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THE EVALUATION OF ECO-ENVIRONMENTAL SUSCEPTIBILITY TO HUMAN ACTIVITY IN YULIN REGION*

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ABSTRACT: The eco-environmental susceptibility is to demonstrate the reaction of a ecosystem under the same influences of the human activity. It comprise many influencing factors which have a complicated relation to the eco-environmental susceptibility. In this paper, the Analysis of Hierarchy Process (AHP) is used to determine the weight of each factor to the eco-environmental susceptibility through analyzing the relationship between human activity and environmental deterioration. And the weighted summation method is used to calculate the eco-environmental susceptibility of different divisions in Yulin region. The result shows that the loess hilly and gully area is more subjective to deteriorating eco-environment than the desert area because of the strong human activity and severe soil erosion.
KEY WORDS: Human activity, eco-environmental susceptibility, AHP, weighted summation method

I. INTRODUCTION

The eco-environmental susceptibility is an index of the response of a regional ecosystem to the human activity, i.e., the possibility and degree of the regional ecosystem deterioration under the influence of human activity. The purpose of studying the eco-environmental susceptibility is to provide a basis for the regional eco-environmental planning and management by evaluating comprehensively the regional natural conditions, the pressure of human activi-

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ty, current landuse and economic development.

II. STUDIED AREA

The studied area is located at the northwestern part of the Loess Plateau, in Shannxi Province (see Fig. 1). The whole area includes one city and eleven counties, they are Yulin City, Shenmu, Fugu, Hengshan, Jingbian, Dingbian, Suide, Mizhi, Jiaxian, Wubu, Qingjian, Zizhou counties, covering an area of about 43,578 km^2 The terrain is inclined from northwest to southeast. The aeolian deflation and soil erosion are the major eco-environmental problems in this region. This area can be divided into two major parts by landform type, to the north of the Great Wall is desert area, with an area of 18,133 km^2, making up 42.21% of the total area, the south east is loess hilly and gully area, with an area of 25,445 km 2, making up 57.79% of the total area. This area belongs to the dry-grass climate region. There are nine main rivers in loess hilly area flowing into the Huanghe River and many small internal lakes in the desert area, which form the basic structure of the hydrology.

III. METHOD AND MATERIALS

1. Factors to Influence Eco-Environmental Susceptibility

The factors to influence eco-environmental susceptibility comprise the following four aspects: the regional natural conditions, the pressure of human activity, current landuse and the influence of economic development on environment.

1.1 *The natural conditions*

The difference of natural conditions influence greatly the susceptibility of ecosystem to human activity. Usually, the poorer the natural conditions of the area, the lower the suitability of the ecosystem to the human activity, and the higher the eco-environmental susceptibility; the better the natural conditions, the easier the ecosystem suits the change of the human influence. The studied area, the ecotone between the grass-pastoral and the agricultural areas, is in transitional zone between the aeolian deflation desert area and the loess hilly area, and between the arid and the semi-arid area, the eco-environment is highly sensitive to human activity, especially because of the severe soil erosion and desertification, the local ecosystem has a lower suitability to the human activity from the whole. The regional vegetation coverage, the percentage of soil erosion area, the soil erosion rate, the percentage of controlled area of soil

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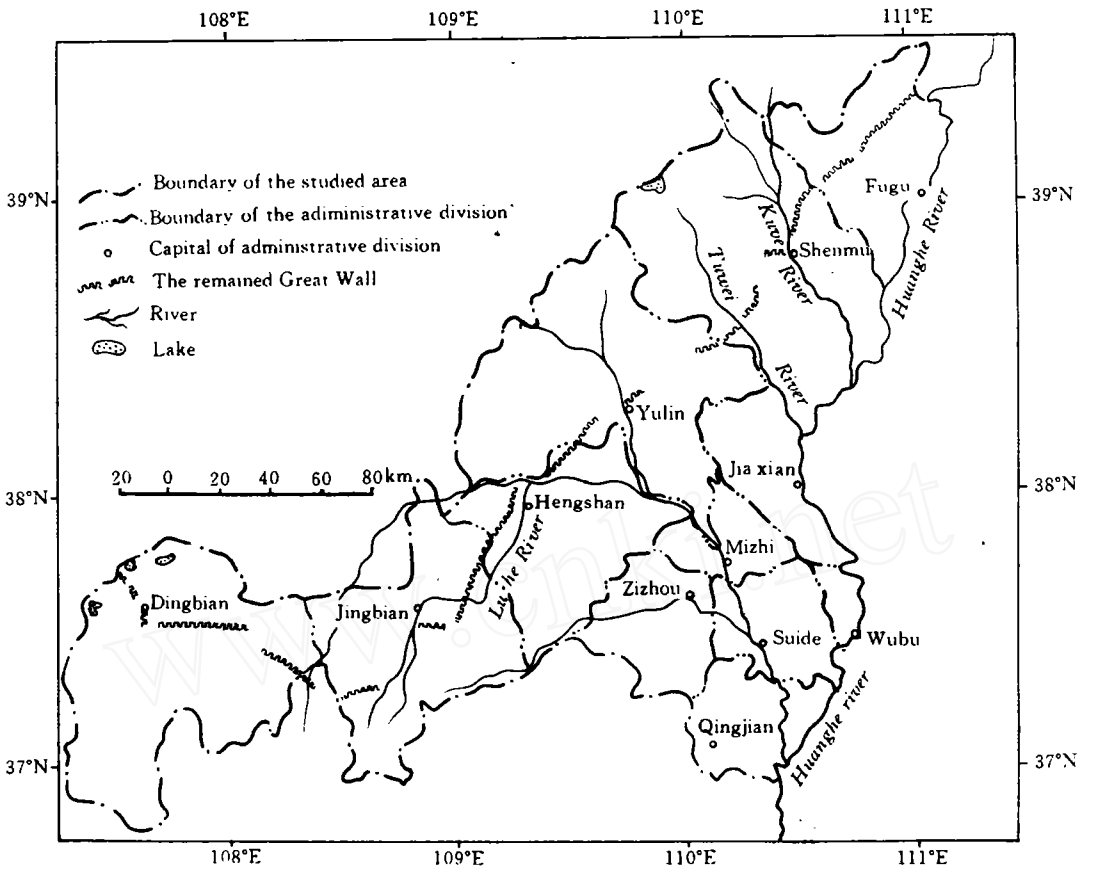

Fig. 1 The situation of the studied area

erosion and the percentage of desert area are considered for evaluating exactly the eco-environmental susceptibility.

1.2 *The pressure of human activity*

The development of human being is a long history from the emergence to present. At the early age, only a small number of people lived in this region, the pressure of human activity on the natural environment was limited, the purpose of the people in that period was mainly to develop the nature and utilize the natural resources, no more eco-environmental problems were concerned. The ecological balance and environment, however, were disrupted under the pressure of human activity with the population growth and increase of the human activity. The pressure of human activity to the ecosystem is becoming greater with the population growth. Since the studied area belongs to the semi-arid and arid climate area, the populationcapacity is very low, whereas a very high population density and strong human activity existed in this area due to the long reclamation history. Generally, the population density is more than

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100 persons per square kilometre in the loess hilly area, even in the desert area, it also exceeds the reasonable population capacity. In this paper, the local population density, population growth rate, the per capita arable area and the per capita cereal yield are taken into account for evaluating the eco-environmental susceptibility.

1.3 *Current landuse*

The pattern of landuse is an important aspect to express the reaction of regional ecosystem to the human activity. In general, the proper landuse do not have too much impact on the eco-environment, however, the irrational landuse could induce the deterioration of the eco-environment. The change of the landuse structure, especially the improper land reclamation could easily result in the deterioration of the natural eco-environment, which is very susceptible to the human activity. For evaluating the eco-environmental susceptibility of this studied area, the percentage of the arable land area, the percentage of basic farmland and the percentage of slope land are chosen as the indices to calculate the eco-environmental susceptibility.

1.4 *The impact of economic development*

The effects of economic development on the ecosystem have two sides. Firstly, the negative effect means the economic development will have a heavier pressure on the natural eco-environment, because economic development needs more resource, which will destroy the natural eco-environment in some extent; secondly, the economic development has a positive effect on the eco-environmental protection, which could provide much more money and energy to improve the environment. Usually its positive effects is more important than the negative one, however, the different economic structure will produce a rather different result, even for the similar natural conditions, which is related to the regional landuse pattern. In this project, the per capita cereal yield, the industry-agricultural product of per square kilometre, gross national product of per square kilometer and the ratio of agriculture in gross national product are used to calculate the eco-environmental susceptibility.

2. The Methods

The twelve counties of Yulin region are chosen as the evaluation units. The weighted-summation-method and Analysis of Hierarchy Process (AHP) are used to calculate the eco-environmental susceptibility and to determine the weight of each factors to eco-environmental susceptibility[1].

2.1 *Setting up the evaluation index system of eco-environmental susceptibility*

The evaluation index system is set up based on the above analysis, it in-

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cludes three levels and sixteen indices, as follows:

A ——Eco-environment susceptibility

B_1——The natural conditions

C_1——Vegetation coverage

C_2——Soil erosion area

C_3——Soil erosion rate

C_4——Desertification area

C_5——Controlled area of soil erosion

B_2——The Current landuse

C_6——Arable land area

C_7——Basic farmland area

C_8——Slopeland area

B_3——The pressure of human activity

C_9——Population density

C_{10}——Population growth rate

C_{11}——Per capita arable land

C_{12}——Per capita cereal yield

B_4——The impact of economic development

C_{13}——Land cereal productivity

C_{14}——Industry-agriculture product value

C_{15}——Gross national product value

C_{16}——Ratio of agriculture in gross national product value

2.2 *Determining the weight of each factors by using the judgement matrix*

The most important work is to acquire the weight point of each factors from the experts on this field through group discussion and giving a mark. Those matri cxan be formed as $A-B$, B_1-C, B_2-C, B_3-C, B_4-C based on the result and the above evaluation index system. The characteristic maximum value of each judgement matrix (λmax) and the characteristic vectors(ω) can be obtained by using addition-integrated-method, and the ratio between CI and RI is used to check if the results are consistent. The judgement matri $A-B$ is taken as a case to express the process of determining the weight of B1, B2, B3, B4 to eco-environmental susceptibility (A)[2].

1) The judgement matrix is formed by comparing the importance of each factors

A	B_1	B_2	B_3	B_4
B_1	1	8/3	8/9	8/3
B_2	3/8	1	1/3	1
B_3	9/8	3	1	1

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B_4 3/8 1 1/3 1

2) Standardizing each cell of above matrix by using the following equation

$$\bar{b}_{ij} = b_{ij} / \sum_{k}^{n} b_{ij} \qquad i \text{ from } 1 \text{ to } 4;\ n = 4$$

3) The following vector is reached through summing the cells in line

$$\bar{\omega} = [1.3912, 0.5218, 1.5652, 0.5218]^T$$

4) Another characteristic vector can be got by standardizing the above vector $\bar{\omega}$, i. e.

$$\omega = [0.3478, 0.1304, 0.3913, 0.1304]^T$$

the value of each cell is respectively the weight of B_1, B_2, B_3, B_4 to level A.

5) The maximum characteristic value (λ_{max}) of the matrix could be obtained by using the following equations

$$AW = \begin{vmatrix} 1 & 8/3 & 8/9 & 8/3 \\ 3/8 & 1 & 1/3 & 1 \\ 9/8 & 1 & 1/3 & 1 \\ 9/8 & 3 & 1 & 1 \\ 3/8 & 1 & 1/3 & 1 \end{vmatrix} \times \begin{vmatrix} 0.3478 \\ 0.1304 \\ 0.3913 \\ 0.1304 \end{vmatrix}$$

$$\lambda_{max} = \sum_{i=1}^{4} \frac{(AW)i}{4 \times Wi} = 4.000000052$$

6) Checking of the consistency

$$CI = \frac{\lambda max - n}{n - 1} = \frac{4.000000052 - 4}{4 - 1} = 0.000000017$$

$$RI = 0.90$$

$$CR = \frac{CI}{RI} = \frac{0.000000017}{0.90} = 0.0000000019 << 0.10$$

Based on the above checking, the result is satisfactory. The weight of the other factors can be reached by using the same way.

2.3 *The weight of level C to level A*

The value of the weight of different levels are listed in Table 1.

IV. RESULT AND DISCUSSION

The value of each factors of the twelve counties were obtained by referring the relevant statistic data. For correctly evaluating the eco-environmental susceptibility, those factors which enable the eco-environment deterioration

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were given positive values, in contrary those factors helpful for enivronmental improvement were given negative values. Before calculating the eco-environmental susceptibility of each counties, the value of each factor must be processed by standardizationn.

1. The Standardization of Value of Each Factors

It is impossible to compare the different factors of the different units. It is necessary to do some processing for calculating the eco-environmental susceptibility. For standardization, the value of each factors was divided by the maximum value in twelve counties, the result was used to calculate the eco-environmental susceptibility.

Table 1 The weight of different levels (*B* to *A*, *C* to *B*, *C* to *A*)

C	B_1	B_2	B_3	B_4	The weight of level *C* to level *A*
	0.3478	0.1304	0.3913	0.1304	
C_1	0.2308	0	0	0	0.0803
C_2	0.2308	0	0	0	0.0803
C_3	0.3462	0	0	0	0.1204
C_4	0.1154	0	0	0	0.0401
C_5	0.0769	0	0	0	0.0267
C_6	0	0.1333	0	0	0.0174
C_7	0	0.5333	0	0	0.0696
C_8	0	0.3333	0	0	0.0435
C_9	0	0	0.4211	0	0.1648
C_{10}	0	0	0.3158	0	0.1236
C_{11}	0	0	0.1053	0	0.0412
C_{12}	0	0	0.1579	0	0.0618
C_{13}	0	0	0	0.1111	0.0145
C_{14}	0	0	0	0.4444	0.0580
C_{15}	0	0	0	0.2222	0.0290
C_{16}	0	0	0	0.2222	0.0290

2. The Result of the Eco-Environmental Susceptibility of Twelve Counties

The result of the eco-environmental susceptibility of twelve counties are

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reached by using the weighted summation method to standardize value of all the relevant factors and their weight. The result is shown in Table 2.

Table 2 The value and sequence of eco-environmental susceptibility of the twelve counties in Yulin region

Region	Susceptibility	Sequence	Region	Susceptibility	Sequence
Yulin	1.00	12	Suide	30.3	1
Shenmu	13.2	9	Mizhi	28.2	3
Fugu	16.8	7	Jiaxian	25.4	5
Hengshan	12.1	11	Wubu	27.6	4
Jingbian	14.0	8	Qingjian	25.4	5
Dingbian	12.2	10	Zizhou	28.6	2

3. Discussion

Since the severe soil erosion and strong desertification, the studied area is a highly susceptible area, however there are much difference in different areas based on the result. Usually, the higher the eco-environmental susceptibility, the more sensitive this area to deteriorate environment at the same pressure of human activity. From Table 2 and Fig. 2, the following results can be concluded.

1) There is a much higher eco-enivronmental susceptibility in the loess hilly area than that in the desert area, which result from the high population density, strong human activity and severe soil erosion. The human activity results in grea change of the natural eco-environment, especially destroy the natural balance and makes the regional ecosystem more sensitive to the human activity.

2) The reasons of the lower eco-environmental susceptibility in desert area are that there is a rather lower population density, a slight influence of the human activity and a lower pressure to the regional ecosystem.

3) The eco-environmental susceptibility in Yulin City is much lower than that in the other counties in the desert area even though they have the similar natural conditions. There are two reasons for this result, firstly, some measures have been taken for controlling the soil erosion and desertification in Yulin, which enhance the ability of ecosystem to withdraw the exterior influence. Secondly, there is a better economic conditions which enable the local people to use more money and more energy to control the environmental deterioration.

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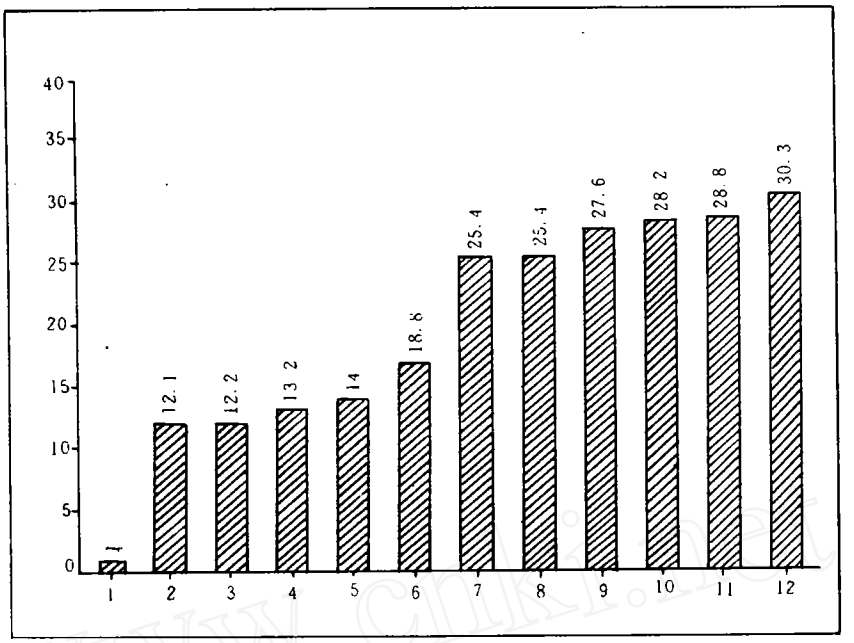

Fig. 2 Comparison of the eco—environmental susceptibility of the twelve city and counties in Yulin region

1—Yulin, 2—Hengshan, 3—Dingbian, 4—Shenmu, 5—Jingbian, 6—Fugu, 7—Qingjian, 8—Jiaxian, 9—Wubu, 10—Mizhi, 11—Zizhou, 12—Suide

V. CONCLUSION

Based on the above analysis, the human activity, current landuse and the natural conditions are the major sensitive factors influencing the eco-environmental susceptibility. The loess hilly and gully area is more sensitive to changing eco-environment than the desert area of the strong human activity and severe soil erosion, even though there is a relative poor natural conditions in desert area.

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