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Factor Analysis on the Factors that Influencing Rural Environmental Pollution in the Hilly Area of Sichuan Province, China

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Abstract By using factor analysis method and establishing analysis indicator system from four aspects including crop production, poultry farming, rural life and township enterprises, the difference, features, and types of factors influencing the rural environmental pollution in the hilly area in Sichuan Province, China. Results prove that the major factor influencing rural environmental pollution in the study area is livestock and poultry breeding, followed by crop planting, rural life, and township enterprises. Hence future pollution prevention and control should set about from livestock and poultry breeding. Meanwhile, attention should be paid to the prevention and control of rural environmental pollution caused by rural life and township enterprise production.

Key words Rural area, Environmental pollution, Influencing factors, Factor analysis, Hilly area in Sichuan Province, China

With the deepening of rural economic and social reform in China, the rural ecological environment problem caused by industrialization, urbanization and agricultural development brings along many direct and potential negative effects on the living environment of the masses. Rural ecological environment has become a serious "bottle neck" that restricting the new village construction of China. Conducting a study of factors influencing rural environmental pollution in some areas is good for knowing well about the overall situation of rural environment in the study area and it is of practical significance in guaranteeing the synergy between regional rural production, life and resource environment and harmonizing regional rural man-land relationship. As a traditional major farming region is southwest China, the hilly area in Sichuan has faced an extreme serious rural environment problem for a long time due to the interference of natural and human factors. Taking the countryside in the hilly area in Sichuan as an example, the paper mainly analyzes main factors influencing regional rural environmental pollution; probes into regional rural production and life optimal management models and optimal production factor input and use structure; provides a theoretical guide to selection of appropriate new strategies for regional rural environmental protection; and offers countermeasures and suggestions on pushing forward sustainable development of rural economy and society.

1 Basis for probing into the factors influencing rural environmental pollution

From the overall perspective, in the past, the research on rural environment mainly focused on the quantitative research

of micro influencing factors both at home and abroad. The research on the basis of the rural area was absent and the research on rural environmental protection system of the special area should be further improved.

1.1 Overseas studies Overseas studies of factors influencing rural environmental pollution deprive from polluted water of agriculture. In 1960s, some developed countries, such as USA, UK, and Japan, took the lead in making such study. After 1970s, all countries in the world began to pay attention to it. In late 1970s, in order to satisfy the demand of rural plan, overseas studies of factors influencing rural environmental pollution and macro-features of rural environmental pollution turned gradually to spatial analysis of main factors and key source areas, which were closely related to pollution control, from initial analysis of related factors and spatial-temporal variability^[1]. After 1980s, oversea studies of factors influencing rural environmental pollution were deepened. Especially, with the development and advancement of computer and satellite remote sensing technology, the "3S" technology represented by landsat database, GIS, etc. were widely applied to the studies of influencing factors relating to rural environmental pollution control^[2]. Thus it can be seen that overseas studies of factors influencing rural environmental pollution are using 3S technology in combination with regional morphologic characteristics to explore new pollution influencing factors.

1.2 Domestic studies

1.2.1 Studies on the factors influencing rural environmental pollution from the micro-perspective. Scholars mainly discuss about the effect of agricultural households' economic behaviors on rural environment and pollution prevention and control in rural areas. The studies of the response of agricultural households' economic behaviors, e. g. farming and operation, and life styles to environment policies have become a hot topic

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in the circle. For example, CHEN Li-ding *et al.* reached a common understanding through studies that the deterioration of rural environment was related directly to agricultural households' farming behaviors and life styles. They described briefly why agricultural households' behaviors did harm to rural environment in combination with their respective study area^[3-5].

1.2.2 Studies on the factors influencing rural environmental pollution from the meso-perspective. Scholars think there are many factors causing environmental pollution in the vast rural areas and the factor varies in different areas. Sequencing the contribution degree of influencing factors of specific areas is instructive in studying regional rural environmental pollution prevention and control. Therefore, specific studies of large-size rural pollution sources were carried out one after another in recent years. For example, through monitoring over typical rural environment in Taihu Area, XIA Li-zhong *et al.* proved that the excessively-high load of water nitrogen and phosphorus in the rural resident concentrated places in the study area was a serious non-point-source pollution source^[6]. Through the monitoring and analysis of water quality at the village catchment area along Jiulong River in Fujian, CHEN Neng-wang *et al.* summarized domestic sewage quality features and drainage characteristics, estimated quantitatively the nutrient salt pollution load of rural domestic sewage in Jiulong River Basin, and firmly believed that water pollution was a major factor causing rural environmental pollution in the study area^[7].

1.2.3 Studies on the factors influencing rural environmental pollution from the marco-perspective. LI Wei-wei *et al.* pointed out that, in the process of nationwide new village construction, rural environmental pollution is an important factor restricting new countryside construction while urban industrial structure transfer, rapid development of township enterprises, large-size livestock and poultry breeding, and outdated planting technology are main factors causing rural environmental pollution^[8].

2 Empirical analysis on factors influencing rural environmental pollution—Taking hilly area in Sichuan Province, China as an example

2.1 Profile of the study area The hilly area in Sichuan is located in the middle of Sichuan Basin, north of Yangtze River,

south of Jiange, Cangxi and Yilong counties, east of Longquan Mountain, and west of Huaying Mountain. The area covers 68 counties (cities, districts) of 16 municipalities, accounting for 37.6% of the total counties (cities, districts) of Sichuan. It covers a land area of 92 000 km², accounting for 18.48% of Sichuan Province. Its total population reaches 51.40 million, accounting for 60.4% of the total population in Sichuan Province. Rural population is 43.247 million, accounting for 63.3% of the total rural population in Sichuan Province. With a population density up to 585.18 persons per km², it is a typical region with vast population but limited arable land, where there is a big population-land contradiction. The study area' arable land and agricultural value added account for 57.19% and 59.15% of those of the province respectively. Its grain-sown area accounts for 60% of the total arable land area of the province, total grain output accounts for more than 90% of total marketable grain quantity of the province. This area is a centuries-old agricultural economic area, the largest farming zone in Sichuan, and an advantageous animal husbandry area^[9]. Theoretically speaking, classification of eco-environment type is done according to the objective realities of natural environment and social and economic conditions. It is impossible to comply with the division of administrative division. However, since human economic activities are influenced and restricted seriously by administrative division and the purpose of rural eco-environment studies is to serve rural environmental protection and comprehensive treatment, 68 counties (cities and districts) in the hilly area of Sichuan are chosen as study sample in order to guarantee the effectiveness of data collection and analysis as well as popularization and application of study findings.

2.2 The establishment of an index system Based on the scope of this study and in combination with collection of data and information and others' studies^[3,10-11], an analysis index system is established from four aspects, *i. e.* crop farming, livestock and poultry breeding, rural life and township enterprise production (Table 1).

2.3 Data source The data involved in the study mainly comes from three sources. The first source is statistical data and industry standards released by government at all levels and summarization materials of relevant departments; the second source is the early investigation results of such projects as "modern agriculture and new countryside construction pilot area

Table 1 Factors influencing rural environmental pollution in the hilly area in Sichuan Province

Goal	System	Indices
Rural environmental pollution intensity	Source of pollution caused by crop planting	X_1 : Fertilizer use density // kg/hm ²
		X_2 : Pesticide use density // kg/hm ²
		X_3 : Agricultural film use // kg/hm ²
		X_4 : Unit area straw output // kg/hm ²
	Source of pollution caused by livestock and poultry breeding	X_5 : Comprehensive livestock and poultry waste utilization rate of large-size breeding farm // %
		X_6 : Livestock and poultry urine and feces density // t/hm ²
	Source of pollution caused by rural life	X_7 : Rural toilet popularity rate // %
		X_8 : Per capita quantity of household waste // kg/person
		X_9 : Per capita quantity of domestic sewage // t/person
Source of rural exogenous pollution	Source of rural exogenous pollution	X_{10} : Quantity of wastewater discharged by township enterprises // $\times 10^4$ t
		X_{11} : Quantity of SO ₂ discharged by township enterprises // $\times 10^4$ t
		X_{12} : Quantity of solid waste generated by township enterprises // $\times 10^4$ t

planning" and "ecological county construction planting", *etc.*, which were carried out in the hilly area of Sichuan Province in the latest two years; the third source is the information collected by spot check and interview.

2.4 Results and analysis It is supposed that the index set matrix of 12 indices of 68 counties (cities, districts) is X_{ij} , where $i=1, 2, \dots, 68; j=1, 2, \dots, 12$.

Firstly, extreme difference treatment method is used to eliminate the dimension of different indices. The calculation formula is as follows:

$$X = (X_i - X_{\min}) / (X_{\max} - X_{\min})$$

Where X stands for the value after standardization, X_i for original index value, X_{\min} and X_{\max} for minimum value and maximum value respectively.

Then software SPSS17.0 is used to analyze factors. Generally speaking, if the accumulated contribution rate of main constituents reaches 80% – 85% or above, the result will be deemed as a satisfactory result, based on which we can decide how many main constituents should be taken. Bartlett's test proves that Bartlett value = 1 081. 17, $P < 0.000 1$. That is to say, related matrix is not a unit matrix. Therefore factor analysis is taken into consideration. The fact that KMO value is 0.761 indicates that the result of factor analysis is good and

factor analysis is suitable. Accordingly, main constituents of factor indices influencing rural influencing rural environmental pollution are taken and analyzed according to the principle of accumulated contribution rate higher than 85%. Table 2 mainly reflects the decomposition of total variance in the process of main constituent analysis. From Table 2, it can be seen that the first four factors influencing rural environmental pollution provide 86.308% of original data information. These four factors have summarized adequately most data and can be used to explain the information contained by original data. Therefore, these four common factors are chosen and they cause no loss to the total quantity of information.

In the initial factor loading matrix, the difference of common factors' loan value on each index variable is not obvious. Initial factor's typical variable is indistinct. The key of factor analysis is to give a new meaning to common factor and provide a reasonable economic explanation. Therefore, the orthogonal rotation method (Varimax) must be used to realize a maximum orthogonal rotation and then get corresponding factor loading matrix (Table 3) so as to judge the primary or secondary position of loads of factors influencing rural environmental pollution.

Table 2 Influencing factors of eigenvalue and contributing rate

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Eigen value	Contribution rate//%	Cumulative contribution rate//%	Eigen value	Contribution rate//%	Cumulative contribution rate//%	Eigen value	Contribution rate//%	Cumulative contribution rate//%
1	4.531	45.766	47.766	4.531	45.766	47.766	3.157	36.311	36.311
2	1.917	18.976	64.742	1.917	18.976	64.742	2.717	22.638	58.949
3	1.333	12.112	76.854	1.333	12.112	76.854	1.850	15.141	74.090
4	1.134	9.454	86.308	1.134	9.454	86.308	1.193	12.218	86.308

Table 3 Load matrix after revolving

Variables	Major factor 1	Major factor 2	Major factor 3	Major factor 4
X_1	0.136	0.821	0.047	0.100
X_2	0.036	0.798	0.081	0.111
X_3	0.193	0.589	0.127	0.021
X_4	0.174	0.617	0.172	0.181
X_5	-0.709	-0.267	-0.112	-0.068
X_6	0.827	-0.081	0.284	-0.286
X_7	-0.297	-0.035	-0.827	-0.075
X_8	0.026	0.234	0.747	0.422
X_9	0.064	0.119	0.860	0.201
X_{10}	0.009	0.001	0.280	0.946
X_{11}	0.010	0.002	0.271	0.949
X_{12}	0.007	0.002	0.270	0.949

The interrelation between four major factors and original variables can be found out from Table 2 and 3. The first major factor's load is large on variables X_6 and X_5 , especially on variable X_6 , where its information load accounts for 32.79% of the information load of all variables. The absolute value of X_5 is up to 0.709, and the information load on X_5 accounts for 28.1% of the information load of all variables. This factor, mainly reflecting the rural environmental pollution caused by livestock and

poultry breeding, is a primary factor used to weigh and probe into the rural environmental pollution.

The second major factor's load is large on variables X_1 , X_2 , X_3 and X_4 , especially on X_1 , where its information load accounts for 23.02% of the information load of all variables. The information load on X_2 , X_4 and X_3 , accounts for 22.38%, 17.3% and 16.52% of the information load of all variables respectively. This factor, mainly reflecting the rural environmental pollution caused by crop planting, is a secondary factor used to weigh and probe into rural environmental pollution.

The third major factor's load is large on variables X_7 , X_8 and X_9 , especially on X_9 , where its information load accounts for 21.09% of the information load of all variables. The information load on X_7 and X_8 accounts for 20.28% and 18.32% respectively. This factor mainly reflects the rural environmental pollution caused by rural life.

The fourth major factor's load is large on variables X_{10} , X_{11} and X_{12} . This factor mainly reflects the rural environmental pollution caused by township enterprise production.

Each major factor and its corresponding variables' load values indicate the relationship between each major factor and its variables and show each factor's features. From Table 2 and Table 3, it can be seen that the loads and percents of factors

show clearly the that rural environment in hilly area in Sichuan Province is influenced by four factors, mainly livestock and poultry breeding, followed by crop planting, rural life, and township enterprise production. Currently, the industrial development direction determined by counties (cities, districts) in the hilly area is "laying stress on two traditional advantageous industries, *i. e.* crop planting and animal husbandry, and striving to develop typical township enterprises, mainly labor force-intensive agricultural product processing enterprises". It can be seen that the above four factors are closely linked to the degree of influence to rural environment and the development direction of regional rural economy. With the improvement of rural economic activity and rural economic level, the degree of influence will be further increased.

3 Conclusion and suggestions

3.1 Conclusions The study on rural environmental problem is a dynamic process. The environmental pollution of countryside in the hilly area in the upper reaches of Yangtze River, typically the hilly area in Sichuan, is caused mainly by livestock and poultry breeding, followed by crop planting rural life, and township enterprise production. Therefore, future pollution prevention and control should set about from livestock and poultry breeding. Meanwhile, attention should also be paid to prevention and control of rural environmental pollution caused by rural life and township enterprise production.

3.2 Suggestions In the first place, the key to preventing the environmental pollution caused by crop planting is to have a good command of crop planting technologies, which fit for regional actual situation, *e. g.* optimal cropland nutriment technology and agricultural water and soil conservation technology, *etc.*. The central feature of these technologies is to help farmers use fertilizers and pesticides scientifically according to standards, increase the degree of precision of cropland nutriment management, put in production factors purposely, improve fertilizer and pesticide utilization efficiency rate. The use of poisonous and residue-prone should be prohibited or restricted and great efforts should be made to develop highly-effective, low-toxicity, and low-residual pesticides and take biological prevention and treatment measures so as to reduce the influence on environment.

In the second place, the key to preventing the environmental pollution caused by rural life is to research and develop economical, suitable, and environmental-friendly rural life facilities and technical systems, *e. g.* regional characteristic garbage collector, highly-effective low-pollution kitchen stoves, clean fuels, *etc.*. The essential feature of these technologies is to re-

duce or even avoid life pollutants before occurrence of pollution so as to strive to prevent the environment from being polluted as much as possible.

In the third place, a common means used to preventing the environmental pollution caused by livestock and poultry breeding is to design matching biogas and research, develop and popularize eco-made technologies, such as, "one pool, three changes", "four in one", *etc.*, so as to prevent pollution effectively.

In the forth place, the key to prevent the environmental pollution caused by township enterprise production is to research and develop necessary waste gas filtering equipment and waste water treatment system, *etc.*, according to such enterprises' discharge capability so as to prevent pollutants from entering soil and water in the process of production and reduce or even avoid occurrence of pollution.

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