# Study on Evaluation of Rural Ecological Environment and Its Influencing Factors in Sichuan Province

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# Abstract

Rural ecological environment is the basic on human survival, analyze its structure and function is the key to crack the problem of agro-ecological environment. This paper studied the evaluation of rural ecological environment and its influencing factors. The results showed that: the rural ecological environment showed declining trend, the value of its input-output efficiency was low and its regional differences was significant; the quality of economic development affected the rural ecological environment in a certain extent, but not the only factor; chemical fertilizer, pesticide, agricultural plastic film, arable land were key factors affecting the rural ecological environment. It implied that there was a large room for improving the rural ecological environment.

Keywords: Rural Ecological Environment, Evaluation, Influencing factors, Sichuan Province

#### 1. Introduction

In recent years, China government has made tremendous efforts in environment protection and achieved remarkable achievements. The improvement of urban environment was more obvious, but the rural ecological environment was still quite grim. Take the typical western agricultural province - Sichuan province for example, according to the environmental capacity analysis report, rural pollution load in the proportion of overall pollution load has reached 30% -40% in some areas, even up to 70%; Livestock discharged COD 3.9 million tons and ammonia 7.9 million tons per year, that of industrial pollution emissions 13 times and 38 times respectively; chemical fertilizer application amounted to 2.2 million tons per year, average 490 kg per hectare, far more than the developed countries setting the standard 225 kg per hectare in order to prevent water pollution and chemical fertilizers, also significantly higher than the national average use of fertilizer 330 kg per hectare (Su, 2007; Wu, 2000). Therefore, the in-depth study of rural ecological environment has important practical significance.

# 2. Theoretical models and research methods

# 2.1 Theoretical models

Principal component analysis (PCA) aims to use reduced-order thoughts, put multiple indicators transformed into a few more comprehensive indexes, and generate objective weight coefficient according to the original information, but its lack of consideration for index relative important degree (Liu, 2005;Wang, 2009). Data envelopment analysis (DEA) is based on the concept of relative efficiency, for the evaluation of multi-input and multi-output with the same type of decision making units whether technology effectively with non-parametric statistical method, the method not need to determine the index of weight, less affected by subjective factors, but can not reflect the preferences of policy makers (Ma, 2009;Zhou, 2009). This paper combines both kinds of models, both absorbing its advantages and overcome its deficiency, to comprehensive evaluation of the rural ecological environment in Sichuan province.

#### 2.2 Research methods

# 2.2.1 Establish evaluation index system of rural ecological environment

This paper chose 19 indexes to establish the evaluation index system, mainly considered from three aspects include rural resources environment, rural production environment, and rural living environment. These indexes included both gross index and average index, also included absolute index and opposite index, basic to fully

reflect the level of the rural ecological environment in Sichuan province. The contents of its evaluation index system shown in Table 1.

# 2.2.2 PCA model analysis

Through calculated the covariance matrix of rural ecological environment evaluation index system, to obtain covariance matrix eigenvalues and eigenvectors, and calculating the evaluation index of the contribution and cumulative total variance contribution to determine the main factor (components), and then respectively calculated for each main component of the linear weighted. Finally, the contribution rate to the principal component weights calculated as the weighted integrated value.

# 2.2.3 DEA model analysis

On the basis of the initial evaluation index system, through analysis of evaluation indexes discrimination to discern the higher indexes, constituted the second round of evaluation index system, and then by low correlation filter-related indexes, constituted the third round of the evaluation index system. Take 21 cities in Sichuan province for decision-making unit, using the DEAP2.1 software to calculate the efficiency evaluation value of the third round of evaluation index system.

# 2.2.4 PCA - DEA model integration

Using linear-weighted method to combine both kinds of models, obtained the comprehensive evaluation value, and more objectively reflected the real situation of rural ecological environment in Sichuan province.

# 3. Empirical Study

# 3.1 Data sources and pretreatment

This paper used data from "Statistical Yearbook of Rural Sichuan ", involving 19 indexes from 2006- 2008. But there were still a few data is missing, including  $X_1(2007)$ ,  $X_7(2007)$ ,  $X_9(2007)$ ,  $X_{14}(2007)$ ,  $X_{17}(2007)$ ,  $X_{18}(2007)$ ,  $X_{19}(2007)$ . Interpolation method for the missing data used in this paper, which taken the average value of the index in two years. By this way, this paper collected 1197 raw data of 21 cities in Sichuan province. The first step of the pretreatment is index data positive processing, mainly to solve the problems of inverse index. There are 8 inverse indexes in this paper, including  $X_2$ ,  $X_3$ ,  $X_4$ ,  $X_5$ ,  $X_7$ ,  $X_8$ ,  $X_{13}$ ,  $X_{15}$ , adopted reciprocal method of positive processing. The second step of the pretreatment is index data dimensionless processing, mainly to solve the problems of inverse processing.

#### 3.2 PCA model evaluation research

This paper adopted PCA model to analysis the time series data (2006-2008) of rural ecological environment in Sichuan province by the SPSS statistical analysis software Factor process. The principal components extraction principle was corresponding eigenvalues greater than 1. Take 2008 data as an example, the results shown in Table 2, Table 3. Table 2 showed that should extract 6 principal components, its accumulative contribution rate had reached 84.27%, and explained that the principal components reflected the index of nearly complete information. The square root of eigenvalues divided by the data matrix in Table 3, and then obtained the principal components of each index of the coefficient. Take the each principal components corresponding eigenvalues proportion of total eigenvalues extracted as weights, and then compute principal component integrated model. The analysis results shown in Table 4- Table 7.

Through the above methods calculate the 2006-2008 evaluation of rural ecological environment in Sichuan province, the results shown in Table 8.

#### 3.3 DEA model evaluation research

#### 3.3.1 Index discrimination analysis

Index discrimination refers to the ability in distinguishing the various characteristics of evaluation units. If all the evaluated units got high or low score in an index, this explained that the index could not accurately distinguish the rural ecological environment in different regions, and the index has lower discrimination ability. Conversely, it showed that the indicator had higher discrimination ability, it could discriminate the rural ecological environment in different regional. This paper defined the deviation coefficient ( $V_i$ ) to study the index discrimination in rural ecological environment. The larger the deviation coefficient is, the higher the index discrimination. According to the above principle, calculated the index discrimination of rural ecological environment in Sichuan province by used the SPSS software, the results shown in Table 9. This paper take  $V_i$  =0.6 as the marginal value. The results showed that retain  $X_2$ ,  $X_3$ ,  $X_4$ ,  $X_5$ ,  $X_7$ ,  $X_8$ ,  $X_9$ ,  $X_{10}$ ,  $X_{11}$ ,  $X_{14}$ ,  $X_{19}$ . The 11 indexes constituted the second round evaluation index system of rural ecological environment in Sichuan

province.

3.3.2 Index correlation analysis

Usually there is some correlation between the evaluation index, which means that the information was reused, enlarge or reduce the influence of certain factors on evaluation of objects, thereby reducing the effectiveness of the evaluation results and lead to evaluation of the results incredible. Through correlation analysis of indexes, deleted the larger correlation coefficient index, could improve evaluation index system scientific. Correlation is significant at the 0.01 level. The results showed that retain  $X_5$ ,  $X_7$ ,  $X_8$ ,  $X_9$ ,  $X_{10}$ ,  $X_{11}$ ,  $X_{19}$ . The 7 indexes constituted the third round evaluation index system.

# 3.3.3 DEA model evaluation

The input indicators were  $X_7$ ,  $X_{11}$ . The output indicators were  $X_5$ ,  $X_8$ ,  $X_9$ ,  $X_{10}$ ,  $X_{19}$ . Table 10 showed the result of DEA model evaluation.

# 3.4 PCA - DEA model integration

According to the results of PCA and DEA calculations, calculated the value of comprehensive evaluation. Table 11 showed the result of rank in the comprehensive evaluation.

# 3.5 Result analysis

# 3.5.1 General situation of the rural ecological environment

2006-2008, only 21 cities' rural ecological environment improvement in Sichuan province, included Bazhong, Yaan, Ganzi, Aba, Liangshan. The other 16 cities showed declining trend in the rural ecological environment. This indicated that the trend of rural ecological environment was deteriorating. Further analysis of economic development in rural areas in recent years, rural per capita GDP rose from 2,329 yuan in 2006 to 3,529 yuan in 2008, which verifies the Environmental Kuznets Curve. The vast rural areas were still in the initial stage of economic development, resource consumption exceeds renewable resources, and the rural eco-environment situation is quite grim.

#### 3.5.2 Regional situation of the rural ecological environment

Chengdu, the highest evaluation of the rural ecological environment, reaching 90.6 points, while Ganzi was only 38.5 points, the former is 2.4 times the latter. This shows that regional differences in rural ecological environment are significant, governance policies and measures to the rural ecological environment should be adapted to local conditions, unfavorable "one size fits all."

#### 3.5.3 Input-output efficiency of the rural ecological environment

The efficiency average value of the rural ecological environment in Sichuan province was 0.72, and the gap was wide if comparing with the efficiency optimization. There are 9 cities in efficiency value reached 1, such as Chengdu, Zigong etc, accounting for 43 percent of the convince. Panzhihua, Luzhou, Guangyuan, Suining, Leshan, Zigong and Bazhong in efficiency average value of the rural ecological environment only were 0.35, mainly caused by the technology inefficient and should focus on improving the efficient use of inputs factors. Luzhou, Meishan, Bazhong, Aba and Ganzi in efficiency average value only were 0.35; the main reason was improper scale and should focus on strengthening the scale adjustment. It should be noted that, Luzhou, Bazhong in terms of technical efficiency and scale efficiency were not optimal. Meanwhile, Luzhou, Nanchong, Bazhong existed the problem of decreasing returns to scale, should appropriately control the scale of inputs in order to achieve a larger output efficiency.

#### 3.5.4 Economic development and rural ecological environment

Whether AHP evaluation results or DEA evaluation results showed, the better regional economic development was, such as Chengdu, Mianyang, Deyang and other cities, the better rural ecological environment. Conversely, the lagging economic development area, such as Bazhong, Ganzi, Aba etc, rural ecological environment were relatively poor. This shows that the economic strength and the rural ecological environment have some certain relevance. But there are exceptions, such as Yaan although economic conditions worse, but the rural ecological environment worse. Therefore, the rural ecological environment can be improved through other relevant factors.

#### 3.5.5 Influence factors of rural ecological environment

Table 2, Table 3 showed the component 1 eigenvalues highest, and  $X_2$ (consumption of chemical fertilizers),  $X_3$  (consumption of pesticide),  $X_4$ (consumption of agricultural plastic film),  $X_8$ (loss of arable land index) higher correlation coefficients in the component 1. It indicated that the  $X_2$ ,  $X_3$ ,  $X_4$ ,  $X_8$  were key factors affecting the

rural ecological environment in 2008. Therefore, improving the rural ecological environment of the key measures is to reduce the consumption of chemical fertilizer, reducing consumption of pesticide, reduced consumption of agricultural plastic film, reducing the amount of arable land loss. Further analysis was improving agricultural production technology to develop "low carbon" agriculture, because "low carbon" agriculture means low consumption of chemical fertilizers, pesticide, and agricultural plastic film. Meantime, the government should strengthen the management of arable land.

#### 4. Conclusions

This paper studied the evaluation of rural ecological environment by PCA-DEA model and drawn the following conclusions: rural ecological environment has not improved with the rapid economic development, and showed declining trend; regional differences in rural ecological environment were significant, governance policies and measures to the rural ecological environment should be adapted to local conditions; the input-output efficiency of the rural ecological environment was lower, caused by the technology inefficient and improper scale; the quality of economic development affected the rural ecological environment in a certain extent, but not the only factor; chemical fertilizer, pesticide, agricultural plastic film, arable land were key factors affecting the rural ecological environment, the measures should be to develop "low carbon" agriculture and protect arable land.

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Category	Index	Units	Code
	Forest coverage	%	X1
	Consumption of chemical fertilizers	Ton	X2
	Consumption of pesticide	Ton	X <sub>3</sub>
	Consumption of agricultural plastic film	Ton	X4
D 1	Consumption of agricultural diesel	Ton	X5
Rural resources environment	Irrigation rates	%	X <sub>6</sub>
	Sulfur dioxide emissions intensity	Ton/km	X <sub>7</sub>
	Loss of arable land index		X <sub>8</sub>
	Nature reserve area ratio	%	X9
	Grain for Green area ratio	%	X10
	Agricultural output value	RMB yuan	X <sub>11</sub>
Downland destion and incomment	Proportion of rural services	%	X <sub>12</sub>
Rural production environment	Consumption of agricultural electricity	KWh	X <sub>13</sub>
	Environmental pollution control costs	RMB yuan	X <sub>14</sub>
	Engel Coefficient		X15
	Rural per capita net income	RMB yuan	X16
Rural living environment	Rural per capita living space	m2	X <sub>17</sub>
	Proportion of the population of rural cooperative medical care	%	X <sub>18</sub>
	Proportion of rural endowment insurance	%	X19

Table 1. Rural ecological environment evaluation index system

Table 2. Rotation Sums of Squared Loadings (2008)

Component	Eigenvalues	Contribution rate (%)	Cumulative contribution rate (%)
1	5.821	30.636	30.636
2	2.851	15.003	45.639
3	2.429	12.784	58.423
4	2.157	11.354	69.776
5	1.817	9.562	79.338
6	1.451	7.636	86.974

Table 3. Rotated Component Matrix (2008)

Index code	Component 1	Component 2	Component 3	Component 4	Component 5	Component 6
X <sub>1</sub>	-0.197	-0.213	-0.196	0.305	0.857	-0.056
X <sub>2</sub>	0.968	0.130	0.005	0.027	-0.089	0.010
X <sub>3</sub>	0.969	0.222	-0.006	0.011	-0.018	-0.003
X4	0.923	0.044	0.125	-0.132	0.119	0.161
X <sub>5</sub>	0.382	0.110	0.286	-0.377	0.521	0.153
X <sub>6</sub>	-0.446	-0.360	0.536	0.323	0.125	0.244
X <sub>7</sub>	-0.030	-0.012	-0.138	-0.125	0.002	-0.919
X <sub>8</sub>	0.883	-0.206	-0.192	-0.054	-0.183	-0.034
X9	0.435	0.598	0.098	0.207	0.525	-0.074
X <sub>10</sub>	-0.012	0.924	-0.046	0.031	-0.103	0.143
X <sub>11</sub>	-0.479	-0.246	0.390	0.121	-0.298	-0.410
X <sub>12</sub>	0.053	0.948	0.132	0.007	-0.009	-0.101
X <sub>13</sub>	-0.101	-0.226	-0.885	-0.064	-0.042	-0.088
X <sub>14</sub>	0.057	-0.078	0.080	0.887	0.154	0.048
X <sub>15</sub>	-0.466	0.021	0.415	0.158	0.548	0.169
X <sub>16</sub>	-0.605	-0.321	0.589	0.361	-0.100	0.045
X <sub>17</sub>	-0.593	-0.344	0.377	0.146	0.065	0.451
X <sub>18</sub>	-0.709	0.162	0.513	0.248	-0.131	0.150
X <sub>19</sub>	-0.234	0.278	0.233	0.832	0.081	0.148

Component	Eigenvalues	Contribution rate (%)	Cumulative contribution rate (%)
1	4.175	21.973	21.973
2	2.565	13.498	35.471
3	2.499	13.153	48.624
4	2.236	11.767	60.391
5	2.044	10.760	71.151
6	1.759	9.260	80.411
7	1.576	8.293	88.704

# Table 4. Rotation Sums of Squared Loadings (2007)

# Table 5. Rotated Component Matrix (2007)

Index code	Component 1	Component 2	Component 3	Component 4	Component 5	Component 6	Component7
X1	0.227	0.172	0.706	0.481	-0.040	-0.221	-0.148
X <sub>2</sub>	-0.810	0.156	0.089	-0.335	0.187	0.242	0.194
X <sub>3</sub>	-0.868	0.290	0.080	-0.213	0.142	0.200	0.179
$X_4$	-0.733	0.348	0.188	-0.409	-0.050	-0.203	0.236
X <sub>5</sub>	-0.391	0.420	0.218	-0.191	-0.431	-0.557	0.042
X <sub>6</sub>	0.779	0.223	0.251	-0.287	-0.035	-0.039	0.113
X <sub>7</sub>	-0.145	-0.347	0.057	0.548	-0.481	0.247	0.468
X <sub>8</sub>	-0.252	-0.581	0.074	-0.398	0.120	0.239	-0.533
X9	-0.445	0.641	0.166	0.258	0.031	0.272	-0.276
X <sub>10</sub>	-0.333	0.549	-0.530	0.383	0.069	-0.245	-0.118
X <sub>11</sub>	0.655	-0.138	-0.229	-0.004	-0.213	0.321	0.131
X <sub>12</sub>	-0.325	0.566	-0.437	0.344	-0.173	0.273	-0.295
X <sub>13</sub>	-0.140	-0.649	0.038	0.415	0.434	-0.333	0.056
X <sub>14</sub>	0.208	0.405	0.572	0.063	0.317	0.295	0.176
X <sub>15</sub>	0.749	0.371	0.365	0.106	0.021	0.134	-0.188
X <sub>16</sub>	0.892	0.206	0.026	-0.204	-0.171	0.175	0.117
X <sub>17</sub>	0.801	0.196	-0.047	-0.234	-0.014	-0.247	-0.239
X <sub>18</sub>	0.542	0.277	-0.595	-0.249	0.054	-0.063	0.157
X <sub>19</sub>	0.500	0.374	-0.219	0.179	0.600	-0.070	0.302

Table 6. Rotation Sums of Squared Loadings (2006)

Component	Eigenvalues	Contribution rate (%)	Cumulative contribution rate (%)
1	4.825	25.393	25.393
2	2.368	12.465	37.858
3	2.030	10.685	48.543
4	1.892	9.958	58.501
5	1.834	9.650	68.151
6	1.640	8.632	76.783

Index code	Component 1	Component 2	Component 3	Component 4	Component 5	Component 6
$X_1$	0.314	-0.248	0.703	-0.043	-0.147	0.347
X <sub>2</sub>	-0.949	0.006	-0.012	0.058	-0.010	0.099
X <sub>3</sub>	-0.953	-0.017	0.038	0.154	-0.087	0.136
$X_4$	-0.854	0.053	-0.065	-0.065	-0.211	0.338
X <sub>5</sub>	-0.276	0.047	-0.102	0.015	-0.418	0.685
$X_6$	0.509	0.553	0.178	-0.421	0.140	0.201
X <sub>7</sub>	-0.009	-0.180	-0.043	-0.011	-0.182	0.009
$X_8$	0.143	-0.154	-0.210	-0.099	-0.212	-0.844
X9	-0.401	0.039	0.530	0.575	0.039	-0.031
X <sub>10</sub>	0.315	-0.104	-0.349	0.668	0.013	0.287
X <sub>11</sub>	0.490	0.398	-0.109	-0.042	0.426	-0.033
X <sub>12</sub>	-0.139	0.119	0.033	0.887	-0.105	-0.008
X <sub>13</sub>	0.085	-0.881	-0.077	-0.226	0.161	-0.140
X <sub>14</sub>	-0.005	0.178	0.800	-0.052	-0.191	-0.030
X <sub>15</sub>	0.612	0.391	0.512	-0.065	0.180	0.109
X <sub>16</sub>	0.628	0.678	0.129	-0.151	0.150	0.010
X <sub>17</sub>	0.700	0.319	-0.004	0.108	0.218	0.139
X <sub>18</sub>	0.103	0.456	-0.294	0.011	0.606	-0.116
X <sub>19</sub>	0.194	-0.159	-0.122	-0.119	0.872	0.068

Table 7. Rotated Component Matrix (2006)

Table 8. PCA model evaluate the rural ecological environment in Sichuan province

Cities	2006	2007	2008	Average	Changes
Chengdu	2.445	1.952	-0.089	1.436	Continuing decline
Zigong	0.016	0.024	-0.509	-0.156	n-type decline
Panzhihua	0.779	1.554	0.977	1.104	n-type decline
Luzhou	0.411	-0.014	-0.228	0.056	Continuing decline
Deyang	0.783	0.576	0.099	0.486	Continuing decline
Mianyang	0.982	0.718	-0.080	0.540	Continuing decline
Guangyuan	0.140	0.418	-0.077	0.160	n-type decline
Suining	-0.177	0.437	-0.298	-0.013	n-type decline
Neijiang	-0.246	-0.656	-0.433	-0.445	u-type rise
Leshan	0.593	0.424	-0.115	0.300	Continuing decline
Nanchong	0.090	-0.100	-0.769	-0.260	Continuing decline
Meishan	0.506	0.376	-0.366	0.172	Continuing decline
Yibin	0.012	-0.157	-0.600	-0.248	Continuing decline
Guang'an	0.124	-0.529	-0.546	-0.317	Continuing decline
Dazhou	-0.004	-0.330	-0.708	-0.347	Continuing decline
Yaan	0.113	-0.317	0.870	0.222	u-type rise
Bazhong	-0.846	-0.483	-0.338	-0.556	Continuing rise
Ziyang	-0.426	-0.271	-0.578	-0.425	n-type decline
Aba	-0.664	-0.966	2.237	0.202	u-type rise
Ganzi	-3.147	-2.236	2.593	-0.930	Continuing rise
Liangshan	-1.482	-0.419	-1.042	-0.981	n-type decline

Table 9. Index discrimination analysis

Index	X1	$X_2$	X <sub>3</sub>	$X_4$	X <sub>5</sub>	$X_6$	X <sub>7</sub>	$X_8$	$X_9$	$X_{10}$
Vi	0.332	0.743	0.615	0.629	0.684	0.311	0.967	1.087	0.853	1.584
Index	X <sub>11</sub>	X <sub>12</sub>	X <sub>13</sub>	X <sub>14</sub>	X <sub>15</sub>	X <sub>16</sub>	X <sub>17</sub>	X <sub>18</sub>	X <sub>19</sub>	
Vi	0.652	0.563	0.516	2.340	0.112	0.231	0.134	0.378	0.921	

Cities	Crste efficiency	Vrste efficiency	Scale efficiency	Scale remuneration
Chengdu	1.000	1.000	1.000	
Zigong	1.000	1.000	1.000	
Panzhihua	0.167	0.167	0.998	
Luzhou	0.409	0.480	0.851	drs
Deyang	1.000	1.000	1.000	
Mianyang	1.000	1.000	1.000	
Guangyuan	0.515	0.519	0.993	irs
Suining	0.403	0.406	0.993	irs
Neijiang	1.000	1.000	0.993	
Leshan	0.388	0.408	0.951	irs
Nanchong	0.985	1.000	0.985	drs
Meishan	0.747	1.000	0.747	irs
Yibin	1.000	1.000	1.000	
Guang'an	0.935	1.000	0.935	
Dazhou	1.000	1.000	1.000	
Yaan	1.000	1.000	1.000	
Bazhong	0.200	0.358	0.558	drs
Ziyang	0.976	1.000	0.976	irs
Aba	0.057	1.000	0.057	irs
Ganzi	0.240	1.000	0.240	irs
Liangshan	1.000	1.000	1.000	

Table 10. DEA model evaluate the rural ecological environment in Sichuan province

Note: crste = technical efficiency from CRS DEA

vrste = technical efficiency from VRS DEA

scale = scale efficiency = crste/vrste

Table 11. AHP-DEA model evaluate the rural ecological environment

Cities	AHP	DEA	Average	Score	Rank
Chengdu	1.436	1.000	1.218	90.6	1
Zigong	-0.156	1.000	0.422	64.1	7
Panzhihua	1.104	0.167	0.635	71.2	4
Luzhou	0.056	0.409	0.233	57.8	16
Deyang	0.486	1.000	0.743	74.8	3
Mianyang	0.540	1.000	0.770	75.7	2
Guangyuan	0.160	0.515	0.338	61.3	11
Suining	-0.013	0.403	0.195	56.5	17
Neijiang	-0.445	1.000	0.278	59.3	14
Leshan	0.300	0.388	0.344	61.5	10
Nanchong	-0.260	0.985	0.363	62.1	9
Meishan	0.172	0.747	0.459	65.3	6
Yibin	-0.248	1.000	0.376	62.5	8
Guang'an	-0.317	0.935	0.309	60.3	13
Dazhou	-0.347	1.000	0.326	60.9	12
Yaan	0.222	1.000	0.611	70.4	5
Bazhong	-0.556	0.200	-0.178	44.1	20
Ziyang	-0.425	0.976	0.275	59.2	15
Aba	0.202	0.057	0.130	54.3	18
Ganzi	-0.930	0.240	-0.345	38.5	21
Liangshan	-0.981	1.000	0.010	50.3	19