

The Analysis of Decision Factors of Indemnificatory Housing

Location Based on GIS

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Abstract: The reasonable location of indemnificatory housing affects people's life quality and social stability. It's an important meaning for the indemnificatory housing location to analyze the determinative factors. The paper summarized the location problems according to China's present spatial distribution and characteristics of affordable housing construction and analyzed the decision factors on location from sufficient employment, residential differentiation, public facilities, economy development, and other respects. Based on the above the factors, the paper constructed the assessment model of indemnificatory housing location rationality combing Analytic Hierarchy Process (AHP) with entropy weight coefficient method based on GIS spatial analysis platform and took Bai Bu Ting community as a case study. The result indicated that the community location possessed the ideal rationality and the factors can effectively assess the rationality of indemnificatory housing location, also supply the decision support for the government to plan the indemnificatory housing location.

Key words: Indemnificatory Housing; Spatial location; Decision factors; Spatial analysis

1. Introduction

“Live and work in peace” is a classic generation on happiness and better life for the most Chinese people, but also one of goals of China's indemnificatory housing policy implementation. Since 2009 with the speed of indemnificatory housing construction, a large number of affordable housing projects were launched in all regions, which alleviated the housing difficulties of low-income families in some extent, but there is still problems found in reality. Firstly, the location is irrational and lack of convenient public transportation, which increased the living costs of low-income families, decreased the employment opportunities, and eventually from “the affordable housing uneconomic” phenomenon, deviate the original purpose of the policy. Secondly, centralized construction intensified the living differentiation, exacerbated the spatial aggregation of low income groups, which most likely to form a new slums leading to sharp social contradictions, class antagonism and other problems; Thirdly, because the site has a strong

housing irreversibility, the site of many irrational can influence the housing space layout and social special structure of urban stock housing in future.

The space site of indemnificatory housing will not only affect the life quality, welfare and development plans of low-income families, but also change the evolution of the social space of the entire city^[1]. Therefore, it is obviously necessary whether the housing site is reasonable and the analysis of decision factors to solve the above mentioned problems and achieve the policy goal. The paper intends to run the affordable housing location reasonable evaluation model by multi-factors comprehensive evaluation method, combining analytic hierarchy process and entropy coefficient, to analyze the location decision factors of indemnificatory housing in order to provide the reference for affordable housing site.

2. Analysis of indemnificatory housing location decision factors

Indemnificatory housing is that the government supplies the housing for low income people in order to achieve resource distribution fairly and equitably in housing field, to restrain and reduce income disparities, to promote social harmony, corresponding with the commodity housing^[2]. So its location decision factors not only to meet the general requirements of housing, but also its own characteristics.

Firstly, the site is close to the job market. The various types of affordable housing are mainly for low household, employment difficulties, the housing shortage group, who would like to solve the job problems in addition to the housing demand. So we must firstly solve the employment problem, the proper solution will better achieve the employment housing radiation effects protection and truly improve the standard of living. Therefore, the site close to job market and convenient transportation area will help them achieve real "live in peace" dream.

Secondly, the affordable district should achieve mixed living. In order to avoid repeating live differentiation, poor areas and other issues in the urbanization process in Western countries, the government advocates that there is some certain percentage of indemnificatory housing in market housing construction, through this approach to achieving mixed population in large scale, communities in small scale, eliminating excessive concentration brought about social problems. For example, the government requires developers construct a certain percentage of affordable housing in commercial projects. and some local authorities made it clear that land is not the highest bidder , but compared with the construction of affordable housing in the area. Thus,

affordable housing should have the "mosaic" geographical features^[3], namely higher levels of residents, relatively concentrated community, no difference of residential environment (or small difference).

Thirdly, the housing location need perfect public service facilities. Currently, the local governments revenue depend on "land finance", always ignored the investment on people ordinary life, which leads to the remote site of affordable housing. The remote location, lack of public services, will lead to less demand for housing and the investment less attractive in the region. The government spend money to construct affordable housing, the results of economic and security effects are unsatisfactory, which not only affects the government's enthusiasm, but cannot solve the housing problems of poor families. Therefore, affordable housing site should have a more complete surrounding infrastructure and good transport accessibility.

Fourth, the affordable housing should be economic and reasonable. China's housing security standard level is slightly lower than developed countries' because of national conditions, which do not regulate the units and areas clearly, but the costs of construction and environmental is also an issue the government and the development of the main priority. In the "mixed living" model, the construction of affordable housing can choose a lower development costs and more idle land area .

Based on above analysis, the reasonable affordable housing decision factors should include sufficient employment, mixed living construction, perfect public facilities and economy effects.

3. Indemnificatory housing location evaluation model

3.1 Theoretical models

The paper make use of multi-factor comprehensive evaluation method to build evaluation model of housing affordable reasonable site, because the site need to consider many factors such as land cost, convenient transportation, public services and other factors^[4].

$$U_i = P_1W_1 + P_2W_2 + P_3W_3 + \dots P_nW_n = \sum_{i=1}^n P_nW_n$$

In formula, P_i represents each index weight, W_i is the evaluation index. Because the impact of each index is different, the index weight is more important.

3.2 Index system

The index of indemnificatory housing location evaluation system does not only meet the general housing site requirements, but also to emphasize on welfare of affordable housing supply

and economic, social weakness of affordable objects ^[5], so the paper will select 7 indicators in 4 categories ^[6] as affordable housing space siting evaluation system (Table.1) based on the mentioned decision factors, combining urban plan indicators.

Tab.1. Location of Indemnificatory Housing evaluation system

NO.	Category	Index
1	Traffic location	Traffic stations distribution distance
		Density of main road net
2	Environment location	Density of public green land
		Noise influence distance
3	Economic location	Surrounding land types and level
		Density of public facilities
4	Employment location	Distance of industrial and commercial block

3.3 Index weight

Method to determine the index weights are generally divided into subjective and objective weighting method. The subjective weighting method mainly depending on people's subjective experience to determine such as expert scoring method. The objective method determined the weight through the law among the data. We choose proper method between two methods according to the data attribute, the degree of availability and the sample size. In general, if the data sample is small and the internal laws among the data are not obvious, subjective weighting method is suitable. If data sample is large and the data law is obvious, the primary choice is objective weighting method. Due to the location of affordable housing data sample is too small, it should focus more on the experience of experts estimate. Therefore, the study initially determined the weight by AHP (Analytic Hierarchy Process), and then assisted to be amended them by Entropy Weight Coefficient method. This comprehensive method effectively solved some information missing problem because the scale of subjective judgment is inaccurate. The specific steps are showed as follow.

(1) It gets expert judgment matrix by AHP X_{ij} ($i = 1, 2, \dots, m; j = 1, 2, \dots, n$)

(2) It implement the normalization process to the matrix element x_{ij} , the results are showed as Y_{ij} , namely $Y_{ij} = X_{ij} / \sum_{i=1}^m X_{ij}$, m is number of alternative solutions.

(3) It calculate the entropy e_j of index j , namely $e_j = -k \sum_{i=1}^m Y_{ij} \ln(Y_{ij})$ ($k > 0, e_j \geq 0$) if

X_{ij} is equal for given index, $Y_{ij} = x_{ij} / \sum_{i=1}^m x_{ij} = 1/m$, now e_j is the maximum value, namely

$$e_j = -k \sum_{i=1}^m \frac{1}{m} \ln \frac{1}{m} = k \ln m, \text{ if at this time } k = 1/\ln m, e_j = 1 (0 \leq e_j \leq 1)$$

(4) It calculates the coefficient g of variation of index j , .for the given j , the difference of x_{ij} is smaller, e_j is greater. When all are equal, $e_j = e_{\max} = 1$ then the index x_{ij} is useless for the program evaluation. Conversely, when the index value of the programs is greater, e_j is smaller, which means the indicator for the evaluation bigger, which can determine the coefficient of variation g_j , namely $g_j = 1 - e_j$

(5) It calculate information weight coefficient μ_j of index j , namely $\mu_j = g_j / \sum_{j=1}^n g_j$

(6) It use information weight coefficient μ_j of index j to adjust the weight h_j of AHP,

then the comprehensive weight is $w_j = \mu_j h_j / (\sum_{j=1}^n \mu_j h_j)$

4. Empirical study

4.1 Overview of research area

Baibuting district is located in Jiangan District in Wuhan city. There are nearly 9000 units of affordable housing and 2000 household. The district has complete public facilities, various industry function, great development room. In the district and surrounding area there are 12 traffic sites including 10 bus stops and 2 light rail stations named Xinrong, Danshuichi. 17 main roads and second level roads cover the area such as Jiefang road, Hanhuang road, Anju road and so on. 80 public green rooms distributed in the area. It has 48 public facilities including 13 hospitals, 8 schools and nurseries, 27 all kinds of shopping malls and 27 supermarkets, 12 industrial and

commercial blocks.

4.2 Technology route

The paper collected land use status map, urban plan map and other concerning basic data, then extract all the layers of affordable housing location decision factors and reclassified. Finally, the study construct rationality evaluation model of affordable housing site by multi-factors comprehensive assessment method, combing AHP and entropy coefficient weight method, based on GIS platform, to calculate the evaluation results. The specific technical roadmap is Figure 1.

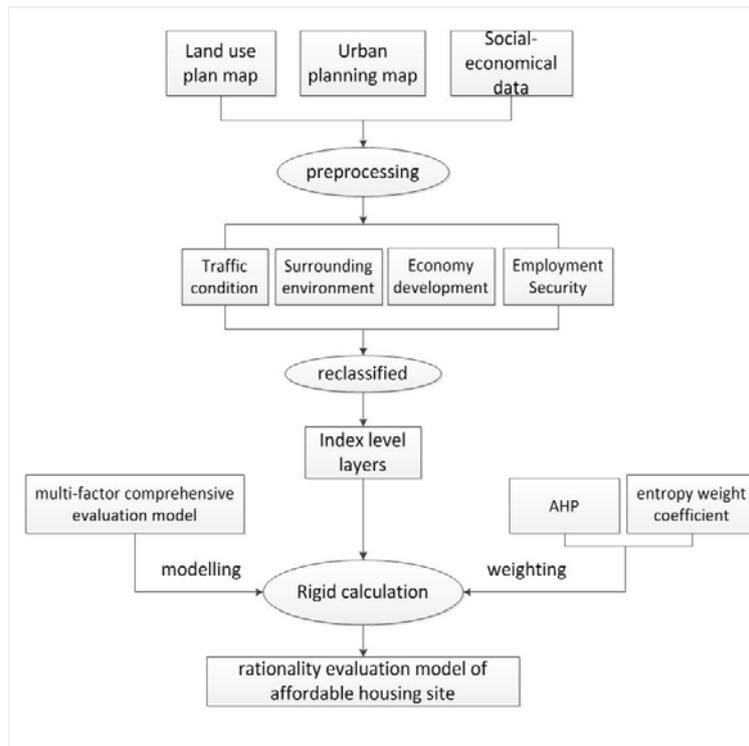


Fig.1 Technology roadmap

4.3 Data preprocessing

The study collect all sorts of basic data such as land use plan map, urban plan map and so on, and extract layers of elements, then reclassified raster attribute value. According to the set standard, the raster maps were special analyzed. In order to calculate the composite score, each index was re-scored according to a serious of influence radius. For instance, the citizen need about 8 minutes (384 meters) to reach bus stop, or 15 minutes (720 meters) to subway station. The distance that the railway noise (30-50 DB) does not disturb people’s sleep is outside of 100 meters. Trunk road network density (radius of 300 meters), green density and the density of public services are more dense locations as possible. Except the railway noise and surrounding land use type, the others were divided into 7 categories by equal distance. The optimal site selection criteria

given new value(a more suitable site for affordable housing, the corresponding index is greater), and all various of factors reclassified diagram by GIS (Table 2 and Figure 2).

Tab.2 Classification of the factors re-assignment

Item	Reclassified value range
bus stop distribution	0-5
subway station distribution	0-5
density of main road	0-5
density of public facilities	1-6
density of green land	1-6
distance level of commercial block	0-5
distance level of industrial block	1-6
railway noise influence distance level	-3-0
surrounding land type and level	1-7

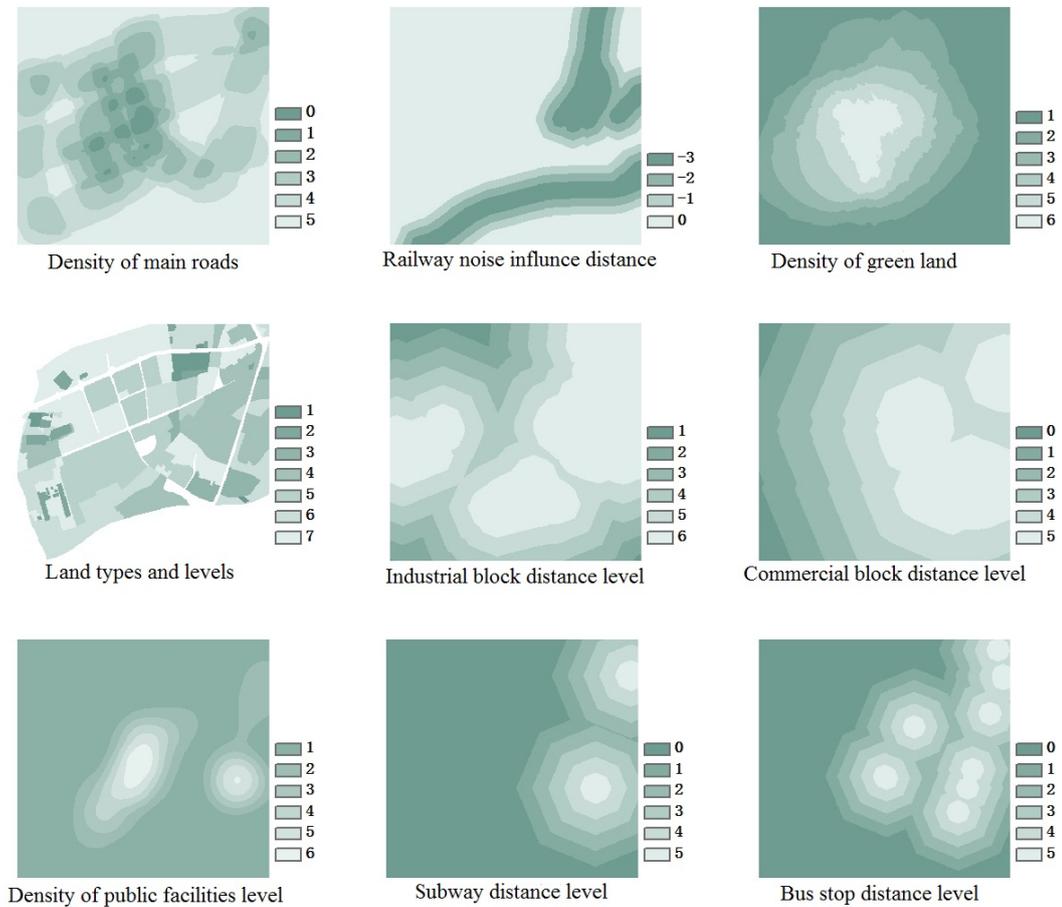


Fig.2 Map of the reclassification appropriate level

4.4 Spatial analysis

4.4.1 Index weighting

According to the mentioned comprehensive weighting law, the weight of judgement matrix by AHP is corrected through entropy weight coefficient method, the blow comprehensive index weight (Table 3)

Tab. 3 Entropy, adjusted for differences in the weight

	AHP				
	original weight	$\sum_{i=1}^m Y_{ij} \ln(Y_{ij})$	e_j	g_j	w_j
close to bus stop	0.1132	-0.7239	0.3720	0.6280	0.1163
close to subway station	0.0856	-0.6148	0.3160	0.6840	0.0925
green centralization	0.0838	-0.6202	0.3187	0.6813	0.0776
low land cost	0.1818	-0.9288	0.4773	0.5227	0.1867
close to industrial and commercial block	0.1556	-0.8705	0.4474	0.5526	0.1616
close to public facilities centralization	0.175	-0.9188	0.4722	0.5278	0.1634
far from the railway line	0.205	-0.9652	0.4960	0.5040	0.2018

4.4.2 Grid computing

This paper utilizes the distance mapping function, density mapping function, data re-classification function, raster calculator to evaluate reasonableness of affordable housing space site. Spatial modeling is a better one of solution of the space problem. Model is the expression of the real world and mainly divided into two categories, A is the model used to express the views of the object called the characterization model. B is used to simulate landscape process model called process model. In geographic information system characterization model is created by a set of data layers, such as buildings, rivers or forests, the process model attempts to describe the mutual effect, each spatial analysis operations and functions can be regarded as a process model^[8]. The affordable housing location evaluation model integrated characterization and process model. The model design can be seen in following steps.

- (1) The problem description: what the mission's goal;
- (2) The decomposition of the problem: In order to achieve the ultimate goal , which sub-goals and what kind of data sets need to be designed ;
- (3) The analysis of the data set: which attributes, content and relationships were contained in data set;
- (4) Perform the analysis: Consider a single model will be implemented and used to establish

the overall model where several analysis tools;

(5) Test model results: whether there is a need to modify the overall standard model, if so, then go back ;

(6) Application of analytical results

According to the evaluation model, the paper extract and visualize the feature layer, then we implement straight line distance (Sld) or density (Den) analysis to get the raster data (Grd), we reclassified (Rec) the data then were computed in grid calculator after weight (W) the raster data, to get the evaluation result. The specific process showed in Figure 3.

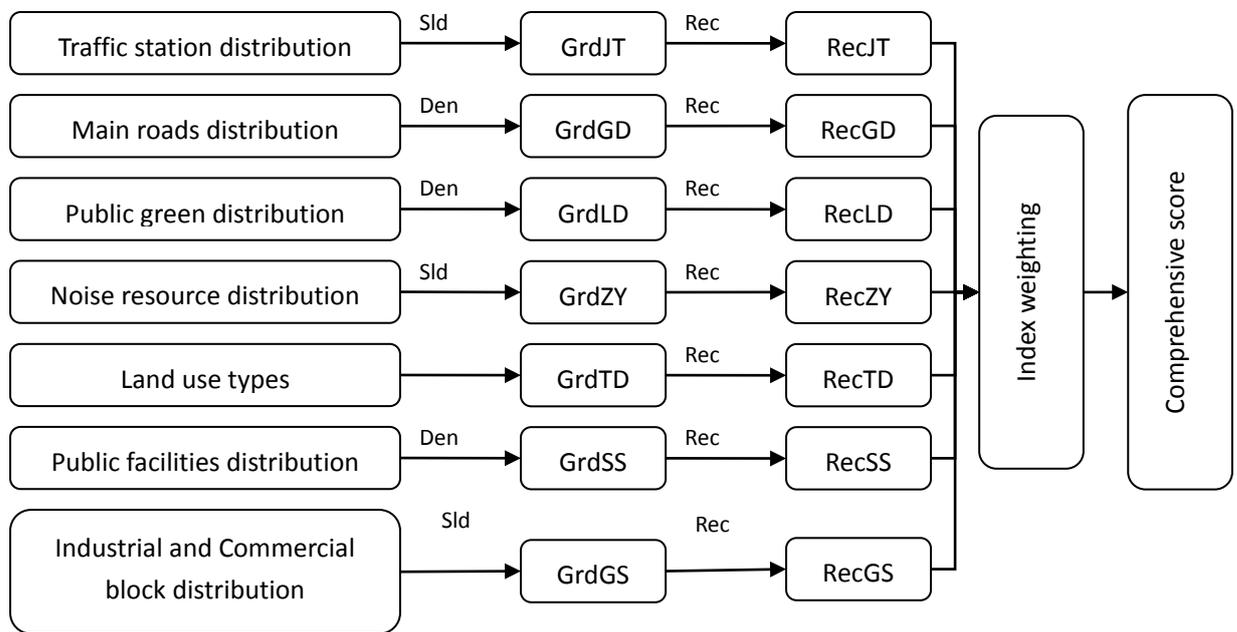


Fig. 3 Raster calculation flow chart

It is showed that the location higher score is more suitable for the affordable housing site, And vice versa. In diagram, the highest score of the white areas is 4.29, the lowest score is 1.08.

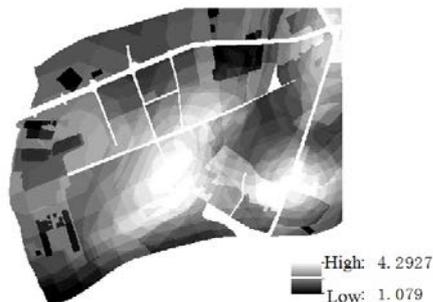


Fig. 4 Composite score map

4.5 The evaluation results

The results are divided into 5 levels, and generate the level distribution diagram of affordable housing location rationality (Figure 5). From the analysis results, the fifth level area covered the west of Baibuting Garden road, south of Anjuxi road, east of Yikang road, and in the area there is more convenient traffic, all kinds of public facilities, sufficient employment, beautiful environment, a amount of reserved land, which is suitable for affordable housing and city redevelopment by government. In forth level area mainly include the outside of the fifth grade, also have better suitable conditions. However, in first and second level areas, because the areas do not meet the demand on evaluation, are not suitable for the affordable housing.

The Baibuting district, located in center of the fifth level, is most suitable for affordable housing area. In actual research study it is showed that the convenient traffic condition, high quality of economic and commercial service facilities in the area, so that the district was named national model for the community for many years, even was visited by national leader, which also reflects the actual residents coincide.



Fig. 5 Distribution of spatial location suitable level

5. Epilogue

Affordable housing space siting concerns the vital interests of the masses, also is one of China's housing reform policy implementation, so spatial location decision factor analysis is very important. According to China's affordable housing space siting characteristics, the paper established spatial location and reasonable evaluation model and supply a reasonable evaluation ideas in order to solve the spatial location of affordable housing and other issues. Taking into account the characteristics of the principle of reality and needs of affordable housing, affordable

housing sites should be integrated land use planning, urban planning and layout of the residential communities conducted by the overall analysis of the surrounding traffic, the environment, employment, public service facilities elements location decisions, improve affordable housing siting decision quality. However, many complex factors can impact affordable housing space siting, so we select evaluation index according to specific issues. And how does the researcher build a more comprehensive and applicable site evaluation criteria, which is still a problem to be studied.

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