

Research on the Adaptive Development of Rural Settlements in Hilly Areas Based on AHP-PCA Model Analysis: Taking the Survey Data of 28 Villages in Hunan as Case Study

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Abstract:

The development of rural settlements in hilly areas during the transitional period mainly focuses on the coordination between the built environment and the natural one, and interprets villages' adaptability of the natural environment and the social one. However, there are few data and achievements in the study of hilly areas in Hunan. By combining and absorbing the theories and methods of interdisciplinary subjects such as the Environmental Behavior, Sociology, Architecture and ect, with 5 first level index, 11 second level index, and 42 third level index of topographical environment, climatic environment, regional culture, economic condition and social environment, the author manages to establish an evaluation system for the adaptive development of rural settlements; in combination with Analytic Hierarchy Process (AHP), Principal Component Analysis (PCA) and SPSS Analysis, 28 typical villages in Hunan are used as samples to conduct empirical research based on the survey data of the village. The research results demonstrate that there are regional differences in the adaptive development of rural settlements in the hilly areas of Hunan: the overall comprehensive evaluation value of villages in eastern Hunan is the lowest, southern Hunan, the highest, and central Hunan, in-between. On the whole, the current situation of adaptive development in traditional villages is better than that of contemporary villages. Therefore, the development of rural settlements in the hilly areas of Hunan has differences in regions and categories, which is somewhat related to the policy support of the country and Hunan Province. It verifies the scientific nature and feasibility of the evaluation system. To better promote the rural construction and development, each region should formulate corresponding policies and guidelines to promote rural revitalization in accordance with the existing cultural environment, economic condition and social environment.

Keywords: hilly area; Hunan region; rural adaptive development; AHP; PCA; SPSS analysis

I. INTRODCCTION

Rural construction has always been one of the key issues concerning national economic development. From the land reform at the beginning of the founding of PRC, to the *Urban and Rural Planning Law*

promulgated in 2008, to the implementation of the rural revitalization strategy today, rural construction and development have increasingly attracted the attention of the nation and all sectors of society. In particular, the start of a new round of territorial and spatial planning at current stage has become an important means and tool for realizing the ecological civilization, as well as a significant way for promoting the modernization of the national governance system and capacity. The central government and various ministries and commissions require all localities to focus on the background requirements of the rural revitalization strategy, the establishment of the territorial and spatial planning system, the deepening of the reform of the rural land system, the comprehensive land rectification across the whole region, and the integration of "planning, construction, management and operation" to actively carry out plan formulation and guide local villages' construction. The formation of "useful, effective, practical" village planning, and the road map of the "urban and rural integration, production, life and ecology integration" to rural revitalization indicate that the relationship between urban and rural areas will be further strengthened, and that the urban and rural development is once again entering a new course[1-2]. With the advancement of new-type urbanization, the construction of beautiful countryside and the strategy of rural revitalization, the mutual flow and interaction among urban and rural elements have been greatly promoted, and the rural form, size, scale, and relationship have also undergone drastic changes[3-6]. The development of urban-rural relations and transitions in social structure have made the rural economy develop rapidly, but it has also broken the previous ecological spatial pattern of the rural areas. The changes in villagers' way of working and living have also altered the ethical relations and moral concepts such as folklore and customs, which have brought great challenges to the sustainable development of rural areas[7-8].

In recent years, the overall appearance of rural areas has been improved to a certain extent, but it still faces a series of problems such as excessive occupation on natural ecological space, gradual disappearance of regional spatial characteristics, and difficulty in inheriting traditional culture and so on[9-13]. As a complicated complex, rural settlements have a crucial impact on rural construction and development. Adaptive development involves the natural environment, social environment and human environment. At present, the research on the adaptive development of rural settlements in the hilly areas of Hunan is still relatively weak, and the existing evaluation system is still not comprehensive [14-16]. Based on this, from the perspective of adaptability, this thesis constructs an evaluation system on the adaptive development of rural settlements in hilly areas of Hunan from villagers' five aspects: topographical environment, climate environment, regional culture, economic condition, and social environment, so as to provide reference value for the development and construction of rural settlements, which carries significance of realistic meaning.

II. THE CONSTRUCTION OF METHOD AND EVALUATION SYSTEM

2.1 Evaluation method

The evaluation elements for adaptive development of rural settlements include evaluation subject, evaluation object, evaluation index, evaluation standard and evaluation method. Rural development is a process that changes over time, instead of existing in the form of a certain or some fixed values. The

calculation result differs with the change of the index value, which is a dynamic-static combination. From the perspective of \system, the evaluation on the adaptive development of rural settlements has a certain complexity, which is reflected in the multi-level and diversity of the establishment of each subsystem, as well as the uncertainty of the evaluation on each subsystem; at the same time, affected by cultural background, living habits and other factors, the evaluation on some elements has certain randomness and ambiguity. Therefore, choosing an appropriate evaluation method can make up for the defects caused by the above problems, thereby improving the correctness and credibility of the evaluation results. At present, there are many evaluation methods for rural settlements, and the commonly used are AHP and BP network model method [17]. Based on the current situation of rural settlements, AHP and PCA are tried in combination, with the introduction of mathematics model and the construction of an evaluation system to comprehensively evaluate the adaptive development of rural settlements in hilly areas, in anticipation of more direct and reasonable evaluation results.

(1) Analytic Hierarchy Process (AHP) is a decision analysis method with qualitative and quantitative combination, which can solve complex problems with multiple objectives. With systematized and hierarchical characteristics, it is one of the mathematical tools of system analysis [18]. Since AHP was introduced to China in the 1980s, it has been rapidly applied in the social and economic fields and has been widely valued and applied. The steps of the AHP include the establishment of the hierarchical structure model, the construction of the judgment matrix, the single-level sorting and the consistency test, see as formula 1[19].

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (1)$$

The formula for consistency test is as formula 2: If $CR < 0.1$, then A is considered to be consistent. Otherwise, adjustments need to be made to A until satisfactory consistency is achieved.

$$CR = \frac{CI}{RI} \quad (2)$$

(2) Principal Component Analysis (PCA) is a technique for simplifying data sets. Also known as principal component regression analysis, it aims to use the idea of dimensional reduction to convert multiple index into several new comprehensive index, and also to interpret the comprehensive index of the data, which is a linear transformation. The specific analysis steps of this method include: standardizing the raw data, calculating the correlation coefficient matrix R , calculating the eigenvalues and eigenvectors of the correlation coefficient matrix, selecting principal components of p ($p \leq m$) to calculate the comprehensive evaluation value and comprehensive score [20].

① Standardizing the raw data:

$$\tilde{a}_{ij} = \frac{a_{ij} - \mu_j}{s_j}, (i = 1, 2, \dots, n; j = 1, 2, \dots, m) \quad (3)$$

$$\mu_j = \frac{1}{n} \sum_{i=1}^n a_{ij} \quad (4)$$

$$s_j = \frac{1}{n-1} \sum_{i=1}^n (a_{ij} - \mu_j)^2 \quad (5)$$

$$\tilde{x}_j = \frac{x_j - \mu_j}{s_j}, (j = 1, 2, \dots, m) \quad (6)$$

② Calculating the correlation coefficient matrix R

$$R = (r_{ij})_{m \times m} \quad (7)$$

$$r_{ij} = \frac{\sum_{k=1}^n \tilde{a}_{ki} \cdot \tilde{a}_{kj}}{n-1}, (i, j = 1, 2, \dots, m) \quad (8)$$

③ Calculating the eigenvalues and eigenvectors of the correlation coefficient matrix:

$$\begin{cases} y_1 = u_{11}\tilde{x}_1 + u_{21}\tilde{x}_2 + \dots + u_{m1}\tilde{x}_m \\ y_2 = u_{12}\tilde{x}_1 + u_{22}\tilde{x}_2 + \dots + u_{m2}\tilde{x}_m \\ \vdots \\ y_m = u_{1m}\tilde{x}_1 + u_{2m}\tilde{x}_2 + \dots + u_{mm}\tilde{x}_m \end{cases} \quad (9)$$

④ Selecting principal components of $p(p \leq m)$ and calculate the comprehensive evaluation value

$$b_j = \frac{\lambda_j}{\sum_{k=1}^m \lambda_k} \quad (j = 1, 2, \dots, m) \quad (10)$$

$$a_p = \frac{\sum_{k=1}^p \lambda_k}{\sum_{k=1}^m \lambda_k} \quad (11)$$

⑤ Calculating the comprehensive score. Use b_j to express the contribution rate of the j^{th} principal component information (formula 11), and evaluate according to the comprehensive score value.

$$Z = \sum_{j=1}^p b_j y_j \quad (12)$$

2.2 Construction of evaluation system

The adaptive development of rural settlements involves topographical environment, climatic environment, regional culture, economic conditions, social environment, and etc. The research on the

evaluation system should be covering to a certain degree, and the selection of factors should be typical and representative, and at the same time, prominent with characteristic value of rural settlements in the hilly areas of Hunan. According to the analysis of relevant literature review, field research, and expert opinions [21-23], after multiple rounds of summary and feedback, it is beneficial for the AHP to finally establish an evaluation system for the adaptive development of rural settlements in hilly areas of Hunan (Table 1).

In this evaluation system, the topographical environment evaluation includes two aspects: village layout and street and lane space. Village layout is the primary attribute of rural development, whereas street and lane space is an important embodiment of rural texture and regional characteristics. The climate environmental evaluation mainly analyzes the mesoclimate and microclimate perception. As the core of the countryside, regional culture is the soul of the adaptive development of rural settlements. The adaptive development of rural culture is evaluated from both material and intangible cultures. Directly reflecting the development and construction of rural areas, the economy is an important indicator for measuring economic development potential and industrial development, including urban and rural spatial accessibility, employment and income. Social environmental evaluation reflects the integration degree of rural society, including infrastructure, public management and service facilities, and social satisfaction, which are important guarantees for the adaptive development of rural settlements.

Table 1. Evaluation Index System for the current situation of Rural Settlements' Adaptive Development in Hilly Areas

Target Layer	Criterion Layer	Index Layer	Index Unit	Index Attributes	Index Description
Evaluation Index for the current situation of Rural Adaptive Development	Evaluation on Topographical Environment (A1)	Longevity of the village location	—	+	Age of the village
		Village appearance maintenance	%	+	Protective degree of the village environment by villagers
		Village location and topographical harmony	%	+	Agreeable degree between the ecological view and landscape intention of the village
		Ability to identify village boundary	—	+	Regular degree of the village boundary shape
		Overall style and integrity of the streets and lanes	—	+	Complete degree of the overall style of the streets and lanes space
		Scale suitability of streets and lanes space	—	+	Appropriate degree of the scale of streets and lanes space
		Node Abundance of streets and lanes space	%	+	Abundant degree of the nodes of streets and lanes space

	Accessibility of streets and lanes space	%	+	Accessible degree of the streets and lanes space
Evaluation on Climatic Environment (A2)	Major location of the village	—	+	Orientation of most buildings in the village
	Relationship between village and wind direction	—	+	Relationship between the village and the perennial wind direction
	Perfection of the village drainage system	%	+	Perfect degree of the village drainage system
	Winter temperature sensitivity	—	+	Villagers' feelings about temperature in winter
	Summer temperature sensitivity	—	-	Villagers' feelings about temperature in summer
	Winter humidity sensitivity	—	-	Villagers' feelings about humidity in winter
	Summer humidity sensitivity	—	+	Villagers' feelings about humidity in summer
	Winter wind speed sensitivity	—	-	Villagers' feelings about wind speed in winter
	Summer wind speed sensitivity	—	+	Villagers' feelings about wind speed in summer
	Evaluation on Regional; Culture (A3)	Continuity of landscape context	—	+
Inheritance of traditional space form		—	+	Inhering degree of the traditional spatial layout of the village
Coordination between old and new buildings		%	+	Coordinative degree between new and old buildings in the village
Application of traditional crafts		%	+	Applying degree of traditional building techniques
Spatial preservation integrity of intangible cultural		%	+	Protective degree of intangible culture
Abundance of intangible cultural heritage categories		%	+	Categories of intangible cultural heritage

	Continuity of traditional folklore	%	+	Continuing degree of traditional folk customs by villagers
	Participation in folklore activities	%	+	Participatory degree of folklore activities by villagers
Evaluation on Economic Conditions(A4)	Spatial accessibility in townships	—	-	The shortest distance from the village to the neighboring township
	Spatial accessibility in districts and counties	—	-	The shortest distance from the village to the neighboring districts and counties
	Spatial accessibility in cities and prefectures	—	-	The shortest distance from the village to the neighboring prefecture-level city
	Major categories of industries	—	+	Village industry categories
	Proportion of agricultural income	%	-	Proportion of agriculture to villagers' income
	Proportion of migrant workers (less than six months)	%	+	Proportion of the migrant population working less than six months
	Proportion of migrant workers (more than six months)	%	-	Proportion of the migrant population working more than six months
Evaluation on Social Environment (A5)	Dynamic traffic perfection	%	+	Perfect degree of dynamic traffic in the village
	Static traffic perfection	%	+	Perfect degree of static traffic in the village
	Completeness of agricultural irrigation systems	%	+	Perfect degree of agricultural canal
	Completeness of agricultural farming roads	%	+	Perfect degree of agricultural farming travel
	Categories of public buildings	—	+	Categories of public buildings in the village
	Quantity of public buildings	—	+	Quantity of public buildings in the village
	Usage frequency of public	%	+	Usage frequency of public buildings in villages

buildings				
Satisfaction with living environment	%	+		Satisfactory degree with the living environment by villagers
Satisfaction with neighbouring relationship	%	+		Satisfactory degree with the neighbouring relationship by villagers
overall satisfaction	%	+		Overall satisfactory degree with the village by villagers

Note: "+" represents a positive indicator, that is, the larger the indicator value, the better the situation; "-" represents a negative indicator, that is, the larger the indicator value, the worse the situation

III. SELECTION OF CASES AND DATA SOURCES

Hunan Province is a typical hilly area, and its hilly areas are mainly distributed among eastern Hunan (mainly referring to Changsha City, Zhuzhou City, Xiangtan City), southern Hunan (mainly referring to Hengyang City, Chenzhou City, Yongzhou City) and central Hunan (mainly refers to Yiyang City, Loudi City, and parts of Shaoyang City). Considering the comparability of the cases and the current situation of the villages, 28 typical villages with clear boundaries and obvious morphological differences were selected for evaluation. The specific distribution of the sample villages is as follows (Table 2): A total of 5 villages were selected in the eastern Hunan region, where the number of traditional villages is relatively smaller with the sample of Hutian Village for analysis, while the contemporary villages are Shaoqian Village, Queshan Village, Shuyi Village and Tanwan Village. There are many more traditional villages in southern Hunan with the sample villages of Gaotian Village, Nanwan Village, Xiaoxu Village, Banliang Village, Waisha Village, Miaoxia Village, Layuan Village, Weijia Village, Fenxiang Village, Lanxi Village, Shanggantang Village, while contemporary villages are analyzed with Shuangjiqiao Village as a sample. There are many more traditional villages in central Hunan region, and the sample villages are Huangshaping Old Street, Tangjiaguan Village, Shangtuan Village, Zhenglong Village, Laowu Village, Lang Shi Village, Cangchang Village, Shuangxi Village, and Shankou Village, Ziwei Village, and Mojia Village are selected as contemporary villages for analysis. These villages are selected for empirical research for on the one hand, traditional villages are all listed into the *Directory of Chinese Traditional Village* in different batches of Hunan hilly areas, which are more representative; while contemporary villages are published by government departments as "beautiful villages" and ordinary villages as more concentrated research objects, so that the analysis results have certain universality; on the other hand, these villages are all self-organized, and none of them have been demolished or rebuilt greatly, so the morphological results are clear.

Table 2. Rural sample selection

Area	City	Village	Remarks
Eastern Hunan	Xiangtan City	Hutian Village	Directory of Chinese Traditional Village (the fourth batch)
		Shaoqian Village	Ordinary villages
	Changsha City	Queshan Village	Beautiful villages
		Shuyi Village	Ordinary villages
		Tanwan Village	
Hengyang City	Gaotian Village		Directory of Chinese Traditional Village (the second batch)
		Nanwan Village	Directory of Chinese Traditional Village (the fourth batch)
		Xiaoxu Village	Directory of Chinese Traditional Village (the fourth batch)
		Banliang Village	Directory of Chinese Traditional Village (the first batch)
		Waisha Village	Directory of Chinese Traditional Village (the first batch)
Southern Hunan	Chenzhou City	Miaoxia Village	Directory of Chinese Traditional Village (the second batch)
		Layuan Village	Directory of Chinese Traditional Village (the third batch)
		Weijia Village	Directory of Chinese Traditional Village (the second batch)
		Fenxiang Village	Directory of Chinese Traditional Village (the fourth batch)
		Lanxi Village	Directory of Chinese Traditional Village (the first batch)
Yongzhou City	Shanggantang Village		Directory of Chinese Traditional Village (the first batch)
		Shuangjiqiao Village	Ordinary villages
		Huangshaping Old Street Village	Directory of Chinese Traditional Village (the first batch)
		Tangjiaguan Village	Directory of Chinese Traditional Village (the second batch)
		Shankou Village	Beautiful villages
Central Hunan	Yiyang City	Ziwei Village	Beautiful villages
		Shangtuan Village	Directory of Chinese Traditional Village (the third batch)
	Loudi City	Zhenglong Village	Directory of Chinese Traditional Village (the third batch)
		Laowu Village	Directory of Chinese Traditional Village (the fourth batch)
		Mojia Village	Ordinary villages
Shaoyang City	Lang Shi Village	Directory of Chinese Traditional Village (the second	

Cangchang Village	Directory of Chinese Traditional Village (the fourth batch)
Shuangxi Village	Directory of Chinese Traditional Village (the fourth batch)

The survey data comes from field surveys in villages from February to May in 2018. Each village was distributed with 100 questionnaires, and the effective sample rate was between 85% and 90%. Supplementary surveys were conducted from September to November in 2018 to improve verification and correction of the evaluation results [24].

IV. OUTCOME ANALYSIS

4.1 AHP evaluation and analysis on the adaptive development of rural settlements

On the basis of the research, the opinions of relevant experts, scholars and functional departments are solicited, the index at all levels are assigned values, and the AHP is used for analysis. After analysis by the AHP software, the results are shown as Table 3. The consistency test result is 0.0780, which is less than 0.1, and the calculation result is considered to pass the test. This also indicates the importance of the topographical environment to the rural adaptive development.

Table 3. AHP evaluation results of rural settlements’ adaptive development in hilly areas

Target Layer	First-level Index	Weights	Second-level Index	Weights
A	A ₁	0.2938	B ₁	0.2203
			B ₂	0.0735
	A ₂	0.1367	B ₃	0.1025
			B ₄	0.0342
			B ₅	0.0904
	A ₃	0.2712	B ₆	0.1808
			B ₇	0.0306
			B ₈	0.1222
			B ₉	0.0785
	A ₄	0.1528	B ₁₀	0.0237
			B ₁₁	0.0432
A ₅	0.1454			

4.2 PCA of rural settlements’ adaptive development

Based on the evaluation system for the current situation of rural adaptive development, combined with the current survey data and the evaluation results of rural adaptive development, the evaluation on the current situation of 28 villages is carried out.

4.2.1 Evaluation on the current situation of topographical environment (A₁)

Calculating the topographical environment index according to the data, and SPSS is used to analyze all

the index, and two main categories are obtained. After the range standardization and index standardization, the index standardization score is obtained as shown in Table 4.

From a regional point of view, the adaptive development of topographical environment for rural areas in eastern Hunan are not very ideal, which is opposite in southern Hunan, and neutral in central Hunan. From the perspective of village categories, contemporary villages are generally not desirable in terms of adaptive development evaluation, ranging from 1.00 to 2.45. The lowest is Tanwan Village, followed by Mojia Village, but the highest is Shuyi Village scoring 2.45; while the overall evaluation on traditional villages is desirable, but the gap is large. The highest is Shanggantang Village with a score of 10.00, followed by Banliang Village of 9.58. The scores of Waisha Village and Miaoxia Village are also higher, with scores of 6.95 and 6.66 respectively. The lowest is Gaotian Village of 1.82, followed by Xiaoxu Village of 2.09. From this, it can be known that Shanggantang Village has a higher evaluation in terms of both village layout and streets and lanes space, while Tanwan Village has the lowest evaluation.

Table 4. Evaluation results of the current situation of topographical environment for sample villages' adaptive development

Name	FAC1_ 1	FAC2_ 1	Weighted Sum	Range Standardization Score	Index Standardization Score
Hutian Village	1.6344	1.5088	1.6123	0.73	5.32
Shaoqian Village	-2.8869	0.7298	-2.2498	0.17	1.49
Queshan Village	-3.3608	1.5398	-2.4975	0.14	1.37
Shuyi Village	-1.1696	1.3347	-0.7284	0.39	2.45
Tanwan Village	-4.1296	-0.2594	-3.4478	0.00	1.00
Gaotian Village	-1.3731	-2.8912	-1.6406	0.26	1.82
Nanwan Village	-0.4118	1.2307	-0.1224	0.48	3.00
Xiaoxu Village	-1.1584	-1.5052	-1.2195	0.32	2.09
Banliang Village	3.8607	1.2213	3.3957	0.98	9.58
Waisha Village	2.8146	0.6029	2.4250	0.84	6.95
Miaoxia Village	2.8066	-0.1086	2.2931	0.82	6.66
Layuan Village	1.7498	-0.2629	1.3952	0.69	4.95
Weijia Village	1.2314	-1.6285	0.7276	0.60	3.97
Fenxiang Village	0.4600	-1.0657	0.1912	0.52	3.33
Lanxi Village	1.2123	-0.3742	0.9328	0.63	4.25
Shanggantang Village	4.1057	0.8079	3.5248	1.00	10.00
Shuangjiqiao Village	-2.6874	0.7263	-2.0861	0.20	1.57
Huangshaping Old Street Village	1.2547	-0.2538	0.9890	0.64	4.33
Tangjiaguan Village	2.1150	0.0509	1.7514	0.75	5.57
Shankou Village	-2.2183	0.8443	-1.6788	0.25	1.79
Ziwei Village	-3.1321	0.9929	-2.4055	0.15	1.41

Shangtuan Village	0.4508	-0.9911	0.1968	0.52	3.33
Zhenglong Village	0.9816	-0.5619	0.7097	0.60	3.95
Laowu Village	-0.9065	-0.6094	-0.8542	0.37	2.35
Mojia Village	-3.2137	-0.5832	-2.7504	0.10	1.26
Lang Shi Village	1.5288	-0.0705	1.2471	0.67	4.71
Cangchang Village	0.2707	-0.1850	0.1905	0.52	3.33
Shuangxi Village	0.1713	-0.2396	0.0989	0.51	3.23

4.2.2 Evaluation on the current situation of climactic environment (A₂)

Calculating the climactic environment index according to the data, and SPSS is used to analyze all the index, and three major categories are obtained [25]. After the range standardization and index standardization, the index standardization score is obtained as shown in Table 5.

From a regional point of view, the adaptability evaluation values for rural climactic environment in eastern and Central Hunan are relatively lower, whereas that in central Hunan is relatively higher. In terms of village categories, among the 11 villages with the lowest evaluation scores, 8 are contemporary villages, and Shaoqian Village has the lowest score of 1.00, followed by Mojia Village and Ziwei Village. Shankou Village has the highest score of 2.71. Among traditional villages, Laowu Village is with the lowest score of 1.07, followed by Huangshaping Old Street of 1.23, Hutian Village of 1.25. Shuangxi Village and Shangtuan Village have lower scores of 2.18 and 2.58 respectively, and Zhenglong Village has the highest score of 10.00, followed by Tangjiaguan Village with a score of 8.52. Weijia Village and Waisha Village also have higher scores of 7.44 and 6.67 respectively.

Table 5. Evaluation results of the current situation of climactic environment for sample villages' adaptive development

Name	FAC1_1	FAC2_1	FAC3_1	Weighted Sum	Range Standardization Score	Index Standardization Score
Hutian Village	-1.5705	-1.4194	-0.6805	-1.3796	0.10	1.25
Shaoqian Village	-2.8902	0.3860	-0.4800	-1.7369	0.00	1.00
Queshan Village	-2.2625	-0.4525	0.8505	-1.3104	0.11	1.30
Shuyi Village	-2.4680	0.7023	0.0335	-1.3220	0.11	1.29
Tanwan Village	-2.7028	0.1690	1.1491	-1.3844	0.09	1.24
Gaotian Village	1.0600	-1.2930	1.5982	0.6329	0.63	4.30
Nanwan Village	1.2925	-0.0243	0.3145	0.8273	0.69	4.85
Xiaoxu Village	1.8718	0.2671	0.0500	1.1935	0.78	6.08
Banliang Village	2.0979	-1.5718	0.2215	0.9516	0.72	5.24

Waisha Village	1.9778	0.7790	-0.1017	1.3441	0.82	6.67
Miaoxia Village	1.4277	-0.663 9	1.2689	0.9354	0.71	5.18
Layuan Village	0.5561	-0.131 5	0.9927	0.4806	0.59	3.92
Weijia Village	1.8944	1.6919	0.0472	1.5229	0.87	7.44
Fenxiang Village	1.4562	-0.211 5	-0.1995	0.7933	0.68	4.75
Lanxi Village	0.7275	-0.153 1	-0.8333	0.2561	0.53	3.41
Shanggantang Village	2.4832	-1.683 0	0.4233	1.1943	0.78	6.08
Shuangjiqiao Village	-1.4008	0.4171	0.1228	-0.7279	0.27	1.86
Huangshaping Old Street Village	-0.5528	-3.130 8	-2.0857	-1.3960	0.09	1.23
Tangjiaguan Village	2.4242	1.0598	0.2818	1.7426	0.93	8.52
Shankou Village	-1.2135	1.2015	-0.0847	-0.4779	0.34	2.17
Ziwei Village	-2.7590	-0.237 7	1.5481	-1.4379	0.08	1.20
Shangtuan Village	-0.2552	-0.552 8	0.4387	-0.1986	0.41	2.58
Zhenglong Village	3.0325	0.8862	-0.0989	2.0025	1.00	10.00
Laowu Village	-1.5360	-0.791 8	-2.9945	-1.6287	0.03	1.07
Mojia Village	-3.3753	1.6962	0.1829	-1.6206	0.03	1.07
Lang Shi Village	1.6101	2.5402	-2.1970	1.1435	0.77	5.89
Cangchang Village	-0.1490	0.3711	0.4280	0.0685	0.48	3.04
Shuangxi Village	-0.7762	0.1495	-0.1960	-0.4681	0.34	2.18

4.2.3 Evaluation on the current situation of regional culture (A_3)

Calculating the regional culture index according to the data, and SPSS is used to analyze all the index, and two major categories are obtained. After the range standardization and index standardization, the index standardization score is obtained as shown in Table 6.

From a regional point of view, rural areas in eastern Hunan score lower, while southern and central Hunan score higher. In terms of village categories, among the top 10 villages with the lowest scores, 8 are contemporary villages. Shaoqian Village has the lowest score of 1.00, followed by Qeshan Village and Ziwei Village of 1.07. Shuyi Village and Tanwan Village both have the same score of 1.30 and Mojia Village has the highest score of 2.41. The scores of traditional villages are significantly different, with the lowest score of 1.18 by Hutian Village, followed by Fenxiang Village of 2.18. Nanwan Village and Cangchang Village also have lower scores of 2.47 and 2.70 respectively. The highest is Banliang Village with a score of 10.00, followed by Shanggantang Village of 9.19. Zhenglong Village and Shangtuan Village have higher scores of 7.08 and 6.68 respectively.

Table 6. Evaluation results of the current situation of regional culture for sample villages' adaptive development

Name	FAC1 _1	FAC2_1	Weighted Sum	Range Standardization Score	Index Standardization Score
Hutian Village	-3.666 9	2.0823	-2.4304	0.07	1.18
Shaoqian Village	-3.625 5	-0.1249	-2.8727	0.00	1.00
Queshan Village	-3.045 5	-1.3428	-2.6793	0.03	1.07
Shuyi Village	-2.754 2	0.0035	-2.1611	0.11	1.30
Tanwan Village	-2.578 3	-0.6753	-2.1691	0.11	1.30
Gaotian Village	-0.377 5	1.3479	-0.0064	0.46	2.90
Nanwan Village	-0.533 6	-0.0756	-0.4351	0.39	2.47
Xiaoxu Village	-0.232 4	1.2973	0.0966	0.48	3.01
Banliang Village	4.2235	0.0749	3.3312	1.00	10.00
Waisha Village	1.0898	1.2179	1.1173	0.64	4.40
Miaoxia Village	1.1543	1.7300	1.2781	0.67	4.67
Layuan Village	1.1889	1.1476	1.1800	0.65	4.50
Weijia Village	0.4180	-0.3784	0.2467	0.50	3.18
Fenxiang Village	-0.769 2	-0.7879	-0.7732	0.34	2.18
Lanxi Village	2.5713	-2.2314	1.5384	0.71	5.14
Shanggantang Village	3.6951	0.9472	3.1041	0.96	9.19
Shuangjiqiao Village	-1.409 9	-0.7086	-1.2590	0.26	1.82
Huangshaping Old Street Village	0.5038	-0.2368	0.3445	0.52	3.30
Tangjiaguan Village	1.6412	-0.4616	1.1889	0.65	4.52
Shankou Village	-0.894 6	0.0654	-0.6882	0.35	2.25
Ziwei Village	-3.399 3	0.0425	-2.6590	0.03	1.08
Shangtuan Village	2.7594	0.3553	2.2423	0.82	6.68
Zhenglong Village	2.9670	0.3263	2.3990	0.85	7.08
Laowu Village	0.9407	-3.3407	0.0199	0.47	2.93
Mojia Village	-0.574 2	-0.2190	-0.4978	0.38	2.41
Lang Shi Village	0.6388	0.4494	0.5980	0.56	3.63

Cangchang Village	-0.274 1	0.0774	-0.1985	0.43	2.70
Shuangxi Village	0.3436	-0.5820	0.1446	0.49	3.06

4.2.4 Evaluation on the current situation of economic conditions (A₄)

Calculating the economic conditions index according to the data, and SPSS is used to analyze all the index, and three major categories are obtained. After the range standardization and index standardization, the index standardization score is obtained as shown in Table 7.

From a regional point of view, the evaluation index value for the economic conditions in eastern Hunan is between 1.00 and 7.12, with an average value of 3.868, which is relatively different; that of southern Hunan is between 1.37 and 10.00, with an average value of 5.62, which is quite different, and that of central Hunan is between 2.34 and 8.69, with an average value of 4.49, and the difference is also very large. Overall speaking, Hutian Village has the lowest score of 1.00, followed by Queshan Village of 1.25 and Miaoxia Village of 1.37. Shankou Village and Zhenglong Village have lower scores of 2.34 and 2.66 respectively. Layuan Village has the highest score of 10.00, followed by Shuangji Village of 9.64, Tangjiaguan Village of 8.69, and Gaotian Village of 8.29. Waisha Village and Tanwan Village also have higher scores of 7.28 and 7.21 respectively.

Table 7. Evaluation results of the current situation of economic conditions for sample villages' adaptive development

Name	FAC1_1	FAC2_1	FAC3_1	Weighted Sum	Range Standardization Score	Index Standardization Score
Hutian Village	-4.052 2	0.2755	-1.7129	-2.6781	0.00	1.00
Shaoqian Village	0.8220	1.6361	0.0712	0.8700	0.81	6.53
Queshan Village	-3.538 4	-0.7891	0.2496	-2.2585	0.10	1.25
Shuyi Village	-0.633 0	0.2077	-0.3197	-0.3910	0.53	3.35
Tanwan Village	2.1015	-0.9156	-0.0234	1.0562	0.86	7.21
Gaotian Village	2.4498	-0.6282	-0.0728	1.3206	0.92	8.29
Nanwan Village	-0.501 0	-0.6514	0.3392	-0.3858	0.53	3.36
Xiaoxu Village	1.1962	-0.4481	0.1749	0.6507	0.76	5.81
Banliang Village	-0.725 2	-0.7252	-0.9463	-0.7643	0.44	2.75
Waisha Village	1.7029	0.3484	-0.1412	1.0762	0.86	7.28
Miaoxia Village	-2.996 1	-0.8101	-0.6008	-2.0874	0.14	1.37
Layuan Village	2.1119	0.2243	2.0160	1.6760	1.00	10.00

Weijia Village	1.3324	1.6870	-0.8834	1.0194	0.85	7.07
Fenxiang Village	0.9964	-1.1577	-0.1662	0.3127	0.69	4.86
Lanxi Village	-1.2154	0.3069	3.2255	-0.0924	0.59	3.93
Shanggantang Village	-0.9127	-0.7655	0.6046	-0.6118	0.47	2.98
Shuangjiqiao Village	2.1806	2.0502	-0.8982	1.6073	0.98	9.64
Huangshaping Old Street Village	-0.7993	1.4638	0.4009	-0.0848	0.60	3.94
Tangjiaguan Village	2.4807	-0.0594	-0.3875	1.4098	0.94	8.69
Shankou Village	-1.3350	-1.2020	0.0134	-1.0671	0.37	2.34
Ziwei Village	-1.9477	2.7306	-1.3173	-0.7979	0.43	2.70
Shangtuan Village	-0.5410	-1.4518	-0.0485	-0.6561	0.46	2.91
Zhenglong Village	-0.9064	-1.2529	-0.0441	-0.8309	0.42	2.66
Laowu Village	-1.6219	1.8291	2.0910	-0.1995	0.57	3.71
Mojia Village	-0.9405	-0.0853	-0.0599	-0.5950	0.48	3.01
Lang Shi Village	1.2381	-0.7171	-0.3920	0.5159	0.73	5.41
Cangchang Village	1.9993	-0.6805	-0.6681	0.9329	0.83	6.75
Shuangxi Village	2.0540	-0.4193	-0.5038	1.0528	0.86	7.19

4.2.5 Evaluation on the current situation of social environment (A₅)

Calculating the social environment index according to the data, and SPSS is used to analyze all the index, and three major categories are obtained. After the range standardization and index standardization, the index standardization score is obtained as shown in Table 8.

From a regional point of view, the index value for the evaluation on rural social environment in eastern Hunan is between 2.25 and 9.32, with an average value of 4.43, showing a significant difference; and that in southern Hunan is between 1.00 and 10.00, with an average value of 4.92, and the difference is very obvious; and that in central Hunan is between 1.57 and 5.55, with an average value of 3.16, which is relatively obvious. From the perspective of village categories, contemporary villages with the lowest index value for the evaluation on social environment is Shuangji Village with a score of 1.67, followed by Shaoqian Village of 2.25. The social environment evaluation of Mojia Village and Ziwei Village is also lower with scores of 2.35 and 2.43 respectively, and the highest is Queshan Village with a score of 9.32, followed by Yamaguchi Village of 5.10. In traditional villages, the social environment evaluation score is between 1.00 and 10.00. Gaotian Village has the lowest score of 1.00, followed by Shuangxi Village of

1.57. Xiaoxu Village and Wejia Village also have lower scores of 2.05 and 2.31 respectively. Lanxi Village has the highest score of 10.00, followed by Shanggantang Village of 9.08 and Banliang Village of 8.08. Layuan Village and Miaoxia Village also have higher scores of 7.92 and 7.76 respectively.

4.3 AHP-PCA overall evaluation on rural settlements' adaptive development

The evaluation scores of each subsystem can neither be simply nor mechanically added up to. It is necessary to combine the weight values obtained in Table 3 of the AHP to perform weighted calculations on Tables 3 to 7 to obtain the evaluation values of the subsystems (Table 9)[26], after which are added up to, a comprehensive evaluation value is obtained.

Table 8. Evaluation results of the current situation of social environment for sample villages' adaptive development

Name	FAC1_1	FAC2_1	FAC3_1	Weighted Sum	Range Standardization Score	Index Standardization Score
Hutian Village	-2.1005	-0.9255	4.3861	-0.6929	0.40	2.52
Shaoqian Village	-1.9830	0.0200	1.3729	-0.9451	0.35	2.25
Queshan Village	3.5981	-0.2064	0.3642	2.1819	0.97	9.32
Shuyi Village	1.2971	-0.1117	-0.2087	0.7182	0.68	4.79
Tanwan Village	-0.9842	2.5489	-0.5027	-0.1149	0.52	3.28
Gaotian Village	-3.5253	-1.2607	-1.8751	-2.7309	0.00	1.00
Nanwan Village	1.1136	-2.4189	-1.7345	-0.1740	0.50	3.20
Xiaoxu Village	-1.8355	-0.6134	0.5009	-1.1512	0.31	2.05
Banliang Village	3.1921	-0.0295	-0.2562	1.8674	0.91	8.08
Waisha Village	-0.7683	0.3441	0.3759	-0.3191	0.48	2.99
Miaoxia Village	2.7324	0.5059	0.1373	1.7794	0.89	7.76
Layuan Village	2.5371	0.7763	0.7087	1.8230	0.90	7.92
Weijia Village	-1.3884	-0.3466	0.1280	-0.8891	0.36	2.31
Fenxiang Village	-0.0821	-1.6403	0.2520	-0.3689	0.47	2.92
Lanxi Village	3.2974	1.7568	-0.1983	2.3374	1.00	10.00
Shanggantang Village	3.8887	-0.7659	-0.2479	2.1243	0.96	9.08
Shuangjiqiao Village	-2.9590	1.9520	-1.4390	-1.6002	0.22	1.67
Huangshaping Old Street Village	1.5515	-1.6663	-0.4848	0.4773	0.63	4.30
Tangjiaguan Village	1.4251	-0.0400	1.0943	1.0414	0.74	5.55
Shankou Village	0.5165	2.0920	0.4629	0.8567	0.71	5.10
Ziwei Village	-1.3652	-0.2516	0.5536	-0.7788	0.39	2.43

Shangtuan Village	-0.4113	-0.2855	-2.0669	-0.6761	0.41	2.54
Zhenglong Village	-0.7548	1.4314	-0.3345	-0.1953	0.50	3.16
Laowu Village	-1.7175	0.3035	0.4959	-0.8776	0.37	2.32
Mojia Village	-1.6888	1.3146	-0.7045	-0.8481	0.37	2.35
Lang Shi Village	-0.7694	-1.2475	-0.5323	-0.8336	0.37	2.37
Cangchang Village	-0.3141	-0.5217	0.1601	-0.2764	0.48	3.05
Shuangxi Village	-2.5021	-0.7141	-0.4072	-1.7349	0.20	1.57

Table 9. Weighted score statistics of the evaluation results of the current situation for sample villages' adaptive development

Name	A ₁	A ₂	A ₃	A ₄	A ₅	Sum
Hutian Village	1.563	0.171	0.320	0.153	0.366	2.573
Shaoqian Village	0.438	0.137	0.271	0.998	0.327	2.171
Queshan Village	0.403	0.178	0.290	0.191	1.355	2.417
Shuyi Village	0.720	0.176	0.353	0.512	0.696	2.457
Tanwan Village	0.294	0.170	0.353	1.102	0.477	2.396
Gaotian Village	0.535	0.588	0.786	1.267	0.145	3.321
Nanwan Village	0.881	0.663	0.670	0.513	0.465	3.192
Xiaoxu Village	0.614	0.831	0.816	0.888	0.298	3.447
Banliang Village	2.815	0.716	2.712	0.420	1.175	7.838
Waisha Village	2.042	0.912	1.193	1.112	0.435	5.694
Miaoxia Village	1.957	0.708	1.267	0.209	1.128	5.269
Layuan Village	1.454	0.536	1.220	1.528	1.152	5.890
Weijia Village	1.166	1.017	0.862	1.080	0.336	4.461
Fenxiang Village	0.978	0.649	0.591	0.743	0.425	3.386
Lanxi Village	1.249	0.466	1.394	0.601	1.454	5.164
Shanggantang Village	2.938	0.831	2.492	0.455	1.320	8.036
Shuangjiqiao Village	0.461	0.254	0.494	1.473	0.243	2.925
Huangshaping Old Street Village	1.272	0.168	0.895	0.602	0.625	3.562
Tangjiaguan Village	1.636	1.165	1.226	1.328	0.807	6.162
Shankou Village	0.526	0.297	0.61	0.358	0.742	2.533
Ziwei Village	0.414	0.164	0.293	0.413	0.353	1.637
Shangtuan Village	0.978	0.353	1.812	0.445	0.369	3.957
Zhenglong Village	1.161	1.367	1.92	0.406	0.459	5.313
Laowu Village	0.690	0.146	0.795	0.567	0.337	2.535
Mojia Village	0.370	0.146	0.654	0.460	0.342	1.972
Lang Shi Village	1.384	0.805	0.984	0.827	0.345	4.345
Cangchang Village	0.978	0.416	0.732	1.031	0.443	3.600
Shuangxi Village	0.949	0.298	0.830	1.099	0.228	3.404

In the comprehensive evaluation on the adaptive development of rural settlements in the hilly areas of Hunan, from a regional point of view, the comprehensive evaluation value of rural areas in eastern Hunan

is between 2.171 and 2.573, with an average value of 2.403, which is a small difference, and that in southern Hunan is between 2.925 and 8.036, with an average value of 4.885, which is a big difference; and that in central Hunan is between 1.972 and 6.162, with an average value of 3.547, which is relatively different. Taking as a whole, the comprehensive evaluation value of rural areas in eastern Hunan is the lowest, that in southern Hunan is the highest, and that in central Hunan is in between. From the perspective of village categories, the comprehensive evaluation on contemporary villages is not desirable, whose value is between 1.972 and 2.925, with an average of 2.314; while the comprehensive evaluation value of traditional villages is between 2.535 and 8.036, with an average of 4.558, so the comprehensive evaluation on rural areas is quite different. Among the top 10 villages with lower scores, contemporary villages account for 8. Ziwei Village has the lowest score of 1.637, followed by Mojia Village of 1.972. Shaoqian Village and Tanwan Village also have lower scores of 2.171 and 2.396 respectively. Shuangji Village has the highest score of 2.925, followed by Shankou Village of 2.533. Among traditional villages, Laowu Village has the lowest comprehensive evaluation score of 2.535, followed by Hutian Village of 2.573. Nanwan Village and Gaotian Village also have lower scores of 3.192 and 3.321 respectively. Shanggantang Village has the highest comprehensive evaluation score of 8.036, followed by Banliang Village of 7.838. Tangjiaguan Village and Layuan Village also have higher comprehensive evaluation scores of 6.162 and 5.890 respectively.

V. CONCLUSION AND IMPLICATIONS

With the assistance of AHP, this thesis establishes an evaluation system for the current situation of the adaptive development of rural settlements in hilly areas of Hunan. On the basis of investigation, and in combination with PCA and SPSS statistical analysis methods, 28 typical villages are taken as examples for research, and the conclusions are drawn as follows: (1) There is little difference in the comprehensive evaluation on rural areas in eastern Hunan, but much in southern Hunan, and relatively much in central Hunan. Eastern Hunan has the lowest rural comprehensive evaluation value; southern Hunan, the highest; and central Hunan is in between. This indicates a big difference in the regional development of rural areas in the hilly areas of Hunan. (2) The comprehensive evaluation on traditional villages varies greatly, while the comprehensive evaluation on contemporary villages is not desirable. On the whole, the current situation of traditional villages' adaptive development is better than that of contemporary villages.

In the face of the impact of urbanization on rural space and culture as well as the demands of human settlements construction and rural revitalization, the empirical research conclusions of this thesis may yield the following implications: (1) Under the identical topographical environment, how to realize the rural revitalization strategy according to local conditions is essential for rural settlements' adaptive development. Villages in different regions should develop adaptively based on resource endowments, and at the same time, based on the current situation of the regional economy, further improve the infrastructure of rural settlements to create a sound social environment for the villagers; (2) Correctly analyzing the characteristics at the level of rural settlement adaptability of different categories, and the advantages and disadvantages in the development process shall accurately select the adaptability strategy for the rural planning in this area. For example, for traditional villages with a long history and ideal cultural resources,

the adaptive development should be based on protection, combined with micro-intervention methods to protect the topography and improve climactic adaptability, and also protect rural traditional culture. But such protection is by no means absolute to move not even a brick; instead, it is a relative protection, so as to better play the demonstration role. For contemporary villages that need to be improved in quality, under the guidance of national policies, by altering the single agricultural industrial structure, improving infrastructure and etc., villagers' spirit and the villages' public environment will be further perfected to meet the spiritual demands of rural areas.

ACKNOWLEDGMENT

This work was supported by key project fund of Hunan Provincial Department of Education (21A0205, 21A0189) and Changsha University of technology introduced doctoral startup fund (000301917) .

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