



Research Article

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AHP entropy method based satisfaction evaluation of rural residence energy saving transformation

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ABSTRACT

In this paper, a three-level index system of residents' satisfaction evaluation of Beijing Yanqing rural residence is built through research and field survey on literatures related to building energy saving, and the weight of each index in the residents' satisfaction index system is obtained by use of AHP entropy method, and the residents' satisfaction is analyzed. Finally, corresponding recommendations are put forward according to the status of residents' satisfaction.

Key words: Rural residential areas; Energy saving transformation; Satisfaction; AHP; Entropy method

INTRODUCTION

Satisfaction index is a new quality index system enthusiastically researched and promoted in many countries and identified as a new trend and thinking of quality management development process after quality inspection management, statistical quality control, and total quality management. Residential customers' satisfaction is the main issue researched in living environment. Monigomery and Johansson (1988) consider that the satisfaction of living conditions correlates to the residential customers' satisfaction. Galster and Hasser(1987;1981) present that the residential customers' satisfaction is exactly the difference between the practical situation of residence and the expected residence[1]. Pickles and Davies (1991), Gober(1992), kendig(1984) put forward that the changes in living are likely to cause the changes of residence demand and expectation. Baldassare (1986) considers that the residential customers' satisfaction is the subjective perception of residents on their living environment. Surveyed from the operability, residential customers' satisfaction covers many aspects [3]. Canter (1983) and Amerigo (2002) emphasize the three aspects of neighborhood relationship evaluation, i.e. space (building and urban planning characteristics), person (social relationship characteristics) and function (service and facilities) [4]. From the above research we can find that the residential customers' satisfaction mainly correlates to the residence size, residence quality, neighborhood relationship and location characteristic, etc.

For rural residence transformation, the existing rural residences are transformed or reconstructed to improve the rural living environment and peasants' living quality and reduce the energy consumption. The transformation items mainly include roof, outer wall, floor, doors and windows, and heating system and cooking system. The transformation methods mainly include reconstruction and renovation. In transformation method, energy-saving materials and insulation materials are mainly used. The research of building energy saving mainly includes energy-saving technology and energy-saving evaluation. The research of building energy-saving technology mainly includes building design and the application of energy-saving materials. In building design, it mainly includes lighting and ventilation design and renewable energy design, e.g. G.Z.Brown, Kark, Dekay (2001) use the natural ventilation design to maintain the comfortable indoor living conditions and create a favorable human settlement [5]. From the angle of solar energy utilization, BU Yaming (2006) analyzed the theory of solar heating system and the computing method of optimum solar fraction [6], and carried out dynamic heating load calculation and analysis to a

small-town residence building in Baoding [7]. The energy-saving materials mainly include new type brick material, building block material and new type insulation material, e.g. Gulseren Baran, Ahmet Sari (2003) point out that the PCM (phase-change material) is used for building envelope, with the features of automatic thermoregulation, “peak clipping and valley filling (offset compensation)”, “temperature peak lagging”, etc, which can effectively reduce the mismatch between energy supply and energy demand in time and speed [8].

The research of building energy saving evaluation mainly includes economic benefit assessment, environmental impact assessment, social impact assessment and energy consumption assessment. As early as 1990, the researchers from Building Research Establishment and some private sectors jointly set out environmental assessment method of Building Research Establishment to provide authoritative guidance to the construction of energy saving building to reduce the adverse effect of building on the global and regional environment [9]. By October, 2000, 19 countries participated in the Green Building Challenge launched and led by Natural Resources Canada to jointly set out scientific and feasible assessment method to evaluate the environmental impact of building [10]. In 1995, an evaluation standard called as Leadership in Energy& Environmental Design (LEED) is formulated by US Green Building Council (USGBC) to meet the requirement assessed by US building market on the green building and improve the operability and economic characteristics of environmental evaluation of energy-saving building; soon afterwards, in March, 2000, its 2.0 edition is published [11]. On March 7, 2006, the Ministry of Construction and General Administration of Quality Supervision, Inspection and Quarantine of the People’s Republic of China jointly published Green Building Assessing Standard (GB/T 50378-2006) which came into effect nationally as of June 1, 2006. The standard is quantified from five aspects, i.e. community environmental planning design, energy and environment, indoor environmental quality, community water environment, materials and resources [12].

This paper is designed to analyze Beijing rural residence transformation, energy use and residents living satisfaction and explore the relation between rural residence transformation and energy use and the satisfaction of transformation effect, and the satisfaction is mainly reflected from housing condition, surroundings, energy use and government policy.

SATISFACTION EVALUATION INDEX SYSTEM OF RURAL RESIDENCE ENERGY SAVING TRANSFORMATION

The object of this search is the residents in the residence transformation. In order to deeply analyze the satisfaction of Yanqing residence transformation, this survey adopts the form of filling in the questionnaire on site. Residents’ satisfaction evaluation index system consists of cause and result. Residents’ satisfaction evaluation mainly assesses the cause of affecting the satisfaction degree, and the index system is classified into 3 layers and 4 parts, i.e. housing condition satisfaction, surroundings satisfaction, energy use satisfaction and government policy satisfaction, as shown in Table 1:

Table 1 Residents’ satisfaction index system

One-level index	Two-level index	Three-level index	Index meanings
Satisfaction of rural residence energy saving transformation	Housing condition	Geographical location	Comfort level of living and work
		Housing quality	Housing construction quality
		Building structure and layout	Aesthetics and comfort level of housing design
		Heating feeling	Comfort level of indoor temperature in winter
		Indoor temperature	Satisfaction degree of indoor temperature in winter after transformation
		Indoor air quality	Acceptance level of indoor air quality
	Surroundings	Sanitary degree of surroundings	Acceptance level of surroundings
		Air quality of surroundings	Acceptance level of surrounding air quality
		Village communal facilities	Complete degree of village communal facilities
	Energy use	Heating facilities	Satisfaction degree of heating facilities
		Heating expense	Acceptance level of heating expense
		Electric charge	Acceptance level of electric charge
	Government policy	Government subsidy	Satisfaction degree of government subsidy
		Housing allocation	Satisfaction degree of housing allocation
		Self-pay expense for transformation	Acceptance level of self-pay expense for transformation
		Transformation method	Satisfaction degree of transformation method

SATISFACTION EVALUATION MODEL FOR RURAL RESIDENCE ENERGY SAVING TRANSFORMATION

In order to make the weight of this paper scientific as far as possible, this paper adopts the combined method of subjective weighting method and objective weighting method to weigh the index. The subjective weighting method can fully mobilize individual knowledge system and experience, and the objective weighting method can fully use the objective information of sample. The subjective weighting method adopts AHP method and the objective

weighting method adopts entropy method.

AHP (ANALYTIC HIERARCHY PROCESS)

AHP (Analytical Hierarchy Process) is a systemic analysis method combined qualitative analysis and quantitative analysis. The basic thinking and basic principle of problem solving: firstly, systematically make a hierarchy to the problems to be solved, i.e. decompose the problems into different components according to the problem characteristics and research purpose, and break up the problems into different hierarchies according to the mutual effect and affiliation of various parts to form a stepped and ordered hierarchical model. Afterwards, quantitatively express the relative importance of element or index of each layer in the model according to judgment of people on objective reality, and then determine the weight of the order of relative importance of all factors of each layer through mathematical method. Finally, calculate the weight of relative importance of each factor according to aggregative indicator, and obtain the combination weight of the order of relative importance of the lowest layer (scheme layer) corresponding to the highest layer (general objective), with which as the basis of evaluating and selecting the scheme [13].

ENTROPY METHOD

Entropy method is a method of dispersing the weight of information amount. Based on the explanation of basic principle of information theory, information is a measurement for the order degree of system, and entropy is a measurement of disorder degree of system; if the less the information entropy of index, the larger the information amount of this index, the effect in comprehensive assessment should be larger and the weight should be higher. The nature of entropy method is still the measurement of dispersion degree of each sample index. The larger the dispersion degree, the less the entropy, and the larger the entropy weight, the larger the difference of index between each sample. The main steps are shown as follows:

Step 1, confirm the evaluation object, establish evaluation index system and build index evaluation matrix R.

$$R = (r_{ij}')_{m \times n} \quad (1)$$

Step 2, standardize the index evaluation matrix R. When j is forward index,

$$r_{ij} = \frac{r_{ij}' - \text{Min}(r_{ij}')}{\text{Max}(r_{ij}') - \text{Min}(r_{ij}')} \quad (2)$$

When j is inverse index,

$$r_{ij} = \frac{\text{Max}(r_{ij}') - r_{ij}'}{\text{Max}(r_{ij}') - \text{Min}(r_{ij}')} \quad (3)$$

Step 3, conduct normalization processing to this matrix, i.e. take the specific value of column vector in r_{ij} matrix and the sum of all elements as the result of normalization, calculated as follows:

$$z_{ij} = \frac{r_{ij}}{\sum_{i=1}^n r_{ij}}, (j = 1, 2, \dots, m) \quad (4)$$

Step 4, calculate the entropy weight of evaluation index

$$H(x_j) = -k \sum_{i=1}^n z_{ij} \ln z_{ij}, \quad j = 1, 2, \dots, m \quad (5)$$

Of which, k is accommodation coefficient, $k = 1 / \ln n$

Step 5, change the entropy of evaluation index into weighted value

$$d_j = \frac{1 - H(x_j)}{m - \sum_{j=1}^m H(x_j)}, \quad j = 1, 2, \dots, m \quad (6)$$

Of which, $0 \leq d_j \leq 1$, $\sum_{j=1}^m d_j = 1$; here the weighted value is obtained.

PROJECT INTRODUCTION OF BEIJING YANQING RURAL RESIDENCE TRANSFORMATION

Yanqing County is located at the northwest of Beijing. It borders upon Huairou in the east, connects to Changping in the south, and borders on Hebei Huailai, Chicheng in the west and north, forming a basin embraced on three sides (north, east, south) by green hills and with the west connected to Guanting reservoir. This basin is called as Huairou-Yanqing basin, with Yanqing at the east of the basin. Yanqing County governs 15 towns and 1 town agency, 376 administrative villages, 22 communities. In 2008, the project of insulated wall is carried out in Yanqing County as a pilot project. There are 209 households in the first batch. All peasant households installed with insulated wall can be provided with over ten thousand Yuan at most as a subsidy.

Based on relevant policy spirit, preferentially arrange municipal new type rural community trial, mountainous area removal villages, county key areas and villages on both sides of main highways and around tourism areas; through scientific planning, centrally implement and comprehensively realize resource coordination. In Shuiyu Village surveyed in this project, about over 130 households move to new Shuiyu Village from former residence due to government occupation of land. It is not required to pay the decoration expense on own account after the house is built, but beside this, the government does not provide any other subsidy. With the implementation of residence transformation in rural areas, the overall satisfaction of residents in the transformation becomes more and more important to the government.

QUOTIENT SPACE THEORY AND TRAFFIC CONGESTION DETECTION

When referring to the classification, we always explicitly or implicitly determine the classification standard. Different standards will get different classification results. For a given a classification result, we can enhance or relax their corresponding classification standard conditions thereby to obtain more detailed than the original classification results or more rough division. For two classification standards given, we can do "and" computing, or "or" computing, then we can get a new classification standard, and get the new division. In other words, human beings can do appropriate adjustments to the classification according to their needs, so the problems will be solved in a complete different level. Zhang B. and Zhang L. proposed the quotient space theory of problem solving [23]. Quotient space theory for solving problems at different levels of granularity has aroused great concern of international scholars and peers, and has become one of the three important models of granular computing.

The causes of traffic congestion are very complicated. The impact factors mainly include three categories: traffic flow characteristics, such as car speed, traffic flow and share; road characteristics, such as road grade, lanes, capacity; traffic control measures, such as setting a one-way street, limiting speed, traffic signal control. To achieve the traffic congestion recognition, the above factors are indispensable. Some of the existing models cannot complete the massive, fuzzy data analysis, and some even completed but will take long computation time, so they are unable to meet the real-time traffic control requirements.

CONCLUSION

The following recommendations are put forward according to the development direction and residents ideas of the housing transformation in Shuiyu Village, Yanqing County:

Firstly, comprehensively upgrade the environmental construction and management level on the basis of the standard of cleanliness and neatness, smooth road and green village, ecological and livable place, scientific management, organizational system in place. Deeply continue to implement rural environment improvement and comprehensive improvement, and management and protection of clean-keeping should be put into practice in the areas such as both sides of village streets, village-level roads, surroundings of village, etc. Further enlarge the management and protection areas to realize the network and full coverage of rural clean-keeping; centrally build a batch of most beautiful villages in the suburb of Beijing.

Secondly, we should adhere to the principle of voluntary declaration. The peasants' residence transformation project is carried out under the guidance of government and the precondition of complete voluntariness. All the residents who are within the range of this implementation plan can put forward transformation application to their villages, and the transformation should be approved by village committee after declaration.

Finally, properly deal with the relation between government orientation and peasants. We should insist on the principle of voluntariness, and completely develop the dominant role of peasants. County and township government

is organizer and impeller, mass peasants are direct participant and constructor, and county forestry department is server and instructor. Provide more policy guidance, technical guidance, work guidance and publicity enlightenment; value the folk custom and mass intentions, select the popular tree species, adopt the supported method to meet the requirement of mass and bring benefits to the mass.

Quotient space theory and rough set theory are granular computing models, and are discussed in the framework of set theory. They regard the granularity as a subset of the problem domain. They are not mutually exclusive, but different in main focus. From the model point of view, both are described in the model of the ability of human to deal with things in different granularity. They believe that the concepts can be expressed in subsets. Different concepts of granularity can be used different sizes of subsets. All of these representations can be described by equivalence relations. Form the research object point of view, the quotient space theory and rough set theory all take the collection of objects discussed as the problem domain. When discussing the relationship between the objects, they are different. The prototype of rough set theory is probably derived through relational database abstraction, that is, use different attribute values of the elements to describe the relationship between the elements and represent different concept granularity according to the classification of different attributes. The prototype of the quotient space theory is Hierarchical method that in addition to the properties of the elements, it also introduced the relationship between the elements. In our approach, we use rough set theory to predict the traffic flow and use quotient space theory to predict the traffic congestion. The results show the effectiveness and efficiency of our methods.

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