A Critical Review on Regional Ecological Environment Assessment

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Abstract. With the continuous advancement of industrialization and urbanization, the relationship between mankind and the ecological environment has become increasingly tense, and the ecological environment assessment has become a research hotspot in recent years. The article summarizes the research content and development process of ecological environment assessment, lists various mainstream assessment methods and introduces their application characteristics, and then divides the weight determination methods into subjective weighting, objective weighting and subjective and objective combination, and analyses their advantages and disadvantages; Meanwhile, the application of remote sensing technology in ecological environment assessment research is analyzed. Finally, the main problems of ecological environment assessment work are summarized and its future development direction is pointed out.

1 Introduction

In order to meet the development needs of industrialization and urbanization, the scope and intensity of human activities continue to expand, ecosystem areas such as urban and rural natural environments and nature reserves have been shrinking, resulting in a substantial shrinkage of ecological resources. At the same time, environmental problems of different scales such as land and water pollution, heat island effect, and global warming caused by human activities have become more and more serious, the degradation of the ecological environment has become a bottleneck restricting the development of human economy. The ecological environment assessment(EEA) could contribute to provide a scientific basis for formulating ecological environmental protection policies and measures, as well as ecological coordination and sustainable development[1].Therefore, it is of great significance to carry out regional ecological environment monitoring and evaluation timely. The article summarizes the content and development of EEA, discusses the main methods of current EEA and the application of remote sensing in EEA, and finally summarizes the shortcomings of current EEA.

2 The content and development of EEA

2.1 Contents of EEA

Ecological environment refers to the entirety of various ecosystems composed of biological communities and non-biological natural factors. The purpose of EEA is to analyze the ecological environmental impact of a region due to human activities and the impact on humans, mainly involving ecological risk assessment, ecological environmental vulnerability assessment, ecological health assessment, ecological footprint, etc, this attributes to carry out ecological management and ecological protection policies, etc[2-3].There are many types of EEA objects based on different perspectives, from the assessment area, they can be divided into administrative EEA and thematic EEA. Administrative ecological environmental assessment studies the impact of various human social activities on a certain administrative area[4-5]. Thematic EEA refers to the assessment of the ecological environment of a certain type of geographic area, such as plateaus[6], lakes[7], highways[8], cities[9],mine [10], etc. According to the element attributes of the assessment object, it can be divided into comprehensive element assessment and partial single element assessment. Comprehensive element assessment takes the study area as an ecosystem and uses landscape ecology[11], ecosystem services[12] and other methods to evaluate the ecological environment from a macro perspective. Partial single element assessment is the evaluation of key elements in the ecosystem, such as diatoms [13], heavy metal toxic elements[14-15], etc.

2.2 The development of EEA

In 1964, the International Conference on

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Environmental Quality first proposed the concept of environmental impact assessment. In 1969, the United States promulgated the National Policy Act (NEPA) and established the world's first environmental assessment system, it is also the beginning of the world's EEA work. Subsequently, the U.S. Environmental Commission further improved it and added relevant content of environmental impact assessment (EIA). EIA is a process that proposes the potential environmental impacts of the development project and proposes appropriate measures to avoid, reduce or compensate for these impacts (called mitigation measures) [16-17].

In the mid-1970s, some developed countries in Europe and the United States improved the shortcomings of EIA and extended its application to the planning level and policy level, this is the strategic environmental assessment (SEA). SEA is used to solve the environmental impact of strategic decisions and designed to incorporate environmental sustainability into strategic decision-making[18]; In 1989, the World Bank stipulated that all major projects under its supervision required ecological environmental assessment[19]. So far, SEA has been widely used worldwide, mainly in the countries of the Organization for Economic Co-operation and Development (OECD) and the client countries of the World Bank, these countries have established the SEA system in the form of legislation, and have formulated the SEA framework to a certain extent[20]. In 2001, the United Nations Foundation and other organizations launched the Millennium Ecosystem Assessment (MA) project, which was implemented from 2001 to 2005.MA uses a new conceptual framework to record, analyze and understand the impact of environmental changes on ecosystems and human activities, it is a summary of the comprehensive evaluation of global ecosystems[21-22]; For the first time, MA has systematically and comprehensively revealed the status and change trends of various ecosystems on a global scale. Since 2005, MA has conducted hundreds of ecosystem assessments of different scales and different themes[23], which has also brought EEA research into a new stage of development.

3 EEA method and weight determination

3.1 Assessment method

After years of eco-environmental assessment and research by experts all over the world, there are currently some more mature eco-environmental assessment methods, such as fuzzy discrimination, biodiversity evaluation, ecological footprint, Index evaluation,etc. Fuzzy discrimination is an assessment method that transforms qualitative evaluation into quantitative evaluation based on the principles of fuzzy mathematics, finally, a certain value between 0 and 1 is used to indicate the relationship between each assessment index and the system, this method is applicable to both large-scale and small-scale areas, Sami comprehensive environmental assessment of the farm system with the help of fuzzy discriminant method[24].The Biodiversity assessment method is based on the investigation of the on-site ecosystem, use Shannon-Wiener index to represent biodiversity, this method can better reflect the relationship between the biological community and the ecological environment; Wang estimated the economic value of China's forest species diversity based on the biodiversity evaluation method[25].The ecological footprint method evaluates the sustainable development of the ecosystem by calculating the profit and loss difference between the ecological carrying capacity and the size of the ecological footprint; this method is suitable for urban EEA with good basic data; Świąder use the ecological footprint method to evaluate the ecological environment carrying capacity in Wroclaw, Poland[26].Index evaluation method is to evaluate each index participating in the evaluation separately, and finally use the weighted sum method to achieve the effect of comprehensive evaluation of the ecological environment. Index evaluation method has the characteristics of difficulty in weighting and quantitative evaluation, because it needs to establish an evaluation system, but it can be more comprehensively evaluated,so it is widely used in ecological environment evaluation, for example, the Ecological Environment Index (EI) proposed in the "Technical Specifications for Evaluation of Ecological Environment Condition (Trial)" promulgated and implemented by the State Environmental Protection Administration of China,the Environmental Quality Index (NWF) proposed by the United States and Canada's Total Environmental Quality Index (EQI)[3].There are many eco-environmental assessment methods and each has its own focus; therefore, when dealing with different eco-environmental assessment issues, it should be determined according to the specific assessment objectives.

3.2 Index weight determination method

The indicator weighting methods in EEA are mainly divided into subjective weighting method (SW) and objective weighting method (OW). SW determines the index weight based on the researcher's prior knowledge and subjective judgment. It is highly subjective. Commonly used methods are as follows: Analytic Hierarchy Process (AHP)[27], Delphi Method[28], Fuzzy Mathematics (FM)[29], etc. OW determines the weight of each indicator based on the correlation between various indicator data. This type of weighting method is less artificially affected and can objectively reflect the relationship between indicators, common OW methods are: Entropy Method (EWM)[29], Principal Component Analysis (PCA)[30], Random Forest (RF)[31],Convolutional Neural Network (CNN) [32], etc. At present, many studies combine the advantages of subjective and objective weighting methods to determine the index weights, which not only avoids the excessive subjectiveness of objective weighting methods, but also combines prior knowledge to judge the importance of the evaluation indicators in the study area, effectively reducing the evaluation Error of result, for example, Li used the PCA-AHP-TOPSIS method to estimate the ecological environment index of the area along the

Beijing-Hangzhou Grand Canal [33], avoiding the subjectivity and extensiveness of conventional multi-factor decision analysis.

4 Application of Remote Sensing in EEA

EEA focuses more on the integration of data and information[34], so the accuracy of data acquisition is very important, in the early days, the evaluation index data was easily restricted by time and space scales, With the development of space science and computer technology, 3S technology has been widely used in ecological environment evaluation. The spatial resolution, time resolution, and spectral resolution of remote sensing data continue to increase, which improves the real-time and operability of remote sensing technology; combines remote sensing image data with long-term statistics and observation data to strengthen the research on dynamic evaluation of the ecological environment. The spatial resolution, time resolution, and spectral resolution of remote sensing data continue to increase, which improves the real-time and operability of remote sensing technology; combines remote sensing image data with long-term statistics and observation data to strengthen the research on the dynamic evaluation of ecological environment. Yao based on Landsat8 data, selected vegetation coverage, bare soil index and slope as evaluation indicators, using Index evaluation method to evaluate the highway ecological environment quality[35].Ying uses ASTER GDEM and Landsat data to extract the three indicators of vegetation coverage, soil index and soil moisture, and determines the weight of each indicator through the Delphi method, and then uses the index evaluation method to analyze the ecological environment quality of the Wujiang River Basin in Guizhou Province, China[36].

In 2013, Xu[30] improved China's EI index and constructed a new remote sensing ecological index RSEI based on PCA using greenness, humidity, heat, and dryness indicators,and verified its effective application in EEA. Based on high-resolution remote sensing images, Hao[37] selected the fractional vegetation cover (FVC), water density (WD), impervious surface coverage (ISC), net primary production (NPP) and land surface temperature (LST) evaluated and analysis of the ecological environmental impact caused by urban expansion in Beijing, China. Based on Landsat data, Zhang[38] used the RSEI index to evaluate the ecological environmental quality of Nanjing, China from 1990 to 2013, and predicted the development trend of ecological environmental quality. Wu[39] selected fractional vegetation cover (FVC), leaf area index (LAI), total primary productivity (GPP), land surface temperature (LST), and wet (Wet) retrieved from MODIS data as evaluation indicators. assessment the ecological environment of China's Tibet from 2006 to 2016.

With the development of network big data, Google has launched a global-scale cloud computing platform for processing earth science data — Google Earth Engine (GEE), compared with traditional geospatial data processing methods, GEE has unprecedentedly improved computational efficiency. It also has advantages such as free and parallel, it is now widely used in remote sensing image classification, land use change monitoring, etc.Chen[40] used Landsat data from the GEE platform to extract four indicators including vegetation index, humidity component, heat and dryness to evaluate and monitor the quality of the ecological environment in China's Three-River Source Region. Based on Landsat images from the GEE platform, Mahdianpari[41]used random forests to assess the spatial dynamics of wetlands in Newfoundland, Canada from 1985 to 2015.In the future, remote sensing technology based on cloud computing and big data analysis will be widely used in EEA, on this basis, with the help of artificial intelligence, knowledge base, etc. to mine the ecological environment big data, enhance the use value of big data, and provide more accurate and efficient services for the decision-making management of the ecological environment.

5 Conclusion

In the era of global climate change and information exchange, monitoring regional ecological environmental changes is of great significance for humans to solve ecological problems. The maturity of 3S technology, the development of big data, and the optimization of machine learning algorithms have further improved the methods and theories of EEA research. Eco-environmental assessment objects are also more targeted, from early large-scale macro-evaluation to partial thematic regional eco-environmental assessment, which provides a theoretical basis for solving typical regional eco-environmental problems. However, due to the regional differences in different research areas, although many EEA work combines local geography, ecology, and social conditions to construct an assessment system, there is still a lack of complete EEA systems suitable for various objects and scales. In addition, the weights of evaluation indicators and the classification of evaluation results tend to be subjective or objective, the use of a single subjective or objective weighting method will lead to deviations in the evaluation results, and inevitable errors in the grading process will cause the evaluation results to be subjective. The future ecological environment evaluation work should fully consider the actual situation of the study area, construct an appropriate evaluation system and determine the index weights according to local conditions, and use big data, emerging technology platforms, etc. to conduct ecological environment evaluation from a multidisciplinary perspective.

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