Evaluation of Ecological Vulnerability of Yulin City under the Background of Returning Farmland to Forests

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Abstract. Yulin City Located in the Shaanxi Province Maowusu Desert and the northern Shaanxi Loess Plateau transition zone, its special geographical location makes the region a typical ecologically fragile area. Based on the "pressure - state - response" model, this paper based on the 14 indicators of soil erosion, population density, NDVI and so on. Based on the natural and human factors, the principal component analysis method was used in GIS and SPSS software. And the ecological vulnerability of the region for 10 consecutive years from 2003 to 2013 was evaluated with a pixel size of 100 m*100 m. The results show that the ecological fragility in the northern part of Yulin City is higher than that in the southern region and the ecological environment has improved in the past ten years. This paper discusses the relationship between ecological vulnerability and human activities, social development and natural environment, and provides reference and basis for ecological maintenance of Yulin city.

1. Introduction

The ecological environment is the basic condition and material security that affects the survival and development of human beings, and is a complex ecosystem that is related to the sustainable development of the social economy (Zhou et al,2009). At present, China's rapid development of social economy and global changes have caused excessive pressure on the ecosystem, which has made the ecological environment more fragile, and related research has become a hot spot. Most of China's ecologically fragile areas are located in ecological transition zones or interlaced areas of vegetation,
which deal with the protection and maintenance of ecosystems and is conducive to the harmonious and sustainable development of human society and nature (Ma Jun, 2014). At present, with the deepening of ecological research, there are many evaluation methods, such as Delphi method, fuzzy evaluation method (Feng et al, 1999), ecological vulnerability index evaluation method (Wang et al, 1998), analytic hierarchy process (Ma et al, 2015), principal component analysis method (Sun et al, 2013; zhong et al, 2011), related evaluation method, comprehensive evaluation method [Qiao et al, 2008], GIS based evaluation method (Wang et al, 2014; Zhang et al, 2000).

Although China contains a variety of ecosystems, relatively different degrees of degradation of various ecosystems have emerged, such as increased desertification and soil erosion. An assessment of ecosystems in a given area can effectively understand the ecological status of the area, which can provide a basis for the area to enhance ecological maintenance and restoration. Yulin City is one of the ecologically fragile areas on the northern interlaced zone of China. Since the implementation of the policy of returning farmland to forests, the ecology of Yulin City has been significantly improved. However, due to the over-exploitation of energy, the ecological environment in some areas of Yulin City has exceeded the scope of its own restoration. Although the implementation of returning farmland to forests, the varieties of artificial forests are too single. Ecosystem stability is poor and ecology is still fragile. Ecological vulnerability assessment can effectively understand the spatial distribution of ecosystem status and ecological vulnerability in Yulin City in the past decade, and use this as a basis to solve problems such as ecological restoration and ecological protection in the region.

2. Study area

The Yulin area (the longitude 107°28′-111°15′, the north latitude 36°57′—39°34′) is a typical ecologically fragile area in the farming-pastoral ecotone in northern China, from the Mu Us Desert to the hilly and gully area of the Loess Plateau in northern Shaanxi. In the transition zone, wind erosion and human economic activities have seriously affected the ecological balance, making the ecological environment more sensitive and variable (Yan et al, 2011). Ecological vulnerability assessment can effectively understand the spatial distribution of ecosystem status and ecological vulnerability in Yulin City in the past decade, and use this as a basis to solve problems such as ecological restoration and ecological protection in the region.

3. Data and source

3.1 Data source

Statistical data collection In the China Knowledge Network, Shaanxi Province, and the Yulin City Statistics Bureau, the statistical yearbooks from 2003 to 2013 or the city and county records were downloaded and compiled into tables; the coverage of natural data such as vegetation in geospatial data Cloud, US Geological Survey (USGS) downloaded NDVI from 2003 to 2013.

3.2 method

The smaller the ecological vulnerability of the evaluation unit, the more stable the ecosystem (Zhou et al, 2008). The formula for calculating the Ecological Vulnerability Index (EVI) is as follows:

$$ EVI_j = \sum_{j=1}^{14} P_j W_j $$ (1)
In the formula, $EV_{ij}$ is the ecological vulnerability index of the $j$th evaluation unit; $W_j$ is the weight of the ecological vulnerability evaluation index; $P_j$ is the standardized value of the $j$th evaluation index.

4. Result

4.1 Analysis and evaluation of ecological vulnerability

Common methods include equal spacing method, number axis method, total frequency curve method (Yan et al., 2011), etc.

Table 1. Principal Component Analysis Results for 2003 and 2013

| main ingredient | 2003 | 2013 |
|-----------------|------|------|
|                 |      |      |
| 1               | 6.092| 6.319|
| 2               | 2.809| 2.731|
| 3               | 1.069| 1.432|
| 4               | 0.804| 0.507|
| 5               | 0.576| 0.442|
| 6               | 0.391| 0.329|
| 7               | 0.139| 0.161|
| 8               | 0.061| 0.038|
| 9               | 0.036| 0.031|
| 10              | 0.016| 0.019|
| 11              | 0.012| 0.011|
| 12              | 0.009| 0.008|
| 13              | 0.004| 0.005|
| 14              | 0.002| 0.001|

With the support of GIS and SPSS Statistics software, the spatial principal component analysis of 14 indicators is carried out. After obtaining the results of principal component analysis, the ecological vulnerability index $EVI$ is further calculated. The results show that the cumulative contribution rate of the first three principal components has exceeded 80%, so the first three principal components are selected for analysis.

Tabl2 above is the calculated index weight coefficient. Principal component analysis is more applicable to index systems with too many indicators and strong correlation between indicators (Li et al., 2011). The advantage is that it reduces the complexity of the data, that is, it uses several indicators covering comprehensive information to represent complex evaluation indicators. This can reduce the human influence in the empowerment process based on the main information of the complete retention evaluation factor.
Table 2. Valuation of evaluation indicators in 2003-2013

| Evaluation index weight (W) | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2010 | 2011 | 2013 |
|----------------------------|------|------|------|------|------|------|------|------|------|
| population density         | 0.082| 0.077| 0.080| 0.089| 0.081| 0.089| 0.079| 0.082| 0.078|
| Oil production             | 0.096| 0.061| 0.086| 0.095| 0.085| 0.056| 0.077| 0.082| 0.089|
| Grain production           | 0.089| 0.093| 0.097| 0.077| 0.092| 0.081| 0.083| 0.086| 0.086|
| cultivated area            | 0.084| 0.093| 0.092| 0.092| 0.090| 0.092| 0.089| 0.090| 0.091|
| Per capita GDP             | 0.091| 0.075| 0.062| 0.072| 0.086| 0.093| 0.094| 0.089| 0.087|
| Urban per capita net income| 0.095| 0.090| 0.098| 0.097| 0.095| 0.092| 0.095| 0.094| 0.093|
| Rural per capita net income| 0.095| 0.092| 0.085| 0.074| 0.080| 0.098| 0.095| 0.094| 0.094|
| Land reclamation rate      | 0.084| 0.090| 0.095| 0.085| 0.081| 0.086| 0.078| 0.077| 0.081|
| Per capita water resources | 0.091| 0.093| 0.089| 0.088| 0.085| 0.082| 0.081| 0.073| 0.073|
| slope                      | 0.070| 0.081| 0.073| 0.071| 0.074| 0.076| 0.072| 0.076| 0.071|
| Land use type              | 0.062| 0.078| 0.059| 0.064| 0.073| 0.074| 0.088| 0.080| 0.078|
| Vegetation Coverage (NDVI)| 0.070| 0.075| 0.084| 0.097| 0.079| 0.081| 0.070| 0.076| 0.080|
| Soil erosion intensity     | 0.083| 0.081| 0.085| 0.084| 0.083| 0.085| 0.082| 0.086| 0.079|
| Surface undulation         | 0.075| 0.077| 0.071| 0.073| 0.077| 0.072| 0.074| 0.072| 0.078|

Table 3. Distribution of ecological vulnerability index

| Vulnerability range | 2003 Year | 2013 Year |
|---------------------|-----------|-----------|
| EVI<0.25            | Microdegree | 424.2 | 424.2 |
| 0.25<EVI<0.35       | Mild       | 12727.11| 14662.3 |
| 0.35<EVI<0.45       | Moderate   | 13879.95| 11944.76 |
| 0.45<EVI<0.55       | strength   | 4248.57 | 14918.46 |
| EVI>0.55            | Severe     | 11827.88| 1157.99 |

From Table 3, it can be seen that in 2003, the ecological vulnerability index of Yulin area was greater than 0.55, accounting for 27.44%, while in 2013, the ecological vulnerability index of Yulin was more than 0.55, accounting for 2.7%. After the implementation of the forestry policy, the ecological environment of Yulin City is gradually improving. Among them, in 2003, the micro-fragile area in Yulin accounted for 0.98% of the total area, the mildly vulnerable area accounted for 29.52%, the moderately vulnerable area accounted for 32.2%, and the intensity and severely vulnerable areas accounted for 37.34%. In contrast, the Yulin area was slightly fragile in 2013. Compared with 2003, the district did not change much by 0.98%, mild vulnerability increased to 34.01% compared with 2003, moderate vulnerability accounted for 27.71%, intensity vulnerability accounted for 34.61%, and severe vulnerability decreased by 24.74% compared with 2003.
In 2013, compared with 2003, the ecological environment in the northern region has improved. For example, the ecology of Yuyang District and Shenmu County has dropped significantly, from the severely vulnerable areas in 2003 to the vulnerable areas. Compared with the ecological fragility in the northern part of Yulin City; the ecological environment in the central region has not changed significantly, but the overall ecological fragility is slightly reduced, that is, the ecological environment is getting better and better and the ecological stability is improving year by year; the southern region has the best ecological environment. Rujia County, Wubao County, Mizhi County and Qingyi County have low vulnerability and high stability, and are all slightly fragile or slightly fragile. The overall ecological vulnerability of the Yulin area has improved under ecological protection measures such as returning farmland to forests.

The negative value indicates the area of ecological improvement compared with 2003; the positive value indicates the area of ecological deterioration compared with 2003. It can be seen from the figure that in 2013, compared with 2003, the ecological environment of the six counties of Zizhou County, Xiangyang District, Shenmu County, Hengshan County, Wubao County and Qingyi County has improved. The ecological vulnerability of the six counties of Fugu County, Suide County, Dingbian County, Jingbian County, Mizhi County and Jia County has increased. Among them, the Fugu County Ecological Vulnerability Index increased the most, increasing by 0.095.
4.2 Discussion

In summary, the coal fields in Yulin are mainly distributed in Xiangyang, Shenmu, Jingbian, Dingbian and four counties in the northern part of Yulin City. The resources and minerals are abundant, the economic development is rapid, the economic activities are active, and the artificial construction and destruction increase. As a result, the ecological environment is seriously damaged and has exceeded the ecological self-maintenance ability. Therefore, the four counties and districts have higher ecological vulnerability than Yulin City as a whole. As a result, people need to increase investment in ecological construction and ecological protection. With the implementation of the policy of returning farmland to forests, the ecological environment of these four districts and counties has improved. The ecological vulnerability of the southern region has also shown a steady or declining trend. It is believed that the ecological environment in the Yulin region will improve year by year.

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