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# A Comprehensive Evaluation of the Community Environment Adaptability for Elderly People Based on the Improved TOPSIS

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Received: 13 November 2019; Accepted: 4 December 2019; Published: 9 December 2019

**Abstract:** As the main way of providing care for elderly people, home-based old-age care puts forward higher requirements for the environmental adaptability of the community. Five communities in Wuhu were selected for a comprehensive assessment of environmental suitability. In order to ensure a comprehensive and accurate assessment of the environmental adaptability of the community, we used the analytic hierarchy process (AHP) to calculate the weight of each indicator and the technique for order preference by similarity to ideal solution (TOPSIS) method to evaluate the adaptability of community, as well as further analyses using a two-dimensional data space map. The results show that the Weixing community is the most suitable for the elderly and outdoor activities of the community.

**Keywords:** community-based elder care; comprehensive evaluation; elderly oriented; TOPSIS analysis method

## 1. Introduction

The aging population has become a serious challenge to global social development. China is the only country in the world with an elderly population approaching 250 million, and old-age support has become a major responsibility for Chinese families and society [1]. With the implementation of the 13th Five-Year Plan for Construction of Social Pension Service System, the old-aged service system that is based on home-based old-age care and that has relied on the community and is supported by institutions has initially taken shape [2]. This new pension model combines home-based care and community service organically so that elderly people can not only receive proper life and spiritual care, but also continue to live in a familiar community environment [3]. Against this background, the quality of the living environment has become an important pursuit of elderly groups to improve the quality of life in their later years, especially elderly people who have the ability to move and who prefer to participate in outdoor activities that can meet their physiological and behavioral characteristics, which puts forward higher requirements for the construction of a community environment that suits elderly people. Thus, research on the assessment of suiting the community environment to elderly people has an important reference value for urban residential environment planning, the regional development model and the development direction of urban real estate, and caters to the will of many elderly people to provide for the aged at home, which has positive social significance [4].

In the 1950s, Doxiadis first proposed the concept of "human settlements science". Since then, scholars have focused on the study of urban livability and the suitability of the community environment for elderly people. Current studies mainly focus on the influencing factors and evaluation methods of a suitable community environment for elderly people to analyze the degree of the suitability of the community environment for elderly people. Rostron put forward the corresponding design principles for the external environment of elderly people's residential areas from the aspects of a site layout and detailed design based on the perspective of the behavioral psychology of elderly people [5]. Salzano explored the concept of livability from the perspective of sustainable development and considered the livable environment of elderly people from the perspective of the sustainable development of urban construction; he believed that factors such as the interpersonal relationships of elderly people, construction of community environmental facilities and location selection would affect the living environment of elderly people [6]. Douglass advanced the basic conditions for the harmonious development of livable cities from the perspective of a correlation among humans, the environment and society [7]. Through studying a comprehensive environmental assessment of elderly communities, the British Economist Intelligence Unit has created an index system for evaluating urban livability that included three groups of indicators, namely, health and safety, culture and the environment, and infrastructure [8]. Harvey proposed to use a geographic information system, an Internet survey and social media to investigate the physical characteristics on the spatial scale of the block and residents' satisfaction to effectively measure the livability of urban communities [9]. In the 1990s, Wu began to conduct relevant research on urban human settlements, established a scientific and theoretical framework for the environment of human settlements, and advanced the principle of people-oriented environmental construction [10]. Based on a survey of the living environment of elderly people in Beijing, Qu compiled a localized gauge that is divided into four dimensions, including a housing environment assessment, community environment assessment, service environment assessment and interpersonal environment assessment for evaluating the living environment of elderly people in cities. It is clear that the key task of constructing a livable community for elderly people in Beijing is to improve the construction of accessible community access, sports venues and other related environmental facilities [11]. He and Wei analyzed the status of building community environment renovation for senior people and raised environment renovation strategies and service facilities configuration [12]. Li proposed construction strategies of endowment facilities during community restructuring [13]. Many factors affect the suitability of the community environment for elderly people, but it is not advisable to integrate them all into an evaluation index system. Therefore, constructing a community environment evaluation index system suitable for elderly people should be based on the specific situation.

Apart from studies on the factors that affected the suitability of the community environment for elderly people, scholars have also paid attention to the evaluation methods on the suitability of the community environment for elderly people. Wu and Tang identified four evaluative objectives, road site adaptability, facility universality, space diversification and environment gracefulness, from the perspective of a rehabilitation landscape and 15 evaluative factors. They also established an evaluation index system for the restoration of the external environment of elderly apartments by using the analytic hierarchy process (AHP) [14]. Lu et al. used principal component analysis to study the quality and spatial pattern of the residential ecological environment in the central city of Hangzhou and obtained the measures that needed to be adopted to protect and repair the fragile zone of the residential ecological environment [4]. Sang et al. established an evaluation index by using qualitative–quantitative methods to test the effectiveness of the suitability of an elderly urban construction index system [15]. Yu and Hu constructed an index system and a calculation model to scientifically evaluate urban leisure Greenland adaptability for elderly people [16]. Gupta sorts green human resource management using the best-worst method (BWM) [17]. Rezaei compared with other multi-criteria decision-making (MCDM) methods and proposed that the BWM method needs less data and pairwise combination, and its result is more reliable [18]. Panmucar et al. employed the full consistency method (FUCOM) in ranking of traffic demand management measures [19]. Eghbali-Zarch et al. used the step-wise weight assessment ratio analysis (SWARA) method to compare and rank the effects of anti-diabetic medication objects, and the validity of the model in determining weights was verified [20]. Mardani et al. categorized the literature and did systematic research on the classification of the MCDM methods, including the new SWARA method [21].

Until now, studies on the evaluation method of the suitability of elderly people's community environment are in the early stage, and the current evaluation methods mainly use quantitative analysis to analyze the degree of suitability of the community environment for elderly people. Although there is abundant literature and experience in the area of community environment research at home and abroad, few studies have been conducted on evaluating the environment of outdoor activities for elderly people. Although the Qingdao, Huzhou, Shanghai and Changning districts (among other places) have introduced an evaluating index system of old-age friendly cities, there are few evaluation tools for an elderly livable community, and the importance of a subjective evaluation of elderly people is seriously insufficient [11]. In the selection of indicators, most of the classification indicators are based on the suitability of environmental human settlements, without considering the actual needs of elderly people from the particularity of their physiological and behavioral characteristics. When using mathematical models for evaluation, only some dimensions are often considered, and the comprehensiveness of the factors is not taken into account.

To fill this important research gap, in this paper, according to the four dimensions comprising site environment, road environment, ecological environment and green environment, a comprehensive evaluation index system including 39 indicators are constructed. Furthermore, using the method of AHP to calculate the weight of each indicator and the improved technique for order preference by similarity to ideal solution (TOPSIS) to evaluate the community environment, would clarify the community environment which is suitable for the old people to live in and move. The hybrid model of AHP–TOPSIS realizes the comprehensive evaluation of qualitative and quantitative indexes and avoids the defects of the single model. Our main contributions are the following: First, considering the factors of the community environment suitable for the aged, a relatively comprehensive evaluation index system is established; second, using the improved TOPSIS method to evaluate the results, the reliability and accuracy of the results are increased; and third, the reference opinions are given to the government and relevant departments in renovating the community environment and considering the living environment of the elderly.

The rest of the paper is organized as follows. In Section 2, the comprehensive process evaluation index system of the suitability of an elderly community environment is established from multiple dimensions, which measures the level of community environment aging. In Section 3, this index system calculates the weight of the indicators by using AHP and on this basis improves the TOPSIS method through a two-dimensional data space map to make the evaluation process more scientific and appropriate. In Section 4, the validity and effectiveness of the method are verified by taking five communities in Wuhu City as evaluation objects. Conclusions and further studies are drawn in Section 5.

## 2. Comprehensive Evaluation Index System of the Suitability of the Community Environment for Elderly People

The premise of the evaluation is to establish an evaluation index system suitable for the community environment of elderly people [22]. Based on the principle of combining quantitative and qualitative indicators, according to the basic concepts of gerontology [23] and the requirements of the Code for the Design of Residential Architecture for the Elderly (GB50340-2016) [24] issued by the Ministry of Housing and Construction in 2016, and referring to the evaluation studies of other livable cities [25,26], this paper studies the suitability of the community environment for elderly people according to the site environment, road environment, greening environment and health. Based on the above four dimensions, an evaluation index system of the suitability of the community environment for elderly people is constructed to realize the standardization of the evaluation process. Considering the differences in the psychological and behavioral characteristics of elderly people at different ages, the evaluation is conducted on the premise of meeting a diversity of outdoor activities for elderly people in the field environment by focusing on factors such as space, safety and facilities. Safety, convenience and a barrier-free road environment within the community are important conditions to maintain outdoor activities for elderly people. Therefore, in terms of road environment, based on the premise of road safety, convenience and barrier-free traffic behavior, the evaluation is performed with factors such as road space, road safety, road signs, etc. Moreover, a good greening environment not only can purify the air and regulate the regional microclimate but also can bring good sensory pleasure to elderly people. At the same time, a good greening environment also has a certain role in health care. Therefore, in terms of a greening environment, the evaluation mainly focuses on factors such as green planting, plant diversity and greening facilities. The quality of the ecological environment is an important prerequisite to ensure the normal activities of the elderly community. In this respect, factors such as the sound environment, water environment and air environment in the community are evaluated in accordance with the relevant standards and norms promulgated by the state.

This paper constructs four evaluative index systems of the suitability of the community environment for elderly people, which includes the four levels of the target level, criterion level, sub-criterion level and indicator level, by using AHP. And the following shows the algorithm flow of AHP (Figure 1).

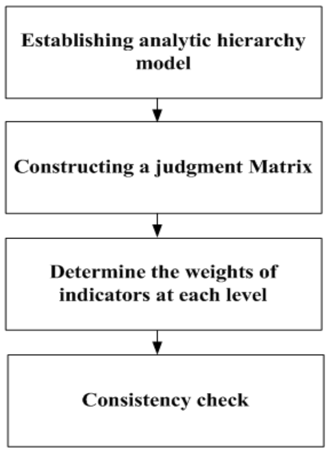


**Figure 1.** Flow chart of analytic hierarchy process.

We invited a panel of 15 experts from the environmental sciences to compare the relative importance of each indicator, find out the weight of each indicator, and meet the consistency test.

Table 1 shows the site environment indicator system of the suitability of a community environment for elderly people, and the next three tables (Tables 2–4) show the road environment indicator system, ecological environment indicator system and greening environment indicator system of the suitability of a community environment for elderly people. The connotation and symbols of each level are shown in the four evaluative index systems, respectively. And they use Ai, Bi, Ci, and Di (I = 1, 2, 3, . . . , m) to represent them. On this basis, a judgment matrix is constructed to determine the weights of the indicators at each level through single ranking, a consistency test and overall ranking [27,28]. Here, we use the AHP method to determine the weight of the indicators, which can reduce the influence of the experts' subjectivity to some extent, and solve the problem that there are too many factors and the situation is complicated to assign the weight [29].

The evaluation of each index is divided into five grades by using $e_k(K = 1, 2, 3, 4, 5)$ for expression (such as Tables 5–8); $e_1$ is the best, and $e_5$ is the worst. In addition, the levels of each grade are set as $e_1 = 1$, $e_2 = 0.75$, $e_3 = 0.5$, $e_4 = 0.25$ and $e_5 = 0$, which is shown in Tables 5–8.

**Table 1.** Site environment indicator system of the suitability of a community environment for elderly people.

| Criterion Layer B | The Sub-Target Layer C | Indicator Layer D | The Description of the Indicator |
| --- | --- | --- | --- |
| Site environment $B_1$ | Site space $C_1$ | Accessibility of site space $D_1$ | Walking distance and accessibility to the activity site |
| | | Satisfaction of the site layout to elderly activities $D_2$ | Could be based on the elderly dynamic, such as static, communication, sitting alone and other different activities to conduct a variety of site layouts |
| | | Share of site area $D_3$ | Proportion between the site area and total community area |
| | Site safety $C_2$ | Flatness of ground pavement $D_4$ | The allowable deviation within 1 $m^2$ does not exceed 2 mm |
| | | Skid resistance of ground $D_5$ | Anti-skidding effect of different ground paving materials |
| | | Safety of height difference processing $D_6$ | Safety of ground height difference treatment at ground, site and road intersections in each zone of the site; rationality of the slope-setting form |
| | | Lamp lighting rate at night on the street $D_7$ | Proportion of normal running streetlamps to all streetlamps within the site |
| | Site activity facilities $C_3$ | Safety of mobile facilities $D_8$ | Effectively ensure the safety of elderly people when using activities and fitness facilities |
| | | Ease-of-use of mobile facilities $D_9$ | Configuration of easy-to-learn and easy-to-operate activity facilities for the behavioral and physiological characteristics of elderly people |
| | | Setting up rate of recreational facilities $D_{10}$ | Proportion between sports and health-care facilities and all facilities |

**Table 2.** Road environment indicator system of the suitability of a community environment for elderly people.

| Criterion Layer B | The Sub-Target Layer C | Indicator Layer D | The Description of the Indicator |
| --- | --- | --- | --- |
| Road environment $B_2$ | Road safety $C_4$ | Smoothness of walking road $D_{11}$ | The allowable deviation within 1 $m^2$ does not exceed 2 mm |
| | | Connectivity of barrier-free routes $D_{12}$ | Avoiding all types of natural or man-made obstacles in accessible routes that hinder elderly people's walking or wheelchair traffic |
| | | The safety of road intersections $D_{13}$ | Blind distance barrier at road intersection |
| | | Lamp lighting rate at night on the street $D_{14}$ | Proportion of normal running streetlamps to all streetlamps |
| | Road space $C_5$ | The suitability of the spatial scale $D_{15}$ | Areal roads, group roads, residential roads, barrier-free access to meet the requirements of the "urban residential area planning and design norms" |
| | | Effectiveness of man-vehicle distribution management measures $D_{16}$ | For the management of pedestrian–vehicle diversion, people flow and traffic flow should be completely separated, and each should go its own way without interference |
| | | The beauty of road landscape $D_{17}$ | The trees, shrubs, turf, flowers and other landscape elements on both sides of the road are well matched and can be well received by elderly people |
| | Road signs $C_6$ | Rationality of sign location $D_{18}$ | Sign board layout covers a wide range of locations and is easy to identify |
| | | The fitness of the visual range for logo plates $D_{19}$ | Logo plates highly meet the recognition needs of elderly people |
| | | Identification of layout information $D_{20}$ | Label size, color and layout of logo board to meet the needs of elderly identification |

**Table 3.** Ecological environment indicator system of the suitability of a community environment for elderly people.

| Criterion Layer B | The Sub-Target Layer C | Indicator Layer D | The Description of the Indicator |
|---|---|---|---|
| Ecological environment $B_3$ | Acoustic environment $C_7$ | Noise in the daytime $D_{21}$ | The interference degree of environmental noise in the daytime community on elderly activities was evaluated according to GB 3096-2008 and the Acoustic Environmental Quality Standard |
| | | Noise at night $D_{22}$ | The interference degree of environmental noise at night in the community for elderly activities was evaluated according to GB 3096-2008 and the Acoustic Environmental Quality Standard |
| | Water environment $C_8$ | The quality of landscape water $D_{23}$ | The landscape water quality of falling water, fountains and pools in the community |
| | | Safety degree of landscape river embankments $D_{24}$ | The considerations of safety design such as height, shape, and anti-slip and anti-fall material of riverbanks and embankments |
| | Air environment $C_9$ | Air quality $D_{25}$ | Evaluation of regional air quality based on "the Quality Standard of Environmental Air" (GB3095-2012) |
| | | Air negative ion concentration $D_{26}$ | Number of negative ions per unit volume of air |
| | | The comfort of air humidity $D_{27}$ | Standard value of relative air humidity: 40–60% in summer, 30−60% in winter |
| | | The comfort of air flow rates $D_{28}$ | Standard value of air flow rates: in summer ≤0.3 m/s, in winter ≤0.2 m/s |

**Table 4.** Greening environment indicator system of the suitability of a community environment for elderly people.

| Criterion Layer B | The Sub-Target Layer C | Indicator Layer D | The Description of the Indicator |
|---|---|---|---|
| Greening environment $B_4$ | Greening planting $C_{10}$ | Green coverage $D_{29}$ | Ratio of total greening coverage area to total area in community |
| | | The per capita green area $D_{30}$ | The per capita green area in the community |
| | | Green looking ratio $D_{31}$ | The proportion of green plants seen by human eyes that focuses on the three-dimensional composition of community greening |
| | | Rationality of multilayer planting $D_{32}$ | The proportion of trees to shrubs is 1:3–1:6, and the area of turf is not higher than 30% of the total area of green space |
| | | Excellence rate of plant growth $D_{33}$ | Assessment of plant growth quality from the perspective of greening maintenance and management |
| | | Accessibility of plant communities $D_{34}$ | A reasonable plant community layout can enable people to enter the plant community for close-range ornamentation |
| | Activity facilities of greenbelt $C_{11}$ | Degree of perfection of protective facilities $D_{35}$ | Refers to the configuration of shading and rainproof greening facilities |
| | | Intact rate of facility $D_{36}$ | Evaluate the quality of greening facilities from the perspective of management and maintenance |
| | Diversity of greening plants $C_{12}$ | Rehabilitative plant planting rate $D_{37}$ | Ratio of the number of plants planted and the total number of plants planted for the health and rehabilitation of elderly people, both physically and psychologically |
| | | Ornamentality $D_{38}$ | Plants have various species, richness levels and obvious ecological benefits |
| | | Regionality $D_{39}$ | The local plant cultivation that evokes emotional identity among elderly people |

**Table 5.** Site environment classification criteria of the suitability of a community environment for elderly people.

| Level Evaluation Index System | | | Level of Evaluation | | | | |
|---|---|---|---|---|---|---|---|
| | | | **$e_1$ : Level** 1 | **$e_2$ : Level** 2 | **$e_3$ : Level** 3 | **$e_4$ : Level** 4 | **$e_5$ : Level** 5 |
| Site environment $B_1$ | Site space $C_1$ | Accessibility of site space $D_1$ | Very easy | Comparatively easy | Easy | Generally easy | Difficult |
| | | Satisfaction of the site layout to elderly activities $D_2$ | Completely satisfied | Comparatively satisfied | Satisfied | Generally satisfied | Unsatisfied |
| | | Share of site area $D_3$ | ≥30% | 29–25% | 24–20% | 19–15% | <15% |
| | Site safety $C_2$ | Flatness of ground pavement $D_4$ | <1 mm | 1–3 mm | 4–6mm | 7–10 mm | >10 mm |
| | | Skid resistance of ground $D_5$ | Completely anti-skid | Anti-skid | Generally anti-skid | Non-skid | Very non-skid |
| | | Safety of height difference processing $D_6$ | Completely safe | Comparatively safe | Safe | Generally safe | Dangerous |
| | | Lamp lighting rate at night on the street $D_7$ | 100% | 100–95% | 94–90% | 89–85% | <85% |
| | Site activity facilities $C_3$ | Safety of mobile facilities $D_8$ | Completely safe | Comparatively safe | Safe | Generally safe | Dangerous |
| | | Ease-of-use of mobile facilities $D_9$ | Very easy to use | Comparatively easy to use | Easy to use | Generally easy to use | Not easy to use |
| | | Setting up the rate of recreational facilities $D_{10}$ | >50% | 49–40% | 39–30% | 29–20% | <20% |

**Table 6.** Road environment classification criteria of the suitability of a community environment for elderly people.

| Level Evaluation Index System | | | Level of Evaluation | | | | |
|---|---|---|---|---|---|---|---|
| | | | **$e_1$: Level** 1 | **$e_2$ : level** 2 | **$e_3$: Level** 3 | **$e_4$ : level** 4 | **$e_5$: Level** 5 |
| Road environment $B_2$ | Road safety $C_4$ | Smoothness of walking road $D_{11}$ | <1 mm | 1–3 mm | 4–6 mm | 7–10 mm | >10 mm |
| | | Connectivity of barrier-free routes $D_{12}$ | Completely connected | Connected | Generally connected | Not very connected | Disconnected |
| | | The safety of road intersections $D_{13}$ | Completely safe | Comparatively safe | Safe | Generally safe | Dangerous |
| | | Lamp lighting rate at night on the street $D_{14}$ | 100% | 100–95% | 94–90% | 89–85% | <85% |
| | Road space $C_5$ | The suitability of the spatial scale $D_{15}$ | Completely suitable | Comparatively suitable | Suitable | Generally suitable | Not suitable |
| | | Effectiveness of man-vehicle distribution management measures $D_{16}$ | Completely effective | Comparatively effective | Effective | Generally effective | Ineffective |
| | | The beauty of road landscape $D_{17}$ | Completely beautiful | Comparatively beautiful | Beautiful | Generally beautiful | Ugly |
| | Road signs $C_6$ | Rationality of sign location $D_{18}$ | Completely reasonable | Comparatively reasonable | Reasonable | Not very reasonable | Unreasonable |
| | | The fitness of the visual range for logo plate $D_{19}$ | Completely suitable | Comparatively suitable | Suitable | Not very suitable | Not suitable |
| | | Identification of layout information $D_{20}$ | Completely identifiable | Identifiable | Generally identifiable | Not very identifiable | Unidentifiable |

**Table 7.** Ecological environment classification criteria of the suitability of a community environment for elderly people.

| Level Evaluation Index System | | | Level of Evaluation | | | | |
|---|---|---|---|---|---|---|---|
| | | | $e_1$ **: Level** 1 | $e_2$ **: Level** 2 | $e_3$ **: Level** 3 | $e_4$ **: Level** 4 | $e_5$ **: Level** 5 |
| Ecological environment $B_3$ | Acoustic environment $C_7$ | Noise in the daytime $D_{21}$ | <35 dB | 36 dB–50 dB | 51 dB–60 dB | 61 dB–70 dB | >70 dB |
| | | Noise at night $D_{22}$ | <25 dB | 26 dB–40 dB | 41 dB–50 dB | 51 dB–60 dB | >60 dB |
| | Water environment $C_8$ | The quality of landscape water $D_{23}$ | Very good | Good | Generally good | Bad | Very bad |
| | | Safety degree of landscape river embankments $D_{24}$ | Completely safe | Comparatively safe | Safe | Generally safe | Dangerous |
| | Air environment $C_9$ | Air quality $D_{25}$ | One-level | Two-level | Three-level | Four-level | Five-level |
| | | Air negative ion concentration $D_{26}$ | ≥1500 | 1500–1000 | 999–650 | 649–500 | <500 |
| | | The comfort of air humidity $D_{27}$ | Completely comfortable | Comfortable | Generally comfortable | Uncomfortable | Very uncomfortable |
| | | The comfort of air flow rates $D_{28}$ | Completely comfortable | Comfortable | Generally comfortable | Uncomfortable | Very uncomfortable |

**Table 8.** Greening environment classification criteria of the suitability of a community environment for elderly people.

| Level Evaluation Index System | | | Level of Evaluation | | | | |
|---|---|---|---|---|---|---|---|
| | | | $e_1$ **: Level** 1 | $e_2$ **: Level** 2 | $e_3$ **: Level** 3 | $e_4$ **: Level** 4 | $e_5$ **: Level** 5 |
| Greening environment $B_4$ | Greening planting $C_{10}$ | Green coverage $D_{29}$ | ≥35% | 34–30% | 29–25% | 24–20% | <20% |
| | | The per capita green area $D_{30}$ | >15 $m^2$ | 15–12 $m^2$ | 11–7 $m^2$ | 6–5 $m^2$ | <5 $m^2$ |
| | | Green looking ratio $D_{31}$ | ≥25% | 24–20% | 19–15% | 14–10% | <10% |
| | | Rationality of multilayer planting $D_{32}$ | Completely reasonable | Reasonable | Generally reasonable | Unreasonable | Very unreasonable |
| | | Excellence rate of plant growth $D_{33}$ | >95% | 94–92% | 91–89% | 88–85% | <85% |
| | | Accessibility of plant communities $D_{34}$ | ≥25% | 24–20% | 19–15% | 14–10% | <10% |
| | Activity facilities of greenbelt $C_{11}$ | Degree of perfection of asylum facilities $D_{35}$ | Very complete | Comparatively complete | Complete | Not very complete | Incomplete |
| | | Intact rate of facility $D_{36}$ | 100% | 100–95% | 94–90% | 89–85% | >85% |
| | Diversity of greening plants $C_{12}$ | Rehabilitative plant planting rate $D_{37}$ | ≥30% | 29–20% | 19–15% | 14–10% | <10% |
| | | Ornamentality$D_{38}$ | Completely beautiful | Comparatively beautiful | Beautiful | Generally beautiful | Ugly |
| | | Regionality $D_{39}$ | ≥35% | 34–25% | 24–15% | 14–10% | <10% |

## 3. The Improved TOPSIS Method

TOPSIS is a sequential optimization method for the similarity of ideal objectives. It is very effective in multi-objective decision-making analysis [30–33]. By normalizing the original data matrix after trends, the corresponding data matrix that is normalized is established, and the best and worst schemes are identified from many schemes. Then, the distance between all index values of each evaluation object and the positive and negative ideal solutions are calculated separately; thus, we can obtain the closeness between the evaluation object and the ideal solution, and the ranking is the basis for evaluating the quality of the object. Because the TOPSIS method uses the relative approximation between ideal solutions to arrange the priority order among different schemes, the TOPSIS method is improved by referencing the literature to avoid contradictions. A two-dimensional data space method is established by changing the closeness degree between the final objective and the ideal solution into all the index values of the known evaluative objects and the distance between the positive ideal solution and the negative ideal solution to relieve the contradiction and decrease order problems. The flow chart of the improved TOPSIS algorithm is as follows (Figure 2):

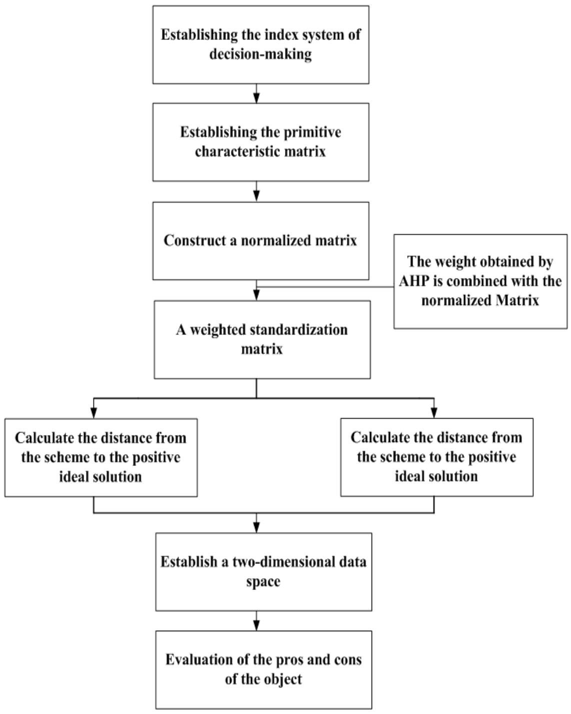


**Figure 2.** Flow chart of improved technique for order preference by similarity to ideal solution.

First, M evaluation objectives are usually established to solve multi-objective optimization problems $H_1, H_2, \ldots, H_m$, $i = 1, 2, 3, \ldots, m$, and each object is accompanied by an N evaluation indicator $X_1, X_2, \ldots, X_n$, $j = 1, 2, 3, \ldots, n$. Second, relevant experts are invited to grade the evaluative indicators (including quantitative and qualitative indicators), and the results are then presented in the form of a mathematical matrix, which establishes the following characteristic matrices:

$$H = \begin{bmatrix} h_{11}\ldots & h_{1j}\ldots & h_{1n} \\ \vdots & \vdots & \vdots \\ h_{i1}\;\ldots & h_{ij}\ldots & h_{in} \\ \vdots & \vdots & \vdots \\ h_{m1}\ldots & h_{mj}\ldots & h_{mn} \end{bmatrix} = \begin{bmatrix} H_1(h_{1.}) \\ \vdots \\ H_i\left(h_{j.}\right) \\ \vdots \\ H_m(h_{m.}) \end{bmatrix} = \left[X_1(h_{.1}), \ldots, X_j(h_{.i}), \ldots, X_n(h_{.n})\right]. \quad (1)$$

After establishing the primitive characteristic matrix, follow the below steps for analysis.

Step 1: Construct a normalized matrix.

By using Equation (2), the original matrix is normalized to obtain the corresponding matrix:

$$R = \left[r_{ij}\right]_{m\times n}, (i = 1,\ 2,\ 3, \ldots, m; j = 1,\ 2,\ 3, \ldots, n)$$

$$r_{ij} = \frac{h_{ij}}{\sqrt{\sum_{i=1}^{m} h_{ij}^2}}, \tag{2}$$

where $r_{ij}$ means the value of the i evaluative object on the j index.

Step 2: The weights obtained by the AHP method are combined with the normalized matrix and establish the weighted decision matrix $A = (A_1, A_2, \ldots, A_n), j = 1, 2, 3, \ldots, n$. Multiply the weight vector A = $(A_1, A_2, \ldots, A_n)$ obtain a weighted standardization matrix as follows:

$$R = \begin{bmatrix} A_1h_{11}\ldots & A_jh_{1j}\ldots & A_mh_{1n} \\ & \vdots & \vdots \\ A_1h_{11}\ldots & A_jh_{ij}\ldots & A_m\ h_{in} \\ & \vdots & \vdots \\ A_1h_{m1}\ldots & A_jh_{mj}\ldots & A_mh_{mn} \end{bmatrix} = \begin{bmatrix} r_{11}\ldots & r_{1j}\ldots & r_{1n} \\ & \vdots & \vdots \\ r_{11}\ldots & r_{ij}\ldots & r_{in} \\ & \vdots & \vdots \\ r_{m1}\ldots & r_{mj}\ldots & r_{mn} \end{bmatrix}. \tag{3}$$

Additionally, it is noted that the positive ideal solution $R^+$ and the negative ideal solution $R^-$ of all indicators of each evaluative object are

$$R^+ = \left(r_1^+, r_2^+, r_3^+, \ldots, r_n^+\right), r_j^+ = \left\{\max_{1\le i\le m} r_{ij}\right\}, \tag{4}$$

$$R^- = \left(r_1^-, r_2^-, r_3^-, \ldots, r_n^-\right), r_{ij}^- = \left\{\min_{1\le i\le m} r_{ij}\right\}, \tag{5}$$

where $j = 1,\ 2,\ 3, \ldots, n$.

Step 3: Calculate the distance scale.

The distance scale is the distance between the best solution and the worst solution of each scheme. It can be calculated by the n-dimensional Euclidean distance. Among them, the distance from the scheme to the positive ideal solution $R^+$ is $S^+$, and the distance to the negative ideal solution $R^-$ is $S^+$:

$$S_i^+ = \sqrt{\sum_{j=1}^{n}\left(r_{ij}^+ - r_{ij}\right)^2}, \tag{6}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n}\left(r_{ij}^- - r_{ij}\right)^2}. \tag{7}$$

Moreover, $i = 1,\ 2,\ 3, \ldots, m$, and $S_i^+$ is the approaching degree of each evaluation target to the optimal target. When the $S_i^+$ value is smaller, the evaluative target is closer to the optimal target, and the scheme is better.

Step 4: Establish a two-dimensional data space.

The two-dimensional data space of each evaluation objective ($S_i^+$, $S_i^-$) is established, and the point (Min ($S_i^+$), Max ($S_i^-$)) is set as the optimum reference point A (Figure 3). Calculate the relative distance between each evaluative object and this point:

$$C_i = \sqrt{\left[S_i^+ - \min\left(S_i^+\right)\right]^2 + \left[S_i^- - \max\left(S_i^-\right)\right]^2}. \quad (8)$$

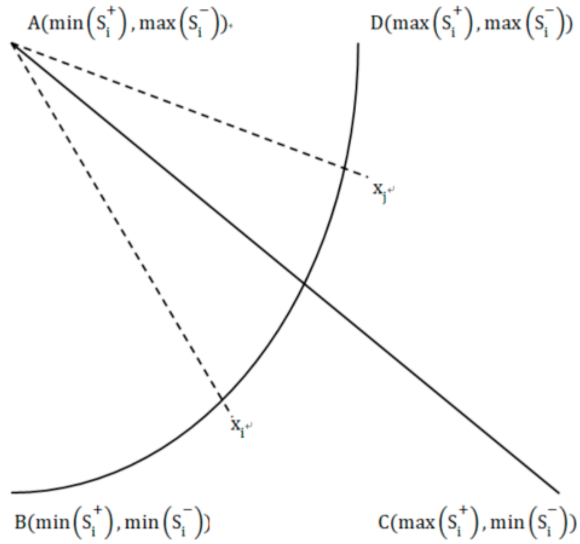


**Figure 3.** Schematic diagram of the improved technique for order preference by similarity to ideal solution (TOPSIS) method.

Step 5: According to the size of the $C_i$ value, when the $C_i$ value is smaller, the evaluative object is better; that is, the nearest point to the reference point A is the best. When the distance between the evaluation object and the reference point is equal, their coordinates can be directly compared on the two-dimensional plane of ($S_i^+$, $S_i^-$), and the degree of the evaluative object can be judged according to the best principle that the evaluation object is near min ($S_i^+$) or max ($S_i^-$).

## 4. Numerical Study

We chose five communities in Wuhu city, namely, Weixing Community, Dongfang Longcheng Community, Jinghu Century Community, Chery Bobo Community and Central Community as the objects of elderly community assessment suitability. We separately mark these $P_1$, $P_2$, $P_3$, $P_4$, and $P_5$. By using AHP to calculate the weight of each index, the result of the B-level single ranking weight is $(0.333, 0.183, 0.381, 0.103)^T$, C-level single ranking weight is $(0.151, 0.575, 0.274, 0.493, 0.137, 0.37, 0.529, 0.309, 0.162, 0.493, 0.137, 0.37)^T$, C-tier total ranking weight is $(0.038, 0.144, 0069, 0.123, 0.034, 0.093, 0.132, 0.077, 0.041, 0.123, 0.034, 0.093)^T$, D-level single ranking weight is $(0.493, 0.37, 0.137, 0.183, 0.381, 0.333, 0.103, 0.309, 0.529, 0.162, 0.265, 0.239, 0.372, 0.124, 0.316, 0.421, 0.263, 0.529, 0.309, 0.162, 0.75, 0.25, 0.333, 0.667, 0.212, 0.189, 0.518, 0.081, 0.152, 0.371, 0.066, 0.173, 0.142, 0.156, 0.667, 0.333, 0.137, 0.493, 0.370)^T$, and D-tier total ranking weight is $(0.01, 0.031, 0.011, 0.015, 0.032, 0.028, 0.009, 0.026, 0.044, 0.014, 0.022, 0.020, 0.031, 0.010, 0.026, 0.035, 0.022, 0.044, 0.026, 0.014, 0.063, 0.021, 0.0258, 0.056, 0.018, 0.016, 0.043, 0.007, 0.013, 0.026, 0.006, 0.014, 0.012, 0.013, 0.056, 0.028, 0.011, 0.041, 0.031)^T$.

Based on the calculation of the weights of each indicator, the evaluation should be performed according to the following steps.

Step 1: According to the actual situation, each indicator is attributed with the relevant value, as shown in Table 9.

**Table 9.** The indicator value of the grade evaluation in each residential environment.

| Indicator | $P_1$ | $P_2$ | $P_3$ | $P_4$ | $P_5$ |
|---|---|---|---|---|---|
| $D_1$ | Very easy | Comparatively easy | Easy | Generally easy | Easy |
| $D_2$ | Comparatively satisfied | Comparatively satisfied | Comparatively satisfied | Generally satisfied | Generally satisfied |
| $D_3$ | 31% | 24% | 21% | 23% | 26% |
| $D_4$ | 4 mm | 4 mm | 2 mm | 5 mm | 1 mm |
| $D_5$ | Completely anti-skid | Generally anti-skid | Anti-skid | Anti-skid | Anti-skid |
| $D_6$ | Very safe | Comparatively safe | Comparatively safe | Safe | Safe |
| $D_7$ | 100% | 94% | 92% | 92% | 93% |
| $D_8$ | Comparatively safe | Generally safe | Safe | Safe | Generally safe |
| $D_9$ | Very easy to use | Not easy to use | Not easy to use | Very easy to use | Very easy to use |
| $D_{10}$ | 51% | 22% | 24% | 53% | 53% |
| $D_{11}$ | 0.8 mm | 7 mm | 5 mm | 7 mm | 8 mm |
| $D_{12}$ | Completely connected | Connected | Connected | Completely connected | Generally connected |
| $D_{13}$ | Generally safe | Generally safe | Safe | Generally safe | Generally safe |
| $D_{14}$ | 95% | 89% | 94% | 86% | 93% |
| $D_{15}$ | Comparatively suitable | Suitable | Generally suitable | Suitable | Suitable |
| $D_{16}$ | Completely effective | Effective | Effective | Comparatively effective | Comparatively effective |
| $D_{17}$ | Completely Beautiful | Comparatively beautiful | Beautiful | Generally beautiful | Beautiful |
| $D_{18}$ | Completely reasonable | Reasonable | Generally reasonable | Completely reasonable | Completely reasonable |
| $D_{19}$ | Comparatively suitable | Not suitable | Suitable | Suitable | Comparatively suitable |
| $D_{20}$ | Identifiable | Generally identifiable | Generally identifiable | Identifiable | Identifiable |
| $D_{21}$ | 33 | 32 | 71 | 63 | 71 |
| $D_{22}$ | 20 | 62 | 43 | 27 | 45 |
| $D_{23}$ | Very good | Good | Generally good | Good | Very bad |
| $D_{24}$ | Safe | Generally safe | Dangerous | Generally safe | Dangerous |

**Table 9.** *Cont.*

| Indicator | $P_1$ | $P_2$ | $P_3$ | $P_4$ | $P_5$ |
|---|---|---|---|---|---|
| $D_{25}$ | One-level | Three-level | Two-level | One-level | Two-level |
| $D_{26}$ | 970 | 490 | 985 | 488 | 487 |
| $D_{27}$ | Comfortable | Very uncomfortable | Uncomfortable | Uncomfortable | Uncomfortable |
| $D_{28}$ | Generally comfortable | Uncomfortable | Generally comfortable | Uncomfortable | Uncomfortable |
| $D_{29}$ | 37% | 22% | 27% | 36% | 28% |
| $D_{30}$ | 18 $m^2$ | 5 $m^2$ | 18 $m^2$ | 6 $m^2$ | 13 $m^2$ |
| $D_{31}$ | 24% | 19% | 17% | 18% | 11% |
| $D_{32}$ | Reasonable | Very unreasonable | Unreasonable | Very unreason-able | Unreasonable |
| $D_{33}$ | 96% | 91% | 90% | 98% | 91% |
| $D_{34}$ | 30% | 23% | 24% | 35% | 23% |
| $D_{35}$ | Very complete | Complete | Comparatively complete | Very complete | Comparatively complete |
| $D_{36}$ | 95% | 93% | 98% | 100% | 94% |
| $D_{37}$ | 35% | 38% | 19% | 18% | 32% |
| $D_{38}$ | Completely beautiful | Beautiful | Completely beautiful | Completely beautiful | Beautiful |
| $D_{39}$ | 31% | 28% | 23% | 34% | 23% |

Step 2: Refer to Tables 5–8, 39 indicators corresponding to different evaluation levels. We have set the scores from $e_1$ to $e_5$ above ($e_1$= 1, $e_2$= 0.75, $e_3$= 0.5, $e_4$= 0.25, and $e_5$= 0). The scoring of each criterion is processed for numeralization according to five levels as shown in Table 10.

**Table 10.** Numeralization of the score.

| Indicator | $P_1$ | $P_2$ | $P_3$ | $P_4$ | $P_5$ | Indicator | $P_1$ | $P_2$ | $P_3$ | $P_4$ | $P_5$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $D_1$ | 1 | 0.75 | 0.5 | 0.25 | 0.5 | $D_{21}$ | 0.75 | 0.75 | 0 | 0.25 | 0 |
| $D_2$ | 0.75 | 0.75 | 0.75 | 0.25 | 0.25 | $D_{22}$ | 1 | 0 | 0.5 | 0.75 | 0.5 |
| $D_3$ | 1 | 0.5 | 0.5 | 0.5 | 0.75 | $D_{23}$ | 1 | 0.75 | 0.5 | 0.75 | 1 |
| $D_4$ | 0.5 | 0.5 | 0.75 | 0.5 | 0.75 | $D_{24}$ | 0.75 | 0.5 | 0.25 | 0.5 | 0.25 |
| $D_5$ | 1 | 0.5 | 0.75 | 0.75 | 0.75 | $D_{25}$ | 0.75 | 0.75 | 0.5 | 0.5 | 0.75 |
| $D_6$ | 1 | 0.75 | 0.75 | 0.5 | 0.5 | $D_{26}$ | 1 | 0.5 | 0.75 | 0.5 | 0.75 |
| $D_7$ | 1 | 0.5 | 0.5 | 0.5 | 0.5 | $D_{27}$ | 0.75 | 0 | 0.25 | 0.25 | 0.25 |
| $D_8$ | 0.75 | 0.25 | 0.5 | 0.5 | 0.25 | $D_{28}$ | 0.5 | 0.25 | 0.5 | 0.25 | 0.25 |
| $D_9$ | 1 | 0.25 | 0.25 | 1 | 1 | $D_{29}$ | 1 | 0.25 | 0.5 | 1 | 0.5 |
| $D_{10}$ | 1 | 0.25 | 0.25 | 1 | 1 | $D_{30}$ | 1 | 0.25 | 0.5 | 0.25 | 0.5 |
| $D_{11}$ | 1 | 0.25 | 0.5 | 0.25 | 0.25 | $D_{31}$ | 0.75 | 0.5 | 0.5 | 0.5 | 0.25 |
| $D_{12}$ | 1 | 0.75 | 0.75 | 1 | 0.5 | $D_{32}$ | 0.75 | 0 | 0.25 | 0 | 0.25 |
| $D_{13}$ | 0.5 | 0.5 | 0.75 | 0.5 | 0.5 | $D_{33}$ | 1 | 0.5 | 0.5 | 1 | 0.5 |
| $D_{14}$ | 0.75 | 0.25 | 0.5 | 0.25 | 0.5 | $D_{34}$ | 1 | 0.75 | 0.75 | 1 | 0.75 |
| $D_{15}$ | 0.75 | 0.5 | 0.25 | 0.5 | 0.5 | $D_{35}$ | 1 | 0.5 | 0.25 | 1 | 0.25 |
| $D_{16}$ | 1 | 0.5 | 0.5 | 0.75 | 0.75 | $D_{36}$ | 0.75 | 0.5 | 0.75 | 1 | 0.5 |
| $D_{17}$ | 1 | 0.25 | 0.5 | 0.75 | 0.5 | $D_{37}$ | 1 | 1 | 0.5 | 0.5 | 1 |
| $D_{18}$ | 1 | 0.5 | 0.25 | 1 | 1 | $D_{38}$ | 1 | 0.5 | 1 | 1 | 0.5 |
| $D_{19}$ | 0.75 | 0.25 | 0.5 | 0.5 | 0.75 | $D_{39}$ | 0.75 | 0.75 | 0.5 | 0.75 | 0.5 |
| $D_{20}$ | 0.5 | 0.75 | 0.75 | 0.5 | 0.5 | | | | | | |

Step 3: The normalization matrix of the above indicators is established as shown in Table 11.

**Table 11.** Normalization processing and optimal-inferior comprehensive data table.

| Indicator | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ | Indicator | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $D_1$ | 0.686 | 0.514 | 0.343 | 0.171 | 0.343 | $D_{21}$ | 0.688 | 0.688 | 0 | 0.229 | 0 |
| $D_2$ | 0.557 | 0.557 | 0.557 | 0.186 | 0.186 | $D_{22}$ | 0.696 | 0 | 0.348 | 0.522 | 0.348 |
| $D_3$ | 0.658 | 0.329 | 0.329 | 0.329 | 0.493 | $D_{23}$ | 0.544 | 0.408 | 0.272 | 0.408 | 0.544 |
| $D_4$ | 0.365 | 0.365 | 0.548 | 0.365 | 0.548 | $D_{24}$ | 0.688 | 0.459 | 0.229 | 0.459 | 0.229 |
| $D_5$ | 0.583 | 0.292 | 0.438 | 0.438 | 0.438 | $D_{25}$ | 0.507 | 0.507 | 0.338 | 0.338 | 0.507 |
| $D_6$ | 0.617 | 0.463 | 0.463 | 0.309 | 0.309 | $D_{26}$ | 0.617 | 0.309 | 0.463 | 0.309 | 0.463 |
| $D_7$ | 0.707 | 0.354 | 0.354 | 0.354 | 0.354 | $D_{27}$ | 0.866 | 0 | 0.289 | 0.289 | 0.289 |
| $D_8$ | 0.688 | 0.229 | 0.459 | 0.459 | 0.229 | $D_{28}$ | 0.603 | 0.302 | 0.603 | 0.302 | 0.302 |
| $D_9$ | 0.566 | 0.141 | 0.141 | 0.566 | 0.566 | $D_{29}$ | 0.625 | 0.156 | 0.312 | 0.625 | 0.312 |
| $D_{10}$ | 0.566 | 0.141 | 0.141 | 0.566 | 0.566 | $D_{30}$ | 0.784 | 0.196 | 0.392 | 0.196 | 0.392 |
| $D_{11}$ | 0.834 | 0.209 | 0.417 | 0.209 | 0.209 | $D_{31}$ | 0.64 | 0.426 | 0.426 | 0.426 | 0.213 |
| $D_{12}$ | 0.544 | 0.408 | 0.408 | 0.544 | 0.272 | $D_{32}$ | 0.905 | 0 | 0.302 | 0 | 0.302 |
| $D_{13}$ | 0.4 | 0.4 | 0.6 | 0.4 | 0.4 | $D_{33}$ | 0.603 | 0.302 | 0.302 | 0.603 | 0.302 |
| $D_{14}$ | 0.688 | 0.229 | 0.459 | 0.229 | 0.459 | $D_{34}$ | 0.521 | 0.391 | 0.391 | 0.521 | 0.391 |
| $D_{15}$ | 0.64 | 0.426 | 0.213 | 0.426 | 0.426 | $D_{35}$ | 0.649 | 0.324 | 0.162 | 0.649 | 0.162 |
| $D_{16}$ | 0.617 | 0.309 | 0.309 | 0.463 | 0.463 | $D_{36}$ | 0.463 | 0.309 | 0.463 | 0.617 | 0.309 |
| $D_{17}$ | 0.686 | 0.171 | 0.343 | 0.514 | 0.343 | $D_{37}$ | 0.535 | 0.535 | 0.267 | 0.267 | 0.535 |
| $D_{18}$ | 0.549 | 0.275 | 0.137 | 0.549 | 0.549 | $D_{38}$ | 0.535 | 0.267 | 0.535 | 0.535 | 0.267 |
| $D_{19}$ | 0.577 | 0.192 | 0.385 | 0.385 | 0.577 | $D_{39}$ | 0.507 | 0.507 | 0.338 | 0.507 | 0.338 |
| $D_{20}$ | 0.365 | 0.548 | 0.548 | 0.365 | 0.365 | | | | | | |

Step 4: The weights of each indicator are combined with the normalized matrix, a weighted decision matrix is established (e.g., Table 12), and the optimum and worst values of all indicators of each evaluation object are identified.

**Table 12.** Weighted decision table and optimal-inferior comprehensive data table.

| Indicator | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ | Indicator | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $D_1$ | 0.028 | 0.021 | 0.014 | 0.007 | 0.014 | $D_{21}$ | 0.043 | 0.043 | 0.000 | 0.014 | 0.000 |
| $D_2$ | 0.017 | 0.017 | 0.017 | 0.006 | 0.006 | $D_{22}$ | 0.015 | 0.000 | 0.007 | 0.011 | 0.007 |
| $D_3$ | 0.007 | 0.004 | 0.004 | 0.004 | 0.005 | $D_{23}$ | 0.015 | 0.011 | 0.008 | 0.011 | 0.015 |
| $D_4$ | 0.005 | 0.005 | 0.008 | 0.005 | 0.008 | $D_{24}$ | 0.039 | 0.026 | 0.013 | 0.026 | 0.013 |
| $D_5$ | 0.019 | 0.009 | 0.014 | 0.014 | 0.014 | $D_{25}$ | 0.009 | 0.009 | 0.006 | 0.006 | 0.009 |
| $D_6$ | 0.017 | 0.013 | 0.013 | 0.009 | 0.009 | $D_{26}$ | 0.010 | 0.005 | 0.007 | 0.005 | 0.007 |
| $D_7$ | 0.006 | 0.003 | 0.003 | 0.003 | 0.003 | $D_{27}$ | 0.037 | 0.000 | 0.012 | 0.012 | 0.012 |
| $D_8$ | 0.018 | 0.006 | 0.012 | 0.012 | 0.006 | $D_{28}$ | 0.004 | 0.002 | 0.004 | 0.002 | 0.002 |
| $D_9$ | 0.025 | 0.006 | 0.006 | 0.025 | 0.025 | $D_{29}$ | 0.008 | 0.002 | 0.004 | 0.008 | 0.004 |
| $D_{10}$ | 0.008 | 0.002 | 0.002 | 0.008 | 0.008 | $D_{30}$ | 0.020 | 0.005 | 0.010 | 0.005 | 0.010 |
| $D_{11}$ | 0.018 | 0.005 | 0.009 | 0.005 | 0.005 | $D_{31}$ | 0.004 | 0.003 | 0.003 | 0.003 | 0.001 |
| $D_{12}$ | 0.011 | 0.008 | 0.008 | 0.011 | 0.005 | $D_{32}$ | 0.013 | 0.000 | 0.004 | 0.000 | 0.004 |
| $D_{13}$ | 0.012 | 0.012 | 0.019 | 0.012 | 0.012 | $D_{33}$ | 0.007 | 0.004 | 0.004 | 0.007 | 0.004 |
| $D_{14}$ | 0.007 | 0.002 | 0.005 | 0.002 | 0.005 | $D_{34}$ | 0.007 | 0.005 | 0.005 | 0.007 | 0.005 |
| $D_{15}$ | 0.017 | 0.011 | 0.006 | 0.011 | 0.011 | $D_{35}$ | 0.036 | 0.018 | 0.009 | 0.036 | 0.009 |
| $D_{16}$ | 0.022 | 0.011 | 0.011 | 0.016 | 0.016 | $D_{36}$ | 0.013 | 0.009 | 0.013 | 0.017 | 0.009 |
| $D_{17}$ | 0.015 | 0.004 | 0.008 | 0.011 | 0.008 | $D_{37}$ | 0.006 | 0.006 | 0.003 | 0.003 | 0.006 |
| $D_{18}$ | 0.024 | 0.012 | 0.006 | 0.024 | 0.024 | $D_{38}$ | 0.022 | 0.011 | 0.022 | 0.022 | 0.011 |
| $D_{19}$ | 0.015 | 0.005 | 0.010 | 0.010 | 0.015 | $D_{39}$ | 0.016 | 0.016 | 0.010 | 0.016 | 0.010 |
| $D_{20}$ | 0.005 | 0.008 | 0.008 | 0.005 | 0.005 | | | | | | |

That is, the best scheme is:

$$\begin{aligned} R^{+} = {} & (0.028, 0.017, 0.007, 0.008, 0.019, 0.017, 0.006, 0.018, 0.025, 0.008, 0.018, 0.011, 0.019, 0.007, \\ & 0.017, 0.022, 0.015, 0.024, 0.015, 0.008, 0.043, 0.015, 0.015, 0.039, 0.009, 0.010, 0.037, \\ & 0.004, 0.008, 0.020, 0.004, 0.013, 0.007, 0.007, 0.036, 0.017, 0.006, 0.022, 0.016)^{T}. \end{aligned}$$

The worst scheme is:

$$\begin{aligned} R^{-} = {} & (0.007, 0.006, 0.004, 0.005, 0.009, 0.009, 0.003, 0.006, 0.006, 0.002, 0.005, 0.005, 0.012, 0.002, \\ & 0.006, 0.011, 0.004, 0.006, 0.005, 0.005, 0.000, 0.000, 0.008, 0.013, 0.006, 0.005, 0.000, 0.002, \\ & 0.002, 0.005, 0.001, 0.000, 0.004, 0.005, 0.009, 0.009, 0.003, 0.011, 0.010)^{T}. \end{aligned}$$

Step 5: According to the best and worst value, the distance between each scheme and the best and worst solution is calculated. That is, the best solution is $S^{+}$ = (0.008, 0.065, 0.076, 0.056, 0.073)$^{T}$. The worst scheme is $S^{-}$ = (0.089, 0.051, 0.028, 0.051, 0.036) $^{T}$.

Step 6: According to Equation (8), the relative distance between each evaluation scheme and the point and ranked variables are calculated. Thus, according to the establishment of the two-dimensional data space map, and the relevant formula steps, the relative distance between the evaluation scheme and the point is calculated as $C_i$ = (0, 0.069, 0.091, 0.061, 0.084).

The five housing estates are ordered according to the TOPSIS evaluative value: $P_1 > P_4 > P_2 > P_5 > P_3$. From this, we can observe that Weixing Community ($P_1$) is the best livable community that is suitable for elderly living and outdoor activities. Whether it is the road environment, site environment or landscape greening, Weixing Community is more consistent with the behavioral characteristics and activity needs of elderly people. Compared with Weixing Community, Jinghu Century Community ($P_3$) and Central Community ($P_5$) perform poorly in the aspect of community environment that suits the elderly. Jinghu Century Community has viaducts, trains and a high noise pollution ratio around its area, which has a certain impact on the outdoor activities of elderly people, while Central Community is located south of Wuhu City, which is developed. Because of the high cost of real estate development, the area of the community infield is limited, and there are fewer activities for elderly people, which do not meet the needs of outdoor activities of elderly people. Oriental Longcheng Community ($P_2$) is located west of Wuhu City, near Tingtang Park, Wuhu. It has a good ecological environment. The site environment and green space environment can meet the needs of elderly activities. However, the road traffic environment in the community is general, which fails to achieve the continuity of accessible traffic and does not meet the needs of elderly people who move with a wheelchair. In the space layout of the site, the reasonable layout of dynamic and static zones is not fully considered.

Next, we use the traditional TOPSIS method to evaluate the suitability of five communities: The traditional TOPSIS method is to calculate the distance according to Equation (9), then the evaluation objects are sorted from large to small, where the bigger $C_i$ is, the better the overall benefit. The calculation is as follows:

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-}. \tag{9}$$

The result is $C_i$ = (0.918, 0.440, 0.270, 0.477, 0.330). The evaluation results are consistent with the improved TOPSIS: $P_1 > P_4 > P_2 > P_5 > P_3$.

The reasons for using the improved TOPSIS approach is that the improved TOPSIS considers the relative closeness degree of each evaluation object to the best and worst plan. Referring to the literature and examples, the disadvantage of using the traditional TOPSIS method is that the best solution and the worst solution of the decision-making scheme may change when new decision-making schemes are added, which leads to the reverse order of our ranking. If there are two evaluation objects about point A and point C symmetry, we have $S_1^+ = S_2^+$ and $S_1^- = S_2^-$, and if using the traditional TOPSIS method, the result will conclude that the two evaluation objects are of the same quality; however, this is not the case [28,29].

In order to increase the sensitivity of the data, we use the osculating value method to validate our model, and its $C_i$-value equation is

$$C_i = \frac{S_i^+}{min(S_i^+)} - \frac{S_i^-}{max(S_i^-)}. \tag{10}$$

The result is $C_i$ = (0, 7.552, 9.185, 6.427, 8.721). The principle of this method is to treat the positive and negative indexes in the same direction and calculate the distance between the evaluation object and the best and worst point, respectively. The closer the distance, the better the effect of the evaluation object. So, we come to the same conclusion as the above model; that is, $P_1 > P_4 > P_2 > P_5 > P_3$. The validity of the evaluation results has been further proved.

## 5. Conclusions

The assessment of community environment suitability is the basis of urban residential environment planning for the environment of the aging population in China. This article established an indicator system of the suitability for elderly people of a community from the four dimensions of site environment, road environment, greening environment and ecological environment to achieve a comprehensive assessment, as well as to use AHP to empower the indicators at all levels. On this basis, we use an improved TOPSIS method to make a comprehensive and objective assessment of the community's adaptability to old age. Finally, by taking five communities in Wuhu Community as an example, the evaluative index system and evaluative method of aging adaptability were applied. The results of this study can provide theoretical and methodological support for the assessment of a community's adaptability to elderly persons in various urban areas in China. The applied research results can help relevant departments and consumers understand the advantages and disadvantages of the community environment in ageing habitations and help them to make relevant decisions. The improved TOPSIS method improves the accuracy of the evaluation results and other countries or similar problems can also be calculated and proved using the model.

Our study has established a more comprehensive evaluation system and the use of an improved TOPSIS method, so that our evaluation results are more accurate. However, for the elderly community, an environmental suitability assessment is a long-term process; we can consider more factors in future research. In addition, the improved TOPSIS method improves the reliability of our assessment results but is inevitably flawed. Therefore, in the extension research, we may use several kinds of models to carry out the comparison and the verification of our computation, thus causing our conclusion to be more perfect.

**Author Contributions:** S.-C.Z., H.W. and Z.L. conceived, designed, and wrote the manuscript; S.Z. and Y.J. contributed significantly to the analysis and manuscript preparation; S.Z. and Z.L. performed the model analyses and wrote the manuscript; S.Z. and T.B. helped perform the analysis with constructive discussions; all authors read and approved the manuscript.

**Funding:** This research was funded by the National Natural Science Foundation of Anhui Province, China (No. 1608085QG168 and No. AHSKQ20182018D08), the Youth Fund Project of Humanities and social sciences of the Ministry of Education (No. 18YJC630110), China Postdoctoral Science Foundation (No. 2018QN058), Major Humanities and Social Sciences Research Projects in Zhejiang Universities (No. 2018QN058) and Ningbo Natural Science Foundation (No. 2019A610037). And the APC was funded by the Natural Science Key Research Project of Anhui Province, China (No. KJ2018A0115).

**Conflicts of Interest:** The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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