

Research on Livable Community Evaluation Based on GIS

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Abstract. Community is the basic unit of the city. Research on livable community could provide a bottom-up research path for the realization of livable city. Livability is the total factor affecting the quality of community life. In this paper, livable community evaluation indexes are evaluated based on GIS and fuzzy comprehensive evaluation method. Then the sum-index and sub-index of community livability are both calculated. And community livable evaluation index system is constructed based on the platform of GIS. This study provides theoretical support for the construction and management of livable communities, so as to guide the development and optimization of city.

1. Introduction

In 1996, the concept of livability was formally and firstly put forward at the second United Nations Conference on human settlement. Livable city should meet the comfort of people's life and the sustainability of urban ecology[1]. The elements of the livable city include the comfort of living, the convenience of traffic, the elegant environment and so on. A community is a basic unit of a city, therefore, the construction of livable city must start from the construction of livable community. At abroad, the United States Indicator of Sustainable Community [2] is one of the most famous cases, which focuses on micro scale, neighborhood health and community vitality. At home, the research on livability is led by Introduction to Sciences of Human Settlements [3]. In recent years the livable community evaluation framework of our country has been established preliminary according to connotation and construction content of livable community.

The research on livability should not stay in the concept, instead, index should be quantified, especially the objective environmental evaluation index [4, 5]: traffic accessibility, fairness of green space, living infrastructure services. Thus, method combined subjectivity and objectivity was proposed. In this paper, GIS is applied to the evaluation of livable communities to provide technical support for the objective evaluation. At the same time, the fuzzy evaluation method is used to evaluate residents' satisfaction. Additionally, Wuhan Community Livable Index Evaluation System is established based on GIS to calculate livability index and estimate the livability of Wuhan community.

2. Basic method

On the one hand, the function of spatial analysis can be used to evaluate the objective elements of livable community quantitatively and display the results visually on map, which is the unique advantage of GIS in spatial computing. On the other hand, residents are the beneficiaries of livable



communities, and their behavior will affect the construction of livable communities. In other words, it is also important to take subjective feelings of the residents into evaluation.

2.1. GIS evaluation

GIS can translate some difficulties skillfully that people can't handle directly, e.g. the following characteristics of community.

(1) The spatial shapes of the communities are different and irregular. The internal spatial difference will affect the evaluation of the community for residents. Differently, a community is simply treated as a point or a polygon by GIS, and the evaluation of one community will have a clear result.

(2) There are thousands of communities in one city. Big data will be a great challenge to human work. However, if GIS is used to calculate indexes of geographical elements intelligently, computers will help people finish a lot of work.

(3) The convenience of community is sensitive to spatial location. Studies have shown that people's understanding of the actual distance is affected by social background and life experience. Therefore, people with different backgrounds may have different criteria for judging distance. However, for GIS, the spatial analysis can measure the straight distance and even walk distance accurately, which avoids the inconsistency of the above results and solves the problem conveniently.

Generally, GIS is very good at dealing with space location problems. Thus, in this paper, GIS is introduced to assess livable indexes related to geographical location.

2.2. Fuzzy comprehensive evaluation

The fuzzy comprehensive evaluation method is a method of quantifying the factors that are unclear and difficult to quantify and evaluating a thing from multiple factors comprehensively. This method is based on the fuzzy mathematics proposed by American scholar. It simulates the human reasoning pattern when analyzing and evaluating factors that have not a clear criterion. Coincidentally, many factors of livable community have a strong subjectivity, which must rely on human assessment but not rely on computer measurement, such as community environment, civilization, security, etc. Thus, the fuzzy comprehensive evaluation method is very suitable for the subjective indexes in study on community livability assessment.

This method uses fuzzy mathematics and fuzzy statistics comprehensively to clarify the factors that affect one thing, and make a scientific evaluation for the object. Firstly, the fuzzy concept is transformed into a fuzzy set, then the fuzzy membership function is established, and finally the fuzzy object is analyzed quantitatively through fuzzy set operation.

3. Livable community Evaluation

3.1. Evaluation index

Framework of livable community evaluation indexes includes 6 first-class indexes, 16 second-class indexes and 30 third-class indexes, the detailed evaluation framework are shown in tab.1. These indexes are divided into two parts based on the connotation and geographical characteristics: geographical element and non-geographical element.

Community convenience is geographical element, evaluation standard of which is the distance between the community and the surrounding facilities. A few fascinating studies have indicated that the greater the number of shops, libraries, banks, community centers and schools in walking distance where a community have, the lower the obesity rate of the residents living there [6]. Thus, it is necessary to measure the neighborhood walkability in livable community evaluation, which is usually realized based on GIS [7]. In this paper, the GIS method is introduced to make an objective and fair evaluation on the rationality of community walking based on Walk Score. The non-geographical element includes the remaining indexes. The evaluation is usually based on survey. Non-geographical elements are further divided into professional and non-professional indexes based on content specialization. Among them, community resource conservation is regarded as a professional

indicator, which involves professional knowledge of renewable energy utilization and rainwater system construction, thus it should be evaluated by experts.

In conclusion, the livable community evaluation needs to be studied from three subjects: GIS, community residents and experts and two cognitive perspectives: qualitative analysis and quantitative analysis.

Table 1. Framework of livable community indexes.

Objective	First-Class Index	Second-Class Index
Community Livability	Community Convenience	Traffic service facility Commercial service facility Cultural and sports facility Healthcare facility
	Community Environment	Ecological environment Landscape environment Hygienic environment
	Community Civilization	Resident diathesis Community culture Community participation
	Community Management	Management tool Community service
	Community Security	Public security Safety device
	Community Resource Conservation	Renewable energy utilization Rainwater system design

3.2. Evaluation model

Livable community model combines subjective analysis and objective calculation. On the one hand, the community convenience score is calculated quantitatively according to evaluation model of community convenience. On the other hand, residents' satisfaction and community conservation scores are described qualitatively by using questionnaires and fuzzy comprehensive evaluation method. Finally community livable index is calculated by using a weighted summation method (Figure 1).

3.2.1. Evaluation of community convenience. Walk Score includes three elements: (a) Classification of service facilities. For example, facilities are divided into grocery store, restaurant, bar, shop, cafe, bank, park, school, bookstore and entertainment venue by Walk Score [8]. (b)Euclidean distance between service facility and center point [7]. (c)Distance decay function of facility convenience. For instance, convenient facilities with 1km,1.6km and 2.4km apart from the central point are assigned to different attenuation coefficient by Walk Score [8].

A single point has a walk score according to the distribution of its surrounding public facilities. Analogously, evaluation model of community convenience is also divided into three parts:

(1) Classification of facilities. In the evaluation model of community convenience, service facilities include four aspects traffic, business, culture sports and health, a total of 9 types of service facilities (Figure 2). Different types of facilities are given different initial values C_i according to the relative

importance of service facilities in daily life, and $\sum_{i=1}^9 C_i = 100$.

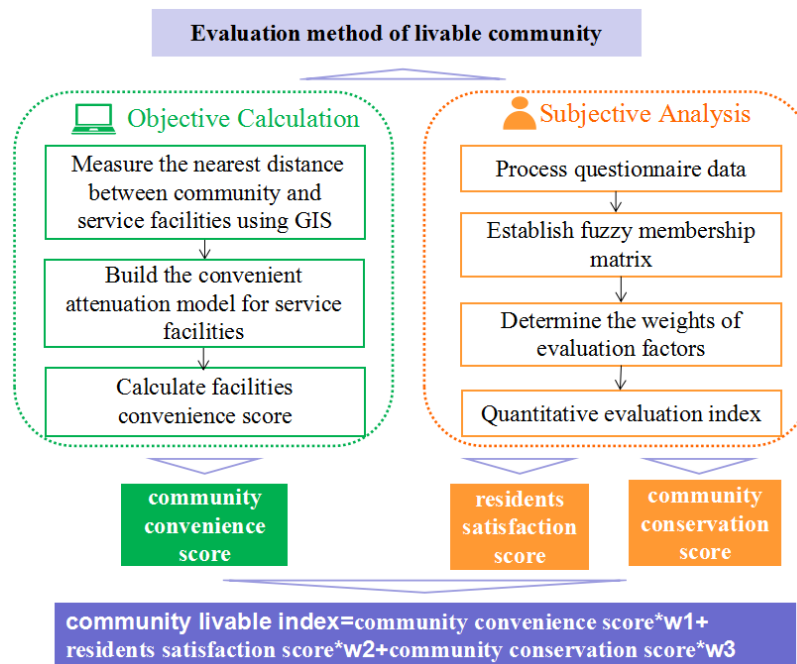


Figure 1. Evaluation method of livable community.

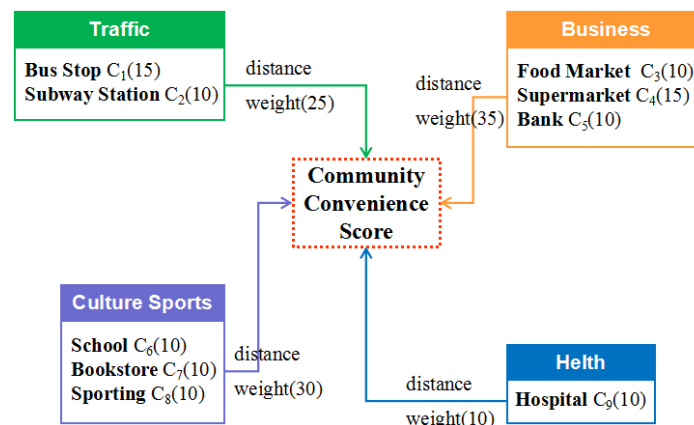


Figure 2. Classification of facilities.

(2) Distance between facilities and community. Euclidean distance is used to express the spatial distance between community and public facilities in this model, which is similar to Walk Score.

(3) Distance decay function of facility convenience. The convenience of service facilities has attenuation, the larger the distance between facilities and community, the worse the convenience, which could be explained by attenuation coefficient. The attenuation coefficient models of different types of facilities may be different, then the attenuation coefficient models with different parameters are established for different types of service facilities combined with the residents travel habits and the coverage of services (Figure 3).

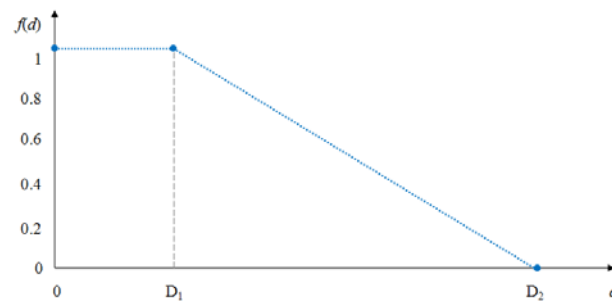


Figure 3. Distance decay function of facility convenience.

3.2.2. Evaluation of community satisfaction and resource conservation. The fuzzy comprehensive evaluation method is usually used in the calculation of community satisfaction, and the basic process is as follows: (a)The community satisfaction evaluation factors set is built according to the evaluation index system.(b)The comment set is determined: $C=[\text{very satisfied}(c_1),\text{satisfied}(c_2),\text{general}(c_3),\text{unsatisfied}(c_4),\text{very unsatisfied}(c_5)]$. The score vector S corresponding to comment set is $S=[95, 85, 75, 65, 55]$. (c)The mapping relation M between factors set and comments set are established, then the membership of each evaluation factor is calculated based on the questionnaire data. (d)The weight of index is calculated by the analytic hierarchy process.(e)The comprehensive fuzzy evaluation vector E is obtained by means of fuzzy transformation and matrix multiplication: $E = W \cdot M$, then E is normalized into $\bar{E}$.(f)The community satisfaction score R is obtained by multiplying the evaluation vector and the score vector, that is: $R = \bar{E} \cdot S$.

In the same way, the community resource conservation score is calculated based on the resource conservation questionnaire data.

3.3. Evaluation System

Wuhan Community Livable Index Evaluation System (Figure 4) is constructed based on the above model, which is composed of service facilities convenience evaluation subsystem, resident satisfaction evaluation subsystem, and resource conservation evaluation subsystem. The three subsystems are used to calculate convenience score, satisfaction score, and resource conservation score, and the system will automatically calculate the community livable index by weighted summation of three subsystems.

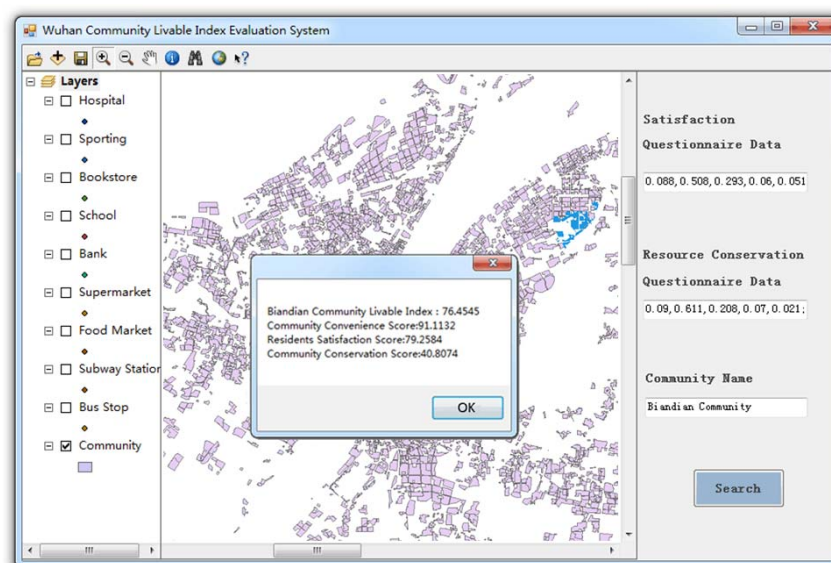


Figure 4. Wuhan community livable index evaluation system.

Users only need to input three items: the name of the community to inquire, the corresponding results of the questionnaire and the results of the questionnaire. Then the spatial position of the community is highlighted, and the community livability index and the score of the three subsystems are automatically feedback in the popup dialog. When the dialog box is closed, users can enlarge the map, and check the surrounding facilities distribution carefully, which provides a reference for later urban planning. The application of this system not only saves the calculation time, but also improves the calculation precision. Furthermore, it is convenient for user to understand the level of livable communities and community short board problem quickly.

4. Conclusion

Wuhan Community Livable Index Evaluation System realizes the visualization of community map and the evaluation of community livability with the help of ArcGIS Engine tool. The research method combines quantitative methods with traditional qualitative analysis, and it gives full play to the advantages of GIS in spatial analysis, which not only overcomes the strong subjectivity in the artificial evaluation work of livable community, but also improves the objectivity and fairness of the comprehensive evaluation results. The system could give the numerical result conveniently and visually. However, actual evaluation should not only stay at the value, but also emphasize the residents' will and lack of construction reflected by the results, and develop effective measures for the weak link. In recent years, a large number of shared bicycles appeared in front of the community gate. The popularization of shared bicycles has greatly facilitated resident's travel, e.g. go to work, go to school, go shopping. Thus, in future research on community convenience, distance parameter values can be increased according to actual riding distance, not walking distance.

Acknowledgments

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