Evaluation for Village Development Based on GRA-TOPSIS Method

Huan Shi and Lu Gan
College of Architecture and Urban-Rural Planning, Sichuan Agricultural University.
Dujiangyan 611830, P.R. China
Email: ganlu_soarpb@sicau.edu.cn.

Abstract. This paper establishes a comprehensive evaluation indication system of village development. Furthermore, the grey relation analysis (GRA) and technique for order preference by similarity to ideal solution (TOPSIS) model were combined to assess village with combinational weights. Then, 12 villages in Tibetan Region of Northwest Sichuan was verified to the validity of the model. Finally, the paper chooses central, basic and weak villages and proposes the suggestions for village development in the future. The results show that the evaluation indication system, as well as evaluation method are valid and reasonable, and it also have guiding significance for in-situ urbanization in ethnic regions.

1. Introduction
New urbanization has become a main challenge all over the developing countries in the 21st century. However, achieving sustainable development needs comprehensive consideration on their respective national conditions indeed, with the high living density in China’s urban area, in-situ urbanization is the most effective approach for sustainable development. The village as a main place for people to live and produce, which its development affects sustainable development of in-situ urbanization directly, a suitable selection of central village is receiving more and more attention. That is to say, the comprehensive evaluation of village development has become the first factor to consider of in-situ urbanization in today’s China.

With the more and more higher living density of the urban areas, in-situ urbanization is the more effective approaches indeed. Therefore, the village development affects sustainable development of in-situ urbanization directly, research focused on problems of the hollow village [1-3], the construction and development potential of central village. Geographers focus on the spatial distribution of village and the relationship between their environment, while Xie & etc [4-15] combined theoretical analysis and empirical analysis for qualitative research. They have utilized mathematical theory, statistical analysis, the central theory [5] to establish the indicators, determine the villages’ location and development potential [6-7]. At the same time, Zhang & etc. [8], uses GIS software platform to lay emphasis on study for location of the central village.

Furthermore, village development has its complexity. It relates to nature, economy, society, culture, population. J.G. kohl & etc. [9] conducted comparative studies on different type villages, emphasizing the topographic differences on village location, while M. Lugeon & etc. [10] analyzed the relationship between village location, topography and sunlight environment. At the same time, A.H. Potosyan & etc. [11] emphasized physical geographical factors are interrelated and interconnected in mountain countries, having a direct influence on distribution of population and settlements, Michael Hill [12] set up a quantifiable rural settlement location selection model.
In rural areas, achieving in-situ urbanization needs comprehensive consideration on their respective area conditions indeed. However, village development is unreasonable, due to natural conditions, historical origins, and other reasons. These problems have been greatly hindering the integration of urban and rural areas, seriously in the poor and backward ethnic areas for a long time. The aim of this paper is to propose a comprehensive evaluation indication system and use quantitative evaluation method for minority areas. GRA-TOPSIS coupling model can consider the correlation degree of the object in the shape situation, while consider the actual distance in the multi-dimensional space. FAHP and EM as two of the most commonly used models is incorporated to the model to handle the weight of indicators.

2. Indication System
China has its own characteristic urbanization road, since the village development history is different from other countries, Yang & etc. [13] studied that Chinese village distribution is influenced by traditional factors, economic development factors, the geographical and water resource. The above studies have been contributing greatly to indication system from diverse perspectives, however, they are more stressing economic development indicators, ignoring local customs and religion in minority areas.

A comprehensive evaluation of village development has become the first factor to consider of in-situ urbanization in today’s China. Based on the large population base, complex social situation and special natural conditions, the existing literature can provide guidance for the research of this subject, Fan & etc. have been studying on the construction and evaluation of village. This article draws under the guidance of urbanization strategy, based on the existing literature reference indicators and field research data, which comes from the history and current development situation of the village. The table 1 for details.

| system | Module       | Index& direction                      |
|--------|--------------|---------------------------------------|
| Location | Altitude (C1)-          |                                       |
|         | Traffic condition (C2)+  |                                       |
|         | Geological disaster situation (C3)- |                         |
|         | Distance to township government (C4)- |                   |
|         | Resource situation (C5)+  |                                       |
| Scale   | Village area (C6)+       |                                       |
|         | Population size (C7)+    |                                       |
| Economy | Per capita annual income (C8)+ |                           |
|         | Collective economy annual income (C9)+ |                        |
| Facilities | Hydropower facilities (C10)+ |                         |
|         | Medical condition (C11)+  |                                       |
|         | Educational Resources (C12)+ |                        |
|         | Business services (C13)+  |                                       |
| Culture | Religious temple culture (C14)+ |                      |
|         | Religious activities (C15)+ |                                       |

3. Methodology
3.1. The Weight Determination
The weights of each evaluation indication element obtained by FAHP and EM are combined by GT, the steps are can be seen Xiang and Luo &etc. [14]. According to the definition of entropy, m elements with n indicators, the weight of each indicator is calculated according to information entropy
and variations in the indicators, the details of which can be seen Guo & etc.[15] FAHP and AHP are basically similar in the step of solving the problem, seen in Wang & etc. [16], but the specific contents of the steps are different.

3.2. GRA–TOPSIS
GRA and TOPSIS were combined to assess village development with combinational weights, m elements with n indicators, T1 and T2 represent efficiency index and cost index respectively. The steps of solving the GRA–TOPSIS are as follows[17].

Step 1 the matrix X = (xij)_{m \times n} is normalized and obtained a new matrix Y = (yij)_{m \times n}

\[
x_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}}, i \in M, j \in T1; \quad y_{ij} = \frac{\min x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}}, i \in M, j \in T2,
\]

Step 2 weighted posterior matrix:

\[
Z = (\omega) y_{ij} m \times n
\]

Step 3 determine the optimal solution Z⁺ and the worst solution Z⁻

\[
Z^+ = (z_1^+, z_2^+ \cdots z_n^+); Z^- = (z_1^-, z_2^- \cdots z_n^-);
\]

\[
z_i^+ = \max z_{ij}, j \in T_1; z_i^- = \min z_{ij}, j \in T_2;
\]

Step 4 the Euclidean distance:

\[
d_i^+ = \sqrt{\sum_{j=1}^{n} (z_{ij}^+ - z_i^+)^2}; d_i^- = \sqrt{\sum_{j=1}^{n} (z_{ij}^- - z_i^-)^2}; i \in M
\]

Step 5 the grey incidence matrix R⁺ and R⁻

\[
R^+ = (r_{ij}^+) m \times n; R^- = (r_{ij}^-) m \times n
\]

Step 6 grey relational grade r_i^+ and r_i^-:

\[
r_i^+ = \frac{1}{n} \sum_{j=1}^{n} r_{ij}^+; \quad r_i^- = \frac{1}{n} \sum_{j=1}^{n} r_{ij}^-
\]

Step 7 a new relational grade:D_i^+ = \frac{d_i^+}{\max d_i^+}; D_i^- = \frac{d_i^-}{\max d_i^-}; R_i^+ = \frac{r_i^+}{r_i^-}; R_i^- = \frac{r_i^-}{r_i^-};

\[
S_i^+ = \alpha D_i^+ + \beta R_i^+; S_i^- = \alpha D_i^- + \beta R_i^-
\]

Step 8 the comprehensive evaluation index:C_i = \frac{S_i^+}{S_i^+ + S_i^-}

4. Case Study

4.1. Study Area
In order to promote in-situ urbanization for minority areas, Aba County in Northwest Sichuan Tibetan Region is chosen as an application to verify the approach outlined in the previous section, shown in Figure1. The data sources are mainly collected by field investigation, which come from Northwest Sichuan Tibetan Region Yearbooks, field research, experts, and relevant departments. After that, the basic data is obtained by logical check and qualitative verification, removing the obvious unreasonable data, and chooses 12 villages to do the research. The Table 2 for details.
Figure 1. Map of Aba County.

Table 2. Village Name.

| Unit | Village Name      | Township         |
|------|-------------------|------------------|
| U₁   | Qi Ka Luo Cun     | Mai Kun Xiang    |
| U₂   | Cao Yuan Cun      | Mai Kun Xiang    |
| U₃   | Ri Ge Zha Cun     | Mai Kun Xiang    |
| U₄   | Five Cun          | A Ba Zhen        |
| U₅   | Six Cun           | A Ba Zhen        |
| U₆   | Seven Cun         | A Ba Zhen        |
| U₇   | Ga Xiu Cun        | Wa Er Ma Xiang   |
| U₈   | Tie Qiong Cun     | Wa Er Ma Xiang   |
| U₉   | Zu Mo Cun         | Wa Er Ma Xiang   |
| U₁₀  | Du Wa Cun         | He Zhi Xiang     |
| U₁₁  | He Zhi Cun        | He Zhi Xiang     |
| U₁₂  | Se Er Gu Cun      | He Zhi Xiang     |

4.2. Results

The evaluation indication system in ethnic areas play an important role in in-situ urbanization, use FAHP, EM and GT to determine the weight of the index, as shown in table 3.

Based on GRA-TOPSIS method to assess village development, and get results: U₂ (0.3757) < U₁₂ (0.4184) < U₁₁ (0.4907) < U₇ (0.5032) < U₆ (0.5084) < U₁₀ (0.5226) < U₅ (0.5380) < U₄ (0.5388) < U₉ (0.5714) < U₃ (0.5745) < U₈ (0.5936) < U₁ (0.6370). The Table 4 for details.

4.3. Discussion

According to the tables 1 and 3, the GT set model proposed by Nash equilibrium as mediation target can minimize the basic weight and possible weight between the deviation, so as to obtain a more comprehensive, scientific and reliable weight. It shows education resources (0.203) and natural resources (0.189) are accounted for a larger proportion, the education resources can cultivate more talents and enrich the local human capital, which plays a decisive role in regional social progress and development, the weight result is consistent with the objective cognition of reality, which shows that the method has strong rationality.
Table 3. Combinational index weights.

| Index | FAHP | EM  | GT  | Index | FAHP | EM  | GT  |
|-------|------|-----|-----|-------|------|-----|-----|
| C1    | 0.0430 | 0.0960 | 0.0936 | C9    | 0.0920 | 0.2085 | 0.2031 |
| C2    | 0.0620 | 0.0795 | 0.0787 | C10   | 0.0637 | 0.2085 | 0.0301 |
| C3    | 0.0890 | 0.0356 | 0.0380 | C11   | 0.0472 | 0.0300 | 0.0308 |
| C4    | 0.0460 | 0.1962 | 0.1892 | C12   | 0.0475 | 0.0291 | 0.0300 |
| C5    | 0.0705 | 0.0299 | 0.0318 | C13   | 0.0317 | 0.0359 | 0.0357 |
| C6    | 0.0375 | 0.0538 | 0.0530 | C14   | 0.1140 | 0.0420 | 0.0453 |
| C7    | 0.0420 | 0.0517 | 0.0513 | C15   | 0.0760 | 0.0359 | 0.0377 |
| C8    | 0.1380 | 0.0475 | 0.0517 |       |       |     |     |

Table 4. The classification of village.

| Classification | Villages |
|----------------|----------|
| Central villages | Tie Qiong Cun, Ri Ge Zha Cun, Qi Ka Luo Cun, Zu Me Cun |
| Basic villages | Ga Xiu Cun, Seven Cun, Du Wa Cun, Six Cun, Five Cun |
| Weak villages | Cao Yuan Cun, Se Er Gu Cun, He Zhi Cun |

Based on the in-situ urbanization perspective, the gathered area should locate nearby the central villages/towns and be conductive to the development of economic production and social life in a long-time. “Qi Ka Luo Cun” needs to develop comprehensively and proposes advanced management strategies to attract villages from other areas. Besides, central villages should take measures to protect their temples and carry forward their religious and local ethnic culture.

Aimed at the balance of the society, economy and ecology, local government needs to minimize distance/cost and maximize comprehensive urbanization level through central villages. Meanwhile, it also needs to guarantee gathered village location keeping away from the disasters high-risk and restricted development area. “Cao Yuan Cun” and “Se Er Gu Cun” are the weak village, which have severe situation of natural sources and geologic hazard around the villages, such as debris flow, earthquake, etc. Therefore, they need to move near to central village and develop urbanization.

5. Conclusion

China has its own characteristic urbanization road, since the development history is different from the developed countries and the other developing countries. In order to develop in-situ urbanization, this paper takes 12 villages in Tibetan Region of Northwest Sichuan for examples, establishes a comprehensive evaluation index system of village evaluation in ethnic areas. Then, with the combination of FAHP, EM, GRA-TOPSIS and GT, this paper analyzes the selection of villages, and finally selects 4 central villages, 5 basic villages, 3 weak villages and proposes the layouts of village to ensure sustainable development in the future. However, the county has 83 administrative villages, so we chose only 14.46% of the sample. If we have more samples and data, the results will be more accurate. In addition, due to regional differences, it’s necessary to adjust the indicators elsewhere and need more future research.

Acknowledgements

This article is supported by the Humanities Social and Sciences Research Funds of Education Ministry (Grant NO.15XJC630001), the Key Funds of Sichuan Social Science Research Institution “System Science and Enterprise Development Research” (Grant NO. Xq15B09), and the Youth Funds of Sichuan Provincial Education Department (Grant NO.14ZB0014). The corresponding author of this article is GAN Lu.
References

[1] Li Dingguo. Study on the Governance of "Hollow Village" in Rural Areas of Hubei Province in the Process of Urbanization [J]. Hubei Social Sciences, 2016 (7): 67-72. (in Chinese)

[2] Liu Jiansheng, Chen Xin. Cooperative Governance: A Theoretical Model of China's Hollow Village Governance - A Case Study of Guangqiu Village in Anfu County, Jiangxi Province [J]. China Land Science, 2016, 30 (1): 53-60. (in Chinese)

[3] Liu Rui. The Dilemma and Outlet of Hollow Village Governance [J]. Zhongzhou Journal, 2016 (10): 78-84. (in Chinese)

[4] Xie Xiaoou. The construction and selection of the central village in Jianghan Plain [D]. Huazhong Agricultural University, 2007. (in Chinese)

[5] Chen Shangshen. Based on the central theory of the central village of location selection and optimization [D]. Henan University, 2013. (in Chinese)

[6] Jiao Fei, Zhang Fengrong, Li can et al. Analysis of the spatial layout of the county center village based on the gravity model -- a case study of changzhi county in Shangxi Province [J]. Resources science, 2014, 36 (1): 45-54. (in Chinese)

[7] An Shuang, Chen Dong, Pu Xindong, et al. Study on the selection of central village in small towns in west-ern underdeveloped areas - a case study of li dian town in jingning county [J]. Journal of Arid Land Resources and Environment, 2014, 28 (6).

[8] Zhang Yanfen, Liu Kewen, Chen Weiqiang. Study on the Site Selection of Central Village Based on AHP and GIS - A Case Study of Xicun Town, Gongyi City [J]. AREAL RESEARCH AND DEVELOPMENT, 2013, 32 (3):149-153. (in Chinese)

[9] Li Hongbo, Zhang Xiaolin. Research Progress and Recent Trend of Rural Settlement Geography in For-eign Countries. Humanities and Geography, 2012 (4): 103-108. (in Chinese)

[10] Jin Qiming. Rural Settlements Geography [M]. Science Press, 1988. (in Chinese)

[11] A.H. Potosyan. Geographical features and development regularities of rural areas and settlements dis-tribution in mountain countries. Annals of Agrarian Science xxx (2017) 1e5.

[12] Hill M. Rural Settlement and the Urban Impact on the Countryside [M]. London: Hodder & Stoughton, 2003:20-36;58-72

[13] Yang Ren, Liu Yansui, Long Hualou. Spatial Distribution of Chinese Villages and Spatial Optimization and Restructuring [J]. SCIENTIA GEOGRAPHICA SINICA, 2016, 36 (2): 170-179

[14] Quan Xiang, Luo jinyao, Li xiaoping, et al. Based on the game theory, the weight of performance eval-uation index of small farmers’ water projects is determined [J]. China rural water conservancy and hy-dropower, 2016 (6):146-149. (in Chinese)

[15] Guo Xiangguang. Application of Improved Entropy Method in Evaluation of Economic Result. Systems engineering theory and practice, 1998, 18 (12): 98-102. (in Chinese)

[16] Wang Yimei. Establishment of Employee Performance Evaluation Index System Based on Fuzzy Ana-lytic Hierarchy Process [J]; Chengdu University of Technology, 2016

[17] Zhou Ya. Study on TOPSIS method in multi-attribute decision-making [D]. Wuhan University of Tech-nology, 2009. (in Chinese)