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Study on the Progress of Ecological Fragility Assessment in China

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Abstract. The basic elements of human survival are based on the ecological environment. The development of social economic and the security of the ecological environment are closely linked and interact with each other. The fragility of the environment directly affects the stability of the regional ecosystem and the sustainable development of the ecological environment. As part of the division of the national ecological security, the assessment of ecological fragility has become a hot and difficult issue in environmental research, and researchers at home and abroad have systematically studied the causes and states of ecological fragility. The assessment of regional ecological fragility is a qualitative and quantitative analysis of the unbalanced distribution of ecological environment factors caused by human socio-economic activities or changes in ecosystems. At present, researches on ecological fragility has not formed a complete and unified index assessment system, and the unity of the assessment model has a direct impact on the accuracy of the index weights. Therefore, the discussion on selection of ecological fragility indexes and the improvement of ecological fragility assessment model is necessary, which is good for the improvement of ecological fragility assessment system in China.

1. Introduction

At present, some scholars believe that the ecosystem is affected by the interference from human society and the environment itself, and the sensing ability and recovery state of the ecosystem is the ecological fragility, which is the property of the ecosystem itself [1, 2]. There is a similar view among other scholars that ecosystem fragility refers to the resilience of an ecosystem evolving from one level to another under certain driving forces [3]. Therefore, it can be concluded that ecological fragility refers to the ability of response and recovery after the ecological environment is disturbed, and it also changes relatively, so no single ecosystem is absolutely stable or absolutely fragile [4, 5].

The study of ecological fragility in foreign countries was earlier. In 1905, Clements mentioned ‘Ecotone’ in his study. Later, the Paris working group redefined Ecotone in early 1987 [6]. At the end of the 20th century, foreign researchers established the assessment system of ecological fragility, drew the ecological fragility assessment map, and analyzed the driving forces of ecological fragility. In recent years, the research on ecological fragility has been carried out in different spatial and derivative fields. Abson used Principal Component Analysis (PCA) to quantitatively study the ecological fragility in South Africa and draw an ecological fragility assessment map [7]. De lange reviewed the application of ecological fragility analysis in risk assessment and described the progress of the new model, and he concluded that ecological fragility assessment may be more appropriate to study when there is a real risk to the ecosystem [8]. Lppolito analyzed the ecological conditions of the two river systems in northern Italy, evaluated the impact of external factors on the fragility of river ecosystems, and analyzed the interactions between human factors and natural environmental factors [9]. Generally speaking, the research on the ecological fragility of foreign countries is relatively mature, and Geographic Information System (GIS) and Remote Sensing (RS) have been widely applied to the study of regional assessment [10]. At the same time, the related concepts of ecological landscape ecology have been integrated into the ecological fragility assessment system [11, 12].

The study of ecological fragility started relatively late in China. With the deepening of the research on the ecological fragility in other countries, the research in China is also beginning gradually. Niu Wenyuan thought that among ecosystems in a variety of ecosystem structures is it ‘interface’ and called the ‘spatial domain of transitional zones’ [13]. Liu Zhenqian et al constructed a systematic fragility index system, then took Analytic Hierarchy Process (AHP) as the assessment model and comprehensively analyzed the fragility degree of the wetland ecosystem in Sanjiang Plain [14]. Xu Guangcai thought that the study of ecological fragility is gradually evolving from a single system to the whole system of man-land system. Ecological fragility should not only consider the bearing capacity of ecological environment, but also analyze its relationship with socio-economic development and strengthen the response to emergencies in ecological fragile region of the man-land system [15]. Zhu Zhenda evaluated the ecological fragility of desertification in China, and he believed that the over-exploitation of resources and the enhancement of economic activities of human beings are the main driving forces [16].

The research on ecological fragility assessment involves many aspects such as climate, topography and socio-economic factors. As one of the main research parts in our country, the objective and reasonable study of ecological fragility can make the ecological space of the country be effectively utilized and reasonably protected, which make the ecosystem function maintain stable. Therefore, the quantitative analysis of ecological fragility has become one of the important contents in the field of environmental assessment. The fragility of regional ecology directly affects the social and economic development of the region and the safety of human living environment, so the accuracy and objectivity of the assessment of ecological fragility directly affect the government’s formulation of some environmental policies, which are of crucial importance to the sustainable development of the regional ecological environment.

2. Methods

There are many ecological fragility assessment models, including fuzzy evaluation [17], grey evaluation [18], artificial neural network evaluation [19], surface landscape evaluation [20], AHP [21] and so on. However, some of them are difficult to operate. For example, neural network requires a large number of historical data that is not easy to obtain, and the operation is complex.

AHP and PCA are the most widely used among these methods. AHP is a multi-objective decision analysis method that combines qualitative and quantitative methods. The main idea is to compare and judge the importance of the two indexes by decomposing the complex problems into several levels and factors, then the judgement matrix is established. By calculating the maximum eigenvalue and the corresponding eigenvector of the judgment matrix, the weight of the importance of different schemes can be obtained, which provides the basis for the selection of the best scheme [22]. However, the index weight of AHP needs to take into account the scores or suggestions of different experts in the process of solving the problem. Due to the different angles and scopes of the different participants on the tradeoffs of the index factors, which makes the acquisition of the weight of the assessment indexes have strong man-made factors, so that the assessment results have certain subjectivity and arbitrariness. PCA is a data preprocessing method that reduces the collection of original data types by using the idea of dimensionality reduction, and more indicator data will be reduced to a few principal component factors [23]. Compared with AHP, the result of PCA is relatively objective, which excludes the influence of major human factors on the weight of indexes. PCA uses the ratio of the variance and the total variance as the weight, and the process also contains subjective components, and the weights of the principal component factors are greatly affected by the variance.

At present, the methods of ecological fragility assessment are basically all based on the analysis of a single assessment model, and there are some shortcomings in determining the weight of assessment indexes.

3. Establishment of assessment index system

The gradual deepening of ecological fragility is manifested by the degradation of ecosystem functions and disappearance of self-adjustment and repair abilities. Studies have shown that the main driving forces involved in ecological fragility come from two aspects: economic activity of human society and the natural environment [24]. The main economic activities of human society are farmland over-expansion, unreasonable exploitation and utilization of energy and mineral resources, overgrazing, land reclamation and excessive population growth. Natural environment factors include rainfall, topography and land cover change and so on. The ecological fragility assessment system includes many index factors, but there are three main factors affecting ecological fragility: climate, topography and socio-economic factors [25]. The index system of ecological fragility is constructed reasonably and comprehensively, which can accurately reflect the changing situation of the ecological fragility in the region. Some researchers put various factors into the assessment index system of ecological fragility, and the ecological fragility assessment system become huge. This will not only increase the difficulty and maneuverability of the assessment work, but also weaken the weights of the main assessment indexes, which may have an unreasonable impact on the assessment results of fragility. Therefore, the selection of assessment indexes of ecological fragility mainly considers some principles (see Figure 1).

1) Typicality. There are many factors affecting the assessment of ecological fragility, but not all indexes are extracted considering the workload and feasibility. Therefore, only representative factors that can reflect the status of ecological fragility in the study area can be selected.

2) Irreplaceability. The indexes that have repetitive information or significant correlation should be minimized, for example, the natural population growth rate is equal to the difference between the population birth rate and the population mortality rate. Only select the natural population growth rate in the assessment of ecological fragility, and the birth rate and the mortality rate can be abandoned.

3) Operability. Due to the many factors covered by the assessment system of ecological fragility index and the incomplete record of historical data or the inappropriate collection methods, some data indexes cannot be obtained. Available data indexes should be chosen on the basis of representativeness and irreplaceability.

4) Integrity. Ecological fragility is influenced by three major factors: climate, topography and social economy, and the selection of the three major factors should take into account its integrity. Only select one or two of the three factors, the constructed index system cannot reflect the actual situation of ecological fragility.

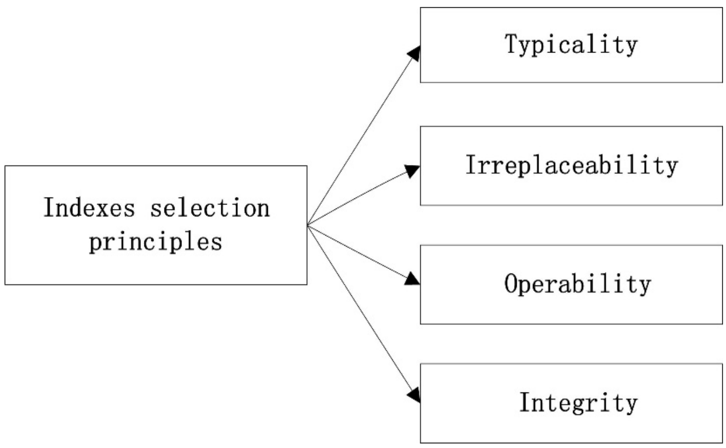

Figure 1 Indexes selection principles

4. Conclusion and prospect

At present, the studies on ecological fragility mainly focus on economically developed regions or ecological fragile regions, and the establishment of ecological fragility index system in these two regions has not yet formed a unified system. Due to the gradual acceleration of industrialization and urbanization, more and more regional environmental degradation and ecological problems are caused, and the area of ecologically fragile areas also increases significantly. Therefore, studies on ecological fragility have also gradually caused widespread attention. The current part of the fragility studies focuses on the qualitative research using some concepts in ecology and geography. Although there are many researches on the influencing factors, model selection, driving force analysis and index system of fragility, no perfect ecological fragility assessment system has been formed yet. There are relatively few studies on the wide range of ecological fragility. The natural environment is complex and special, besides, human activities have a long history and profound impact on it, and so the indexes of regional ecological fragility are not the same. How to establish a relatively uniform assessment system and reflect their own ecological characteristics is a difficulty in current researches.

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References

[1] Adriaenssens V, De Baets B, Goethals PL, et al. Fuzzy rule-based models for decision support in ecosystem management[J]. Science of the Total Environment, 2004, 319 (1): 1-12.
[2] Alewell C, Manderscheid B. Use of objective criteria for the assessment of biogeochemical ecosystem models[J]. Ecological modelling, 1998, 107 (2): 213-224.
[3] Aspinall R, Pearson D. Integrated geographical assessment of environmental condition in water catchments: Linking landscape ecology, environmental modelling and GIS[J]. Journal of Environmental Management, 2000, 59 (4): 299-319.
[4] Change IPOC. Climate change 2007: impacts, adaptation and vulnerability[J]. Genebra, Suíça, 2001.
[5] Downing TE. Climate change and vulnerable places: global food security and country studies in Zimbabwe, Kenya, Senegal and Chile[J]. 1992.
[6] Harris L D. Edge effects and conservation of biotic diversity[J]. Conservation Biology, 1988, 2(4): 330-332.
[7] Abson DJ, Dougill AJ, Stringer LC. Using principal component analysis for information-rich socio-ecological vulnerability mapping in Southern Africa[J]. Applied Geography, 2012, 35 (1): 515-524.
[8] De Lange H, Sala S, Vighi M, et al. Ecological vulnerability in risk assessment—a review and perspectives[J]. Science of the Total Environment, 2010, 408 (18): 3871-3879.
[9] Ippolito A, Sala S, Faber J, et al. Ecological vulnerability analysis: A river basin case study[J]. Science of the Total Environment, 2010, 408 (18): 3880-3890.
[10] Ohlmacher GC, Davis JC. Using multiple logistic regression and GIS technology to predict landslide hazard in northeast Kansas, USA[J]. Engineering Geology, 2003, 69 (3): 331-343.
[11] Di B, Yang Z, Ai N. Evaluation on Degraded Ecosystem in Jinshajiang Xerothermic Valley Using RS and GIS-A Case Study of Yuanmou County in Yunnan[J]. Scientia Geographica Sinica, 2005, 25 (4): 484.
[12] Li S, Sun W, Li F, et al. Study on the characteristics and the cause of sandy desertified land in the west of Hainan Island[J]. Acta Geographica Sinica, 2005, 61: 433-442.
[13] Niu WY. Fundamental Determination of Ecological Environment Vulnerability-ECOTONE[J]. Journal of Ecology, 1989, 9 (2): 97-105. (In Chinese)

[14] Liu ZQ, Liu HY, Lv XG. Study on ecological vulnerability of Sanjiang Plain Wetland[J]. Chinese Journal of Applied Ecology, 2001, 12 (2): 241-244. (In Chinese)
[15] Xu GC, Kang MY, He LN. Ecological vulnerability and its research progress[J]. Journal of Ecology, 2009, 29 (5): 2578-2588. (In Chinese)
[16] Zhu ZD. China 's fragile ecological belt and land desertification[J]. Journal of Desert Research, 1991, 11 (4): 11-22. (In Chinese)
[17] Adriaenssens V, De Baets B, Goethals PL, et al. Fuzzy rule-based models for decision support in ecosystem management[J]. Science of the Total Environment, 2004, 319 (1): 1-12.
[18] Zeng G, Jiang R, Huang G, et al. Optimization of wastewater treatment alternative selection by hierarchy grey relational analysis[J]. Journal of Environmental Management, 2007, 82 (2): 250-259.
[19] Džeroski S. Applications of symbolic machine learning to ecological modelling[J]. Ecological modelling, 2001, 146 (1): 263-273.
[20] Zhao Q, Ding D, Huang Q. Preliminary Study on Quantitative Assessment of Regional Eco-environment—A Case Study of Longmen County in Guangdong Province[J]. Areal Research and Development, 2005, 24 (6): 104-108.
[21] He L, Chan CW, Huang GH, et al. A probabilistic reasoning-based decision support system for selection of remediation technologies for petroleum-contaminated sites[J]. Expert Systems with Applications, 2006, 30 (4): 783-795.
[22] Saaty T L. Analytic hierarchy process[M]//Encyclopedia of operations research and management science. Springer US, 2013: 52-64.
[23] Abdi H, Williams L J. Principal component analysis[J]. Wiley interdisciplinary reviews: computational statistics, 2010, 2(4): 433-459.
[24] Liu MS, Zhang QH, Lin LS. Spatiotemporal Evaluation of fragile eco - environment in Jiangxi Province based on GIS[J]. Journal of Jiangxi Science, 2008, 26 (5): 803-807. (In Chinese)
[25] Isidori M, Lavorgna M, Nardelli A, et al. Integrated environmental assessment of Volturno River in South Italy[J]. Science of the Total Environment, 2004, 327 (1): 123-134.