Spatiotemporal Evolution Characteristics and Influencing Factors of Ecological Resilience in Rural China: Postprint

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Date: 2024-12-04T00:00:00+00:00

Abstract

Drawing on resilience governance theory, this study utilizes panel data from 30 provinces (municipalities) across China for the period 2004–2021, constructs evaluation indicators from three dimensions—pressure, state, and response—to objectively measure and systematically depict the spatio-temporal evolution characteristics of rural ecological resilience in China, and empirically examines the factors influencing rural ecological resilience through a spatial Durbin model. The findings reveal that: (1) Although national rural ecological resilience demonstrates an upward trend, it remains at a relatively low level overall, exhibiting the characteristic pattern of major grain sales areas > major grain production areas > grain production-sales balanced areas. (2) Rural ecological resilience scores during the observation period display features of a rightward-shifting curve, elongated right tail, and increased width. Moreover, decomposition of regional gaps using the Dagum Gini coefficient indicates that overall regional disparities are not severe and exhibit a continuously narrowing trend. (3) Through decomposition of spatial spillover effects, environmental regulation intensity is found to significantly positively affect rural ecological resilience levels while generating a significant negative spillover effect; urbanization rate significantly negatively affects rural ecological resilience levels while generating a significant positive spillover effect; rural economic growth level and government fiscal support for agriculture exert positive and negative influences on rural ecological resilience, respectively, but these effects are not statistically significant; from the perspective of indirect effects, both demonstrate significant negative spillover effects.

Full Text

Spatial and Temporal Evolution Characteristics and Influencing Factors of Rural Ecological Resilience in China

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Abstract

Based on resilience governance theory, this study utilizes panel data from 30 provinces (municipalities) in China from 2004 to 2021 to construct an evaluation index system from three dimensions: pressure, state, and response. It objectively measures and systematically characterizes the spatiotemporal evolution of China's rural ecological resilience and empirically investigates its influencing factors using a spatial Durbin model. The results indicate that: (1) Although the national rural ecological resilience shows an upward trend, it remains at a relatively low level overall, exhibiting a pattern of main grain marketing areas > main grain producing areas > grain production-marketing balance areas. (2) During the observation period, rural ecological resilience scores demonstrate characteristics of "curve shifting rightward, right tail extending, and width broadening." Decomposition of regional disparities using the Dagum Gini coefficient reveals that overall regional differences are not severe and show a continuous narrowing trend. (3) Analysis of spatial spillover effects shows that environmental regulation intensity significantly and positively influences rural ecological resilience levels, with a significant negative spillover effect. Urbanization rate significantly and negatively affects rural ecological resilience levels, with a significant positive spillover effect. Rural economic growth level and government financial support for agriculture positively and negatively influence rural ecological resilience, respectively, but these results are not statistically significant. From the perspective of indirect effects, both factors exhibit significant negative spillover effects.

Keywords: rural ecology; resilience; spatiotemporal evolution; influencing factors

1 Introduction

The rural revitalization strategy represents a strategic deployment for building a modern socialist country, while green and sustainable development of the rural ecological environment constitutes a crucial component of this strategy. President Xi Jinping has profoundly articulated the importance of rural ecology, stating that "for China to be beautiful, its rural areas must be beautiful" and that "the rural environment directly impacts the rice bag, vegetable basket, water tank, and urban backyard," thereby clarifying the significance of rural ecology for people's production and livelihood. However, in recent years, unbounded, unrestrained, and unsustainable extensive production and lifestyles have led to excessive exploitation of rural resources and emerging environmental pollution problems. According to National Bureau of Statistics data, China's chemical fertilizer use reached substantial levels, with agricultural water use remaining under high pressure. Per capita water resources are only a fraction of the world average, and water pollution coexists with low water resource utilization efficiency, seriously affecting rural ecosystems and weakening rural ecological carrying capacity while increasing ecological risks. Additionally, rural environmental protection infrastructure construction lags behind, and awareness of rural ecological protection remains weak, posing prominent issues that greatly limit the pace of rural ecological civilization construction. Against this backdrop, a series of important policies including the "14th Five-Year Plan for Promoting Agricultural and Rural Modernization," the "Three-Year Action Plan for Rural Living Environment Improvement," and the "Action Plan for the Battle Against Agricultural and Rural Pollution" have proposed enhancing the quality and stability of rural ecosystems. As an important guarantee for rural ecosystem quality and stability, rural ecological resilience is particularly vital for maximizing risk resistance and rapidly restoring ecosystem functions. Therefore, systematically evaluating rural ecological resilience levels and comprehensively understanding the spatiotemporal evolution patterns and influencing factors of rural ecological resilience represent major scientific issues urgently requiring research in the new development stage.

Resilience originated in physics, referring to the property of an object being flexible and not easily broken. Holling first introduced resilience into ecology to characterize the stable structure and function within ecosystems. As a hot topic, ecological resilience has attracted considerable scholarly attention. Research on rural ecological resilience primarily includes three aspects: First, the connotation of rural ecological resilience. Scholars have actively explored its definition, suggesting that the connotation of rural ecological resilience keeps pace with the advanced requirements of the times. Its essential requirements are risk resistance and recovery capacity, through which the ecological subsystem within the rural system, via self-regulation and diverse human governance measures, internalizes, disperses, or transfers external shocks to avoid rural ecological damage or achieve consequence restoration. Second, measurement of rural ecological resilience levels. Research from a rural perspective on ecological resilience is generally lacking, with relevant methods mostly existing in comprehensive studies of rural resilience. Most scholars use the entropy method and TOPSIS method to construct rural resilience evaluation index systems from the production-living-ecology perspective, incorporating multiple dimensions including rural ecology, economy, and culture. The rural ecological resilience dimension typically selects representative indicators such as rural soil and water conservation capacity, rural ecological resources, rural carbon emissions, and rural ecological regulation capacity. Some scholars have used the analytic hierarchy process to study specific aspects of rural ecological resilience, such as comprehensive resilience of rural human settlements. Others have constructed a one-dimensional rural ecological sustainability index to measure rural ecological resilience levels. Furthermore, some scholars have pointed out that indicator systems should be constructed from multidimensional perspectives to systematically evaluate rural ecological resilience, encompassing dimensions such as production resilience, living resilience, and environmental resilience. Third, influencing factors of rural ecological resilience. Scholars have used spatial econometric models and panel data models such as Tobit models and fixed effects models to explore influencing factors from natural and human activity perspectives. Natural factors including climate, terrain, and water resources significantly affect rural ecological resilience. Human activity factors including urbanization, population agglomeration, technological innovation, economic development level, and labor supply have also been confirmed as playing key roles.

Through literature review, we find that recent research on rural ecological resilience has primarily treated it as a dimension of rural resilience for connotation definition, level measurement, and influencing factor analysis, providing many references for this study. However, few studies have directly measured China's rural ecological resilience level, with empirical research particularly scarce. Especially as China enters the new development stage of the "14th Five-Year Plan," new requirements have been proposed for strengthening ecological civilization construction and accelerating green and low-carbon development. Against this realistic background, there is an urgent need for a comprehensive understanding of China's rural ecological resilience development level. Therefore, this study first employs the entropy method and TOPSIS method to construct a comprehensive evaluation index for rural ecological resilience. Second, it uses kernel density estimation to explore the dynamic evolution characteristics of rural ecological resilience and the Dagum Gini coefficient to decompose regional differences. Finally, it constructs a spatial Durbin model to investigate factors influencing rural ecological resilience and, based on research conclusions, extracts corresponding policy implications to provide reliable decision-making basis and macro-micro policy recommendations with operability that facilitate sustainable rural ecological development.

1.1 Study Area

This paper takes 30 provinces (municipalities) in China as the study area (excluding Tibet, Hong Kong, Macao, and Taiwan). Meanwhile, as food security is paramount, rural areas serve as endowed regions for agricultural population, grain economic resources, and grain ecological environment, as well as production bases for grain and important agricultural product supply, making tremendous contributions to China's food security. However, the high-input, high-consumption extensive agricultural production mode has significant negative externalities, with intensifying environmental pollution and cultivated land degradation that seriously threaten sustainable rural ecological development.

Therefore, while investigating the overall spatiotemporal evolution characteristics of China's rural ecological resilience, this paper further draws on official grain production layout regional divisions (China has designated 13 main grain producing areas, 7 main grain marketing areas, and 11 basic balance areas. The main producing areas include Heilongjiang, Jilin, Liaoning, Inner Mongolia, Hebei, Henan, Shandong, Jiangsu, Anhui, Jiangxi, Hubei, Hunan, and Sichuan. The main marketing areas include Beijing, Tianjin, Shanghai, Zhejiang, Fujian, Guangdong, and Hainan. The production-marketing balance areas include Shanxi, Ningxia, Qinghai, Gansu, Yunnan, Guizhou, Chongqing, Guangxi, Shaanxi, Tibet, and Xinjiang) to deeply explore rural ecological resilience in China's main grain producing areas, main marketing areas, and balance areas, aiming to improve the targeting precision and local adaptation of relevant policies.

1.2 Data Sources

Data primarily come from the *China Rural Statistical Yearbook*, *China Environmental Statistics Yearbook*, *Urban and Rural Construction Statistics Yearbook*, and *China Statistical Yearbook* from 2004 to 2021. Some data (such as chemical fertilizer use per unit sown area) were calculated from basic data. For individual missing data, moving average and linear interpolation methods were used for imputation. Relevant economic data were deflated using 2004 as the base year to eliminate inflation effects.

1.3 Selection Basis and Composition of the Indicator System

The PSR (Pressure-State-Response) model is a classic framework for studying ecological and environmental issues, reflecting the interaction between humans and the environment. In the rural ecological domain, humans obtain necessary resources for survival and development from the rural natural ecology through agricultural production and living activities, while simultaneously discharging waste into rural areas, thereby changing natural resource reserves and environmental quality. Deterioration of the rural environmental state, in turn, affects rural residents' socio-economic activities and welfare, which forces humans to respond through policies and targeted awareness and behavioral changes, creating a cyclical "pressure-state-response" relationship between humans and rural ecology. This paper uses this model to form first-level indicators, specifically including pressure dimension, state dimension, and response dimension. Based on first-level indicators and combined with representative literature research results and data availability, 20 second-level indicators were constructed, as shown in .

1.4 Descriptive Statistics of Influencing Factors Indicators for Rural Ecological Resilience

To further clarify the influencing factors of rural ecological resilience, referring to existing literature and comprehensively considering the development characteristics of rural ecological resilience and data availability, this study selects indicators including environmental regulation intensity, urbanization rate, rural economic growth level, and government financial support for agriculture to analyze their impact on rural ecological resilience. The calculation method for environmental regulation intensity adopts the ratio of pollution control investment to GDP multiplied by area, specifically: (Pollution control investment/GDP) × (GDP × 10,000/area). Urbanization rate is measured by "the proportion of urban population to total regional population." Rural economic growth level is measured by "rural per capita GDP." Government financial support for agriculture is measured by "the proportion of fiscal expenditure on agriculture, forestry, and water affairs to total fiscal expenditure." The descriptive statistics of influencing factors for rural ecological resilience are shown in .

1.5 Methodology

1.5.1 Entropy Method Scoring The entropy method calculates the discrete degree of each indicator based on the information entropy characteristics of observed data, then objectively assigns weights according to the degree of dispersion. Specific calculation steps are provided in reference [21].

1.5.2 TOPSIS Method Correction Since entropy method scoring may cause indicator weight bias due to large numerical dispersion in certain indicators, this paper adopts the TOPSIS method for correction. Specific calculation steps are provided in reference [22].

1.5.3 Dagum Gini Coefficient Decomposition By solving and decomposing the Dagum coefficient, this study analyzes the overall differences and sources of variation in rural ecological resilience levels, and explores specific pathways to address regional differences through intra-regional, inter-regional, and hypervariable density decomposition. Specific formulas are provided in reference [23].

1.5.4 Kernel Density Estimation Method To explore the dynamic evolution characteristics of rural ecological resilience levels, this paper conducts kernel density estimation using rural ecological resilience level as the indicator. The function expression is provided in reference [24].

1.5.5 Spatial Econometric Model This study uses the spatial Durbin model for spatial econometric regression. The spatial Durbin model expression is [25]:

$$y_{it} = \alpha + \rho w y_{it} + \beta x_{it} + \gamma w x_{it} + u_i + \delta_t + \varepsilon_{it}$$

where y_{it} represents rural ecological resilience in region i at time t; x_{it} represents various factors influencing rural ecological resilience in region i at time t; α is the model intercept; β and γ are parameter vectors to be estimated; ρ is the spatial lag coefficient; w is the geographic distance weight matrix; u_i is the province (municipality) fixed effect for region i; δ_t is the year fixed effect; and ε_{it} is the random disturbance term for region i at time t.

2 Results and Analysis

2.1 Spatiotemporal Evolution Characteristics of Rural Ecological Resilience

2.1.1 Spatiotemporal Characteristics Analysis of Rural Ecological Resilience The national average level of rural ecological resilience shows an upward trend, reaching only 22.581% in 2021, with a relatively fast growth rate (see). However, as of 2021, the overall level remains low, indicating that rural ecological governance still faces a long and arduous task.

Analysis of rural ecological resilience levels by region shows that main producing areas, main marketing areas, and production-marketing balance areas all exhibit upward trends. Since 2016, main marketing areas have maintained stable growth, becoming the leading region in national rural ecological resilience. Main producing areas show a fluctuating upward trend, while production-marketing balance areas maintain steady levels. In terms of average levels, main marketing areas have the highest average rural ecological resilience level throughout the years, followed by main producing areas, and then production-marketing balance areas. This may be because main marketing areas have developed economies, strict environmental requirements, and well-developed rural infrastructure. Additionally, as urbanization accelerates, farmers' dependence on land decreases, the area of "non-grain" cultivation expands annually, reducing ecological pressure on rural areas. To compensate for grain deficits, main marketing areas must transfer grain from main producing areas, increasing ecological pressure on main producing areas and leading to prominent issues such as serious soil organic matter degradation and insufficient farmland water conservancy facilities. For production-marketing balance areas, economic development lags behind, and most provinces are located in remote western regions with prominent problems such as soil desertification and scarce cultivated land resources, relatively backward rural infrastructure, and low starting points for rural ecological resilience levels.

2.1.2 Dynamic Evolution of Rural Ecological Resilience Using kernel density estimation to analyze the dynamic evolution patterns of rural ecological resilience levels, the results are shown in [Figure 1: see original paper]. During the observation period, national rural ecological resilience scores exhibit the characteristics of "curve shifting rightward, right tail extending, and width broadening" over time. The rightward shift indicates continuously improving rural ecological resilience scores and certain development in rural ecological resilience. The broadened distribution and gradually extending right tail indicate expanding spatial disparities nationwide, with the increasing width suggesting greater variation among provinces.

2.1.3 Regional Differences and Analysis of Rural Ecological Resilience Levels The Gini coefficient of national rural ecological resilience levels remains below 0.2 in all years, indicating that overall differences are not particularly severe. From a developmental perspective, the Gini coefficient shows a fluctuating downward trend, decreasing from 0.167 in 2004 to 0.115 in 2021. Comparing intra-regional Gini coefficients (see [Figure 2: see original paper]), among the three major regions, production-marketing balance areas show a fluctuating upward trend, while main producing areas and main marketing areas show fluctuating downward trends, with production-marketing balance areas having the highest Gini coefficient, followed by main marketing areas, and then main producing areas. Comparing inter-regional Gini coefficients (see [Figure 3: see original paper]), the mean values among the three major regions rank from largest to smallest as: production-marketing balance areas vs. main marketing areas, production-marketing balance areas vs. main producing areas, and main producing areas vs. main marketing areas. Trend analysis shows that differences among the three major regions exhibit a fluctuating narrowing pattern. Analysis of the decomposition of overall differences in rural ecological resilience levels and their sources (see [Figure 3: see original paper]) indicates that sources of spatial differences rank by contribution rate from largest to smallest as: hypervariable density, inter-regional, and intra-regional. Developmental trend analysis reveals that hypervariable density shows a fluctuating upward trend, inter-regional differences show a fluctuating downward trend, and intra-regional differences remain relatively stable with little change.

2.2 Analysis of Influencing Factors of Rural Ecological Resilience Levels

This study first examines the global Moran's I index of rural ecological resilience levels, with results showing that most years during the observation period pass significance tests, indicating significant spatial clustering of China's rural ecological resilience. Local Moran's I analysis reveals that China's rural ecological resilience follows a spatial distribution pattern where high-value provinces are adjacent to one or more high-value provinces, or low-value provinces are adjacent to low-value provinces. Next, this study identifies the driving forces of rural ecological resilience to provide empirical and policy references for enhancing rural ecological resilience in various regions.

Regarding spatial econometric model selection, this study first uses the LM test to determine the selection between spatial error models and spatial lag models, then uses the Hausman test to choose between fixed effects and random effects models. On this basis, it further conducts the Wald test to determine whether the spatial Durbin model can be reduced to spatial error or spatial lag models. Test results show that the spatial Durbin model cannot be reduced to spatial lag or spatial error models, and using only these two models to study spatial spillover effects may introduce bias. Therefore, the spatial Durbin model is selected to explore factors influencing rural ecological resilience.

Spatial Durbin model regression results are shown in . Considering that when the spatial autoregressive coefficient is significantly non-zero, the simultaneous presence of explanatory variables and spatial lag terms of the dependent variable in the model may cause systematic bias in spatial spillover effects, this study adopts the method proposed by LeSage and Pace [27], using partial differential decomposition for unbiased treatment of spatial regression coefficients. Direct effects analyze the impact of explanatory variables within each province on the dependent variable, while indirect effects analyze spatial spillover effects, with results shown in .

From direct effects, environmental regulation intensity has a significantly positive coefficient at the 1% level, indicating that environmental regulation intensity has a significant positive impact on rural ecological resilience within the province. This is because enhanced environmental regulation intensity tightens restrictions on pollutants such as agricultural wastewater and exhaust emissions, stimulates green transformation of rural enterprises, and strengthens informal environmental regulation through increased rural residents' participation in environmental protection activities and public opinion guidance, correspondingly reducing behaviors detrimental to rural ecological construction such as domestic wastewater discharge and random garbage accumulation, thereby enhancing ecological resilience. The urbanization rate coefficient is negative and significant at the 1% level. This is because, on the one hand, some provinces are still in a period of accelerated urbanization, with macro factors such as natural resources, political and legal systems, economic society, and science and technology tilting more toward urban construction, leaving rural ecological governance constrained by factors such as capital and human resources. On the other hand, urbanization leads to large-scale outflow of rural youth, causing rural labor shortages, increasing input intensity of labor-substituting factors such as chemical fertilizers and pesticides, while resulting in rural land idleness and abandonment issues that reduce land biodiversity, all of which are unfavorable for improving rural ecological resilience. The rural economic growth level coefficient is positive but not statistically significant, indicating that rural economic growth level has a positive but insignificant impact on rural ecological resilience within the province. This may be because the victory in poverty alleviation occurred only a few years ago, and while increased rural per capita GDP may lead rural residents to pay attention to ecological issues after solving food and clothing problems, their economic investment in enjoying material life remains greater in the short term, and their understanding of the ecological environment still needs improvement. The government financial support for agriculture coefficient is negative but not significant, indicating that government financial support for agriculture has a negative effect on rural ecological resilience. Currently, provincial financial support for agriculture may focus more on infrastructure construction and rural industrial economic development, neglecting rural ecological governance, while lacking a financial support policy system and constraint mechanism oriented toward green ecology and rational utilization of rural ecological resources and production environment protection. Moreover, existing financial support policies suffer from insufficient precision, directionality, and effectiveness, resulting in insignificant environmental protection outcomes for rural ecological resilience.

From indirect effects, environmental regulation intensity has a significantly negative coefficient at the 1% level, indicating a significant negative spatial spillover effect of environmental regulation intensity on rural ecological resilience. This is due to the "pollution haven effect," where some provinces with slow transformation and high-pollution, high-energy-consuming agricultural enterprises transfer to regions with low environmental regulation intensity, increasing pollution pressure on other provinces and reducing their rural ecological resilience. The urbanization rate coefficient is positive and significant at the 5% level, showing a positive spatial spillover effect. The rural economic growth level coefficient is negative and passes the 5% significance test, indicating that increased rural per capita income in the province may cause neighboring provinces' rural residents to envy and easily abandon environmental protection for short-term economic growth, thereby negatively impacting rural ecological resilience. The government financial support for agriculture coefficient is negative and significant at the 1% level, indicating a negative spatial spillover effect of government support on rural ecological resilience development levels. This is because policy preferences from high financial support for agriculture in the province may attract qualified high-quality enterprises from neighboring provinces to relocate, leaving some rural resources such as cultivated land idle and abandoned in neighboring provinces, while those unable to transfer are often high-pollution, high-energy-consuming agricultural enterprises lacking green transformation capacity, posing enormous challenges to neighboring provinces' rural ecological resilience. From total effects, urbanization rate significantly promotes the development of China's rural ecological resilience overall, while environmental regulation intensity, rural economic growth level, and government financial support for agriculture have negative effects on China's rural ecological resilience development. Additionally, the spatial autoregressive coefficient ( ) is significantly positive, indicating that the rural ecological resilience development of a province (municipality) is positively influenced by that of neighboring regions.

3 Discussion

Unlike previous studies that treated rural ecological resilience as a dimension of rural resilience for connotation definition, level measurement, and influencing factor analysis, this study uses scientific criteria to employ the entropy method and TOPSIS method to determine indicator weights, thereby establishing a comprehensive, quantifiable, and statistically feasible rural ecological resilience evaluation index system. It directly measures China's rural ecological resilience level, deeply investigates its spatiotemporal evolution, and uses a spatial Durbin model to explore influencing factors, aiming to provide reliable decision-making basis and macro-micro policy recommendations with operability for enhancing China's rural ecological resilience and facilitating sustainable rural ecological development. From temporal evolution, rural ecological resilience from 2004 to 2021 shows an upward trend but remains at a low level overall, consistent with research conclusions by Zheng Yanjie et al. [11] and Wang Xin et al. [13]. From spatial evolution, rural ecological resilience levels exhibit characteristics of main marketing areas > main producing areas > balance areas, which existing research has not addressed. Using the spatial Durbin model to explore influencing factors of rural ecological resilience reveals that urbanization rate significantly and negatively affects rural ecological resilience levels, consistent with Tian Jian et al.'s [15] research findings using Tibet as a case study. Rural economic growth and government financial support for agriculture both positively affect rural ecological resilience, consistent with Wang Cheng et al.'s [18] research using Chongqing as a case study.

4 Conclusions and Implications

4.1 Conclusions

This study draws the following conclusions: (1) From 2004 to 2021, China's rural ecological resilience showed an upward trend but remained at a relatively low level overall. By region, rural ecological resilience levels exhibit characteristics of main marketing areas > main producing areas > balance areas. In terms of average levels, main marketing areas have the highest average rural ecological resilience level throughout the years, followed by main producing areas, and then production-marketing balance areas. (2) Rural ecological resilience scores demonstrate characteristics of "curve shifting rightward, right tail extending, and width broadening" over time. Decomposing regional differences using the Dagum Gini coefficient reveals that the national rural ecological resilience Gini coefficient is relatively low, overall differences are not severe, and show a downward trend. (3) China's rural ecological resilience shows strong spatial correlation. Environmental regulation significantly and positively affects rural ecological resilience levels, with a significant negative spillover effect. Urbanization rate significantly and negatively affects rural ecological resilience levels, with a significant positive spillover effect. Rural economic growth level and government financial support for agriculture positively and negatively affect rural ecological resilience, respectively, but these results are not statistically significant. From the perspective of indirect effects, both factors exhibit significant negative spillover effects.

4.2 Implications

Based on these findings, this paper offers the following policy implications: (1) While adhering to the principle of balancing economic and ecological development, top-level overall planning should be strengthened. The basic national policy of resource and environmental protection should be upheld to comprehensively promote the "three reductions" in agriculture and change the traditional high-energy-consumption production mode. Based on ecological foundations and natural endowments, natural and artificial protection and restoration measures should be scientifically allocated to effectively protect important ecosystems, biological species, and genetic resources, ensuring ecological and biological security. People-oriented approaches should gradually improve rural living environments and enhance village appearance. (2) Main grain producing areas have made tremendous contributions to ensuring food security and should receive ecological compensation in policy. Additionally, they should actively promote green transformation of agriculture, promote input reduction and efficiency improvement, enhance pollution prevention effectiveness of non-point sources, and properly address key issues including resource conservation, cultivated land protection, ecological maintenance, and rural harmony. Production-marketing balance areas have low starting points for rural ecological resources and environmental development and should receive appropriate policy 倾斜 and resource assistance. Meanwhile, they must adhere to the basic principle of prioritizing ecological environmental protection while 兼顾 social and economic development, fully considering ecological environmental factors in the rural revitalization process, continuously strengthening biological resource protection, and boosting sustainable development. (3) Regional development awareness should be strengthened, geographical connectivity effects should be valued, and the radiating and driving role of provinces with high rural ecological resilience should be fully leveraged. A development concept of shared green technology facilities and ecological communities oriented by composite functions should be advocated to enhance overall rural ecological carrying capacity. Meanwhile, based on existing foundations, environmental regulation tools and means should be innovated, and environmental regulation policies should be optimized and adjusted in real time to effectively serve local rural ecological resilience development while avoiding policy distortion during implementation. During urbanization, rural ecological protection work should be actively conducted, and idle rural resources should be utilized in more scientific and rational ways. With rural economic growth, grassroots governments should popularize rural ecological protection 思想 to make ecological civilization a mainstream socialist value that enters the daily lives of thousands of villages and households and integrates into every 环节 of ecological rural construction. When providing government financial support for agriculture, funding for rural ecology should be increased to ensure adequate capital for rural ecological protection.

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Note: Figure translations are in progress. See original paper for figures.