

Study on livability evaluation and planning countermeasures of Community space based on multi-source data -- Taking Changsha as an example

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Abstract. Since the 18th CPC National Congress, General Secretary Xi Jinping put forward people-centered as the value orientation of all work. He advocates a development paradigm of “innovation, coordination, green, openness, and sharing”, which poses new challenges to urban planning in China. Based on this context, 15-minute life circle is proposed to be the basic unit for creating community life in Changsha city. The work is carried out in two main phases: the first is to carry out evaluation of community livability and construct a five-dimension evaluation index system for livability of community space in residence, employment, travel, life, and recreation, and assess 719 communities (villages) in downtown Changsha, the second part is to put forward the planning countermeasures of a 15-minute life circle in order to improve the quality of community space, which includes the five aspects of residence, employment, travel, life and recreation. Based on these two tasks, the planners assist the local government in constructing a path to community space governance that uses “quantitative assessment” to find problems and solve problems with “policy tools”.

1. Introduction

1.1. Community and space livability

Community is the basic unit of a city. It has a series of characteristics, such as social economy, regional attribute and natural environment [1]. Under the background of tight constraints of current resources and environment, China's urban construction has shifted from "incremental expansion" to "stock quality", from "material construction" to "human oriented" [2]. Community is the cell of the city, and livable community is the foundation of livable city. Strengthening community building has become increasingly important [3]. Therefore, it is very necessary to understand the livability of the environment at the community level. By reflecting the problems of community construction in different regions of the city, it provides a more concrete reference for the government to build a livable city. On the other hand, with the emergence of new data and the innovation of technical tools, a large number of multi-dimensional, fine-grained and space-time observational data are growing, so that urban spatial research can be built on smaller size research objects, thereby more comprehensively describing urban spatial characteristics, sensing the intrinsic problems of cities, and assisting in the formation of precise planning strategy [4].



Because of the rich connotations of livability, many scholars further discuss the livability of [5, 6]. According to the "Habitat Agenda" in 1996, the basic standard was "the characteristics and quality of space, society and environment". This study focused mainly on spatial quality, while paid attention to community equity and sustainable development. On this basis, With the community as the basic research unit and the goal of improving the quality of life of the residents of the community, "Community space livability" mainly starts from the perspective of the physical space elements and analyzes whether the community material space meets the daily needs of residents [7].

This paper takes 719 communities (villages) within the metropolitan area of Changsha City as the research object, evaluates its current space livability, and proposes planning strategies in conjunction with the assessment results.

1.2. The "Five" dimension index system of community space livability

By drawing on the cases at home and abroad, this study defines "livability" from five dimensions, namely, "habitation", "employment", "travel", "life", and "recreation". Appropriate "living" means suitable housing level, diversified housing type and dynamic shared residential environment. Appropriate "employment" means more employment opportunities near the community. Appropriate "travel" means convenient external traffic links and comfortable and safe internal slow traffic. "Life" means a multi-layered, diversified and convenient public service facility. "Recreation" means multi-type, multi-level, high-quality and efficient recreation space. Then the livability evaluation index system of "15-minute life circle" integrating 5 dimensions, 15 categories and 41 indicators is built [8].

2. Data, methods and technical routes

2.1. Sources of data

The basic data of the study are divided into two categories. One is used to describe the space position, including the scope of research, community boundaries, 15-minute of life circle, virtual centroid, 15-minute walking range, etc. The other is the evaluation index for describing living community or its 15-minute walking range coverage. The main data comes from planning approval data, second-hand housing data in 58.com, "multiple-plan coordination" database in Changsha City, Amap POI data, road and public traffic database.

2.2. Research Methods

The calculation method of facility coverage mainly measures the convenience of community residents to arrive at a facility. In the existing research results, most of the methods such as buffer analysis and nearest neighbor analysis are used to characterize the accessibility of facilities. However, this method ignores the possible obstacles in reality and tends to overestimate the convenience of the facility [9]. From the previous study, some scholars have used real time traffic travel data to simulate the service range of facilities. Compared with the traditional traffic network analysis, it has more accurate road network modeling, easy availability, and can accurately reflect the actual situation, etc. [10]. On this basis, this paper uses real-time traffic travel data to simulate the service circle of facilities, and divides the service circles into three layers, such as 0 - 5min, 5 - 10 min and 10 - 15min. Then the area of each community is covered by each service circle, and the weight coefficients are given to the three layers according to the range sensitivity of the different types of facilities. As Table 3 shows, the coverage of a certain facility in each community is obtained by the weighted superposition calculation method. The formula is as follows:

$$C = (F\beta_1 + T\beta_2 + H\beta_3) / M \quad (1)$$

C represents the coverage of some kind of facilities. F, T, and H represent the coverage area of 0-5min, 6-10 min and 10-15 min respectively. β_1 , β_2 , β_3 respectively represent their weight coefficients, and M indicates a community area.

Table 1. Weight coefficient list of various facilities

Category	Facilities	Connotation	Weight coefficient
First class	Kindergartens, vegetable markets, convenience stores, bus stops, community parks, convenience services, etc.	Frequently used, high distance sensitivity	6:3:1
Second class	Primary schools, secondary schools, pension facilities, rail stations, community health service stations, sports facilities, comprehensive parks, etc.	Frequent use, moderate range sensitivity	5:3:2
Third class	Large supermarkets, large hospitals, cultural facilities, fire agencies, police agencies, etc.	Less frequent use and lower range sensitivity	4:3:3

2.3. Technical route

This paper is based on the traditional research method of "asking questions - analyzing problems - solving problems". The first part is the origin of the problem. Through the study of community space livability, the five dimensions of "livability" are formed, and the index of evaluation is established. The second part uses the "coverage" model to evaluate the "livability" of the community space in Changsha, and focuses on three aspects: factor relevance, clustering of living communities, and spatial fairness to identify problems behind Internal factors. In the third part, in combination with the evaluation results, the corresponding 5 kinds of planning strategies are put forward.

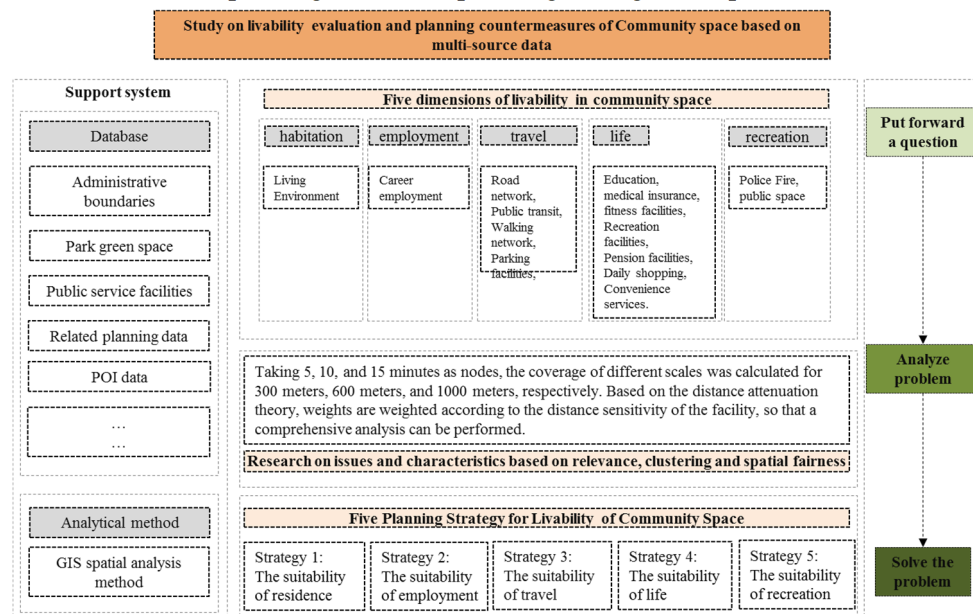


Figure 1. Technical roadmap

3. Evaluation and analysis

3.1. Evaluation results

On the whole, the current level of livability of Changsha community is relatively low. About 62% of the communities are located under medium ratings even below, and the construction of livable communities needs to be strengthened. From the perspective of administrative division, most of the communities in Furong District are well rated and above, and the communities of Kaifu District,

Yuelu District and Yuhua District are evenly distributed, and the overall livability of Changsha county and Wangcheng District is weak.

3.1.1. The suitability of residence. About half of the community is located at the middle even lower level, and are mainly distributed in the core urban area and the outer circle. The outer circle is still in an undeveloped stage, and the level of urbanization is relatively low. The level of livability in the middle circle is relatively high, which indicates that the construction of the new area has achieved certain results.

3.1.2. The suitability of employment. Most of the communities in the built-up urban areas have poor employment attributes, which indicates that it is difficult to achieve a balance of employment and residence within the community. Employment sites are mainly distributed in the core city zone and Xingsha area, which are the main gathering place of the third industry and the second industry in Changsha. On the whole, the employment attribute of Furong district is better, and more than 60% of the community is in good rating and above.

3.1.3. The suitability of travel. More than 80% of the communities are above medium ratings, among which excellent ratings and above are mainly distributed along subway lines. At the same time, there are some poor rating areas in urban built-up areas, which need attention. Secondly, Xingsha area is an important urban employment area. Most of the communities are medium rated and need to improve their ability to travel.

3.1.4. The suitability of life. About 50% of the communities are located under medium ratings and below. Among them, the excellent rating is mainly located in the core areas of the city, such as the Wuyi Square plaza, and so on. On the whole, the life quality of Furong District is good, all of which are above medium rating. There are more than half of the communities in Kaifu District, Tianxin District and Yuhua District located above the good rating.

3.1.5. The suitability of recreation. The suitability of recreation in the community is good, over 70% of the area is in the medium rating and above, the excellent ratings and above are mainly located in the Mount Yuelu area, the peach blossom area, the Meixi Lake and other regions, and the recreational properties of the central urban area are weak.

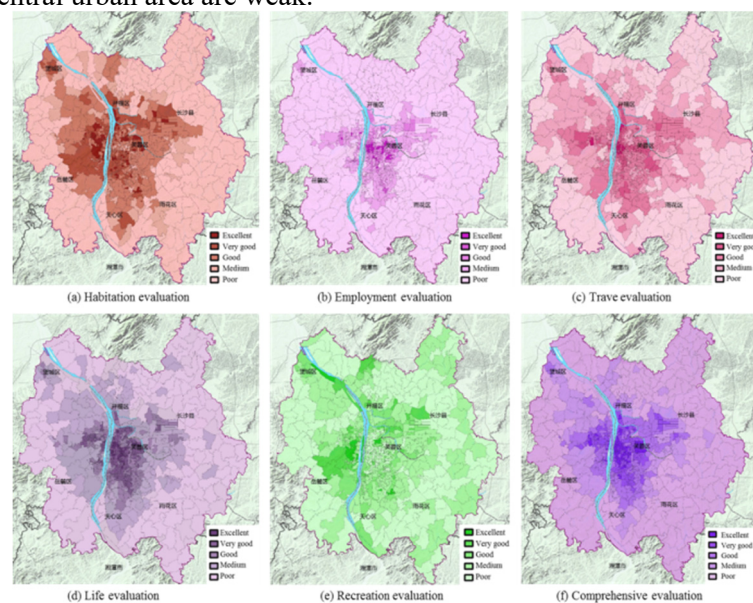


Figure 2. Evaluation results

3.2. Results analysis

3.2.1 Correlation analysis: the importance of "living" dimension in community life is weakened. The formula (2) can be used to calculate the evaluation value of life community in terms of employment, travel, service, leisure and comprehensive evaluation.

$$F_{ij} = \sum r'_{ij} w_j \quad (2)$$

r'_{ij} is the normalized matrix data and w_j is the weight of item j index.

The correlation analysis of housing prices, floor area ratio, greening rate, building age, population density and other comprehensive statistics is carried out. The results of analysis are shown in Figure 3. These indicators are not correlated with the comprehensive evaluation of living communities. The results show that there is no obvious linear relationship between the most primitive living attributes of the community and other derivatives such as employment, travel, life and recreation in Changsha. Nowadays, the original demand for residence is no longer an important factor to dominate people's choice of residence, and travel, service and other factors are more important.

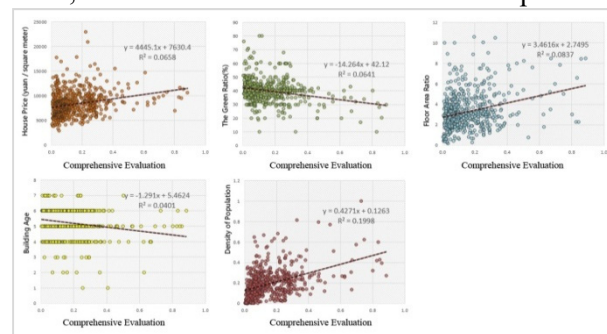


Figure3. Correlation analysis between residential indicators and comprehensive evaluation

3.2.2 Cluster analysis: "old city" is more livable, and "new city" needs improvement. Using the K-Means clustering method, according to the 4 evaluation results of the employment, travel, life and recreation of each living community, the living communities in Changsha metropolitan area are divided into 4 categories, and then the clustering results are analyzed with ArcGIS software for spatial visualization. It shows that. The first category is in the periphery of the urban construction land. The second types are in the Wuyi Road, West Jiefang Road, South Cai E Road, West Renmin Road and Mid-Furong Road, the liberation West Road, the Cai E South Road, the people's West Road and the Furong Middle Road. The third types are along with the subway line 1 and the line two, The fourth category is located at the mixed area of old and new cities, such as the perimeter of Sifangping, surrounding of Huoju village, south Meixi Lake, North Xianjia Lake, perimeter of Zuojiatang, surrounding of Yangjiashan -Wanjiali area, and surrounding of Jingwanzi- Hongxing Village.

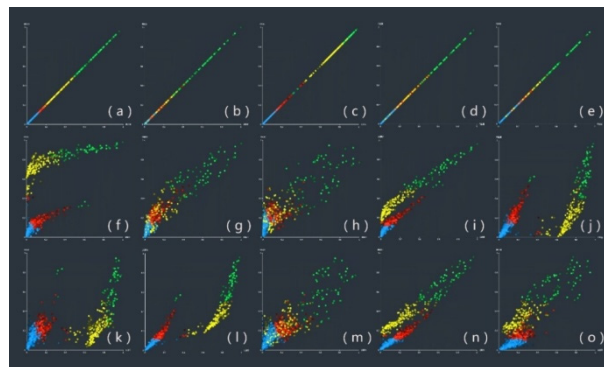


Figure4. Clustering feature analysis

(a) comprehensive evaluation (b) Employment Evaluation (c) travel assessment (d) life assessment (e) recreation-evaluation (f) employment-travel (g) employment-life (h) employment-recreation (i) employment-comprehensive (j) Travel-life (k) travel-recreation (l) travel-synthesis (m) life-recreation (n) life-comprehensive (o) recreation-integrated

Note: In the employment-travel, vertical axis indicates travel, horizontal axis indicates employment, other figures are the same as that in (f).

The first-class communities' proximity to employment, transportation, life services and recreation are all at a relatively low level. The first-class communities' proximity to employment, transportation, life services and recreation are all at a relatively low level.

3.2.3 Equilibrium analysis: the balance of "recreation" dimension is well, while other dimensions show higher intensity agglomeration. The corresponding TIN model is generated through the evaluation data of different community indexes, and the TIN model is transformed into an equivalent distribution interval map (Figure 5). In terms of employment, Changsha has shown a distinct single center structure, and the employment opportunities are concentrated in and around Wuyi Square Plaza, and In terms of travel, it is highly related to the subway line; in terms of services, it is characterized by a higher level of Hedong and a weaker level of Hexi; in terms of recreation, the spatial distribution is relatively balanced. The spatial fairness of its comprehensive evaluation shows similar characteristics to traffic travel.

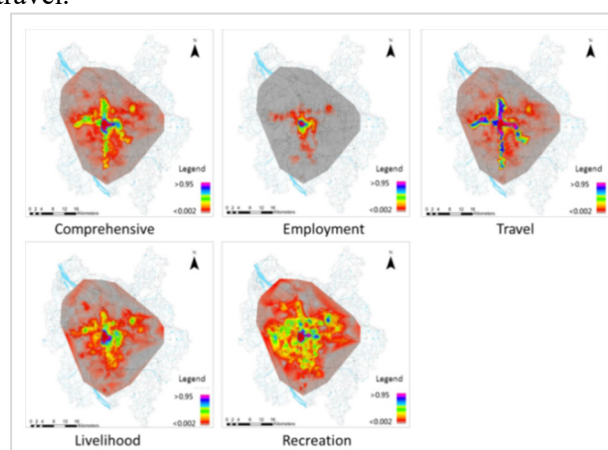


Figure5. Equivalency Circle Spatial Analysis Based on Evaluation Results

Through fractal analysis, it is possible to provide a dimension for quantitative description of seemingly complex and irregular forms. The fractal dimension can be understood as the degree of filling of complex space in the geospatial structure, reflecting the agglomeration and diffusion state of space. The formula can be expressed as:

$$F(m) \propto m^{-D} \quad (3)$$

$$\ln F(m) = C - D \ln m \quad (4)$$

m represents the order of all the indicators evaluated in the spatial distribution, $F(m)$ indicating the value of the indicator when the order is m , C is the constant, and D is the fractal dimension.

As shown in Figure 6, the spatial fractal dimension of integration, employment, travel, service and recreation corresponds to **1.029**, **1.483**, **1.185**, **1.062** and **0.689** respectively. The spatial distribution of recreational indicators such as walking environment, park, square, green space, museum and library is the most balanced; medical, education, catering, shopping, entertainment, pension and other service indicators are balanced; road network density, bus line, subway station The spatial distribution of travel indicators such as parking facilities is relatively concentrated; the employment points of companies, business buildings and office buildings show strong agglomeration characteristics.

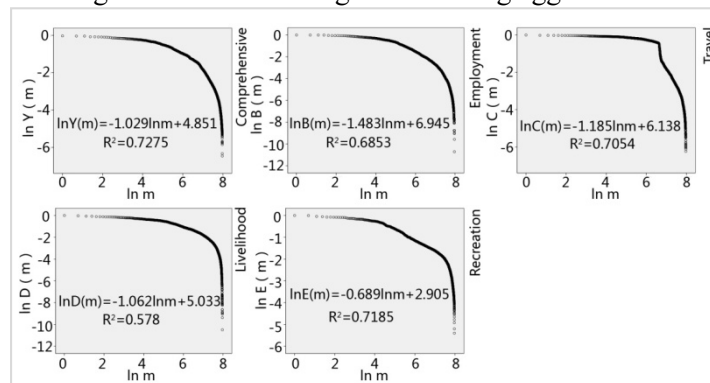


Figure 6. Fractal dimension analysis based on evaluation results

4. Planning countermeasures [11]

According to the results of assessment and analysis, combined with the current reality of urban development, this paper puts forward five strategies for coping with the five dimensions of livability.

4.1. Appropriate strategies for habitation: Moderate density, functional mix

We should encourage compact development and ensure the vitality of the community through the moderate population density in the walking life circle. Middle size supermarkets (80%) and high school (60%) are the two facilities that residents most want to walk to and have the highest population standards. of population. According to its size allocation standard, the population density within the 15 minute life circle should not be less than 10 thousand person / square kilometers. The focus of building a pedestrian living circle should be based on convenient living facilities, an active community atmosphere, and a pleasant and comfortable community environment. In order to meet the appropriate population concentration, the spatial range of Changsha's walking life circle should be controlled at about 2 square kilometers.

4.2. Employment suitability strategy: "H+W" mode, compound vitality

We encourage the establishment of functional composite communities in the process of new construction and renovation, and enhance the ability of the community to absorb the employment population through composite functions. According to the study of American Urban Land Association, the complex urban development must have 3 or more than 3 types of use that can create significant income, such as retail, office, residence, hotel and entertainment, and have mutual promotion but not completely single dependence. At the same time, . At the same time, it encourages the interactive operation of multi formats, such as entertainment centers, department stores, supermarkets, restaurants, hotel apartments, cinemas, etc. They will be scientifically deployed in the community to build a new community with complete formats and high degree of integration. Among them the systematic

combination of various functions and high efficiency network connection are emphasized, which helps to balance the distribution of residences and jobs.

4.3. Travel suitability strategy: Walking to reach the last mile

We should ensure accessibility on foot and promoting more green travel through precise and effective facility configuration. According to the requirements of different types of behavior characteristics and service radius of facilities [12], the layout optimization of demand-oriented facilities is carried out to fully meet the walking accessibility and improve the utilization rate of facilities. The establishment of a convenient and accessible walking facility is encouraged to arrange facilities for the elderly and children in the 5-minute walking circle, such as kindergartens, vegetable farms, and so on. Facilities with close ties will be set up and distributed in a centralized manner, and high-association facility circles with children, the elderly, and office workers as the core using groups will be formed. Building a comfortable and continuous walking network - parks, square, bus stations, facilities and other places to form a good walking contact, is a necessary condition to improve the green travel.

4.4. Life suitability strategy: Taking into account differences, inclusiveness and coordination

We advocate different types of residents to live in moderate mix. Strengthen humanized community services for the elderly, children and other groups. To strengthen the construction of old-age facilities - the proportion of people over 60 years old reaches more than 25% of the total population, or the proportion of elderly people over the age of 65 has reached 15% or more, major consideration should be given to old-age facilities. When the proportion of senior citizens aged 80 or above accounts for more than 10%, it is necessary to increase the medical care, daily trusteeship and family care facilities for the elderly. To strengthen the construction of infant and infant facilities - when the proportion of children aged 3 and below is high, the basic guarantee for the function of child rearing should be strengthened and the facilities for infant and child rearing and trusteeship should be increased. Facilities should be distributed nearby-----Placing facilities that the elderly and infants use more frequently within five minutes-walk, such as food markets, street parks, plazas, and baby custody.

4.5. Recreation suitability strategy: Blocks opening, space sharing

Building a humane scale open community and forming a pedestrian friendly street pattern. High density and public service facilities are placed in the urban interface, the landscape interface is set with low density and landscape leisure; between the two, roads and landscapes can be used for transition and tandem. Open space setting: the core main axis open space is formed by the combination of commercial street or centralized commercial and public space, and the commercial streets penetrate into the community to improve the degree of community opening. Priority setting of public space: frequent and timely setting of square and landscape nodes, providing communication space for activities. Road system design: Respecting the regional-level transportation planning and orderly undertaking the external roads; the internal roads and communities of the community roads are gradually contracted, mixed and walked, and the roads are designed to make the roads become public spaces.

5. Conclusion

This article first defines the community livability by constructing a five-dimension evaluation index system. Taking 719 communities in Changsha metropolitan area as the research object, through the established basic database, the current big data is used to analyze the advantages of urban space issues. In this paper, ArcGIS, SPSS, python, Excel and other technical tools are used to make an empirical study of the urban community livability in Changsha. the characteristics of community space livability construction and its problems are identified, and planning strategies are proposed. However, because of the problem of collecting data, the data collection cannot be exhausted, and at the same time, the application of large data in solving space problems is still in the exploration stage, which will leave further space for the research exploration.

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