The application of MATLAB-based analytic hierarchy process in Hainan residential quarter function factor evaluation

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Abstract. Since being designated as an international tourist island, Hainan has become an overwhelmingly favored choice of real estate investment. This paper first constructed Hainan residential quarter function factor index system, then evaluated relevant factors, and finally solved the problem of factor importance ranking. In this specific case, the software MATLAB was used to facilitate AHP calculation. The evaluation results have guiding and referential value to both real estate developers and residential consumers.

1. Introduction

As an integral part of modern people's life, house is characterized as an investment with high values, high returns as well as high risks. In recent years, the real estate development boom in Hainan has overwhelmed. Hainan has changed a lot since it was rated as an international tourist island. As a base for leisure and health，Hainan market attracts developers and capital investment. However, now that the real estate development is highly-invested, highly-risky and highly-technological, the failure of the decision-making is sure to cause a huge waste of national and enterprise resources and even social wealth. At present, the function-cost analysis is based on the experiences of researchers which are susceptible to such influencing factors as personal knowledge and judgment. Therefore, it is necessary that the advanced decisive ideas to be introduced, and the residential quarter evalu ation system be established for a better function-cost factor analysis, a more accurate decision and a reduction of property market risks.

2. Function factor index system of Hainan residential quarters

Hainan province, located at the north edge of the tropics, is an island with mountains and plateaus surrounded by sea. With a monsoon climate, its average temperature is 22-26 °C and is vulnerable to typhoons. As to a function factor index system, the residential quarter is expected to meet not only the living but also the social and environmental needs. Specific to Hainan, the index system is briefly classified into six parts, of which the living condition is the most basic index while the living taste functions as the index for living improvement. Currently, residents have a stronger awareness of privacy and emphasize the communication with others, so it is necessary to consider the facilities within the community. Hainan is a tourism-oriented province with a good ecological environment where people have naturally higher demands for residential greening, so the environment should be included in the evaluation system as well. Furthermore, a large proportion of urban residents are the elderly and the young who have relatively higher requirements for the infrastructure and life services. Considering all the above, we built Hainan residential quarter function factor index system as shown in Table 1.

TABLE 1. Function factor index system for residential quarters in Hainan.

First level indexes	Second level indexes	First level indexes	Second level indexes
Living conditions	Building quality	Living taste	Indoor decoration
	Type design		Public place decoration
	Equipment and facilities		Humanistic environment
Residential environment	Greening	Living services	Shopping conditions
	Vegetation growth		Education and medical service
	Landscape		Fitness and Recreation
	Square		Property Management
Infrastructure	Water supply and drainage	Facilities	Security
	Power supply		Management and Monitoring
	Gas supply		Information Network
	Road		
	Parking space		

3. The application of AHP and MATLAB

3.1 Introduction of AHP

The Analytic Hierarchy Process (AHP) is a systematic analytic method proposed in the 1970s by Professor A. L. Saaty of the University of Pittsburgh, U.S.A. As a qualitative and quantitative multi-objective technology for decision analysis, it simulates human decision-making and helps solve complex problems. The basic principle is to break the complex problem into several levels, the decision-makers or experts give scores through pair-wise comparison of the respective importance of each level, to construct the judgment matrix with the scores gained, to figure out the feature vectors to ensure the next-level index's contribution, and to finally achieve the importance ranking results. The general steps are as follow:

(1) Establish the hierarchical structure of the model.

(2) Construct the judgment matrix. On the basis of questionnaires, the scaling method of 1-9 and their multiplicative inverses is used to give pair-wise scores for the identification of ranking differences. The specific meaning of the scale is shown in Table 2.

TABLE 2. The meaning of the 1-9 scale.

Scale a_{ij}	Meaning
1	Factor i and factors j are equally important
3	Factor i is slightly important than the j factor
5	Factor i is more important than factor j
7	Factor i is much more important than factor j
9	Factor i is absolutely important than factor j
2、4、6、8	In-between states
Multiplicative inverses	If factor j is compared with factor i, the result is $1/a_{ij}$

(3) Rank the relative weights and levels of each function index, and have the consistency test. Firstly, the matrix is regulated and the factors in every vertical line are added up. Secondly, regulate again to get the feature vector, calculate the maximum feature root E to get the value of the consistency test $CI=(E-n)/(n-1)$. Finally, have the consistency test with the CR value. If $CR=CI/RI＜0.1$, the matrix consistency is considered acceptable. If not, the matrix is supposed to be corrected.

(4) Sort an importance order for the general goal factors. Sum up all the multiplication results of the general goal factor weight vectors and respective sub-factor weight vectors. And then, sum up the multiplication results of the general goal factor weight vectors and the random consistency index. The consistency index RI is obtained by the division of the former summation by the latter one. When the $RI≤0.1$, the ranking consistency is satisfactory.

3.2 MATLAB for AHP computing
MATLAB (Matrix Laboratory) has been selected as the analytical tools in this study in that the software offers a good working platform, a pleasant programming environment, and an easy-to-use programming language. Specifically, the latest version of MATLAB R2011b is used.

There are three computing steps:

(1)AHP programming. Firstly, go to user interface, fill in the index matrix values of various levels, then a comparative matrix for the function factor index system will be naturally formed; calculate for the weight vectors and the maximum feature values at all levels; and lastly have consistency test and judge the acceptability of the matrix.

(2)When in real practice, the software default window is used. In this case, fill AHP program into the Command window and press "Enter" to run the program.

(3) Fill the function factor index system and feature values in the format of [a b c; d e f] and press "Enter" to get the corresponding weight vectors and the maximum feature values.

4. AHP analysis of Hainan residential quarter function factors

4.1 Operation
⑴On the basis of the questionnaires and the newly-built function factor index system, we get the function weight table of Hainan residential quarters and construct judgment matrix. (For space limitation, this process is omitted)

(2)Calculate the weight vectors of every index as well as the maximum feature values, and then give the consistency test. The test results are shown in Table 3.

TABLE 3. Hainan residential quarter function weight table.

First level indexes	Weight vectors	Maximum feature values	Matrix consistency	Second level indexes	Weight vectors	Maximum feature values	Matrix consistency
Living conditions	0.4481			Building quality	0.6370	3.0385	acceptable
				Type design	0.2583		
				Equipment and Facilities	0.1047		
Living taste	0.0549			Indoor decoration	0.7143	3	acceptable
				public place decoration	0.1429		
				Humanistic environment	0.1429		
Residential environment	0.2181			Greening	0.2778	4.0458	acceptable
				Vegetation growth	0.3659		
				Landscape	0.2326		
				Square	0.1238		
Living services	0.1088	6.4681	acceptable	Shopping conditions	0.1759	4.0658	acceptable
				Education and medical services	0.2888		
				Fitness and Recreation	0.0591		
				Property Management	0.4762		
Infrastructure	0.1469			Water supply and Drainage	0.1829	5.2916	acceptable
				Power supply	0.6037		
				Gas supply	0.0439		
				Road	0.0847		
				Parking space	0.0847		
Facilities	0.0233			Security	0.5591	3.0536	acceptable
				Management and Monitoring	0.0887		
				Information Network	0.3522		

(3)Rank the general goal factors according to their respective importance. The results are shown in Table 4.

TABLE 4. Hainan residential quarter function ranking.

	Living conditions	Living taste	Residential environment	Living services	Infrastructure	Facilities	Weight values	Ranking
	0.4481	0.0549	0.2181	0.1088	0.1469	0.0233		
Building quality	0.6370						0.2854	1
Type design	0.2583						0.1157	4
Equipment and facilities	0.1047						0.0469	10
Indoor decoration		0.7143					0.0392	11
Public place decoration		0.1429					0.0157	16
Humanistic environment		0.1429					0.0157	17
Greening			0.2778				0.0606	7
Vegetation growth			0.3659				0.0798	6
Landscape			0.2326				0.0507	9
Square			0.1238				0.0270	13
Shopping conditions				0.1759			0.0191	15
Education and Medical services				0.2888			0.0314	12
Fitness and Recreation				0.0591			0.0064	21
Property Management				0.4762			0.0518	8
Water supply and drainage					0.1829		0.0269	14
Power supply					0.6037		0.0887	5
Gas supply					0.0439		0.0065	20
Road					0.0847		0.1244	2
Parking space					0.0847		0.1244	3
Security						0.5591	0.0130	18
Management and Monitoring						0.0887	0.0021	22
Information network						0.3522	0.0082	19
$\sum a_j \cdot CI$	0.0086	0	0.0033	0.0024	0.0107	0.0006		
$\sum a_j \cdot RI$	0.2599	0	0.1963	0.0979	0.1645	0.0135		

(4)Test the ranking consistency.

$$RI = \frac{0.0086 + 0 + 0.0033 + 0.0024 + 0.0107 + 0.0006}{0.2599 + 0 + 0.1963 + 0.0979 + 0.1645 + 0.0135} = 0.035 \le 0.1$$

It can be safely concluded that the consistency is satisfactory.

4.2 Result Analysis

The above research shows that the building quality, road, parking space, type design and power supply are the five factors people most concern in Hainan house consumption, among which the building quality is always the key index. Considering the Hainan's humidity, a good building quality is the guarantee for long service life. With the improvement of living standards in Hainan, automobile has become the common means of transportation, so people have special requirements for roads and parking services. Additionally, interior design and power supply are factors currently concerned, since interior design affects sunlight and ventilation while power supply ensures the convenience of life. By contrast, the fitness and recreation facilities as well as the management and monitoring are minor factors. Real estate developers are suggested reducing investments in these two areas while saving money and energy for more important function factors.

5. Conclusions and prospects

Residential building is a risky investment. A scientific evaluation of residential function factors can not only help coordinate the relationship between human, nature and society, but also help reduce the resource waste and bring huge economic returns to real estate developers. This study concerns project management, computer programming and software development, and its research results provide guidance and suggestions to both developers and residents in terms of their respective investments. With the speeding construction of Hainan into an international tourist island, residential preferences consequently change, so the function factor index system is supposed to change as well. Particularly, as the aging population increases in Hainan, the "people-orientation" is more likely to become the core value of local community. It is expected that the relationship between nature and society becomes even closer, and the evaluation index system and methods that better match appear in further studies.

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