week and one day of the weekend. The number of questionnaires issued for each typical public space was about 30, and 230 questionnaires were collected, with 221 valid questionnaires and an effective recovery rate of 96.09%. Among them, 124 valid questionnaires were collected from 4 nodal spaces and 97 valid questionnaires

were collected from 3 road spaces. The validity of the research data was tested using SPSS 25 software. Cronbach's coefficient (Cronbach's α) was used for a reliability test, and the results showed that the Cronbach's α of the node questionnaire data was 0.733, while that of the road questionnaire data was 0.815, indicating that the data had good consistency and fulfilled the requirements of the reliability test. The demographic structure of the questionnaire data shows that males accounted for 52.94% of the sample population, while females accounted for 47.06%. In terms of the age structure of the population, the number of elderly people over 60 years of age accounted for 34.84%. The demographic structure coincided with the current characteristics of the resident population of Liangqu Village.

3.4. Importance-Performance Analysis for Public Spaces

Current classification methods for optimizing demand for public space mainly include the Kano model and the IPA model. In the Kano model, questions are asked for each demand from both positive and negative perspectives to measure the respondents' reactions to the provision or non-provision of a certain element. The questionnaire design is complex, and respondents are prone to exclusion, which affects the accuracy of the data. The Importance–Performance Analysis (IPA) model collects respondents' importance and satisfaction ratings for each factor; plots each demand factor in a two-dimensional matrix; and divides the four zones of advantage maintained, status quo maintained, improvements to be made, and urgently needs to be improved to identify the critical needs to improve. In this study, importance and perception evaluations of various types of public spaces were quantified using the SD method, so the IPA model was chosen to judge the optimization needs of public spaces in river valley plain villages. The villagers' perception ratings of each evaluation factor were taken as the data of the vertical axis of the IPA matrix, the weights of each factor were taken as the data of the horizontal axis, the average of the two was taken as the demarcation line of the X–Y axis, and each evaluation factor was classified into the four categories with quadrants using SPSS 25.

4. Results

4.1. Public Node Space Perception Evaluation

4.1.1. Results of the Criterion-Layer Perception Evaluation

Figure 4a illustrates the results of the ratings converted to percentages for the criterion layers. In terms of functional services, the four node spaces had the highest differences in ratings. The village council square was rated the highest (64.26). This was because most of the public service facilities and public activities in the river valley plain-type villages are set in the village committee squares, which are the most functional spaces. The Happiness courtyard square had the lowest rating (35.84), which was mainly affected by the poor accessibility of the site, as well as the lack of corresponding supporting facilities. In terms of landscape features, there were no significant differences between the evaluations of the public spaces of the other three nodes, except for the square under the bridge. This was because these three important node spaces are dominated by the government and have significant rural regional characteristics. The perceived rating of the square under the bridge was significantly lower, at only 48.47, which indicates that this general public node space is weak in terms of landscape construction. In terms of spatial form, except for the square under the bridge, all the spaces received good perceptual evaluations that basically met the villagers' needs for spatial scale. Among them, the pavilion square, despite its small area, had the highest perception evaluation in terms of openness and area scale, indicating that the appropriate scale had a positive effect on the villagers' psychological perception. The square under the bridge received the lowest evaluation (51.21). This was because of the shortage of land resources in the loess gully area. Flat areas are prioritized for agricultural and residential development. A lack of land for public space has led to the need to use road corners, areas under bridges, and other alien spaces as node spaces. In terms of the environmental senses, the node spaces located in the center of the built-up area of the village (the pavilion square and the square under the bridge) received significantly lower

perceptual evaluations than the node spaces located on the edge of the village (the village committee square and the Happiness courtyard square). This was because of the limitations of the topographic conditions, as the node spaces often expand from the corner of a road and are easily affected by traffic noise. Moreover, the absence of green infrastructure led to lower environmental sensory ratings in this area.

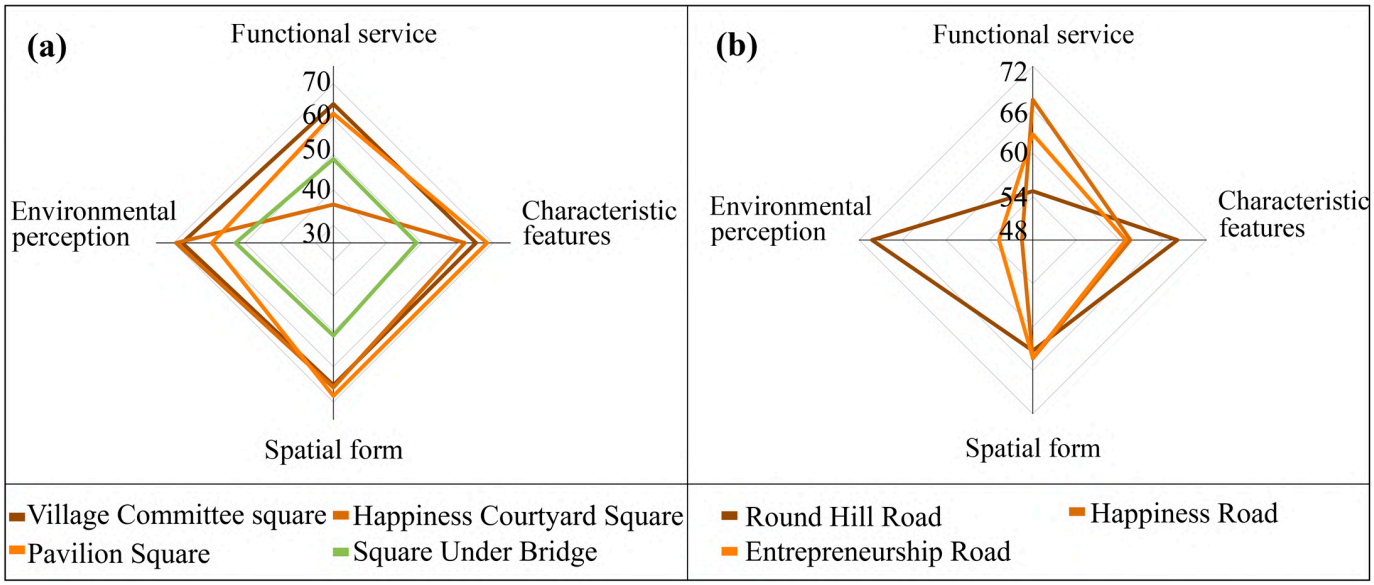


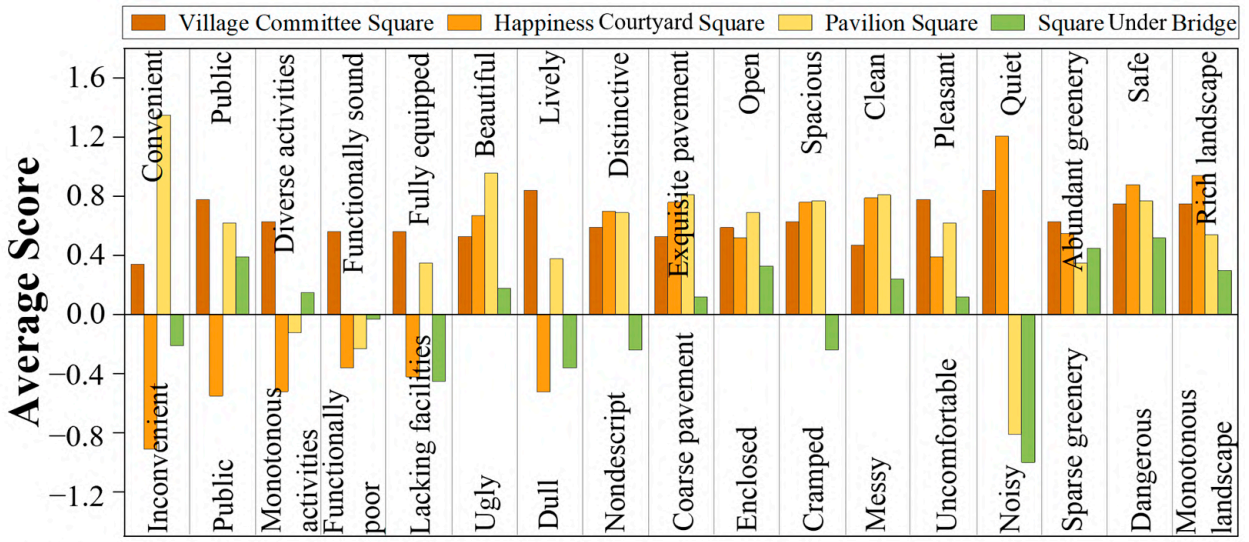
Figure 4. Criterion-layer scores for two types of public space: (**a**) nodes and (**b**) roads.

4.1.2. Indicator-Level Perception Evaluation Results

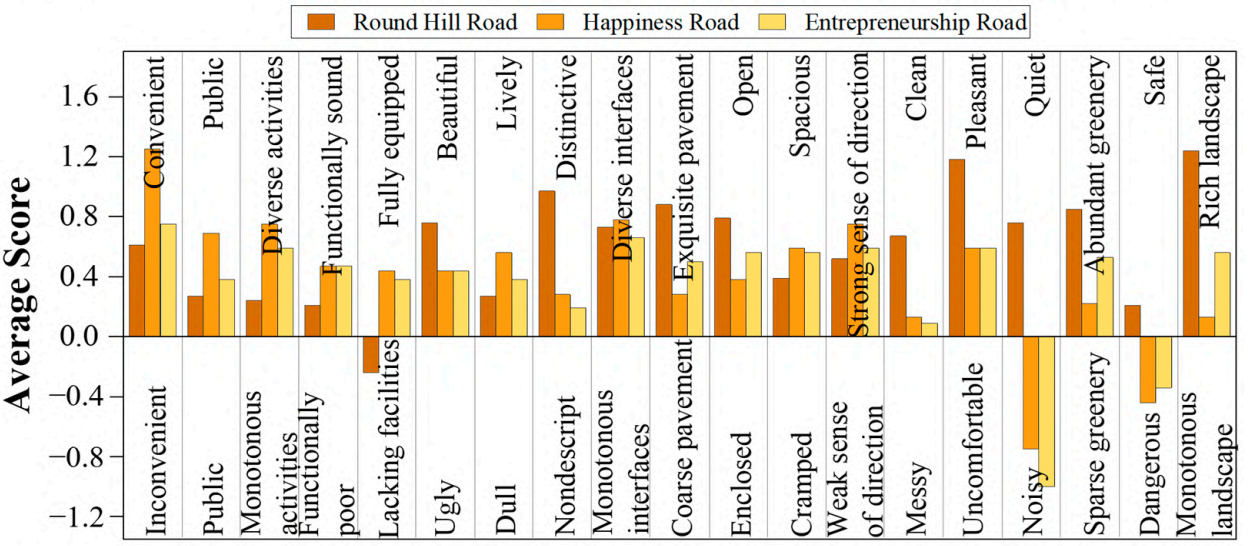
Figure 5a shows the evaluation results of the villagers' perception of the spatial indicator layer at four nodes. Among them, the village community square had the highest perception score of 65.58, and there was no negative evaluation. The villagers' psychological perception of its spatial atmosphere can be summarized as "lively (0.84)" = "quiet (0.84)" > "pleasant (0.78)". As a core public space, the village community square has more public service facilities and a good aggregation effect, but the environmental quality needs to be improved. The overall evaluation of the pavilion square was more positive, with a score of 62.83, and its spatial atmosphere was "convenient (1.35)" > "beautiful (0.96)" > "clean (0.81)" = "noisy (−0.81)". With the highest levels of daily gathering and vigor, the pavilion square stands out as the area where villagers come together.

This site was constructed by the government and has a good environmental style that uses materials with regional characteristics such as wood and green bricks. However, the isolated pavilions are poorly shaded, not sheltered from the wind, and not suitable for cold rural areas, which resulted in poor ratings for activity diversity and functionality. In addition, transit traffic is prevalent in river valley plain-type villages. Thus, they all received poor ratings for tranquility. The Happiness courtyard square ranked third with a score of 54.07, and its spatial and psychological perception can be summarized as "quiet (1.21)" > "landscape-rich (0.94)" > "inconvenient (−0.91)". The Happiness courtyard has an open sightline with good environmental and landscape conditions. Meanwhile, the surrounding buildings adopt the architectural form of traditional kiln caves and retain a better vernacular style. However, because of height differences, the accessibility of the square is weak, and it is only used by elderly individuals from the neighboring nursing home and a few villagers. In addition, as a node space for the elderly, the site lacks an age-friendly design and related supporting facilities, resulting in a lack of vitality. The square under the bridge had the lowest perception score of 50.02. It received negative ratings on eight evaluation dimensions. The villagers' psychological perception can be summarized as "noisy (−1.00)" > "safe (0.52)" > "inadequate facilities (−0.45)". The square utilizes the

space under a bridge of a transit road and is heavily affected by traffic noise. It is also less accessible due to its location on the edge of the village, and the fitness facilities within the site are poorly maintained.



(a) Seventeen factors affecting the perception evaluations of the public node spaces



(b) Nineteen factors affecting the perception evaluations of the public road spaces

Figure 5. SD scores for two types of indicator layers in public spaces: (**a**) nodes and (**b**) roads.

When comparing the perceived differences in the typical node spaces, it was found that the three factors with the largest evaluation differences were accessibility (2.26), tranquility (2.21), and vitality (1.36). This was due to the common belt layout pattern of river valley plain-type villages, where there are significant differences in the accessibility of village public spaces. Secondly, transit traffic, such as motorways and railways, is usually present in river valleys, and it has significant negative impacts on the village environments along its routes. In addition, the resources for public activities and facilities in the villages are mainly concentrated in important nodes with political or religious functions such as the village committee square, while the remaining node spaces have fewer supporting facilities. This leads to insufficient living and recreational facilities and generally low vitality in the node spaces.

4.2. Public Road Space Perception Evaluation

4.2.1. Results of the Criterion-Layer Perception Evaluation

Figure 4b shows the results for the spatial guideline tiers of the roads with the scores converted to a percentage scale. The results show that there were significant differences in the villagers' perceptions of the public space of alleys in terms of "functional services". Happiness Road, as the main road, received the highest rating (67.37). Secondary roads located in the periphery of the village received lower ratings. In terms of "landscape character", Round Hill Road in the old village received the highest rating (67.98) because of its rich landscape and vernacular materials, while the other two new roads were rated less favorably. This was because new river valley villages were constructed following the Feng Shui custom of living facing the water. As a result, most of the residential buildings are orientated in the east–west direction, resulting in closed and monotonous façades along most of the roads. In terms of "spatial morphology", the three roads received similar perceptions. This was because most of the roads were uniformly designed with a minimum width due to the limitations of the land use conditions, and there is not much difference in the morphology. The "environmental sensory" rating was the most important criterion-level factor that affected the villagers' perception of the road space, which differed from the spatial functional service at the nodes. Huanshan Road, located in the old village, had a better road environment perception score (70.20), while the two newly built roads had significantly worse environment perception evaluations.

4.2.2. Indicator-Level Perception Evaluation Results

Figure 5b shows the evaluation results of the spatial indicator layer for each road. The highest score in the perceptual composite evaluation was obtained by Huanshan Road (64.57), followed by Happiness Road (58.68) and Entrepreneurship Road (58.36). Huanshan Road is located at the intersection of a river valley area and a gully area. It was highly evaluated for all indicators and only received a negative evaluation for the item of facility improvement (−0.24). Its spatial feeling is summarized as "rich landscape (1.24)" > "comfortable (1.18)" > "with local characteristics (0.97)". This indicates that the landscape of Round Hill Road is in good condition and has local character. However, there is a lack of lighting on this type of road, which poses a night-time safety hazard. Both Happiness Road and Entrepreneurship Road are located in the built-up area of the village in the river valley, and the perceptions they received were close to each other. The highest-rated indicator of the two roads was accessibility, and the lowest-rated value was tranquility. The villagers' psychological perception of Happiness Road can be described as "convenient (1.25)" > "variety of activities (0.75)" > "strong sense of orientation (0.75)", and the perception of Entrepreneurship Road can be described as "noisy (−1.00)" > "convenient (0.75)" > "pleasant (0.59)". Combined with the field research, the two roads had significantly lower scores for three factors, namely tranquility, safety, and cleanliness, and their acoustics and safety were poor. This was due to the fact that the main roads and lanes in river valley plain-type villages are often interrupted by transit roads or directly attached to the construction of transit roads and railways. At the same time, there is a general lack of sound insulation facilities and green belts between village roads and transit roads, resulting in road environments that face serious noise pollution. In addition, due to land constraints in the river valleys, the roads and lanes are narrow. They are often designed to meet needs related to accessibility and do not increase livability, and mixing of pedestrians and vehicles is more common. As important activity sites for the elderly and children in the countryside, there are greater safety risks.

The perceptual ratings for each road showed significant differences in tranquility (1.76), landscape richness (1.12), and locality (0.78). The differences in tranquility were mainly because of the influence of transit traffic in the river valley. In terms of landscape richness, roads and lanes set in the village core tend to have closed interfaces, with a lack of green configurations and landscape nodes, while roads and lanes located at the edge of the

village have better landscape interfaces. In addition, the construction of road space in this type of village is mostly copied from urban roads, with insufficient regional characteristics.

4.3. Determination of Public Space Optimization Needs

Figure 6 shows the results of the optimization demand hierarchy for four representative node spaces: the village committee square, the Happiness courtyard square, the square under the bridge, and the pavilion square. Among them, the factors in the first quadrant received higher importance and perception evaluations and belonged to the "advantage retention" type of public node space. The factors in the second quadrant had lower importance but received higher evaluations from the villagers and were "status quo maintenance" factors. The factors in the third quadrant had lower importance and lower perception evaluations, and they were "secondary to be improved" when possible factors. The factors in the fourth quadrant had high importance, but the villagers' evaluations of their statuses were low, and they were "primary to be improved" factors. The optimization of public spaces in nodes should first focus on factors that are "primary to be improved".

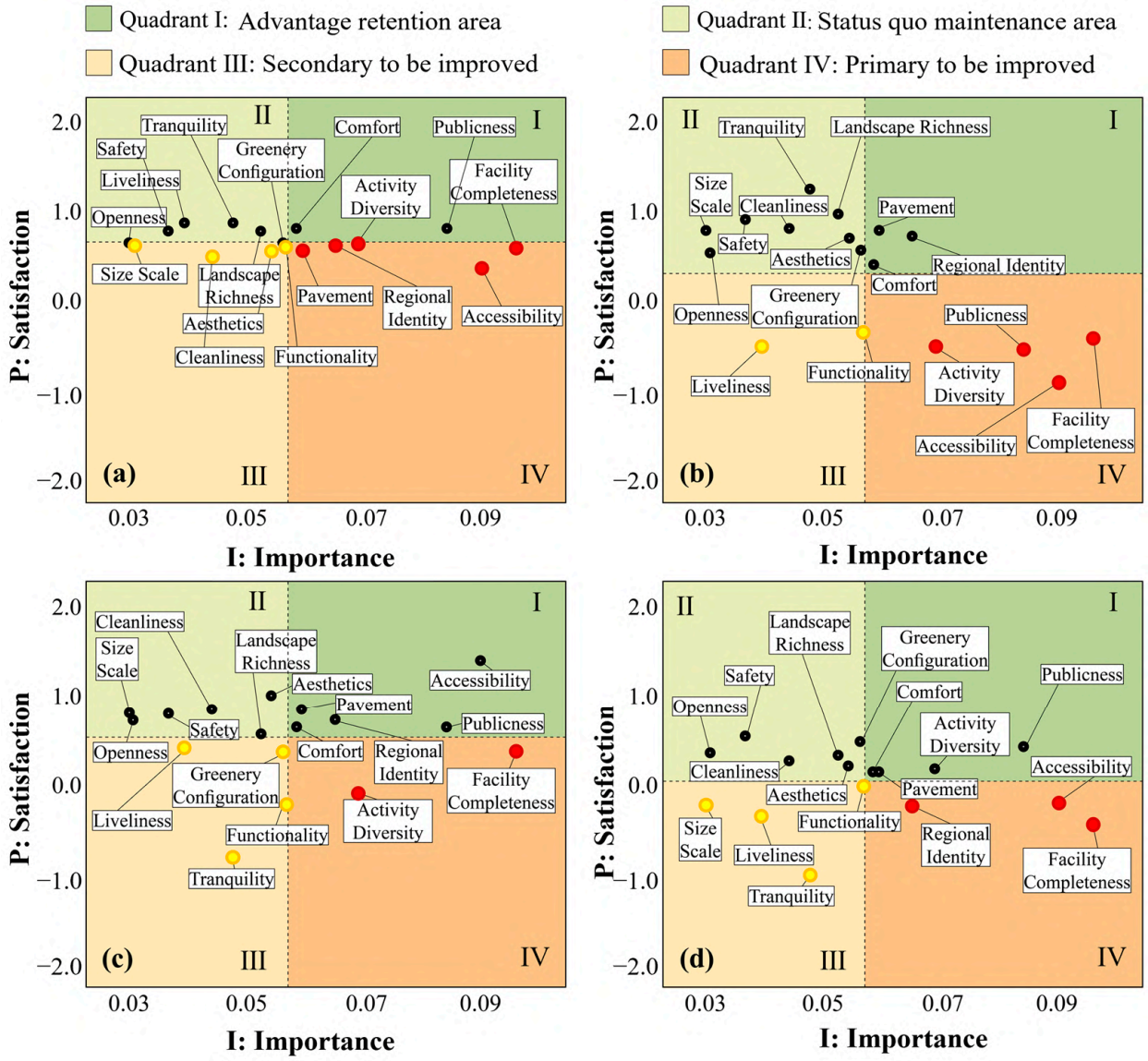


Figure 6. Spatial importance–satisfaction analyses of four nodes: (**a**) the village committee square; (**b**) the Happiness courtyard square; (**c**) the pavilion square; and (**d**) the square under the bridge.

The factor with the highest frequency was "facility improvement", which belonged to the "primary to be improved" type in all four node spaces. This was followed by "accessibility" (three times), "activity diversity "(three times), and "locality" (twice). In addition, the factors in the "secondary to be improved" zone should be optimized if there is still room for village development. The most frequent "secondary to be improved" factors included "vigor" (three times), "tranquility" (twice), "size scale "(twice), and "greening configuration" (twice).

Figure 7 shows the results of the hierarchy of optimization needs for the public spaces on the three roads. Among the evaluation factors in the "primary to be improved" area, the most frequent factor was "safety" (three times), which indicates that creating a safe road environment is the need that most urgently requires optimization in the river valley plain villages at present. Secondly, the factors of "facility improvement" and "functionality" both received high importance ratings and are also regarded as "primary to be improved" factors. In addition, the factors of "interface change", "shade", and "landscape richness" all appeared once and should be considered in light of the actual situations in the road spaces. In the third quadrant, the factors "secondary to be improved" mainly included "cleanliness" (twice), "tranquility" (twice), and "locality" (twice). These factors mainly reflect the environmental and landscape construction of the road spaces, indicating that villagers' satisfaction with the current state of the environmental and landscape construction of the road spaces is low and that they should be optimized and improved.

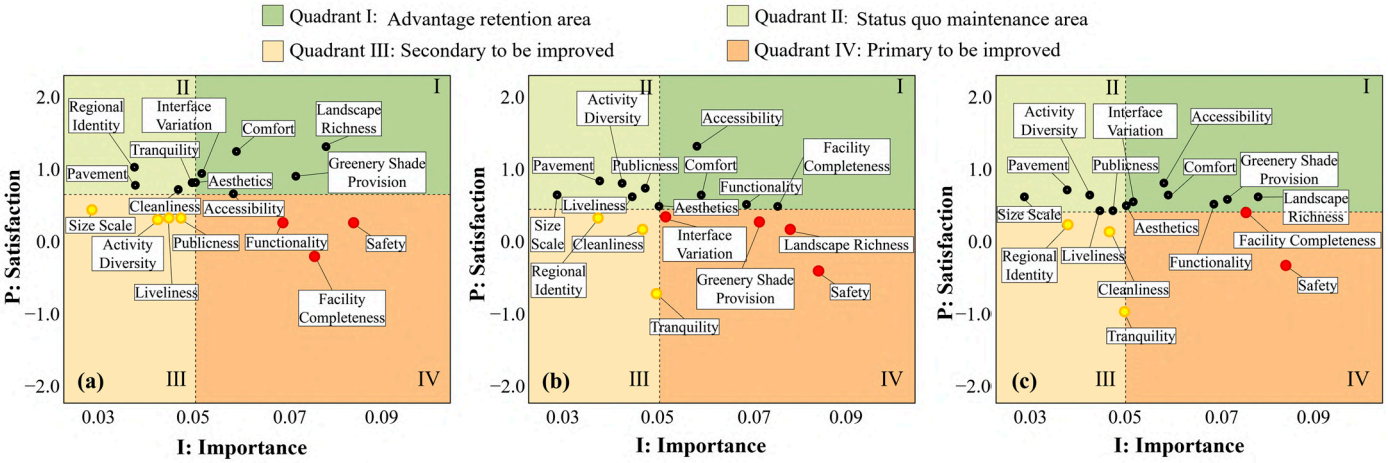


Figure 7. Demand hierarchy for optimizing village public road spaces: (**a**) the Round Hill Road; (**b**) the Happiness Road; and (**c**) the Entrepreneurship Road.

5. Discussion

5.1. Comparison with Similar Studies

In the context of the continuous and in-depth promotion of rural revitalization, villagers' main positions and needs are gradually being focused on during the construction and development of rural public spaces. This study evaluates the perception of public spaces in a typical river valley plain village in the Loess Plateau region from the villagers' perspective. Comparing to similar studies, a study in Nanjing, Jiangsu Province of China, showed that for local residents, shelter facilities, seating, accessibility, space type, and fitness facilities had a significant effect on the vitality of public space in suburban rural communities [60]. This is consistent with the factors deemed "primary to be improved" for node spaces, including accessibility and activity diversity. On the other hand, Polish studies show that functionality is the most important influence on rural public space [11,61]. A study in Handan, Hebei Province of China, evaluated rural public spaces from the perspective of university students using eye-tracking, and the results showed that prioritizing architectural, greening, and landmark elements can effectively improve the overall design of rural public spaces and enhance the overall experience [28]. This is consistent with this

study's factors of the "primary to be improved" for the road space, including functionality, shade provision, and landscape richness. However, there are some studies that show significant differences with the results of this study. A study in Foshan, the Greater Bay Area of China, shows that openness is the most important indicator of public space [62], whereas in this study, spatial scale and openness are not significant, which may be due to the different physical characteristics of the region. In the Loess Plateau, where the summer is hot and the winter is cold, the more openness leads to less effective shading in summer and wind protection in winter. This suggests that there may be significant differences in the perceptual evaluation results of some factors across different countries and regions with varying geographic characteristics. Compared with similar studies in plain areas with better economic conditions in the same province of Shaanxi, there are also some differences in the results of this study. In this study, the highest weight is given to the criterion factor "functional service" for public node space, while the highest weight is given to the factor "environmental perception" for street space. In comparison with the study of villages in the Guanzhong Plain region of Shaanxi, which has a strong economy, the spiritual needs of villagers are prioritized over the needs of spatial environment perception [59]. This suggests that in loess gully areas with poor natural conditions, improving their functional and environmental quality is the primary focus, rather than non-material aspects.

5.2. Optimization Strategy for Public Spaces

Based on the public space perception evaluation method developed in this study, the results can guide the optimization strategies for rural public spaces in the Loess Plateau region. For public nodal space, the factors of "primary to be improved" in Figure 6 include facility completeness, accessibility, and activity diversity. These factors fall under functional services in the criterion layer in Table 1, while the Happiness courtyard square and the square under the bridge in Figure 4a received the lowest scores for functional services. Therefore, the optimization strategy for these two public spaces should prioritize improving their facility completeness, accessibility, and activity diversity. Given the resources and funding limitation in the Loess Plateau, the village committee can enhance the functions of these spaces by integrating living and production activities, such as adding fitness, recreation and entertainment facilities, such as adding fitness, recreation, and public production facilities like drying areas and marketplaces. Next, in Figure 6, the factors of "secondary to be improved" are the tranquility and greening configuration, which corresponds to the environmental perception of criterion layer. As shown in Figure 4a, the environmental perception scores for the square under the bridge and the pavilion square are low. After optimizing the factors of "primary to be improved", sound insulation facilities can be added near transit traffic, and drought-resistant native trees can be used to enrich the green landscape of the space.

For public road spaces, the factors "primary to be improved" in Figure 7 is safety, while "secondary to be improved" factors are cleanliness and tranquility. These three indicators relate to the environmental perception in criterion layer in Table 1. The lowest environmental perception scores are found on Happiness road and Venture road in Figure 4b. Transit traffic passing through villages creates fragmented negative spaces, leading to safety hazards, noise pollution, and sanitation issues. This is a common challenge for villages in the Loess Plateau due to their hilly terrain and land constraints. Therefore, the optimization strategy for village road public space should include installing speed bumps, streetlights, turning mirrors, and safety signs to alert vehicles. Given the limitation of road width, pedestrian space can be delineated using different paving material and color to enhance safety. To address cleanliness and quietness, the negative impact can be mitigated by adding garbage bins and noise barriers.

5.3. Implication and Limitation

This study confirms that significant differences may exist in the evaluation results of rural perceptions across different regions, even within the same province with similar

cultural characteristics. Therefore, in developing countries where economic levels vary greatly, results from other regions should not be applied blindly when formulating strategies to optimize village public space. Given that research on village public spaces in the Loess Plateau primarily focuses on traditional and tourist villages with good resource endowments [40,63], it is essential to conduct further research from the villagers' perspective to achieve sustainable development in less populated areas with poor natural conditions. Additionally, this study has some limitations. To ensure a comprehensive representation of public space types and an adequate sample size, we chose Liangqu Village, which has better construction conditions and a larger population, as the research site; villages with smaller populations may require further study.

6. Conclusions

This study took the public spaces of Liangqu Village, a river valley plain-type village in the loess gully area, as the research object; constructed a public space perception evaluation system for river valley plain-type villages; and ultimately proposed a design strategy for optimizing public spaces based on the perspective of villagers' perceptual needs. The main conclusions are as follows: (1) A public space perception and evaluation system for river valley plain villages consisting of four criterion factors and nineteen indicator factors was established, the weights of the perception evaluation factors were determined for nodes and roads, and comprehensive evaluation results were obtained. The most important factors affecting villagers' perception evaluations of public node spaces were identified as "facility perfection", "accessibility", and "publicity", while the most important factors were identified as "safety", "security", and "publicity". "Safety", "landscape richness", and "facility perfection" were the most important factors affecting villagers' perceptions of public road spaces. (2) Based on the results of the perception evaluation, the optimization needs of rural public spaces were divided into four priority levels, and the factors that urgently need to be improved were identified, such as "facility improvement" and "safety". This study analyzed villagers' perceptual evaluations and needs related to public space from their perspective, addressing the shortcomings of existing evaluation methods in the region and providing a scientific basis for establishing a bottom-up (villager-demand based) approach to public space optimization design.

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Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

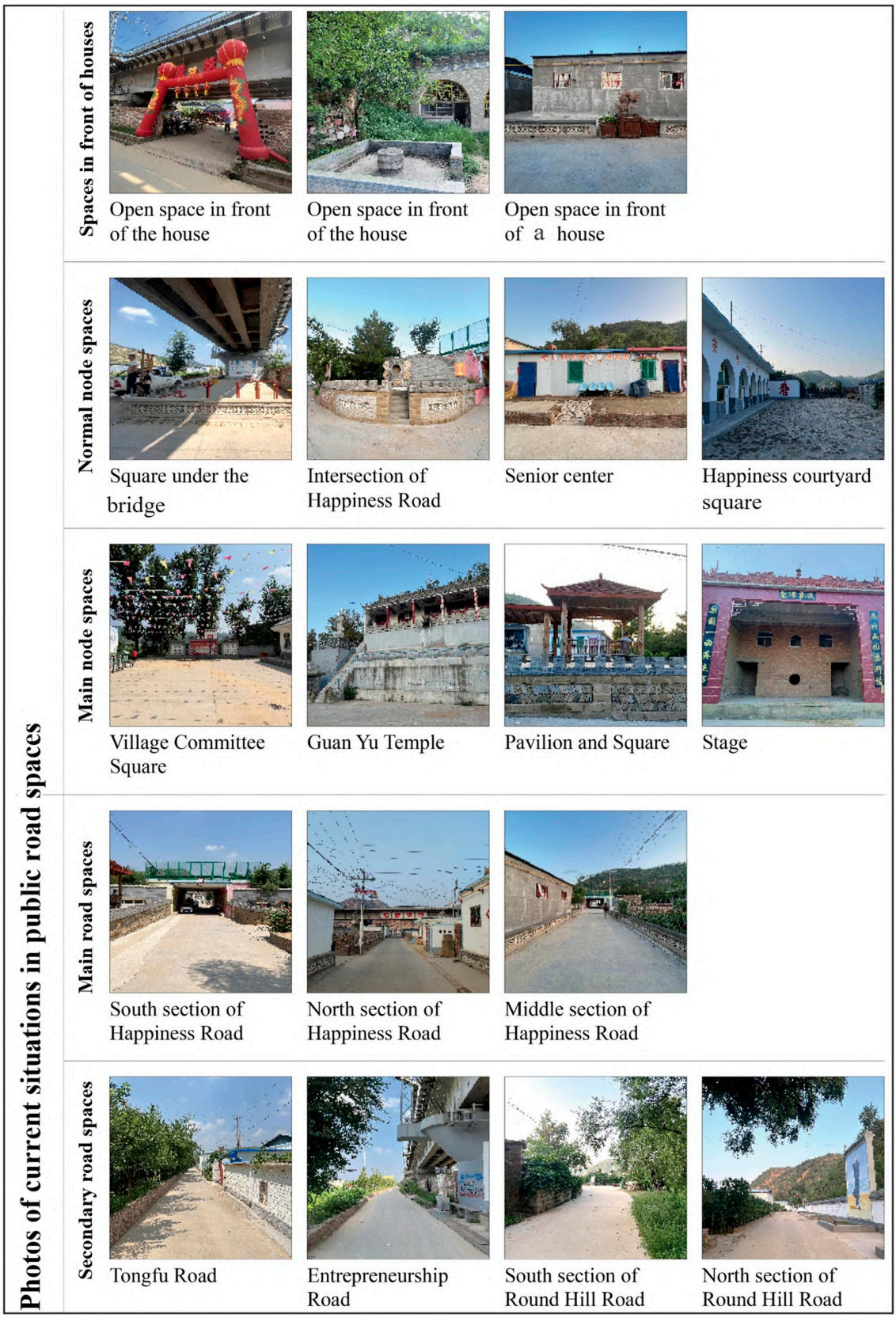

Figure A1. Statuses of public space construction in the nodes of Liangqu Village.

Hello! I am a postgraduate student in architecture and I am conducting a research on the perception of public space in your village. I have selected the following questions in the hope that I can truly understand your feelings and opinions in this regard. Please fill in the questionnaire according to your personal opinion and tick the boxes directly. This questionnaire is for academic research only, it is anonymous and will not be disclosed to the public, thank you for your support.

Research Location: _____

1. Your gender:

□Male □Female

2. Your age:

□under 18 years old □18-35 years old □36-60 years old □over 60 years old

3. What activities do you typically do here:

□Rest and relaxation □Chatting and socialising □Accompanying children
□Playing games □Cards and entertainment □Fitness activities
□Religious rituals □Watching performances □Singing and dancing
Others_____

4. How long does it take to get from your home to here:

□Within 5 minutes □Within 10 minutes □Within 15 minutes □More than 15 minutes

5. What time frame do you usually come here:

□6:00-9:00 □9:00-11:00 □11:00-13:00 □13:00-17:00 □17:00-20:00

6. The frequency of your visits to the venue is generally:

□several times a day □once a day □three or four times a week
□once a week □once a mont

7. How long do you usually stay:

□within 5 minutes □5-15 minutes □15-30 minutes □30-60 minutes □more than one hour

8. Do you think the facilities on the premises are adequate:

□very perfect □relatively perfect □generally perfect
□relatively unsatisfactory □very unsatisfactory

9. What facilities do you think should be added to the premises:

□Sanitation facilities □Lighting facilities □Rest seats □Landscaping
□Recreation facilities □Fitness facilities Others_____

10. What events at the venue do you think you would be interested in attending:

□Film screening □Lectures and exhibitions □Literary performances
□Market gatherings □Physical exercise Others _____

11. Of the following adjective phrases, please tick the one that matches your mental perception of the space:

		very	slightly	generally	slightly	very	
Accessibility	Convenient						Inconvenient
Publicness	Public						Private
Activity Diversity	Diverse Activities						Monotonous Activities
Functionality	Functionally Sound						Functionally Poor

Figure A2. *Cont.*

Facility Completeness	Fully Equipped						Lacking Facilities
Aesthetics	Beautiful						Ugly
Liveliness	Lively						Dull
Regional Identity	Distinctive						Nondescript
Pavement	Exquisite Pavement						Coarse Pavement
Openness	Open						Enclosed
Size Scale	Spacious						Cramped
Cleanliness	Clean						Messy
Comfort	Pleasant						Uncomfortable
Tranquility	Quiet						Noisy
Greenery shade	Abundant Greenery						Sparse Greenery
Safety	Safe						Dangerous
Landscape Richness	Rich Landscape						Monotonous Landscape
Interface Variation (road)	Diverse Interfaces						Monotonous Interfaces
Sense of Direction (road)	Strong Sense of Direction						Weak Sense of Direction

12. Please rank the following factors affecting public space in villages according to how important you think they are (1 to 4 points):

☐Functional service ☐Characteristic features ☐Spatial form ☐Environmental perception

13. To what extent do you think the following influences are important to the village public space:

	Very Important	Relatively Important	Generally Important	Relatively Unimportant	Very Unimportant
Accessibilit					
Publicness					
Activity Diversity					
Functionality					
Facility Completeness					
Aesthetics					
Liveliness					
Regional Identity					
Pavement					
Openness					
Size Scale					
Cleanliness					
Comfort					
Tranquility					

Figure A2. *Cont.*

Greenery Configuration					
Safety					
Greenery shade					
Interface Variation (road)					
Sense of Direction (road)					

Figure A2. Questionnaire on perception of public space in a typical village.

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