

Regional Ecology Supporting Sustainable Development

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Abstract: Regional sustainable development is the primary goal of regional ecological research. Regional ecology aims to support sustainable development from an ecological perspective at the regional scale. In nearly half a century of the development of the discipline, regional ecology has developed into an essential branch of ecology. However, due to the complexity of regional ecosystems and ecological problems, regional ecology does not define clear research methods and research objects. This editorial sorts out the definition, research methods, and important research contents of regional ecology, including regional ecological security evaluation, regional sustainable development evaluation, regional resource analysis represented by water-food-energy relationship, and ecosystem service value evaluation.

Keywords: ecological security; water-energy-food nexus; ecosystem service evaluation; SDGs

1. The Definition of Regional Ecology

The definition of a region is different in geography, economics, and political science. From an ecological point of view, a region refers to a regional complex with a relatively complete ecological structure, ecological process, and ecological function formed by ecological media [1]. Regional ecology is an essential subject in the ecological subject system. The discipline arose from the discovery of spatial scale in ecology in the 1970s, which made the regionality of ecological problems arouse the attention of scholars [2]. So far, regional ecology has developed for nearly half a century. In a narrow sense, regional ecology studies the ecological structure, process, and function within a region and the coupling and interaction mechanism of ecological elements between regions [3]. In a broad sense, regional ecology is a branch of ecology. It is a practice-oriented discipline aimed at solving regional ecological environment problems, improving the service function of the regional ecosystem, realizing regional ecological integrity, ecological civilization, and sustainable development using multidisciplinary approaches such as ecology, geography, environmental science, and social sciences [3].

2. Research Methods of Regional Ecology

When solving ecological problems at different scales, scholars adopt a wide range of different tools. Based on controls, manipulation, randomization, and independent replication, classical experimental methods often draw causal inferences with data significance. However, when operating and replicating at large spatial scales (i.e., ecosystem scales), classical experimental methods show dubious characteristics, such as the fact that they are time-consuming and costly; moreover, they can overlook the effects of random events, and their manipulations may interfere with nature. With the increase of the experiment's spatiotemporal scope, the effectiveness of the classical experimental method diminishes. Regional ecology often adopts methods between descriptive analysis and natural experiments, which are quasi-experiments, and treating time and space as control variables



Citation: Mao, S.; Deng, H. Regional Ecology Supporting Sustainable Development. *Sustainability* **2022**, *14*, 7302. <https://doi.org/10.3390/su14127302>

Received: 30 May 2022

Accepted: 12 June 2022

Published: 15 June 2022

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in experiments. Pseudo-repetitions may exist in quasi-natural experiments, but this approach is still believed to be encouraged for regional ecological research [4]. Besides, the geographic information system technology provides a technical bridge for linking the ecological process between regions and other scales (i.e., local scales). The application of spatial information technology and mathematical model helps couple the interaction between elements in the region and illustrate the dynamic process of ecological phenomenology.

Regional ecology has not yet established a complete theoretical system and methodology. The research on regional ecology is mainly to systematically analyze the characteristics and changes of regional ecological structure, process, and function through 4S technology, mathematical models, and other cross-disciplinary methods. It is worth noting that the remote sensing data and the field measured data should be combined in ecological research. Otherwise, the remote sensing data will not have ecological significance.

3. Research Hotspots of Regional Ecology

3.1. Regional Ecological Security

In a broad sense, ecological security is a composite artificial ecological system formed by natural, economic, and social security, and it refers to a state in which human life, health, basic rights, sources of safety and necessary life resources, social order, and human ability to adapt to environmental changes are not threatened [5]. In a narrow sense, it refers to the security of semi-natural and natural ecosystems, in other words, the integrity and health of ecosystems [6]. Recent regional ecological security studies mainly focus on aspects of assessing ecosystem changes according to pollutants' concentration and distribution characteristics or on constructing and applying ecological security evaluation models [7].

There are three widely used ecological security evaluation models, pressure-state-response (PSR), driving force-state-response (DPSIR), and driving force-pressure-state-influence-response (DPSIR) models. The PSR model is biased toward environmental indicators. The DPSIR model adds social, economic, and other human indicators to the PSR model. The DPSIR model adds driving force and influence to the PSR framework and mainly focuses on economic indicators. The ecological security evaluation system adopting the ecological footprint method has gradually emerged in recent years. The advantage of this method is that it reflects the stability of the local ecological environment [8]. There are some limitations in the current ecological security evaluation study. Given that the classification of ecological security level thresholds is unclear, and given that there is no unified evaluation index system, further research on the impact factors of driving force and coupling effect is required [7].

3.2. Regional Sustainable Development

With the introduction and development of the Sustainable Development Goals (SDGs), sustainable development has become a significant issue of common concern in economics, ecology, and sociology. SDGs point out that social progress, economic development, and environmental protection are the three pillars of sustainable development [9]. Regional sustainable development is an integral part of sustainable development. Compared with the global system, the regional system is more convenient for management and policy implementation. That is to say, based on a deep understanding of the process of regional socio-economic development and environmental change, regional sustainable development is easier to achieve than sustainable development [10]. The main difference between sustainable development and regional sustainable development has three dimensions. One is regional systems' openness (or interconnectedness); for example, emissions from one region may affect other regions through inter-regional diffusion; the second is the aspects that do not level off on a regional scale compared to the global one, which means we need to distinguish between global and regional equilibrium; the third is the regional authority of public goods [11]. The spatial heterogeneity of global resource distribution or environmental pollution causes uneven resource shortage or environmental pollution in regions, which means regions bear different resource and ecological pressures. Surpluses may com-

pensate for the depletion of primary resources from one region in other regions. Ecological compensation is thus a feasible tool for cross-regional and cross-temporal resource and environmental management.

Regional ecology aims to support sustainable development from an ecological perspective at the regional scale. Regional sustainable development is the primary goal of regional ecology research. Regional sustainable development focuses on the differences in regional sustainable development modes, the variation and transformation of the driving forces of regional sustainability at different scales, the impact of regional dependencies on sustainability, and the interactions between local and global sustainable equilibrium and economic development [12]. Global climate change profoundly affects regional ecosystem services and human well-being, affecting regional sustainability. Enhancing the comprehensive coordination of regional social, economic, and environmental systems is vital for promoting high-quality regional development and achieving global sustainable development goals.

3.3. Regional Water-Energy-Food Nexus

Water, energy, and food are the necessary resources for human survival and development, and they are also the limiting factors of regional sustainable development. The three resources have long been the hotspots of sustainable development research. Recently, research that treats the three as a whole, namely the water-energy-food nexus, and studies their internal dependencies or the impact of external factors, such as climate change and population growth, is developing rapidly. Water-energy-food nexus research regards water, food, and energy as an interrelated system and studies the correlation between the three resources. Its purpose is to meet human demand while protecting the ecosystem [13].

One of the characteristics of the water-energy-food nexus is its locality. There may be significant differences in water, energy, food endowment, industrial structure, and climate environment in different regions, causing different nexus structures and characteristics. For example, water resources are the main limiting factor for ecological and economic development in Loess Plateau, China, while food in urban agglomerations such as Beijing-Tianjin-Hebei mainly relies on external inputs. Currently, water-energy-food nexus research focuses on theoretical analysis such as clarifying the concept, establishing research frameworks, the trade-off and synergy relationship within resources, the comprehensive quantitative model, and the driving mechanism of the nexus. In-depth localized decision analysis and applied research based on the nexus are relatively lacking.

3.4. Ecosystem Service Value Assessment

Ecosystem services are ‘the benefits that humans derive from ecosystems’ [14] or ‘the direct or indirect contributions of ecosystems to human well-being and benefits’ [15]. From the perspective of ecological functions, ecosystem services can be classified into four categories, provisioning (providing food and products), regulating (maintaining the role of the earth’s biosphere), supporting (providing living space for creatures on the earth and providing preconditions for the existence of all ecological resources), and cultural services (providing opportunities for recreation and research, education, aesthetics, art, etc.) [16].

Ecosystem service value assessment is a quantitative assessment of ecosystem services from the perspective of monetary value based on ecological principles, economics, and sociological methods [16]. By the end of the 20th century, the evaluation of ecosystem services had attracted extensive attention in academia. The ecosystem service value assessment has formed a logical chain of ‘ecological components-ecological process-ecological function-ecosystem service-ecological benefit-ecological compensation’ [17]. The value evaluation index system has been continuously improved, and the value evaluation method has gradually been modeled, precise, and dynamic [17]. Current research focuses on ecological asset pricing and marketization.

4. The Special Issue of Regional Ecology and Sustainability

This Special Issue discusses both classic topics and emerging frontiers in regional ecology. The classical topics include ecosystem services trade-offs caused by their spatiotemporal heterogeneity and the interaction between regional economic growth and the environment. To be specific, the former includes coupling coordination between ecological footprint and ecosystem services and ecosystem service trade-offs and synergies in ecologically important regions [18,19]. The latter includes the effects and mechanism of how OFDI affects carbon emission, as well as the coupling relationship or decoupling phenomena between regional economic growth and the environment [20–22]. Especially, this Special Issue introduces the dimension of culture into regional ecology studies. For example, the distribution, landscape patterns, and impact factors of traditional villages and the spatial distribution of ethnic groups in Southwest China are recognized to support regional sustainable development [23,24].

5. Conclusions

Regional ecology is the ecological study between the micro and macro scales. Since natural experiments are difficult to repeat at the regional scale, regional ecology often adopts quasi-natural experimental methods with time and space as variables. Analytical results based on ecological inferences are encouraged in regional ecology. Due to the complexity of regional ecosystems and environmental problems, regional ecology does not define clear research methods and research objects in a broad sense. The research hotspots of regional ecology include regional ecological security evaluation, regional sustainable development evaluation, regional resource analysis represented by the water-food-energy relationship, and ecosystem service value evaluation.

Author Contributions: Conceptualization, H.D.; writing—original draft preparation, S.M.; writing—review and editing, H.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Natural Science Basic Research Program of Shaanxi, grant number 2021JQ-546 and State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, China.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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