Elderly Suitability of Park Recreational Space Layout Based on Visual Landscape Evaluation

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Abstract: Urban parks are critical for sustainable urban development. They are of theoretical and practical significance for analyzing the visual landscape of recreational spaces from the perspective of the elderly. This analysis can be used for exploring new methods for optimizing recreational space layouts to improve the physical and mental health of the elderly in parks, thus realizing the sustainable development of urban society. Taking Ziyang Park in Shangrao Central District of Jiangxi Province, China, as an example, starting from the visual characteristics of the elderly, this study quantitatively calculated the landscape viewability, total view ratio, and water view ratio for the elderly in each recreational space using Python Scripting for ArcGIS. We briefly express the elderly suitability of the visual landscape for each recreational space through a weighted synthesis of the calculation results. Our findings show that, in Ziyang Park, the elderly suitability of the visual landscape for recreational spaces is not only low overall, but also gradually decreases from the interior to the exterior of this park. Moreover, this spatial distribution may be caused by the location of zoning, surface elevation, and road slopes, as well as the individual characteristics of each recreational space. Finally, we discuss the requirements of the elderly for some geographical factors, along with the feasibility of using ArcGIS 3-D analysis to optimize the layout of the park recreational space, with the aim of providing a new research perspective and an effective reference method for designing layouts of such spaces that are favorable for the elderly to better guarantee the sustainable development of urban society.

Keywords: visual landscape; park; recreational space; elderly suitability; GIS; Python; sustainable development

1. Introduction

The world’s population is aging [1]. By 2030, the proportion of people over 60 in the United States, Japan, and the United Kingdom will increase to 26.1, 27.8, and 37.3%, respectively [2]. In China, due to the large population base, longer life expectancy, and continuous decrease in the population of child-bearing age, the proportion of the elderly population may rise to 25% or higher [3]. Parks are the most commonly visited public green spaces for the elderly in the city. They play an indispensable role in maintaining the physical and mental health of the elderly and promoting social interaction. Therefore, faced with the severe trend in population aging, an increasing number of scholars have begun to focus on the elderly suitability of parks (also referred to as “aging-suitability” [4], which essentially reflects the suitability of parks for the elderly) and have aimed to improve this suitability to ameliorate the health and living conditions of the elderly, finally promoting the sustainable development of urban society [4,5].

However, a large number of studies have shown that 80% of people’s perception of spatial information occurs through their vision [6–8], meaning that the visual landscape of spaces can greatly affect our judgment of its suitability. Visually attractive outdoor...
spaces can often result in a higher or better perceived suitability [9]. However, at present, scholars have considered the suitability of parks for the elderly only from the perspective of the facility configuration [5,10–12], space security [5,12], space accessibility [5,13], space sociality, environmental comfort [5,14], and space diversity and scale [15]. This shows that although there is evidence that the elderly have high-quality visual needs for park space [14], there is no research to date that evaluates the elderly suitability of parks from the perspective of vision or visual landscapes.

In recent decades, as the visual landscape of a space will affect, to a significant extent, people’s judgment of the suitability of that space, some scholars and organizations (such as the American Society of Landscape Architects) have attempted to improve outdoor space suitability, as well as examining the theme of space visual landscape and identifying many visual landscape evaluation methods. These methods mainly include field observation scoring [16], network questionnaire surveys [17–19], computer image analysis [20], expert evaluation [19,21], the analytic hierarchy process and scenic beauty evaluation method [22], and geographic information systems (GIS) comprehensive analysis [23]. However, as noted from existing visual landscape research, there is also no specific precedent to optimize the elderly suitability of parks based on a visual landscape evaluation and analysis.

To summarize, current research on the suitability of parks for the elderly, whether for evaluation or optimization, lacks thought and practice from the vision or visual landscape dimension. However, the visual perception ability of the elderly (such as visual distance and visual acuity, among others) is generally not as good as that of the young [8]. Therefore, in a park, if the layout, quantity, and terrain of its spaces are not reasonable, the elderly may suffer more visual interference or obstacles than the young in the same space. Accordingly, their visual landscape (such as the landscape scope and angle) based on this space will also be limited, inevitably affecting their quality of life, even hindering the sustainable development of urban society [24]. Therefore, referring to the view of Ma [25], i.e., adjusting the spatial relationship of urban landscapes can eliminate or reduce the spatial resistance to urban sustainable development, attention must be focused not only on the degree and characteristics of park landscape beauty, but also on the elderly’s visual perception suitability of the layout, quantity, and terrain of the park spaces [26]. Further, these aspects should be taken as the basis for optimizing the spatial layout of parks and improving the suitability of parks for the elderly.

Lorenzo [27] and Zhang [23] show that the most critical technology restricting the evaluation and analysis of the visual landscape is the simulation and analysis of spatial visual relationships; GIS software can just meet these technical requirements. However, this paper holds that the efficiency of previous studies that have used GIS to manually complete visual landscape evaluation and analysis is excessively low. Therefore, to compensate for the above deficiencies, this study takes Ziyang Park in Shangrao Central District of Jiangxi Province, China, as an example. Based on the concept and evaluation index system of the elderly suitability of the visual landscape of park recreational spaces, this study evaluates and analyzes the elderly suitability of the visual landscape of the recreational spaces in Ziyang Park using Python Scripting for ArcGIS; we discuss the feasibility of optimizing the layout of these spaces using ArcGIS 3-D analysis, combined with the requirements of the elderly for some terrain factors. This study aims to provide a new research perspective and an implementation method for designing layouts of park recreational spaces that are favorable for the elderly to better guarantee the sustainable development of urban society.

The remainder of the study is organized as follows: Section 2 provides a literature analysis on the elderly suitability of parks and the spatial visual landscape. Section 3 demonstrates the materials and methods used in this study. Section 4 illustrates the results of the evaluation, analysis, and optimization. Finally, Section 5 presents the discussion and conclusions.
2. Related Literature

The visual landscape is one of the main topics in the field of landscape science, but its definition remains ambiguous across academic circles. A few scholars use “visual environment of landscape” or “visual environment” to express the “visual landscape”, but all refer to people’s visual perception of the objective environment and tend to focus more on the visual attributes of landscapes [28].

A systematic literature review shows that existing visual landscape research can be divided into three categories: visual landscape quality evaluation, visual landscape preference research, and visual impact evaluation [29]. Based on this categorization, the relevant literature from the past 20 years was reviewed; the following key points summarize our findings:

1. Some scholars engaged in park landscape research have mainly focused on the forest edge landscape and plant landscape of parks. Only a few scholars have conducted research on the visual landscape of park recreational spaces [30] and main pedestrian corridors [31,32], where they only focused on the relationship between the visual preference or visual influence of visitors and the landscape designs or operations of scenic spots.

2. Among the existing visual landscape evaluation methods, the most commonly used is the scenic beauty estimation method (SBE), followed by the expert evaluation method. However, due to a lack of on-site experience, the SBE sometimes produces deviations; the expert evaluation method excessively relies on the subjective judgment of professionals, such that its evaluation results are one-sided. In contrast, the more comprehensive GIS analysis method can partially improve upon the objectivity and accuracy of the evaluation [23].

3. In terms of visual landscape preference research and visual impact evaluation, Cakci [19] stated that the orderliness, spatiality, maintainability, and prominence of landscape elements directly affect the users’ landscape preferences. Yao [9] found that the visual perception of green landscapes in rural residential areas is affected by the vegetation type, vegetation area, color contrast, green space openness, terrain type, and positive human factors. Scarfò [31] evaluated the visual impact of forest operations on the landscape through a GIS analysis of three landscape features (visibility, forest landscape quality, and visual sensitivity) in the main tourism corridors of a reserve. Polat [30] found that the water area, widths of pedestrian passages, and functions of leisure areas have a positive impact on the visual quality of the landscape area. Qi [33] stated that the advantage of country park landscapes lies in their sufficient water landscape construction space, whereas a disadvantage is the visual interference caused by surrounding high-rise buildings. Liu [16] reported that the sight distance, visual disturbance frequency, green looking ratio, inter-visibility, openness, and the relative angle and relative area of the artificial matrix are seven specific indicators that affect the visual landscape quality of country parks.

As mentioned in Section 1, there is still a lack of elderly suitability evaluations of parks from the perspective of vision or visual landscape. However, for the optimization aspect of the elderly suitability of parks, Carstens [34] proposed that an elderly community should establish external space and facilities “suitable for the elderly” to adapt to all aspects of the elderly’s abilities. Marcus [35] proposed that a “therapeutic” garden should be set up in a community for the elderly according to the health care needs of the elderly. Cao [36] stated that urban public spaces for the elderly should be designed according to the “5D” strategy (density, diversity, pedestrian space, accessibility, and fault tolerance). Thus, the main starting points for scholars to optimize the elderly suitability of parks are the health needs, behavioral ability, and characteristics of the elderly.
In summary, there is little research on how to scientifically develop and plan park spaces according to the vision or visual landscape; moreover, there is an even greater lack of research on how to evaluate and optimize the elderly suitability of a park based on the visual ability characteristics of the elderly and their visual landscape.

From the viewer’s perspective, combined with the spatial distribution of the landscape and its surrounding facilities, the analysis of the visual field characteristics that visitors can see in the process of visiting a park is an important basis for the development and planning of urban parks [26,29]. Therefore, combined with the above literature analysis, this paper takes the most commonly used recreational space for the elderly as a study example. The selected recreational spaces include stone/wood benches, characteristic pavilions, cultural corridors (i.e., corridors designed to convey cultural characteristics), and hydrophilic platforms (i.e., platforms extending from land onto a water surface, accessible for recreation), among others. Such spaces are mostly distributed in the interior of landscape points (some landscape points are also considered recreational space) or on both sides of the main walkways.

3. Materials and Methods

3.1. Research Area

Shangrao is located in northeastern Jiangxi Province, China, at the intersection of the Yangtze River Delta Economic Zone, Haixi Economic Zone, and Poyang Lake Ecological Economic Zone. Since ancient times, Shangrao has been known as an “excellent and rich city of ecology” and “thoroughfare in all directions”. In 2016, Shangrao Central District was designated as the provincial sub-central city of Jiangxi Province, with a permanent resident population of approximately 1 million; the elderly population above 60 years accounted for approximately 12.74% of the city’s population. This shows that the degree of population aging in Shangrao Central District is relatively high.

Ziyang Park is located in northeastern Shangrao Central District, bordering Jiyang Road to the east, Chasheng Road to the south, Guihua Road to the west, and Fenghuang Avenue to the north. It covers an area of approximately 8.78 hectares, of which the water area accounts for approximately 21.52%; the park is a monument to the memory of Zhu Xi, a famous philosopher and educator of the Southern Song Dynasty. The functional space is composed of five areas: the main entrance square, children’s recreation, water activity, mountain amusement, and culture and history exhibition areas (Figure 1). In terms of the external spatial relationships, Ziyang Park is adjacent to each residential district in all directions other than to the west and north, which are adjacent to the commercial city (Figure 2). Therefore, Ziyang Park is a public outdoor space with a strong living atmosphere in this area.

Pavilions (such as the Ziyang Pavilion, Liuhua building, Zhizhi Pavilion, Meihua Pavilion, Zhulu Pavilion, Miaowan teashop, and Pleasure-boat Pavilion, among others), with different styles, are the favorite attractions of the elderly in Ziyang Park. They provide a strong cultural atmosphere, meeting the needs of the elderly to enjoy the calligraphy of famous masters and cherish the memory of the sages. On the winding wooden bridge in the park, the elderly can also observe fish in the lake and interact with nature. Therefore, Ziyang Park is a suitably representative choice as the research case.
3.2. Research Data

Two types of data were used in this study. First, general attribute data on various ground elements in the case park, mainly including the name and category of each ground element, were obtained from the field investigation. Second, geospatial data on roads, buildings, lakes, landscapes, pavilions, benches, and other facilities in the case park were considered. Among them, 2D geospatial data were mainly sourced from the Shangrao tourism map compiled by the Jiangxi map publishing station in September 2013; it was obtained by scanning paper maps and performing classified vectorizing using ArcGIS 10.4. The 3-D DEM data were mainly obtained using hand-held global positioning system tools. In addition, as mentioned in Section 1, the evaluation should first consider elderly sightline barriers to simulate the geographical environment of the elderly. Therefore, using the above-mentioned geospatial data, the tin surface of Ziyang Park, which is also a part of the geospatial data used in this study, was created.
3.3. Research Methods

3.3.1. Evaluation Indices and Weights

According to the aforementioned literature analysis, there are many factors that affect the visual landscape, but many studies on quality are based on subjective judgment. Therefore, to further understand the needs of the elderly in the park visual landscape and the factors influencing the park visual landscape for the elderly, we designed a paper questionnaire according to the research in the literature [5,8,14,34,37–39] and conducted a questionnaire survey on some elderly people in five local parks. A total of 90 questionnaires were issued, and 74 valid questionnaires were collected. The statistical results show that the visual distance, landscape visibility, landscape aesthetic degree, landscape scale, size of the visual field, and the proportion of the water area in the visual field are the main factors influencing the park visual landscape for the elderly. The broad visual field, high landscape visibility, beautiful landscape, a certain size for the landscape scale, and an appropriate proportion of waterscapes are the main needs of the elderly in the park visual landscape. Based on this, combined with the research methods used in a previous study [40] and after removing some non-spatial factors and the elderly’s own factors, we set three influencing factors for the elderly’s visual landscape in park recreational spaces: landscape viewability, total view ratio, and water view ratio. We then proposed that the landscape viewability for the elderly (ELV) of a recreational space refers to the proportion of the number of landscapes that the elderly can see in this recreational space with respect to the total number of park landscapes. The total view ratio for the elderly (ETVR) of a recreational space refers to the proportion of the total surface area that the elderly can see in this recreational space with respect to the total surface area of the park. The water view ratio for the elderly (EWVR) of a recreational space refers to the proportion of the water area that the elderly can see in this recreational space with respect to the total water area of the park. Second, we defined the weighted synthesis of the landscape viewability, the total view ratio, and the water view ratio for the elderly in a recreational space as the elderly suitability of the visual landscape of this recreation space (ESVL). Finally, based on evaluations by 20 experts and an analysis using the analytic hierarchy process (AHP), we obtained the weight coefficients of the ELV, ETVR, and EWVR in the ESVL evaluation of park recreational spaces, which were 0.36, 0.52, and 0.12, respectively, as follows:

\[
ESVL = ELV \times 0.35 + ETVR \times 0.52 + EWVR \times 0.12.
\]

3.3.2. Evaluation Hypotheses

To ensure authenticity and availability, three minor hypotheses were applied in the evaluation stage, as follows:

1. The elevation of a recreational point, i.e., the elevation of an observation point, was assigned according to the principle of “the ground elevation of the recreation point + 1.2 m (which is the approximate height of an elderly man’s eyes above the ground when he sits down)”.

2. A landscape point, i.e., a target point, was represented by the centroid point of its ground plane; its elevation was assigned according to the principle of “the centroid point’s elevation + the landscape’s height”.

3. Referring to the field investigation results, the longest distance for the elderly to recognize the type of scenery was assumed to be 170 m.

3.3.3. Measurement of Evaluation Indices by Python Scripting for ArcGIS

ArcPy is a Python site package launched by ESRI after ArcGIS 10.0 containing 91 functions, 37 classes, and 5 modules; it allows users to flexibly create simple or complex workflows through Python Scripting for ArcGIS, aiding in the efficient automation of geographic processing tasks [5,41–43]. Therefore, referring to the manual process of using ArcGIS intervisibility analysis and viewshed analysis tools [44], as well as documents on
the use of the ArcPy function, this study measured the above three evaluation indices according to the following methods.

1. Measurement of Landscape Viewability for the Elderly

We first obtained the line network of sight from each recreational point to each landscape point by loading the layers of the recreational points, landscape points, and tin surface, and then using the Python script (Appendix A.1) to call the construct sightlines [45] and intervisibility [46] functions of ArcPy. Then, after excluding some lines of sight that were more than 170 m in length, we obtained the landscape viewability for the elderly in any recreational space by classifying and summarizing the attribute data for the sight line network.

2. Measurement of the Total View Ratio and Water View Ratio for the Elderly

By converting the park tin surface to the park grid surface, loading the layers of the recreational and landscape points, and using the following two steps in the Python script (Appendix A.2), we obtained the total view ratio for the elderly in any recreational space according to the definition (Section 3.3.1).

Step 1: call the select_analysis function of ArcPy to separate the Shp layer with 16 recreational points into 16 single point layers.

Step 2: call the viewshed [47] function of ArcPy to solve the grid cells intersecting the park grid surface and each recreational point layer, so as to obtain the total view area (counted by the number of grids) for the elderly in any recreational space.

Then, using the Python script (Appendix A.3) to call the extractbymask function of ArcPy, the grid cells intersecting any total view area and the park lake surface were solved to obtain the water viewshed area for the elderly in any recreational space. Finally, according to the definition given in Section 3.3.1, we further obtained the water view ratio for the elderly in any recreational space.

4. Results and Analysis

4.1. Evaluation and Measurement Results

Using the above hypothesis and methods described in Section 3.3.3, we obtained the measurement results for the three evaluation indices in each recreation space of Ziyang Park (Table 1).

| Recreation Space | ELV (%) | ETVR (%) | EWVR (%) | Recreation Space | ELV (%) | ETVR (%) | EWVR (%) |
|------------------|---------|----------|----------|------------------|---------|----------|----------|
| Wood bench 0     | 45.5    | 15.8     | 49.7     | Wood bench 8     | 53.5    | 23.9     | 63.8     |
| Wood bench 1     | 72.7    | 21.6     | 51.3     | Wood bench 9     | 45.5    | 15.7     | 56.2     |
| Wood bench 2     | 36.4    | 27.4     | 39.5     | Zhizhi pavilion 10 | 72.7   | 29.4     | 60.7     |
| Wood bench 3     | 36.4    | 20.4     | 21.6     | Miaowan teahouse 11 | 36.4   | 17.0     | 55.0     |
| Stone bench 4    | 9.1     | 8.2      | 0.0      | Zhulu pavilion 12 | 18.2    | 19.9     | 0.0      |
| Stone bench 5    | 9.1     | 7.3      | 0.0      | Meihua Pavilion 13 | 36.4   | 25.4     | 27.3     |
| Xinghe teahouse 6| 72.7    | 26.3     | 62.0     | Daohua Pavilion 14 | 0.0    | 13.5     | 0.0      |
| Cultural corridor 7 | 63.6 | 30.8     | 60.6     | Hydrophilic platform 15 | 90.9   | 25.6     | 51.3     |

Based on the above table and Equation (1), we obtained the elderly suitability evaluation results of the visual landscape in each recreation space of Ziyang Park (Table 2). Descriptive statistics show that the elderly suitability mean value was small (0.31), the minimum value (0.07) was close to 0, the maximum value (0.52) was small, and the standard deviation was small (0.151). This indicates that the visual landscape of Ziyang Park’s recreation spaces is not suitable for the elderly and is not able to meet the visual perception demands of the majority of the elderly.
Table 2. Elderly suitability of the visual landscape in each recreation space of Ziyang Park.

| Recreation Space         | ESLV | Recreation Space         | ESLV | Recreation Space         | ESLV | Recreation Space         | ESLV |
|--------------------------|------|--------------------------|------|--------------------------|------|--------------------------|------|
| Daohua pavilion 14       | 0.07 | Wood bench 3             | 0.26 | Wood bench 9             | 0.31 | Cultural corridor 7      | 0.46 |
| Stone bench 5            | 0.07 | Miaowan teahouse 11      | 0.29 | Wood bench 2             | 0.32 | Xinghe teahouse 6        | 0.47 |
| Stone bench 4            | 0.08 | Meihua Pavilion 13       | 0.30 | Wood bench 8             | 0.40 | Zhizhi pavilion 10       | 0.49 |
| Zhulu pavilion 12        | 0.17 | Wood bench 0             | 0.31 | Wood bench 1             | 0.44 | Hydrophilic platform 15  | 0.52 |

4.2. Spatial Distribution Characteristics and Causes of Elderly Suitability of Visual Landscape

Based on the above evaluation results, by overlaying the park tin surface, recreation points, and main walkway layers in ArcMap 10.4, as well as using the natural breaks method to render the park recreational point elements with different symbols according to the elderly suitability value of their visual landscapes, we created a spatial distribution map of the elderly suitability of the visual landscape for the recreation spaces of Ziyang Park (Figure 3).

Figure 3. Spatial distribution of the elderly suitability of the visual landscape for the recreation spaces of Ziyang Park.

Figure 3 divides all of the recreation spaces in Ziyang Park into three types. The spatial distribution indicates that the elderly suitability of the visual landscape in the recreational spaces of Ziyang Park gradually decreases from the interior to the exterior. More specifically, Figure 3 indicates that the elderly suitability level of the visual landscape of recreation space type I is the lowest, and that it is mainly distributed at the main entrance and the overlook areas of the park, which are stone bench 4, stone bench 5, Daohua Pavilion 14, and Zhulu Pavilion 15. The elderly suitability level of the visual landscape of recreation
space type II is medium, which is mainly distributed on both sides of the park’s main walkway, as well as in low-lying areas. The elderly suitability level of the visual landscape of recreation space type III is the highest, which is mainly distributed in the center of the park and the higher elevation section of the main walkway (such as wood bench 1 and hydrophilic platform 15); most of these areas are characteristic pavilions (such as Zhizhi Pavilion, Xinghe teahouse, and the cultural corridor, among others).

Based on the above findings, the comprehensive analysis suggests that the above spatial distribution characteristics may be caused by differences in the location zoning type, surface elevation, road slope, and the characteristics of each recreation space. First, the main entrance of the park is an important channel for users to enter and leave the park; therefore, the recreation space at this location is generally not used by tourists to watch or rest for an extended period. The overlook points of the park are generally distributed at the highest peak on the outer edge of the hill, which are mainly for tourists to enjoy the park’s exterior scenery. As a result, the number of park landscapes and the area of the visual field that elderly users can see when sitting in the recreation space of these two sub-areas are generally few or small. Thus, the elderly suitability level of the visual landscape of recreation space type I is the lowest. Second, if tourists are in low-lying areas, the lines of sight are easily blocked by hills or buildings. Therefore, although recreation space type II is closer to the center of the park than recreation space type I, the elderly suitability of its visual landscape can only reach a medium level. Third, the park center is generally open, often acting as the landscape center, such that the recreation space here generally has certain characteristics, usually characterized by a better observation perspective and a wider field of vision. In addition, some of the recreation spaces in space type III are located in the high slope section of the main walkway, so that they also provide a good perspective and broader vision. For these two reasons, the visual landscape of recreation space type III is the highest and most suitable for the elderly.

4.3. Aging Optimization of Ziyang Park’s Recreational Space Layout

As mentioned above, the park’s main entrance is generally not suitable for resting, whereas the park overlook points are generally designed to enjoy the exterior scenery of the park. Therefore, we dismissed the layout optimization of recreation space type I, instead selecting recreation space type II (i.e., recreation spaces on both sides of the main walkway) for layout optimization. Moreover, the established objective was to make the new recreation space layout of Ziyang Park more conducive for the elderly to obtain a superior visual landscape of the park.

4.3.1. Rules and Restrictions

According to the above evaluation results and the optimization goal, we established several optimization rules and restrictions based on the geographical elevation, road slope, adjacent distance, and plot area as the investigation factors referring to the classification standard of building slopes [48].

1. Newly built recreation spaces should be located in plots with a higher elevation or road sections with a higher slope.

2. For each section of the main walkway, if the road slope of a section is high (such as the medium and steep slope sections with a slope >6°) and the existing recreation spaces of this section are scarce, priority should be given to adding small-scale recreation spaces (such as single seats or benches).

3. For plots adjacent to the main walkway, if the plot has a high elevation, low slope (such as flat, gentle, and medium slope plots with slopes <10°), and is sufficiently open (area >100 m²), priority should be given to adding a large-scale recreational space (such as a characteristic cool pavilion, chess board, or card field) in such plots.
4.3.2. Sample Plot Selection and Analysis

(1) Sample plot selection of small-scale recreation space based on road slope analysis

According to the above rules and restrictions, to measure the road slope of each section of the main walkway as accurately as possible, we first used the editor tool in ArcMap to segment the main walkway from the south entrance of the park at an interval of 10 m to obtain 72 sections (the last section is 9.29 m). Second, we used equation (2) to calculate the slope of each section and rendered all sections according to the slope value (Figure 4). Finally, we extracted the high-altitude endpoints of all road sections with a slope value >6°, and used them as the sample plots in which small-scale recreational spaces can be added, i.e., the 11 nodes (v1–v11) in Figure 4.

\[
A = \sin^{-1}\left(\frac{|FH - TH|}{\sqrt{(FX - TX)^2 + (FY - TY)^2}}\right)
\]

where \(FH\) and \(TH\) represent the elevation values of the starting and terminal nodes of the road section, respectively; \(FX\) and \(TX\) represent the X coordinates of the starting and terminal nodes of the road section, respectively; and \(FY\) and \(TY\) represent the Y coordinates of the starting and terminal nodes of the road section, respectively.

![Figure 4](image-url) Rendering of the main walkway slope and sample plot selection of small-scale recreational spaces. Note: we also conducted experiments at intervals of 20 and 30 m; however, through comparisons, we found that the calculation results using 10 m intervals were closer to the field survey.

(2) Sample plot selection of large-scale recreational spaces based on surface slope analysis

The adjacent areas of the main walkway were the optimal places for large-scale elderly recreational spaces. Considering that steep terrain will yield many difficulties and costs for construction, areas with gentle slopes should be selected for the site if possible. Combined with the approximate distance between the elderly activity areas and the main walkway obtained from the field survey, we first calculated the surface slope of areas within 30 m of the main walkway (Figure 5). We then selected a total of 10 sample plots suitable for the construction of large-scale elderly recreational spaces by combining two conditions: “the area of a single plot should be >100 m²” and “the surface slope should be <10°” (Figure 6).
(3) Elderly Suitability Analysis of the Visual Landscape of Sample Plots
Using the same evaluation and analysis method as above, the elderly suitability of the visual landscape in the 21 sample plots was obtained (Tables 3 and 4).

Table 3. Elderly suitability of the visual landscape in small-scale sample plots.

| Sample Plot | ESVL | Sample Plot | ESVL |
|-------------|------|-------------|------|
| V4          | 0.491| V1          | 0.187|
| V5          | 0.454| V10         | 0.148|
| V7          | 0.350| V11         | 0.110|
| V6          | 0.337| V9          | 0.109|
| V2          | 0.280| V8          | 0.051|
| V3          | 0.258| Average     | 0.252|
Table 4. Elderly suitability of the visual landscape in large-scale sample plots.

| Sample Plot | ESVL | Sample Plot | ESVL |
|-------------|------|-------------|------|
| L2          | 0.477| L7          | 0.346|
| L10         | 0.465| L4          | 0.345|
| L8          | 0.444| L5          | 0.334|
| L1          | 0.402| L6          | 0.228|
| L3          | 0.398|-            | -    |
| L9          | 0.388| Average     | 0.383|

From Tables 3 and 4, we found that only V4, V5, V6, and V7 in the small-scale sample plots exceeded the existing mean (0.31), whereas only L6 in the large-scale sample plots was slightly lower than the existing mean.

4.3.3. Optimization Suggestions

For optimizing the of Ziyang Park’s Recreational Space Layout for the elderly the sample plots with an elderly suitability of the visual landscape higher than the existing mean should be selected. However, based on the analysis results presented in the previous section, adding or adjusting large-scale recreational spaces may more easily improve the elderly suitability of the visual landscape of Ziyang Park’s recreation spaces. Therefore, combined with the classification rendering in ArcMap (Figure 7), we suggest the following:

(1) First, priority should be given to the addition of large-scale recreational spaces at L1, L2, L3, L4, L5, L7, L8, L9, and L10, with a preferred order as follows: L2 > L10 > L8 > L1 > L3 > L9 > L7 > L4 > L5. In addition, according to the comparison of adjacent spaces, we also suggest that the existing “Miaowan teahouse” recreational space should be adjusted to the L3 location.

(2) Second, while adding large-scale recreational spaces, we should also consider adding small-scale recreational spaces at V4, V5, V6, V7, with a preferred order as follows: V4 > V5 > V7 > V6.

Figure 7. Elderly suitability classification of the visual landscape of the sample plots.
5. Discussion and Conclusions

Elderly evaluations on the suitability of park spaces largely depends on visual perception. However, research to date has not discussed how to evaluate and optimize the suitability of parks for the elderly from the perspective of vision or visual landscapes. Based on the influence of the park recreational space layout on the visual landscape for the elderly and their associated needs for visual landscape suitability, this paper constructed an evaluation index system for the elderly suitability of the visual landscape of park recreational spaces. Further, a method was proposed to achieve the appropriate layout of such spaces based on the evaluation and analysis of the visual landscape from the elderly perspective. The main conclusions are as follows:

1. The elderly suitability of the visual landscape of the recreational spaces in the case park was not only low overall, but also gradually decreased from the interior to the exterior of the park.

2. The above spatial distribution of the elderly suitability of the visual landscape in the case recreational spaces may be caused by the location zoning type, surface elevation, road slope, and the characteristics of each recreational space.

3. The introduction of GIS can transform the original abstract evaluation of elderly suitability of the visual landscape into quantitative data and visual graphics. This is helpful for guiding the development of park features for the elderly in an intuitive and concise manner, and it could promote the sustainable development of urban societies. Moreover, the combined application of the Python Scripting technology also significantly improved the efficiency and accuracy of our evaluation and optimization.

This study proves that the elderly suitability evaluation and analysis of the visual landscape of park recreational spaces can really provide a positive enlightenment for the aging construction of urban parks. However, in practical applications, the influence of other non-spatial factors on the visual landscape should also be considered, such as the specific form of a recreational space and the time node of the elderly’s activities. Located in the western part of the case park, the cultural corridor is the most commonly used and favorite recreational space of the elderly; its specific form is a strip from the east to the west. Our results indicate that the elderly suitability of the visual landscape of this space is highest. However, in spring and summer, owing to the lush flowers and trees along the lakeside, the number of landscapes, field of vision, and water area that the elderly can enjoy in this space is significantly less than the theoretical value. Therefore, in the specific optimization practice, considering such non-spatial factors should be combined with field investigations, with appropriate adjustments or supplements to the theoretical optimization scheme.

The results of this study can also be applied adapt other spaces in the park, such as park fitness spaces, for the aging population. However, in the process of visiting the park, elderly tourists generally expect to have a step-by-step visual experience of changing scenery. Therefore, the landscape repetition rate may be a key point that should be considered in future research. In planning and design, if the landscape repetition rate of adjacent recreational spaces can be effectively reduced, we can more likely create an increasingly suitable recreational space for the elderly. Although Li et al. [26] have considered the landscape repetition rate problem in terms of the viewshed analysis of parks, whether we can use their research to achieve a solution still remains a future challenge.

At present, as there is a lack of research on the elderly suitability of visual landscapes, there is no comparable basis or reasonable range for the elderly suitability of visual landscapes in relevant spaces. Compared with previous studies (especially those supported by GIS) [5,9,16,20,23,40], despite their identical intuitive guiding significance for planning and transformation, this study has two innovations. First, the concept of elderly suitability of the visual landscape and its evaluation index system were proposed. This provides a new research perspective to evaluate and optimize the elderly suitability of parks. Second, Python Scripting for ArcGIS was used to evaluate the elderly suitability and analyze the visual landscape efficiently, which provides a reference method for related research. How-
ever, this study still has limitations. As the selected park is a small-scale community park, the relevant geographic elevation could only be measured manually; therefore, certain deviations in the data inevitably occurred. In addition to the limited visual distance, other visual features of the elderly should be considered in future studies.

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**Appendix A**

The following key codes were customized by Python Scripting for ArcGIS, in which the sentences beginning with # are the comments on the codes.

**Appendix A.1. Calculate the Line Network of Sight from Each Recreation Point to Each Landscape Point, so as to Obtain the Visible Landscape Number and the Landscape Viewability for the Elderly in Each Recreation Space**

```python
import arcpy

arcpy.env.workspace = 'F:/ZY20/1004'  # Set environments

arcpy.ddd.ConstructSightLines("zqd_16", "jgd_12", "z16_j12_sls.shp", "Obs_Z", "Tar_Z", "<None>", 1, "OUTPUT_THE_DIRECTION") # zqd_16 and jgd_12 are the shplayer of recreation points and landscape points, respectively, and z16_j12_sls is the line network of sight.

arcpy.ddd.Intervisibility("z16_j12_sls", "zybetin10", "Visibility")
```

**Appendix A.2. Separate zqd_16.shp into Several Independent Shplayers, and then Calculate the Total Viewshed Area for the Elderly in Each Recreation Space by the Viewshed Function of ArcPy, so as to Calculate the Total View Ratio for the Elderly in Each Recreation Space**

```python
import arcpy,math,sys,os

from arcpy import env
from arcpy.sa import *

in_feature = "F:/ZY20/Oct/AvShed/zqd_16.shp"

split_field = "Name"

field_data_list = []

with arcpy.da.SearchCursor(in_feature,split_field) as cursor:
  for row in cursor:
    if row[0] not in field_data_list:
      field_data_list.append(row[0])
```
Appendix A.3. Calculate the Water Viewshed Area for the Elderly in Each Recreation Space by the ExtractByMask Function of ArcPy, so as to Calculate the Water View Ratio for the Elderly in Each Recreation Space

import arcpy
from arcpy import env
from arcpy.sa import *
in_feature = “F:/ZY20/Oct/AWvShed/zqd_16.shp “
split_field = “Name”
WvShName_list = []
with arcpy.da.SearchCursor(in_feature,split_field) as cursor:
    for row in cursor:
        if row[0] not in WvShName_list:
            WvShName_list.append(row[0])
env.workspace = “F:/ZY20/Oct/AWvShed/WvShed.gdb”
for select_data in WvShName_list:
    outExtractByMask = ExtractByMask(“V”+select_data, “HmDgm”) # “Hmdgm” is the park lake surface.
    outExtractByMask.save(“F:/ZY20/Oct/AWvShed/WvShed.gdb/Wv”+select_data) # “Wv”+select_data is the water viewshed area of a recreation point.

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