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Evaluating the Landscape Quality of Residential Communities: A Case Study of the Chinese City Yangling

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Abstract: Due to continuous urbanization and an increasing need to improve living quality, citizens' pursuit of landscape quality in residential communities is constantly improving in developing countries, e.g., China. This is especially true in the period when citizens were locked down in their home cities or communities in the context of the COVID-19 pandemic. Studying whether the current landscape in residential communities still meets citizens' needs is of significance as it is crucial for city planners, landscape architects, and city managers. In this study, we used the analytic hierarchy process method to evaluate the landscape quality of five residential communities, using the case city of Yangling, China. In total, 516 valid questionnaires were collected in May 2022. The results showed that good organization of residential roads and pedestrian systems, the rationality of rest facilities, and the hierarchical richness of plants were the most important aspects for residents. Based on these, optimization design strategies were summarized. We hope to provide a reference for future landscape optimization of existing residential communities, especially in developing countries.

Keywords: residential communities; landscape evaluation; analytic hierarchy process; optimization design

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1. Introduction

Due to continuous urbanization around the world, more and more people are living in urban areas. Accordingly, half of the global population were living in urban areas by the end of 2018, and two-thirds of the world's population will be living in cities by 2050 [1]. In the future, the increase in the urban population will mainly take place in developing countries, e.g., China, India, and countries in Africa [2]. Sustainable development goal (SDG) 11 from the United Nations emphasizes that sustainable urbanization with affordable housing is foundational to family life [3]. However, due to rapid urbanization in developing countries, the demand for residential communities has increased sharply. This has resulted in unsustainable urbanization and issues with living environments. For example, poor household landscape conditions are still a major issue in countries like India [4,5], Bangladesh, Kenya, Egypt, Tanzania, and Ethiopia [3]. It is of great significance to upgrade the landscape of existing residential communities.

Researchers in developed countries, such as Canada [6], the Netherlands [7], and Singapore [8], have studied urban renewal strategies and methods which aim to solve the above-mentioned dilemma between rapid urbanization and the low quality of living environments and landscape in residential communities. The governments in developing counties have also made efforts towards urban renewal. The Indian government launched the "smart cities mission" in 2015 [4,5,9,10], while the Chinese government started the "shantytown renovation program" in the early 2000s [11–16]. Improving the landscape quality of residential communities is one of the main aspects of urban renewal, as residential communities are closely connected with people's daily life. As reported, residential

environment quality significantly influences residents' health, well-being, and life satisfaction [17]. A poor household environment adversely influences people's health and productivity [4,5].

Combined with social and economic development, citizens in developing countries increasingly pursue high living quality, especially in terms of landscape quality in residential communities [18,19]. This is especially true in the context of the COVID-19 pandemic when citizens were locked down in their home cities or residential communities. Citizens were reliant on the public areas of their residential communities to perform outdoor physical activities instead of being able to perform these at public parks [20–22]. It is worth pondering if the landscape of current residential communities can still meet the needs of increasing resident activity. Thus, forming an understanding of residents' perceptions is important, and evaluating the landscape quality of residential communities is necessary.

Landscape quality evaluation has been conducted in many areas. A study evaluated the visual preferences of wetlands in Turkey, using landscape photographs to develop sustainable recreational areas [23]. An assessment of China's forest landscape quality at the national level was conducted to identify areas with high visual quality and protection values [24]. The landscape quality of a small island in the north of Cuba was evaluated by interviewing representatives of the main socio-economic sectors to improve tourism [25]. A survey of 858 respondents in Switzerland was carried out to assess public views on landscape quality in terms of diversity, the naturalness of land cover, and urban sprawl [26]. By integrating street view images based on deep learning and landscape ecology, urban street quality was evaluated in the case city of Xiamen Island, China [27]. The coastal areas in the Van Lake Basin in Turkey were assessed in terms of their visual landscape quality in order to help with planning and design [28]. The plant landscapes of 91 rivers in the rural Qingxi area of Shanghai, China, were examined using a comprehensive evaluation model to propose optimization strategies [29].

There is also interesting research regarding residential communities' landscape evaluation. A study evaluated the benefits of community greenways in high-density residential areas, focusing on the everyday activities of residents [30]. The effect of green space quality (including plant community structure and foliar habits) on residential satisfaction was studied, and the results showed that the impact of green space quality is more significant than the quantity of green space [19]. A study regarding the cultural ecosystem services of residential green spaces showed that residential green spaces can effectively compensate for the lack of nearby parks in residential areas [31]. To study public understanding of and demand for the health benefits of residential open space, a contingent valuation of 1348 respondents in China was conducted to evaluate the perceived monetary value of different residential landscape elements, such as plants and activity areas [32]. However, resident attitudes, perceptions, and satisfaction towards the residential communities' landscape environment in terms of functions, aesthetics, and ecology have not been widely explored, especially after the COVID-19 pandemic.

In this study, using five residential communities in Yangling City, China, as our case study, we evaluated resident perceptions with the aim of gaining an understanding of how residents perceived the landscape quality of their residential communities. Since academic research on landscape quality is relatively broad, involving many aspects [33]. In this paper, landscape quality mainly means the functionality and visual quality of open space and basic facilities, as well as the ecological efficiency of plants in residential communities. This study can shed light on improvements in the environment and landscape quality of residential communities for city managers, urban planners, and landscape architects in developing countries.

2. Case Selection

The urbanization rate in China has increased from 20.6% (1980) to 64% (2020) within the last 40 years [34]. Due to this rapid urbanization, residential communities in many cities have suffered from living environment problems [35]. Many communities were constructed

in the years 1970–1990s. The landscape quality in these communities is poor, with limited green space, few rest and recreation facilities [35], and a lack of property management companies or municipal and community service facilities [36,37]. In the past decade, a large number of rural residents have also moved into residential communities, which have been built on their original living places where the old houses were demolished. The landscape quality in these residential communities is usually poor, with their plant landscapes often in chaos, plants with unpleasant odors or poisonous plants, street lights and fountains not being functional, and pedestrian–car interweaving [36,38]. Therefore, China can be taken as an example of how developing countries deal with the above-mentioned dilemmas of rapid urbanization and low landscape quality.

Yangling City is located in Shaanxi Province, China. Before the year 1997, Yangling was a small town surrounded by rural villages. The total population was 110,300, with an urban population of 30,000. In the year 1997, the Chinese central government decided that Yangling should become the first Agricultural Hi-tech Industries Demonstration District. By the end of 2019, its total population was 212,300, with an urban population of 140,300. In only 22 years, the urbanization rate increased rapidly from 28.1% in 1997 to 66.07% in 2019. Meanwhile, in the past 25 years, Yangling's economy was also growing rapidly. The GDP has increased from 0.383 billion RMB (≈56.65 million dollars) in 1997 to 15.778 billion RMB (≈2335 million dollars) in 2021, with an average annual growth rate of 6.4%. Residential communities in Yangling suffered from many of the residential community landscape quality problems mentioned in the introduction. Landscape quality is often poor in old residential communities, and most of the villages surrounding Yangling have disappeared in the past two decades. The houses of rural residents were demolished, and their land was developed into urban residential communities. However, the landscape quality in most of the resettled residential communities for the original rural residents was poor. There is a dilemma caused by the issue of balancing rapid economic development and living environment and landscape quality. This issue was further complicated by the COVID-19 pandemic. Therefore, Yangling, as a representative of small- and medium-sized cities, can be taken as an example of cities needing to focus efforts on urban renewal. After an onsite viewing of residential communities in Yangling, we selected five communities that were built in different years, as in the cases of Tianyuan, Jinyadu, Hengda, Rencai, and Qinyuanchun (Figure 1).

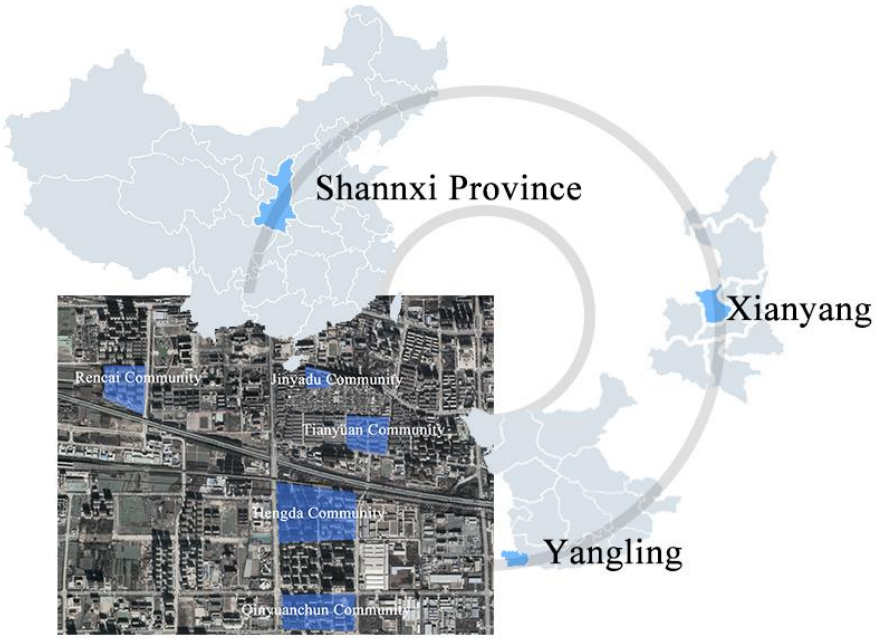

Figure 1. The geographic location of cases of residential communities.

3. Method

The analytic hierarchy process (AHP) is a flexible decision-making method used in both qualitative and quantitative studies. It can effectively solve complex problems without the need for precise numerical results. It has been widely used in landscape quality evaluation in studies focusing on urban agricultural landscapes [39], public space landscapes [40], urban parks [41], and forest parks [42]. In this study, we used AHP as the method to evaluate residents' perception of the landscape quality of residential communities.

3.1. Establishing the Landscape Quality Evaluation System for Residential Communities

In this study, 3 criteria layer factors (functionality, ecological efficiency, visual quality) and 15 index layer factors were selected in the landscape quality evaluation system (Table 1). The selection of the factors was adapted from [43]. The weight of each indicator was calculated using an expert focus group. The expert focus group includes 8 professors from several Chinese universities and 2 landscape architects from design companies. Questionnaires were prepared using a 1–9 scale [44] and distributed to experts. To calculate the weight value and to carry out the consistency test, a judgment matrix of A-B, B1-C, B2-C, and B3-C was conducted based on the questionnaire. The weight values of the 10 experts can be found in the Supplementary (Tables S1–S4). According to the consistency test principle, the results were satisfactorily consistent, meaning that the distribution of weights coefficient was reasonable.

Table 1. The landscape quality evaluation system.

Target Hierarchy A	Criteria Hierarchy B	Index Hierarchy C
The landscape quality evaluation of residential communities in Yangling City	Functionality (B1)	Good organization of residential roads and pedestrian system (C1)
		Accessibility to green space (C2)
		Abundance of spatial types (C3)
		Suitability of spatial scale (C4)
		Good functional of lighting facilities (C5)
		Rationality of rest facilities (C6)
		Adequacy of barrier-free facilities (C7)
	Ecological efficiency (B2)	Greening rate (C8)
		Diversity of woody plants (C9)
		Adaptability of plants (C10)
		Hierarchical richness of plants (C11)
	Visual quality (B3)	Trimmed shape of plants (C12)
		Aesthetics of landscape facilities (C13)
		Seasonal changes of plants (C14)
		General landscape of the residential community (C15)

3.2. Questionnaire Survey

We designed the questionnaire based on the indicators in the AHP evaluation system. The Likert five-point scale method was adopted when conducting a questionnaire survey with residents. The five options for each question correspond to a score from 1–5. The corresponding scoring standards were established to set up landscape evaluation grades, with grade I being a score of [0–2.5), grade II a score of [2.5–3), grade III a score of [3–3.5), grade IV a score of [3.5, 4), and grade V a score of [4, 5]. The scoring standards of quantitative indicators ("greening rate" (C8) and "diversity of woody plants" (C9)) are shown in Supplementary (Tables S5 and S6).

A total of 520 questionnaires were distributed in the five communities in May 2022, and 516 valid questionnaires were recovered, with a recovery rate of 99.23%. When conducting the questionnaire survey, we expressed the questions in an easy-to-understand way. For example, for the indicator "The trimmed shape of plants", we asked, "How do you think of the shape of the trees?". The specific number of questionnaires collected from different communities is shown in Supplementary (Table S7). The evaluation results for resident perception are calculated using the score given by residents multiplied by the weights given by experts. YAAHP 12.8 software was used in the evaluation system construction to give a calculation of the weights and the consistency test.

4. Results

The comprehensive scoring results of residents and evaluation grades of the 5 residential communities were summarized in Table 2. The rank from highest to lowest for the landscape quality of the 5 residential communities placed Hengda at the top, followed by Qinyuanchun, Rencai, Tianyuan, and Jinyadu. Figure 2 shows the current status of landscape in the five residential communities. The final comprehensive weights based on the landscape quality evaluation system are shown in Table 3. The weights of "good organization of residential roads and pedestrian system" (C1), "rationality of rest facilities" (C6), "adequacy of barrier-free facilities" (C7) were relatively high and were of the greatest concern to the residents.

Table 2. Landscape evaluation of residential communities scored by residents.

Residential Communities / Criteria and Index	Hengda	Qinyuanchun	Rencai	Tianyuan	Jinyadu
Functionality (B1)	4.23 (V)	4.22 (V)	4.09 (V)	3.47 (III)	3.41 (III)
Ecological efficiency (B2)	3.91 (IV)	3.80 (IV)	4.00 (V)	3.79 (IV)	3.26 (III)
Visual quality (B3)	3.99 (IV)	3.98 (IV)	3.57 (IV)	3.49 (III)	3.03 (III)
Good organization of residential roads and pedestrian system (C1)	4.15 (V)	4.06 (V)	3.97 (IV)	3.45 (III)	3.50 (IV)
Accessibility to green space (C2)	3.98 (IV)	4.11(V)	3.78 (IV)	3.40 (III)	3.46 (III)
Abundance of spatial types (C3)	3.56 (IV)	3.83 (IV)	3.28 (III)	3.30 (III)	2.82 (II)
Suitability of spatial scale (C4)	3.62 (IV)	3.80 (IV)	3.77 (IV)	3.26 (III)	3.37 (III)
Good functional of lighting facilities (C5)	3.69 (IV)	3.70 (IV)	3.57 (IV)	3.48 (III)	3.43 (III)
Rationality of rest facilities (C6)	4.06 (V)	3.75 (IV)	3.92 (IV)	2.66 (II)	3.37 (III)
Adequacy of barrier-free facilities (C7)	3.78 (IV)	4.01(V)	3.70 (IV)	2.84 (II)	2.69 (II)
Greening rate (C8)	4.15 (V)	4.05 (V)	4.50 (V)	4.50 (V)	3.00 (III)
Diversity of woody plants (C9)	4.15 (V)	4.15 (V)	3.60 (IV)	4.10 (V)	2.85 (II)
Adaptability of plants (C10)	3.41 (III)	4.10 (V)	3.60 (IV)	3.07 (III)	3.56 (IV)
Hierarchical richness of plants (C11)	4.05 (V)	4.05 (V)	3.50 (IV)	3.31 (III)	2.62 (II)
The trimmed shape of plants (C12)	3.63 (IV)	3.58 (IV)	2.68 (II)	3.12 (III)	3.33 (III)
Aesthetics of landscape facilities (C13)	3.66 (IV)	3.78 (IV)	3.43 (III)	3.21 (III)	3.23 (III)
Seasonal changes of plants (C14)	4.06 (V)	4.07 (V)	3.88 (IV)	3.93 (IV)	3.50 (IV)
The general landscape of the residential community (C15)	3.81 (IV)	3.76 (IV)	3.87 (IV)	3.88 (IV)	3.81 (IV)
Comprehensive results (A)	4.33 (V)	4.30 (V)	4.12 (V)	3.80 (IV)	3.48 (III)

* Grade II means a score of [2.5–3), grade III means a score of [3–3.5), grade IV means a score of [3.5,4), and grade V means a score of [4,5].

Figure 2. Current stauts of landscape of the five residential communities.

Table 3. Final comprehensive weights based on the landscape quality evaluation system.

Target Hierarchy A	Criteria Hierarchy B	W [a]	Index Hierarchy C	WCn [b]	W [c]
The evaluation of landscape quality by the residential communities in Yangling City (A)	Functionality (B1)	0.5340	Good organization of residential roads and pedestrian system (C1)	0.2990	0.1522
			Accessibility to green space (C2)	0.1512	0.0910
			Abundance of spatial types (C3)	0.0969	0.0392
			Suitability of spatial scale (C4)	0.1551	0.0391
			Good functional of lighting facilities (C5)	0.0991	0.0471
			Rationality of rest facilities (C6)	0.1872	0.1075
			Adequacy of barrier-free facilities (C7)	0.0911	0.0438
	Ecological efficiency (B2)	0.2051	Greening rate (C8)	0.4523	0.0658
			Diversity of woody plants (C9)	0.0716	0.0698
			Adaptability of plants (C10)	0.4761	0.0504
	Visual quality (B3)	0.2609	Hierarchical richness of plants (C11)	0.4988	0.1228
			The trimmed shape of plants (C12)	0.0609	0.0267
			Aesthetics of landscape facilities (C13)	0.1154	0.0929
			Seasonal changes of plants (C14)	0.2926	0.0948
			The general landscape of the residential community (C15)	0.0323	0.0595

[a] "W" refers to the weights of criteria layer indicators relative to target layer indicators. [b] "WCn" refers to the weights of index layer indicators relative to the criteria layer indicators. [c] "W" refers to the weights of index layer indicators relative to target layer indicators.

4.1. An Evaluation of "Functionality" and Its Corresponding Indicators

Compared with other indicators in the criteria hierarchy, experts considered "functionality" (B1) as having the greatest effect on landscape quality evaluation, with a weight of 0.5340 (Table 3). The evaluation results of residents' perception showed that the grades of functionality (B1) in Jinyadu and Tianyuan were III, scoring lower than the other 3 communities (Rencai, Qinyuanchun, and Hengda), whose grades were V. It indicates that the functionality of the landscape in Jinyadu and Tianyuan was far from satisfactory for the residents. Immediate improvement in functionality is necessary for these two residential communities.

To find the specific gaps of landscape quality between different residential communities in terms of "functionality" (B1), the scores of the indicators in the index hierarchy (from C1 to C7) were analyzed in depth. The "good organization of residential roads and pedestrian system" (C1) was found to be positively correlated with "accessibility to green space" (C2). There was also a big difference among the residents' perceptions in terms of the two indicators in the five communities. Hengda and Qinyuanchun received higher scores than the other three. Based on the site visits to these communities, this was likely due to pedestrians and vehicles being separated in the two communities.

In terms of "abundance of spatial types" (C3), the score for Jinyadu is far lower than other communities. This was due to the fact that in Jinyadu, almost all activities were conducted in one square, and the types of activity space were far less abundant than in the other communities. The scores for "suitability of spatial scale" (C4) and "good functional of lighting facilities" (C5) in the 5 communities were similar, with no major flaws. Compared with other communities, Tianyuan had lower scores in "rationality of rest facilities" (C6), possibly due to the unreasonable layout and inappropriate material selection of rest facilities. Tianyuan and Jinyadu scored lower in the aspect of "adequacy of barrier-free facilities" (C7). This means the lack of barrier-free facilities should be paid attention to in the two communities.

4.2. An Evaluation of "Ecological Efficiency" and Its Corresponding Indicators

The weight of the "ecological efficiency" (B2) in the criteria hierarchy was the lowest, with 0.2051, far lower than the "functionality" (B1) (Table 3). This means that experts considered that the effects of "ecological efficiency" (B2) on landscape quality in residential communities were the least obvious in the criteria hierarchy. Regarding the communities, as shown in Table 2, Rencai scored highest, and Jinyadu scored lowest. This indicates that the landscape in Rencai had the best ecological efficiency, while Jinyadu should pay attention to improvements in the ecological efficiency of the community landscape.

Deep analysis was conducted on indicators "greening rate" (C8), "diversity of woody plants" (C9), and "adaptability of plants" (C10) in the index hierarchy towards "ecological efficiency" (B2). Most of residents in the communities, except those in Jinyadu, considered that the greening rate in their residential communities was high, with the scores given regarding greening rates all being above 4. In terms of diversity of woody plants, Jinyadu had the lowest score with 2.85 (rating II), while Hengda and Qinyuanchun scored highest with 4.15, a rating of IV. Based on the onsite investigation, there were only 27 kinds of woody plants in Jinyadu, while 53 kinds of woody plants were found in Qinyuanchun. The environment for plant growth was similar in the communities. The scores of the "adaptability of plants" (C10) were within rating III in four communities, with Qinyuanchun scoring higher with a rating of IV.

4.3. An Evaluation of "Visual Quality" and Its Corresponding Indicators

As shown in Table 1, experts did not give a high weight to the aspect of "visual quality" (B3) for landscape quality in residential communities. Residents' perceptions of the visual quality of their residential communities were clearly very different. Residents in Hengda and Qinyuanchun thought the visual quality of their communities was good, with the scores being close to 4.00. However, the score for Jinyadu was only 3.03, meaning

the residents were less satisfied with the visual quality of landscape of their residential community.

The indicators in the index layer focusing on "visual quality" (B3) were also analyzed. In terms of the "hierarchical richness of plants" (C11), Hengda and Qinyuanchun received the highest scores, while Jinyadu had the lowest. In Jinyadu, the plant configuration was chaotic with a lack of aesthetic order. Future improvements could focus on the richness of the plant hierarchy. Regarding the "trimmed shape of plants" (C12), Rencai scored lowest with 2.68, while the other four scored more than 3.00. Many trees in Rencai had been cut at the top, leading to a less visually satisfying plant shape. Residents in Rencai wanted more visually pleasing plant morphology. In the aspects of "aesthetics of landscape facilities" (C13), "seasonal changes of plants" (C14), and "environmental harmony" (C15), there was no big difference between the communities.

5. Discussion

The COVID-19 pandemic has changed people's behavior around visiting green spaces; this has meant that the visiting of public spaces in residential communities has increased [45,46]. Functionality was weighted highest by the experts in the study, while "good organization of residential roads and pedestrian system" and "rationality of rest facilities" were weighted highest by the residents. In terms of visual quality, residents were concerned mostly about the "hierarchical richness of plants".

5.1. Functionality

5.1.1. Good Organization of Residential Roads and Pedestrian System

Pedestrian–car interweaving is a prominent problem in old residential communities in Chinese cities [36]. Traffic accidents are common in residential communities, especially with children or seniors. This has led to traffic safety issues being a major point of concern for residents [47]. As mentioned in Section 4.1, Jinyadu had the lowest score in the organization of roads and pedestrian system aspect, probably due to pedestrian–car interweaving. The two communities which received the highest scores (Hengda and Qinyuanchun) both had separate areas for pedestrians and motor vehicles. In the future, separating pedestrians and motor vehicles should be a focus for urban renewal.

Narrow roads and low traffic capacity are the main issues in residential communities (Peng and Wang, 2020). It was reported that the increased traffic density in residential communities might lead to poor emotional and behavioral problems in children [48]. Re-evaluating the road system may be a solution that would improve the traffic patency of old residential communities. In addition, as reported, many seniors living in old residential communities had issues with road accessibility, which hindered their daily outdoor activities [35]. Thus, proper and timely maintenance should be conducted on the pedestrian areas. Barrier-free facilities should be built to facilitate the use of wheelchairs. These actions will be a benefit for traffic patency in residential communities.

5.1.2. Rest Facilities

Seats along roads or rest facilities in recreational areas are an important element for people wishing to rest [35]. In our study, the rationality of rest facilities achieved the highest weights. It was reported that seat availability and barrier-free facilities are the major concern for seniors [35]. This indicates how the layout of rest facilities along roads and recreational areas is of significance when making improvements to the living environment in residential communities.

5.2. Visual Quality of Plants

The richness of plants was of great concern to residents, showing the extent to which it is a fundamental part of the landscape of residential communities. It is reported that interaction with nature at a young age is highly beneficial for human well-being [49]. Similarly, green areas in residential communities help to form a better childhood emotional status,

while a lack of exposure to nature creates poorer emotional status and behavioral problems in children [48]. In addition, the richness of plants and increasing vegetative cover to improve structural diversity help to improve the biodiversity of residential communities [50]. Residents were willing to pay for plants in their residential communities [32].

Thus, increasing planting is important for improving the landscape quality of residential communities. Without a proper design method in terms of plants, the visual quality may look messy. It is reported that from a viewer's perspective, a mix of species of plants with a clear designated boundary would be more visually pleasing than those without a boundary [50]. Thus, alongside ecological function, the visual quality of plants should be paid attention to by the designers.

6. Conclusions

In this paper, using the AHP method, we have constructed a landscape quality evaluation system and applied it in five residential communities in the case city of Yangling City, China. Ten relevant experts were used as a focus group and were invited to create a weighting of factors in the evaluation system. The weights given by experts indicated how the functionality of the landscape significantly affects the evaluation of landscape quality in residential communities, while ecology efficiency has the least effect. Moreover, "good organization of residential roads and pedestrian system", "rationality of rest facilities", and "hierarchical richness of plants" were the most concerning problems for residents in the residential communities.

Four recommendations are provided for the urban renewal of residential communities in developing countries: (i) Good organization of residential roads and pedestrian system significantly affect the evaluation results. Thus, separating pedestrian and vehicle traffic in residential communities is important. (ii) When attempting to take care of special groups, it is necessary to set up barrier-free slopes and easily identifiable landscape signs. (iii) In terms of plants, landscape designers should choose native species and focus on their hierarchical richness. In addition, reasonable maintenance is needed. (iv) Reasonable setting of the rest facilities is important for improving living experience of residents in residential communities.

This paper reported the problems existing in residential communities in the case city of Yangling and provided suggestions for improving their landscape quality. Similar problems may exist in residential communities in many developing countries. This paper can be a reference for city managers, urban planners, and landscape architects on how to improve the landscape quality in residential communities and urban renewal in developing counties.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land12010057/s1, Table S1: A-B judgment matrix for experts. Table S2: B1-C judgment matrix for experts. Table S3: B2-C judgment matrix for experts. Table S4: B3-C judgment matrix for experts. Table S5: Evaluation grade for "diversity of woody plants". Table S6: Evaluation grade for "diversity of woody plants". Table S7: The specific number of questionnaires from the 5 residential communities.

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