The Construction of Low-Carbon Renewal System of **Rural Community**

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Abstract

Global climate change has been an impending cosmopolitan issue influencing human survival and development. As the basic functional unit, community is the basic space to achieve low-carbon and use sustainable idea. To cope with climate change will require substantial and sustained reductions of greenhouse gas emissions and low-carbon technology is the inevitable choice of global development. China is a large agricultural country, and the number and the average of existing rural buildings is huge so it is urgent to conduct low-carbon retrofitting of rural community and set up evaluation method of its low-carbon level to promote new rural construction. This paper proposes low-carbon renewal KPI of rural community from five aspects: layout planning, traffic and road, architecture planning and design, environment engineering and municipal engineering. Than we build an performance evaluation system of low-carbon renewal system for rural community renewal in china. The system will be used to indicate low-carbon degree for rural community renewal. Finally, the paper selects a rural community in Hubei Province as a case for practice.

Keywords: climate change; low-carbon; rural community ; KPI

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Introduction

Global climate change has been an impending cosmopolitan issue, and leads to a whole new batch of problems which seriously threaten the living environment and health of humans. Countries around the world have realized a high degree of unification on controlling the emission of carbon discharge as the effective measures and method towards slowing up the climate change[1][2]. The Fifth Assessment Report (AR5) of IPCC argues that more than half of the observed increase in global average surface temperature since the 1950s was caused by the human influence. Based on the CMIPS models, it is projected that global warming will continue. Relative to 1986-2005, the global mean surface temperature by the end of the 21st century will increase by 0.3-4.8℃. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions and low-carbon technology is the inevitable choice of global development.

The number and the average of existing rural buildings in China is huge. Statistics show that rural people has reached nearly 0.618 billion, accouting for 45.23% of the whole until 2014. The overall gross area is 27.8 billion square metres and most of them don't use low-carbon technology. As the development of rural economy and the improvement of people's life quality, the energy demand for rural community increases rapidly. Existing rural community waste resources and destroy the environment, which also could hardly meet the strong demand for living function and quality of existing rural community. So it is urgent to conduct low-carbon retrofitting of rural community and set up evaluation method of its low-carbon level to promote new rural construction. With the widely spread of the concept of low-carbon, low-carbon community has become a new model of rural development in China and the construction low-carbon renewal system of rural community in China of has attracted many scholars. Research in this field mainly concentrated in the design of evaluation method and choosing of index system[3]-[7]. However, the above research mainly focused on low-carbon urban community while low-carbon renewal on rural community is less involved. Furthermore, they ignore the differences between the community and use the same set of index system to evaluate different communities. The evaluation results are not comparable and it's also hard to find a set of complete index system to evaluate all communities. Faced with the problem, we built an evaluation index system for low-carbon community renewal for rural community in china.

Analysis of the Low-carbon Renewal KPI of Rural Community

Key Performance Indicators (KPI) of Low-carbon Renewal of Rural Community

Low-carbon Rural community emphasizes on carbon emission reduction and carbon sink extension. It demands compact space planning , flexible traffic system , low energy consumption buildings, livable community environment ,higher energy use efficiency, perfect municipal facilities , low-carbon and environmental protection consciousness as well as effective public participation ability[8]-[10]. According to “Technical Guideline for Low-carbon Community Planning ” involved in project of “National Science and Technology Support Program for the 12th Five-year Plan of China” compiled by us, the practice of low-carbon Rural community has some of the following aspects.

(1) layout planning
As the basis of low-carbon community planning, layout planning should involve a comprehensive investigation and consulting about the details of the community and the surrounding environment facilities. The content of layout planning involves community site selection, overall layout and Land layout.

(2) traffic and road
Traffic carbon emission is one of the main carbon sources of community. To build low-carbon traffic system is a main measures of reducing energy consumption and carbon emissions. The content of traffic planning involves road network system and traffic system.

(3) architecture planning and design
Building is the biggest carbon source of community. Low-carbon buildings need to save resources, protect the environment and reduce pollution, and can also provide people with health, applicable and efficient space. The content of architecture planning and design involves architecture layout, form and structure ,energy and equipment.

(4) environmental engineering
Feasible environment planning is a precondition for residents to enjoy a better life and could promote the harmony of nature. The content of environment planning involves community water environment, garbage disposal and community greening system.

(5) municipal engineering
As part of the government-led public service system and also the foundation of community construction operations management, community municipal engineering has an important position in the construction of low-carbon community. The content of municipal engineering planning involves water supply engineering, water sewerage engineering and energy system.

Structure model of KPI based on ANP

The relationships between Key Performance Indicators (KPI) of Low-carbon Renewal of Rural Community are expressed by the Tab.1. The last side of the table column identifies the corresponding influence index of the secondary index.

Tab.1 The relevance among KPI

indicator	first grade indicator	second level evaluation index	influence index
	layout planning U1	community site selection U11	U12,U13,U21,U22,U41,U42,U51,U52, U53
		overall layout U12	U11,U13,U21,U22,U31,U43,U44,U51, U52,U53
		Land layout U13	U11,U12,U21,U31
	traffic and road U2	road network system U21	U12,U13,U22,U31
		traffic system U22	U11,U12,U21,U31
	architecture planning and design U3	architecture layout U31	U11,U21,U13,U21,U22,U43,U44
		form and structure U32	U11,U31
		energy and equipment U33	U11,U31
	environmental engineering U4	community water environment U41	U42,U43,U44,U52,U53
		garbage disposalU42	U12,U22
		community greening system U43	U11,U12,U21,U33,U44
	municipal engineering U5	energy system U51	U11,U31
		water sewerage engineering U52	U11,U21,U31,U51,U53
		water supply engineering U53	U11,U21,U31,U51,U52

Considering low-carbon community system has high complexity, and some factors have influence on others, we use Analytic Network Process(ANP) to analyze influence and feedback inside. This method can help to raise the scientific of the low-carbon evaluation system. Based on the relevance among KPI the In table 1， we use Super Decisions (SD) Software to construct ANP structure model of low-carbon community, shown in Fig.1.

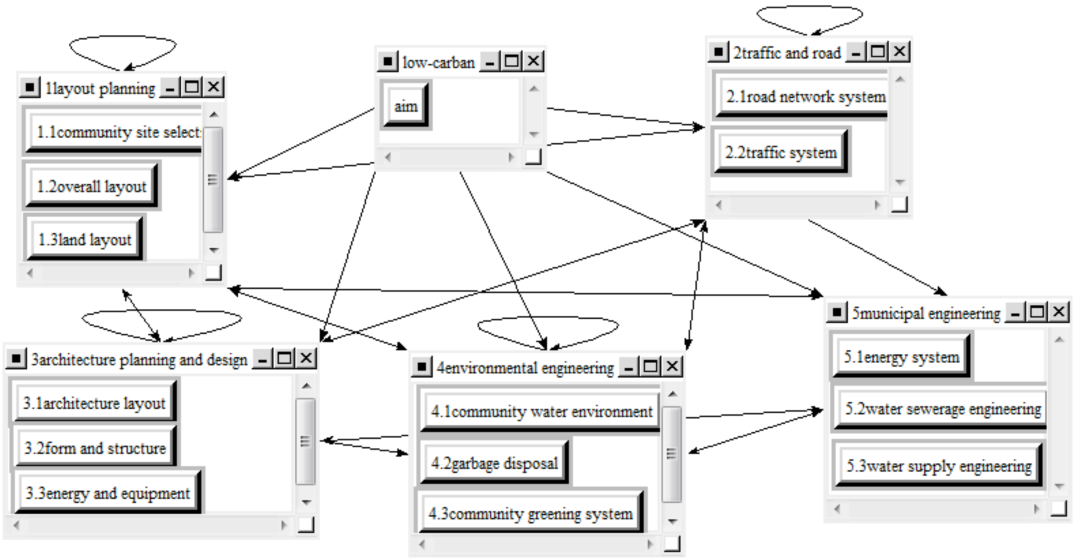
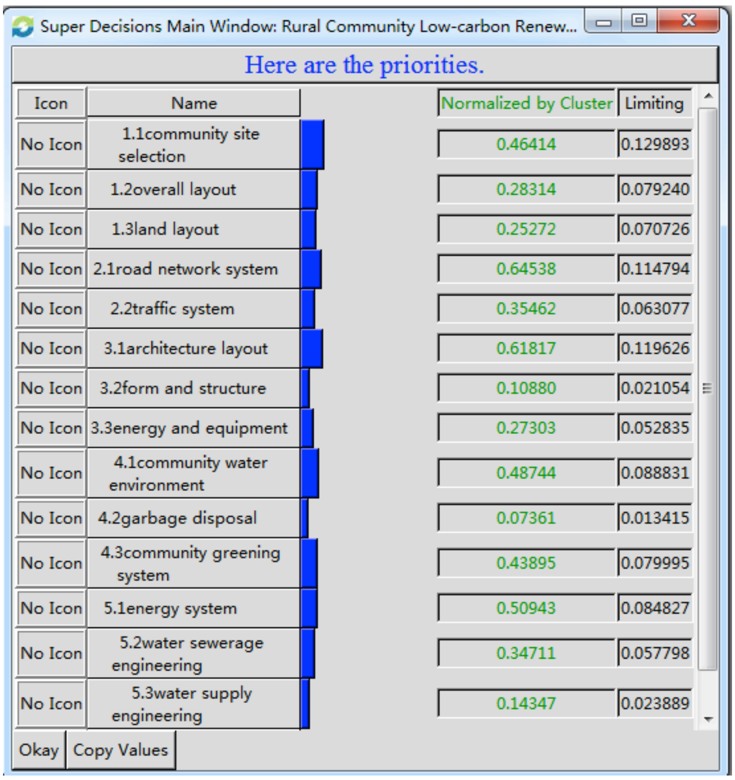


Fig.1 Structure model of index system based on ANP

After construction of the ANP structure model, we invited four experts who have taken part in the community's planning and design to do cluster comparison and node comparison and put the average data into Super Decision software. The software can automatically generated Unweighted Super Matrix, weighted Super Matrix, Limit Matrix and Cluster Matrix which can infer the weight of each index. Results of node weights which are shown in Fig.2.


Super Decisions Main Window: Rural Community Low-carbon Renew...

Here are the priorities.

Icon	Name	Normalized by Cluster	Limiting
No Icon	1.1community site selection	0.46414	0.129893
No Icon	1.2overall layout	0.28314	0.079240
No Icon	1.3land layout	0.25272	0.070726
No Icon	2.1road network system	0.64538	0.114794
No Icon	2.2traffic system	0.35462	0.063077
No Icon	3.1architecture layout	0.61817	0.119626
No Icon	3.2form and structure	0.10880	0.021054
No Icon	3.3energy and equipment	0.27303	0.052835
No Icon	4.1community water environment	0.48744	0.088831
No Icon	4.2garbage disposal	0.07361	0.013415
No Icon	4.3community greening system	0.43895	0.079995
No Icon	5.1energy system	0.50943	0.084827
No Icon	5.2water sewerage engineering	0.34711	0.057798
No Icon	5.3water supply engineering	0.14347	0.023889

Okay | Copy Values

Fig.2 Results of node weights in SD Software

Performance Evaluation of Rural Community Low-carbon Renewal

The procedures of fuzzy synthetic evaluation

This thesis, based on fuzzy mathematics theory, applies the method of fuzzy comprehensive evaluation into the Performance evaluation of the Rural Community. When Carrying out the method of fuzzy comprehensive evaluation, what is important is to establish the assessment factors system and to define the relative weights and we use ANP structure model to get the weight.

The procedures of fuzzy synthetic evaluation approach are as follows:

(1)Determine the set of basic criteria/factors $C = \{c_1, c_2, .., c_m\}$, where m is the number of criteria.
(2)Determine the set of grade alternatives $E = \{e_1, e_2, \ldots, e_n\}$, where n is the number of alternatives. For example, e_1 = very low; e_2 = low; e_3 x= mod erate; e_4 = high; and e_5 = very high. Grades will be given for each alternative, such as 1 = very low; 2 = low; 3 = moderate; 4 = high; and 5 = very high.
(3)Determine weight for each criterion/factor $W = \{w_1, w_2, \ldots, w_m\}$. The weight of each criterion can be obtained by various approaches, for example, ANP used in this paper, expert scoring, etc.
(4)For each criterion, an evaluation is a fuzzy subset of grade set, whose membership function can be established by the risk assessment group.

The procedures of Performance Evaluation

(1)establish the evaluation set
As for low carbon community, we can establish evaluation set for low-carbon degree C = {c1, c2, c3, c4 ,c5} = { high, relatively high, moderate, relatively low, low }.

(2)Determine the single factor fuzzy evaluation matrix
We selected 10 experts in the field of low-carbon and judge the second level evaluation index respectively. Single Factor fuzzy evaluation matrix could be got by statistics.

$$U(x_i) = \begin{Bmatrix} u_{11} & u_{12} & u_{13} & u_{14} \\ u_{21} & u_{22} & u_{23} & u_{24} \\ \vdots & \vdots & \vdots & \vdots \\ u_{n1} & u_{n2} & u_{n3} & u_{nn} \end{Bmatrix}$$

x_i means first level indicators, u_{nn}means the degree of membership about the second level evaluation index towards evaluation set.

(3) Single factor fuzzy evaluation

We can reach the score of Single factor fuzzy evaluation by the following formula.

$$B_i = W_i * U(x_i)(i = 1,2,3,4,5)$$

w_i means the weight for each second grade indicator and $W = \{w_1, w_2, \ldots, w_m\}$ is generated by the SD software.

$$U = \begin{bmatrix} B_1 & B_2 & B_3 & B_4 & B_5 \end{bmatrix}^T$$

(4) Fuzzy comprehensive evaluation

We use the formula of B = W * U to Calculate fuzzy comprehensive evaluation score. W means the weight for each first grade indicator $W = \{w_1, w_2, \ldots, w_m\}$ and is also generated by the SD software.

(5) The evaluation conclusion

By the value of the elements in matrix B, We can get the conclusion of fuzzy comprehensive evaluation of the community.

Case study

Yanhe Eco-village is located in mountainous area in Xiangyan city of Hubei province, China. It has 12 million m^2 land including 7.33 million m^2 forest, 0.64 million m^2 basic farmland, 0.66 million m^2 tea garden, 0.07 million m^2 construction land 0.01 million m^2 water area and other land. We could view the community clearly from Fig.3 to Fig.6.

Fig.3 General planning of village construction

Fig.4 Architectural designing of green farmer house

Fig.5 Eco-building in yanhe new village

Fig.6 Old house renewal demonstration

We selected 10 experts in the field of low-carbon and judge the low-carbon effect in Yanhe Eco-village and the results are shown in Tab.2.

Tab.2 Statistic results for experts' opinions on low-carbon factors

first grade indicator	second level evaluation index	Expert evaluation score(low-carbon degree)				
		high	relatively high	moderate	relatively low	low
layout planning 0.279859	community site selection 0.46414	0.7	0.2	0.1	0	0
	overall layout 0.28314	0.6	0.1	0,3	0	0
	Land layout 0.25272	0.2	0.6	0.2	0	0
traffic and road 0.177871	road network system 0.64538	0.3	0.2	0.4	0.1	0
	traffic system 0.35462	0.2	0.3	0.5	0	0
architecture planning and design 0.193515	architecture layout 0.61817	0.5	0.3	0.2	0	0
	form and structure 0.10880	0.2	0.8	0	0	0
	energy and equipment 0.27303	0.1	0.4	0.4	0.1	0
environmental engineering 0.182241	community water environment 0.48744	0.2	0.6	0.2	0	0
	community greening system 0.07361	0	0.4	0	0.4	0.2
	garbage disposal 0.43895	0	0.6	0.2	0.2	0
municipal engineering 0.166514	energy system 0.50943	0.4	0.4	0.2	0	0
	water sewerage engineering 0.34711	0.3	0.7	0	0	0
	water supply engineering 0.14347	0.2	0.5	0.3	0	0

Fuzzy comprehensive evaluation:

$$B = W * U$$

$$= \begin{bmatrix} 0.279859 & 0.177871 & 0.193515 & 0.182241 & 0.166514 \end{bmatrix}$$

$$* \begin{bmatrix} 0.5453 & 0.2728 & 0.1819 & 0 & 0 \\ 0.2645 & 0.3645 & 0.3064 & 0.0645 & 0 \\ 0.3581 & 0.3817 & 0.2318 & 0.0273 & 0 \\ 0.0975 & 0.5853 & 0.1853 & 0.1172 & 0.0147 \\ 0.3366 & 0.5185 & 0.1449 & 0 & 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0.3428 & 0.4080 & 0.2084 & 0.0381 & 0.0027 \end{bmatrix}$$

$$\max(B) = \max\begin{bmatrix} 0.3428 & 0.4080 & 0.2084 & 0.0381 & 0.0027 \end{bmatrix} = 0.4080$$

Form the result of the Fuzzy comprehensive evaluation, low-carbon degree of Yanhe Eco-village can be identified based on the light of maximum subject degree and the result is relatively high.

Conclusion

The aim in construction of low-carbon renewal system of rural community in China is not only to guide the construction of low-carbon rural community but also to provide t rural community residents a harmonious, comfortable, green and healthy life. Many standards have yet to emerge and the technology in rural community renewal is still in flux and we wish to put forward a more complete KPI and performance evaluation system in the future.

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