Study on Spatial and Temporal Changes of Ecological Vulnerability in Weinan Area Based on GIS

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Abstract: With the development of urbanization, the ecological environment of the typical agro-development city-Weinan is disturbed to varying degrees, and it restricts the coordinated development of resources, population and environment in the region. This paper combines social, economic and climate data to propose an index system suitable for the evaluation of ecological vulnerability in Weinan. The analytic hierarchy process was used to quantitatively evaluate the ecological vulnerability of the Weinan region. The results showed that from 2000 to 2011, the urban ecological vulnerability index (EVI) was higher than that of the surrounding counties, which had a great relationship with the impact of urbanization on ecological vulnerability. The extremely fragile areas of ecological vulnerability in Weinan were mainly distributed in the urban areas of Linwei District and Hancheng. The main reason was that these cities had a fast development speed and a strong industrial base, which had a great impact on the ecological vulnerability.

1. Introduction
The deterioration of the ecological environment will lead to the transformation of the ecosystem pattern, ecological processes and service functions, which threaten the sustainable development of ecosystems and social economy [1].

The most significant breakthrough at this stage is the combination of landscape ecology methods and remote sensing techniques, forming a new approach to ecological assessment [2]. Other research on the sensitivity of China’s ecological environment and regional differences using GIS technology, divided China into seven ecologically sensitive areas, and explored the characteristics of each subregion [3].

In the study of ecological vulnerability assessment, scholars use the combination of other academic indicators to conduct ecological vulnerability assessment, including analytic hierarchy process (AHP) [4], principal component analysis (PCA) [5], fuzzy comprehensive evaluation method [6]. Based on GIS and RS analysis method, the economic, social and natural indicators were used to construct a reasonable ecological vulnerability assessment index system. And using the analytic hierarchy process method quantitatively analyzes the ecological vulnerability of Weinan.

2. Study area
Weinan is the most extensive area of the Guanzhong Plain, which contains 11 districts and is the main agricultural producing area of the Guanzhong Plain. Weinan is a warm temperate semi-humid and semi-arid monsoon climate with four distinct seasons, sufficient sunshine and moderate rainfall. The annual average temperature in the area is 12.7 ~ 15.6 °C. The annual precipitation is 390.7~592.2 mm.
The annual light distribution is uneven, and the total sunshine hours in the jurisdiction are 1851.9~2393.0 hours.

3. Evaluation of the index system
The vulnerability of the ecological environment is caused by the interaction or overlap of different factors, even if the same cause causes the ecological vulnerability to be different[7]. The change of natural conditions is the direct influencing factor of ecological vulnerability. This study combines the environmental characteristics of Weinan with external stress factors, including annual average precipitation, annual average temperature, annual average evaporation, sunshine hours, elevation and slope. Human beings are an extremely important part of the ecological environment. In this evaluation study, the reclamation rate, population density, and natural growth rate per capita GDP and agricultural/industrial output value were selected.

4. Data analysis model
There are many different methods for determining the comprehensive weight of the evaluation index system at home and abroad[8]. According to the perspective of empowerment, it can be divided into two categories: subjective and objective[9]. The subjective empowerment method uses qualitative methods such as expert opinions and comprehensive consultation scores to determine the weights, and then comprehensively judges the dimensionless data.

The Analytic Hierarchy Process (AHP) is a multi-objective decision-making method combining qualitative and quantitative analysis, which is proposed by Saaty in the early 1970s [10]. The determination of the weighting factor is introduced into the analytic hierarchy process, which is easy to operate, rigorous in theory, and has the advantages of simplicity and systemicity. In the determination of the weight coefficient of each indicator in this study, the author mainly refers to the opinions of experts and scholars and the existing research results in Weinan area using the analytic hierarchy process to assign weights to each indicator. According to the establishment of the above judgment matrix, the weights of each indicator in the evaluation system are finally calculated.

5. Ecological Vulnerability Assessment Index
In the evaluation process of ecological environment vulnerability, it is necessary to convert each indicator into a numerical value that can be uniformly quantified, and then the calculation can be performed to obtain the final evaluation result. The ecological vulnerability index is summed by the product of standardized data and weights. The EVI indices of the districts and counties in Weinan in 2000, 2005 and 2011 can be calculated by the following formula:

\[ EVI_x = 0.0154 \times C_1 + 0.0981 \times C_2 + 0.0304 \times C_3 + 0.0928 \times C_4 + 0.0648 \times C_5 + 0.0093 \times C_6 \\
+ 0.0546 \times C_7 + 0.0141 \times C_8 + 0.1271 \times C_9 + 0.1645 \times C_{10} + 0.3289 \times C_{11} \]

Where \( EVI_x \) in the formula represents the ecological vulnerability index, \( C_1, C_2, \ldots, C_{11} \) represents the data after each evaluation factor criterion.

6. Results and discussions

6.1. Study on the Distribution of Ecological Vulnerability in Weinan Area
In 2000, the highest EVI index was Hancheng, followed by Baishui and Shaoguan. The lowest EVI index was Huaxian, followed by Dali and Heyang. In 2005, the highest EVI index was in Linwei District, followed by Hancheng and Baishui. The lowest EVI index was Huaxian, followed by Huayin and Shaoguan. In 2011, the highest EVI index was Hancheng, followed by Linwei District and Dayi County. The lowest EVI index was Huaxian. The extremely fragile areas of ecological vulnerability in Weinan were mainly distributed in the urban areas of Weinan City and Hancheng. The main reason was that the city has a fast development speed and a strong industrial base, which has a great impact on the ecological environment vulnerability (see Figure 1).
6.2 Analysis of Spatial and Temporal Changes of Ecological Vulnerability in Longnan Area

Compared with the EVI index in 2000 and 2005, Huayin, Chengcheng, Fuping and Pucheng all showed a downward trend. Linwei District, Huaxian County, Dali, Heyang, Baishui and Hancheng all showed an increasing trend. Compared with the EVI index in 2005 and 2011, Huaxian, Shaoguan, Chengcheng, Pucheng and Baishui all showed a downward trend, and Datun, Heyang, Fuping, Huayin and Hancheng all showed an increasing trend. Compared with the EVI index in 2000 and 2011, Chengcheng, Fuping, Huayin, Pucheng and Baishui all showed a decreasing trend, and Linwei, Huaxian, Dali, Heyang and Hancheng all showed an increasing trend (see figure 2). From 2000 to 2011, the urban ecological vulnerability index was higher than that of the surrounding counties, which has a great relationship with the impact of urbanization on ecological vulnerability.

7. Conclusions

From 2000 to 2011, the urban ecological vulnerability index was higher than that of the surrounding counties, which has a great relationship with the impact of urbanization on ecological vulnerability.

The extremely fragile areas of ecological vulnerability in Weinan were mainly distributed in the urban areas of Weinan City and Hancheng. The main reason is that the city has a fast development
speed and a strong industrial base, which has a great impact on the ecological environment vulnerability.

In addition to the natural causes, as well as the social causes and the level of economic development, the factors affecting the vulnerability of the ecological environment have only adopted 11 impact factors to form an evaluation system due to the conditional constraints. Among them, the indicators of social causes and economic development levels are too small. The work will continue to improve the evaluation system, make a more reasonable and comprehensive interpretation of the ecological environment vulnerability in Weinan, and provide a scientific basis for the ecological environment construction of the research area.

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