

Research on Rural Revitalization Pathways in Arid Areas Based on Resource and Environmental Carrying Capacity: A Case Study of Ningxia (Postprint)

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Abstract

Resource and environmental carrying capacity constitutes a critical constraint on regional socio-economic development in arid zones. Elucidating the status of resource and environmental carrying capacity and investigating the distribution characteristics of resources and environment along with existing problems in typical areas constitute the foundation for scientifically implementing rural revitalization in arid regions in the new era. Taking Ningxia as a case study, this research explores pathways for achieving rural revitalization in arid areas based on the PS-DR-DP (Pressure-Support; Destruction-Restoration; Degradation-Enhancement) regular hexagon interaction force model of resource and environmental carrying capacity and an analysis of the coordinated development status within the three pairs of interaction forces. The results indicate that Ningxia exhibits relatively weak resource and environmental carrying capacity, with notable variations in the internal degree of coordinated development of the three interaction force pairs across different counties. The carrying capacity in the northern Yellow River irrigation region surpasses that of the southern mountainous area, while resource-based cities experience severe ecological degradation. Overall, the development degree of resource and environmental carrying capacity throughout Ningxia remains low. According to the advantages and disadvantages of resource and environmental carrying capacity in each region, Ningxia is classified into four zones: high-carrying-capacity agglomeration enhancement zone, high-carrying-capacity characteristic protection zone, medium-carrying-capacity ecological restoration zone, and low-carrying-capacity ecological conservation zone. Implementing the rural revitalization strategy requires not only planning revitalization pathways at the macro level but also regulating based on the resource and environmental carrying capacity of each region to foster sustainable socio-economic development in rural areas.

Full Text

Rural Revitalization Pathways in Arid Regions Based on Resource and Environmental Carrying Capacity: A Case Study of Ningxia

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Abstract

Resource and environmental carrying capacity represents a critical constraint on socioeconomic development in arid regions. Clarifying the status of resource and environmental carrying capacity and investigating the distribution characteristics and underlying problems of resources and environment for rural revitalization in typical areas constitute the foundation for scientifically implementing rural revitalization strategies in arid regions during the new era. Taking Ningxia as a case study, this research employs the PS-DR-DP (Pressure-Support, Destructiveness-Resilience, Degradation-Promotion) regular hexagon interaction force model to evaluate resource and environmental carrying capacity and analyzes the coordinated development status within these interaction forces to explore viable pathways for rural revitalization in arid regions. The results demonstrate that Ningxia's overall resource and environmental carrying capacity is weak, with significant regional variations in the coordinated development degree of internal interactions among counties. The carrying capacity in the northern Yellow River irrigation area substantially exceeds that of the southern mountainous region, while resource-based cities suffer from severe ecological degradation. Across the entire region, the development degree of resource and environmental carrying capacity remains low. Based on the comparative advantages and disadvantages of resource and environmental carrying capacity in each region, Ningxia is classified into four functional zones. The study concludes that achieving rural revitalization requires not only macro-level strategic planning but also region-specific regulation according to local resource and environmental carrying capacities to promote sustainable socioeconomic development in rural areas.

Keywords: resource and environmental carrying capacity; rural revitalization; arid region; Ningxia

1. Introduction

Since the reform and opening up, China's urban-biased and industry-biased policies have propelled rapid urbanization, yielding staged achievements in urban socioeconomic development. However, the excessive pursuit of high-speed

urbanization while neglecting integrated urban-rural development has generated not only “urban diseases” such as overcrowding, traffic congestion, soaring housing prices, and environmental pollution, but also “rural diseases” including rural hollowing, land abandonment, and population aging. The concurrent “dual diseases” have escalated urban-rural conflicts and accelerated rural regional decline.

In recent years, numerous domestic scholars have shifted their research focus to rural areas, producing abundant scholarship on rural reconstruction, rural transformation development processes, rural regional functions, rural revitalization pathway exploration, and rural evaluation. Nevertheless, few studies have examined rural revitalization pathways from the perspectives of resource and environmental endowments, carrying capacity, and socioeconomic development status.

Natural resources constitute the foundation and prerequisite for regional development. With modern technological advancement, widespread application of innovations, economic globalization, and market competition, regions with scarce natural resources can develop strong competitiveness through effective utilization, rational allocation, and industrial structure optimization. However, socioeconomic development has also led to severe degradation of natural resource conditions, ecological destruction, and poor economic foundations in rural areas due to unreasonable cultivation practices, fertilizer abuse, and land abandonment caused by population mobility. China’s vast territory exhibits significant ecological differences between north and south, with varying natural resource endowments and differential resource consumption and environmental pollution from long-term production activities. Therefore, achieving rural revitalization and enhancing comprehensive rural development necessitates evaluating rural resource and environmental conditions, analyzing regional advantages and disadvantages based on carrying capacity assessments, scientifically planning rural industrial structures, and formulating ecological protection measures.

Rural revitalization in arid regions is directly constrained by resource carrying capacity. Factors such as surface runoff, groundwater levels, land desertification, and salinization create distinctly different revitalization pathways across regions. This study selects Ningxia as the research area, decomposing regional resource and environmental carrying capacity into three pairs of interaction forces—pressure-support, destructiveness-resilience, and degradation-promotion—to construct an evaluation index system that identifies resource and environmental advantages and disadvantages in rural regional development. Exploring spatial differentiation characteristics of rural systems at the micro-regional level based on carrying capacity provides scientific reference for promoting rural revitalization.

2. Methods

2.1 Data Sources

This study takes the county-level unit as the minimum research unit, treating Xingqing District, Xixia District, and Jinfeng District collectively as Yinchuan municipal district. Data were primarily obtained from the *China County Statistical Yearbook*, *China Forestry Statistical Yearbook*, *Ningxia Statistical Yearbook*, *Ningxia Soil and Water Conservation Bulletin*, as well as annual reports and publicly available information from various government departments in Ningxia.

2.2 Evaluation Method for Resource and Environmental Carrying Capacity

Resource and environmental carrying capacity generally refers to the degree to which resource and environmental conditions in a specific region can support human life and adapt to socioeconomic development while ensuring ecosystem stability and regional sustainability. The national rural revitalization classification includes agglomeration and upgrading type, suburban integration type, characteristic protection type, and relocation and consolidation type, which are largely based on resource carrying capacity levels, characteristic resource advantages, industrial development levels, and historical and cultural heritage. The rural regional system is a complex, open, and comprehensive system, consistent with the dynamic and open characteristics of carrying capacity. As rural areas develop, industrial transformation, technological progress, population changes, and land use intensity all influence changes in resource and environmental carrying capacity, thereby affecting regional sustainable development capacity and the quality of rural revitalization.

This study applies the PS-DR-DP regular hexagon interaction force model to decompose carrying capacity into the sum of six forces: pressure-support, destructiveness-resilience, and degradation-promotion. This approach comprehensively evaluates the current status of regional resource and environmental carrying capacity while considering the short-board effect to analyze the coordination degree among the six forces.

Ningxia is located in the middle and upper reaches of the Yellow River in northwestern China (35°14' ~39°23' N, 104°17' ~107°39' E), situated in the transition zone between the Loess Plateau and the Inner Mongolia desert. It features a typical continental arid and semi-arid climate. The terrain is high in the south and low in the north, with elevations ranging from 1100 to 1200 m. The region can be divided into three parts: the northern Yellow River irrigation area with flat terrain and superior water-soil conditions; the central arid wind-sand belt with perennial drought and poor water-soil conditions; and the southern mountainous area with complex gully terrain and cold, humid climate.

2.2.2 Calculation of Carrying Capacity Contribution Values

The comprehensive graphic method of fully permuted polygons, proposed by Wu Qiong et al., reduces subjective arbitrariness. This study modifies and applies it to resource and environmental carrying capacity evaluation.

Assume there are N standardized indicators, with their upper limit values forming a central N-polygon. The N indicators form (N-1) N-polygons. The ratio of the average area of these N-polygons to the area of the central N-polygon represents the carrying capacity contribution value of each sub-item, indicating its impact on resource and environmental carrying capacity.

The formula is:

$$G = \frac{\sum_{i=1}^{N-1} \sum_{j=i+1}^N C_i C_j}{N(N-1)/2}$$

Where: G represents the carrying capacity contribution value of a sub-item; N represents the number of indicators in the sub-item; C_i and C_j are the i-th and j-th indicators in the m-th indicator system.

2.2.3 Index System Construction and Carrying Capacity Classification

Resource and environmental carrying capacity is mainly comprehensively reflected by resource support capacity and environmental capacity. Combined with rural regional development systems and urban-rural integration development theory, one of the dominant factors constraining rural revitalization development is the resource and environmental baseline conditions. Therefore, following the principles of scientificity, comprehensiveness, regionality, systematicity, and data availability of evaluation indicators, and referencing existing research on resource and environmental evaluation index systems and the *Guidelines for Evaluation of Resource and Environmental Carrying Capacity and Territorial Space Development Suitability*, this study constructs a resource and environmental carrying capacity index system that reflects rural regional development (Table 1). Among them, the quantity and utilization of water and land resources, as well as population and grain output, characterize resource utilization efficiency; pollutant emissions and treatment volumes characterize environmental stability; and soil erosion area and treatment area, afforestation area, forest land area, and agricultural fertilizer application amount characterize ecological stability.

Regional resource and environmental carrying capacity continuously changes with urbanization development. Although China's existing urban-rural dual system hinders the flow of population, technology, and other elements, the flow of natural resources and environmental elements between rural and urban areas still exists. The development trend of urban and rural areas is mainly toward integrated development. Therefore, this study draws on the *China Modernization*

Report: Urban Modernization Study and rural development process mechanisms to classify carrying capacity status into four urbanization stages (Table 2).

Table 1. Index evaluation system of resources and environment carrying capacity

Category	Indicators
Pressure	Crop planting area, Urban village and industrial/mining land, Rural population in permanent residents, Regional GDP, Rural water demand
Support	Rural available land area, Rural employment, Average annual precipitation, Water resource supply
Destructiveness	Industrial smoke dust emissions, Total industrial wastewater discharge, General industrial solid waste generation
Resilience	General industrial solid waste disposal, Industrial wastewater treatment, Industrial smoke dust treatment
Degradation	Agricultural fertilizer application, Soil erosion area, Land desertification area
Promotion	Soil erosion treatment area, Desertification treatment area, Rural residents' disposable income

Table 2. Classification of resources and environment carrying capacity

Carrying Capacity Contribution Value Mean	Carrying Capacity State
≤ 0.30	Low-level carrying, near-stable state
$0.30 < \text{value} < 0.65$	High-speed development, unstable state
$0.65 \leq \text{value} < 0.85$	Reasonable carrying, near-stable state
≥ 0.85	Full carrying, unstable state

Note: The carrying capacity contribution value mean is the average of sub-item carrying capacity contribution values.

2.2.4 Measurement and Classification of Coordinated Development Degree of Resources and Environment

Rural development relies on regional natural resource conditions and inevitably causes damage to the natural environment during the development process.

When rural revitalization planning and development goals conflict with environmental constraints and develop blindly, it will destroy the self-repairing capacity of the resource and environmental system, causing imbalance among the six forces and leading to unsustainable rural socioeconomic development. Therefore, this study measures the coordination degree and development degree of the six forces of resource and environmental carrying capacity to assess the stability of regional resource and environmental systems and regional sustainability.

Drawing on relevant research on coordinated development degree and the current status of resources and environment in Ningxia, the coordination degree and development degree are classified into five levels (Table 3). The calculation methods are as follows:

$$X = \frac{\sum_{i=1}^3 \sum_{j=i+1}^3 R_i R_j}{\sqrt{\sum_{i=1}^3 R_i^2 \sum_{j=1}^3 R_j^2}}$$

$$F = \alpha \sum_{i=1}^3 R_i + \beta \sum_{j=1}^3 R_j$$

Where: F is the development degree of each resource and environmental force; X is the coordination degree; α and β are coefficients, both taken as 0.5; R_i and R_j are the carrying capacity contribution values of resource and environmental subsystems.

Table 3. Classifications of coordination degree and development degree

Coordination Degree (X)	Development Degree (F)	Classification
≤ 0.30	≤ 0.30	Severe imbalance type / Severe recession type
$0.30 < X \leq 0.50$	$0.30 < F \leq 0.50$	Mild imbalance type / Mild recession type
$0.50 < X \leq 0.70$	$0.50 < F \leq 0.70$	Basic coordination type / Basic development type
$0.70 < X \leq 0.90$	$0.70 < F \leq 0.90$	Good coordination type / Good development type

Coordination Degree (X)	Development Degree (F)	Classification
$0.90 < X \leq 1.00$	$0.90 < F \leq 1.00$	Premium coordination type / Premium development type

3. Results

3.1.1 Resource and Environmental Carrying Capacity Level

Based on the classification of resource and environmental carrying capacity, the average contribution value (Figure 1) shows that in 2018, the carrying capacity contribution value means of Pengyang County, Longde County, and Jingyuan County were 0.65, 0.68, and 0.70 respectively, belonging to the “reasonable carrying, near-stable state.” Except for these three counties, the remaining counties in the region have carrying capacity contribution value means between 0.30-0.65, belonging to the “high-speed development, unstable state.”

The pressure-support carrying capacity contribution value results (Figure 2) show that the difference between pressure and support in central and southwestern Ningxia counties is small, while pressure far exceeds support in northern and southeastern counties. Since the end of the 20th century, northern Ningxia, with its unique natural production conditions, entered a period of rapid urbanization development, attracting population migration from southern Ningxia and causing rapid population density increases and continuous urban expansion in the north. Consequently, pressure in northern cities far exceeds their support capacity. In contrast, due to population outflow and infrastructure improvements during the poverty alleviation period, pressure and support are relatively balanced in the southern region.

The destructiveness-resilience carrying capacity contribution value results (Figure 3) show that in Lingwu City, Huinong County, Pingluo County, and Qingtongxia City, resilience exceeds destructiveness, while in remaining counties, destructiveness exceeds resilience. This is because industrial enterprises in resource-based cities have well-established pollution treatment facilities, while agriculture-dominated cities lack industrial pollution treatment systems.

The degradation-promotion carrying capacity contribution value results (Figure 4) show that in Haiyuan County, Pengyang County, and Tongxin County, promotion exceeds degradation. However, in Yinchuan municipal district, Yongning County, Helan County, Lingwu City, Dawukou District, Huinong District, Litong District, Hongsibu District, Yanchi County, Longde County, and Jingyuan County, degradation far exceeds promotion. Northeastern Ningxia borders the Mu Us Desert, and the northwestern area lies within the Tengger Desert range, featuring fragile ecological environments and severe

land desertification, resulting in weak ecological promotion capacity. The southern mountainous area, as a concentrated poverty region in Ningxia, has harsh natural living conditions that force farmers to overexploit nature for livelihood, exacerbating ecological environmental degradation. Although the government has implemented various ecological restoration policies in recent years, long-accumulated human-land contradictions persist.

In summary: Pengyang County, Jingyuan County, and Longde County are in a state of reasonable carrying capacity and near stability, but their carrying status values are relatively poor. These three counties are located in the southernmost part of Ningxia's southern mountainous area, with geographical environments dominated by loess hilly and gully regions. Population pressure and ecological fragility have created low carrying capacity in these counties. Since the poverty alleviation campaign began, the southern mountainous area has intensified ecological protection and restoration efforts, showing significant improvement in promotion capacity compared to the northern region.

3.1.2 Analysis of Coordinated Development Level

This study analyzes the coordination and development capacity of resource and environmental carrying capacity across the region by calculating the coordination degree and development degree of the three pairs of forces: pressure-support, destructiveness-resilience, and degradation-promotion. The results are shown in Figure 5.

Coordination Degree Analysis: The pressure-support coordination degree shows that Dawukou District, Huinong District, Longde County, and Jingyuan County are in basic coordination. Among them, Dawukou District and Huinong District, as energy cities and major agricultural counties, have long-term mining and farming activities that cause excessive land load. Longde County and Jingyuan County have natural condition limitations that lead to low population carrying capacity and tense human-land relationships.

The destructiveness-resilience coordination degree shows significant differences among counties, with central arid belt and southern mountainous counties showing mild imbalance. Low precipitation, strong winds, and fragile ecological environments result in low environmental stability in these counties.

The degradation-promotion coordination degree shows that cities along the Yellow River economic belt have lower coordination. These areas have high urbanization rates and are major agricultural production and industrial agglomeration zones, where high-density population and economic activities reduce regional ecological stability.

Development Degree Analysis: From the internal development degree of each pair of forces, pressure-support calculation results show that except for Yinchuan municipal district, which is a mild recession type, other counties are basically developing types. As the provincial capital, Yinchuan's concentration

of population and commercial activities has reached the maximum carrying capacity, and excessive agglomeration and development will reduce resource and environmental carrying capacity.

Destructiveness-resilience calculation results show that Pingluo County, Zhongning County, and Shapotou District are mild recession types. The concentration of coal enterprises in Pingluo County and chemical enterprises in Zhongning County cause low development degrees in these two areas.

Degradation-promotion calculation results show that Pingluo County and Qingtongxia City are mild recession types. Long-term agricultural production and management activities in Pingluo have reduced land ecological environment restoration capacity.

Comprehensive Comparison: According to comprehensive comparison of coordination degree and development degree calculation results: Northern Ningxia has relatively high resource and environmental carrying capacity and good development degree, but long-term development and construction have reduced the coordination degree of degradation-promotion. Southern Ningxia's mountainous areas suffer from severe soil erosion, with low resource and environmental carrying capacity and development degree. According to research data, the southern mountainous area is a high-poverty-incidence region in Ningxia, located in the transition zone from semi-arid to arid desert areas of the Loess Plateau, with poor water-soil matching. In recent years, the degradation-promotion coordination degree in the southern region has significantly improved, and ecological restoration and construction have achieved remarkable results since the poverty alleviation campaign.

Overall, resource and environmental carrying capacity is not only related to regional natural conditions, topography, and geographic location, but also to economic development, regional policies, and human activities. During rural revitalization, the flow of various production elements will inevitably occur, causing high-quality production elements to flow out of areas with resource and environmental problems and making ecological fragility more prominent, further adversely affecting regional socioeconomic development and rural revitalization. Moreover, understanding the baseline conditions of rural regional resources and environment is essential for fundamentally judging development pathways for each rural region and formulating rural revitalization plans while ensuring the ecological environment is not damaged.

3.2.1 Identification of Resource and Environmental Problems

Based on the carrying capacity contribution values of pressure-support, destructiveness-resilience, and degradation-promotion, the criterion for identifying resource and environmental problems is when the difference between internal carrying capacity contribution values of a pair of forces exceeds the mean minus standard deviation. Counties where this difference exceeds the threshold are considered problem areas.

Calculation results show: 8 counties have problems with pressure-support carrying capacity contribution values, 12 counties have problems with destructiveness-resilience carrying capacity contribution values, and 10 counties have problems with degradation-promotion carrying capacity contribution values. Some counties have multiple problems simultaneously. After eliminating duplicate problem counties, four types of problem counties are identified:

- 1) **Fragile Support Type:** Mainly concentrated in core regional cities and their surrounding areas in Ningxia. These regions have good terrain conditions, complete urban infrastructure, high economic development levels, and agglomeration characteristics of population and economy. Long-term economic development and population agglomeration have led to high pressure carrying capacity in these areas.
- 2) **Fragile Resilience Type:** Mainly concentrated in southern mountainous areas and some central arid belt cities in Ningxia. These regions have complex terrain conditions, poor water-soil matching, fragile ecological environments, and are important ecological protection areas in Ningxia. In recent years, ecological protection measures such as ecological migration and returning farmland to forest in southern mountainous areas have improved resource and environmental carrying capacity.
- 3) **Fragile Promotion Type:** Mainly concentrated in the Yellow River economic belt in Ningxia. These regions have superior water and soil resources, good ecological environments, strong agricultural foundations, and have developed industries such as energy, chemicals, new materials, and equipment manufacturing. Long-term agricultural economic activities and industrial development have resulted in weak promotion capacity in these regions.
- 4) **Fragile Carrying Capacity Type:** Including Dawukou District, Litong District, Hongsibu District, Jingyuan County, and Longde County. These areas have low overall resource and environmental carrying capacity levels. The reasons for low carrying capacity vary by county: Dawukou District suffers from severe ecological environmental damage and weakened restoration capacity due to long-term coal mining; Hongsibu District is located in the central arid belt with low precipitation and high evaporation, resulting in harsh climate conditions; Litong District, as part of Wuzhong City, is located on the edge of the Mu Us Desert, suffering from year-round wind-sand attacks and severe land desertification, combined with high population density, resulting in weak regional carrying capacity; Jingyuan County and Longde County are located in the southern mountainous area, where unfavorable natural living conditions force farmers to continuously exploit nature for livelihood, exacerbating ecological environmental degradation.

3.2.2 Revitalization Pathways

Rural regional socioeconomic development depends on the coupling and coordination of resource and environmental carrying capacity. The purpose of rural revitalization is to promote coordinated development of various elements in rural areas and achieve sustainable urban-rural integration development. Natural resource conditions vary significantly across Ningxia, so rural revitalization pathways must not only be planned macroscopically based on resource and environmental baseline conditions and economic development foundations, but also be tailored to each region's current situation through agricultural industrial structure adjustment, infrastructure improvement, and promotion of sustainable rural development.

Based on the carrying capacity contribution values of pressure-support, destructiveness-resilience, and degradation-promotion, and using the criterion that the difference between internal carrying capacity contribution values of a pair of forces exceeding the mean minus standard deviation indicates a problem, four types of problem counties are identified. Correspondingly, four functional zones are proposed for rural revitalization:

- 1) **High-Carrying Agglomeration and Upgrading Zone:** Mainly includes core regional cities and their surrounding counties. These areas have superior geographic location, high urbanization levels, complete infrastructure, and high resource and environmental carrying capacity. The basic conditions and geographic location are favorable for developing rural industries and leveraging urban driving effects on rural areas. This zone should encourage population flow to rural areas, develop urban agriculture and agricultural product processing industries, promote integrated development of the three rural industries, strengthen rural infrastructure construction, improve intensive utilization of rural living space, and enhance land use efficiency.
- 2) **High-Carrying Characteristic Protection Zone:** Mainly includes central and western counties of Ningxia, located in the Yellow River gravity irrigation area at Ningxia's entrance, serving as an important transportation hub connecting northwest and north China. Major industries include tourism, metallurgy, characteristic planting and breeding, and agricultural product processing. This zone should rely on national desert geological park resources to improve tourism infrastructure, integrate tourism resources, promote combination of rural agriculture with leisure economy and sightseeing industries to create a dominant rural tourism industry; promote the construction of production chains for characteristic agricultural products such as goji berries, selenium-sand melons, high-acid apples, and facility vegetables to create agricultural characteristic brands; accelerate the transfer of idle land to promote agricultural scaling, industrialization, and standardization; and improve agricultural infrastructure.
- 3) **Medium-Carrying Ecological Restoration Zone:** Mainly includes

northern Ningxia energy cities. These areas focus on coal resource development with high industrial development levels and complete industrial chains, but long-term resource extraction has caused severe ecological environmental damage and resource and environmental carrying capacity degradation. The priority is to intensify mine geological environment restoration and ecological protection and restoration to recover regional resource and environmental carrying capacity; secondly, adjust and optimize industrial structure, increase the radiation and driving effects of new material industries and service industries on rural areas; and rely on regional coal machinery production bases.

- 4) **Low-Carrying Ecological Conservation Zone:** Mainly includes southern Ningxia mountainous areas and some central arid belt counties. These areas have prominent soil erosion problems, fragile ecological environments, and are important ecological protection areas and ecological agricultural zones in Ningxia. This zone should consider promoting relocation of remote mountainous and ecologically fragile areas to optimize rural living space; enhance ecological service functions, carry out biodiversity and water resource protection, implement soil erosion control and returning farmland to forest projects; combine tourism with ecological environment, folk customs, and health industries to create ecological green tourism; implement medium-low yield field improvement and efficient irrigation agriculture development; and improve agricultural infrastructure.

4. Discussion

Resource and environmental carrying capacity in arid regions is characterized by overall weakness, overloaded resources and environment, limited carrying capacity development potential, and huge restoration costs after overloading. Rural revitalization in arid regions needs to explore revitalization pathways based on resource and environmental carrying capacity evaluation. This study preliminarily discusses the current status of rural resource and environmental carrying capacity, resource and environmental constraints, and revitalization pathways in Ningxia. However, factors affecting resource and environmental carrying capacity are extremely rich, and the selection of evaluation indicators may affect evaluation results due to different regions and socioeconomic development levels. Additionally, due to data acquisition difficulties, it is challenging to conduct a comprehensive evaluation of county-level resource and environmental carrying capacity, which affects the accuracy of evaluation results to some extent, and some county evaluation results may have deviations. Moreover, this study only discusses resource and environmental carrying capacity at the county level; subsequent research should further refine the evaluation index system and research scale, select sample points for different carrying capacity regions, and conduct specific studies on rural revitalization pathways.

5. Conclusions

This study takes Ningxia counties as research units, applies the PS-DR-DP regular hexagon interaction force theoretical model to express county resource and environmental carrying capacity through three pairs of interaction forces, and analyzes the shortcomings of resource and environmental carrying capacity in each county by measuring the coordination degree and development degree of the interaction forces. Finally, based on the resource and environmental carrying capacity evaluation, it explores implementation pathways for rural revitalization in Ningxia.

The main conclusions are:

1. Based on resource and environmental carrying capacity measurement, resource and environmental constraints for achieving rural revitalization in each county are identified. The spatial distribution characteristics of these constraints are obvious, and their distribution patterns are not only affected by geographic environments but also have complex relationships with regional policies, resource conditions, and economic development.
2. In the coordination degree and development degree of the three pairs of forces, the northern Yellow River irrigation area has high resource and environmental carrying capacity, but population and industrial agglomeration have caused low development degrees in some counties. The southern mountainous area has low resource and environmental carrying capacity due to inherent natural condition defects, but its development degree has gradually improved under the influence of ecological restoration policies.
3. Sustainable development of rural regions depends on the coupling relationship between resource and environmental carrying capacity and economic development. Under the opportunities of new economic development, achieving rural revitalization strategy in Ningxia requires not only macro-level planning of revitalization pathways but also regulation according to each region's resource and environmental carrying capacity to promote sustainable socioeconomic development in rural areas.

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Figures

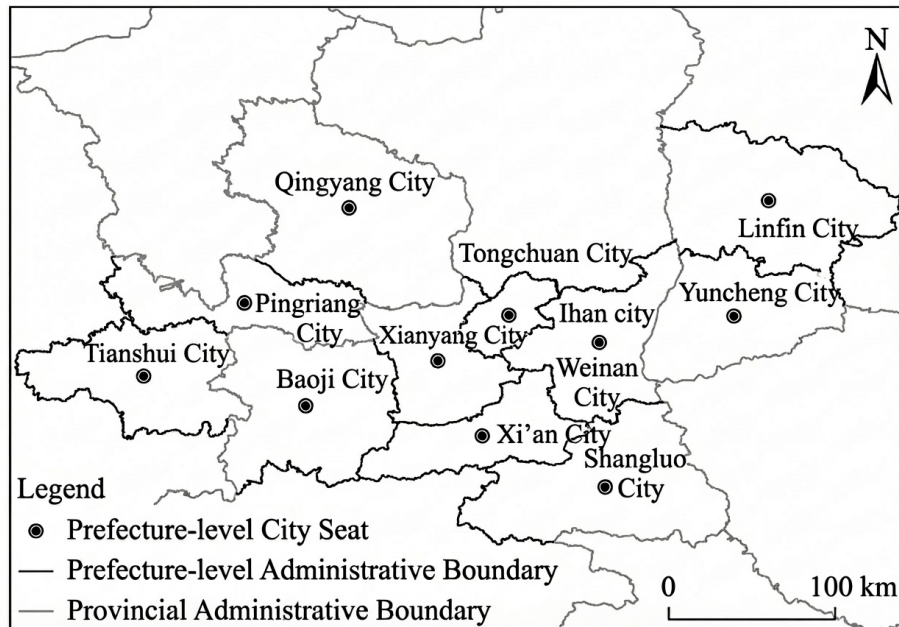


Figure 1: Figure 1

Source: ChinaXiv –Machine translation. Verify with original.

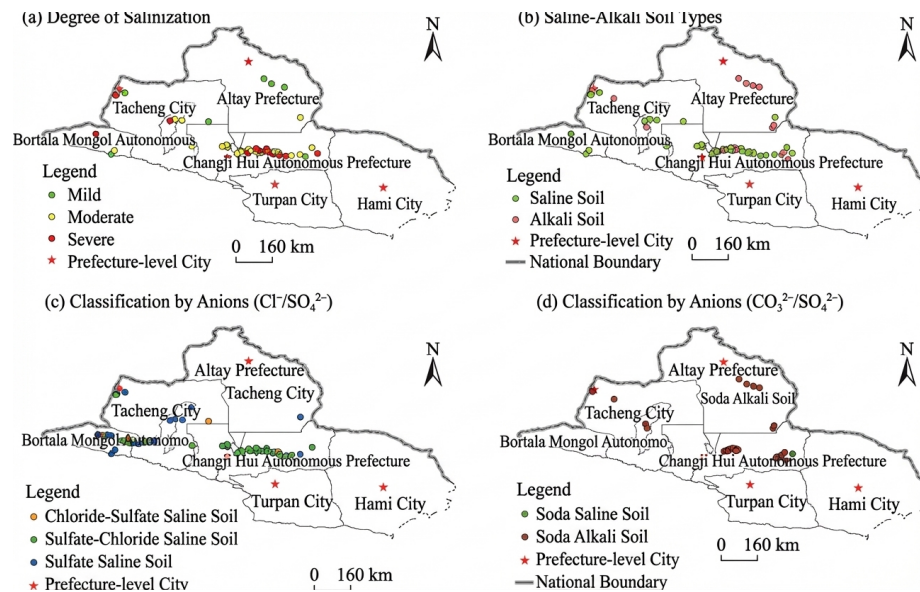


Figure 2: Figure 2

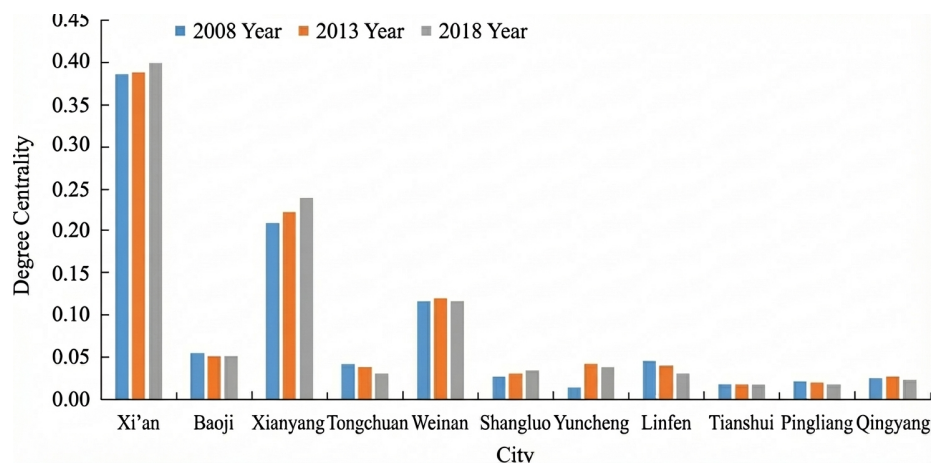


Figure 3: Figure 3

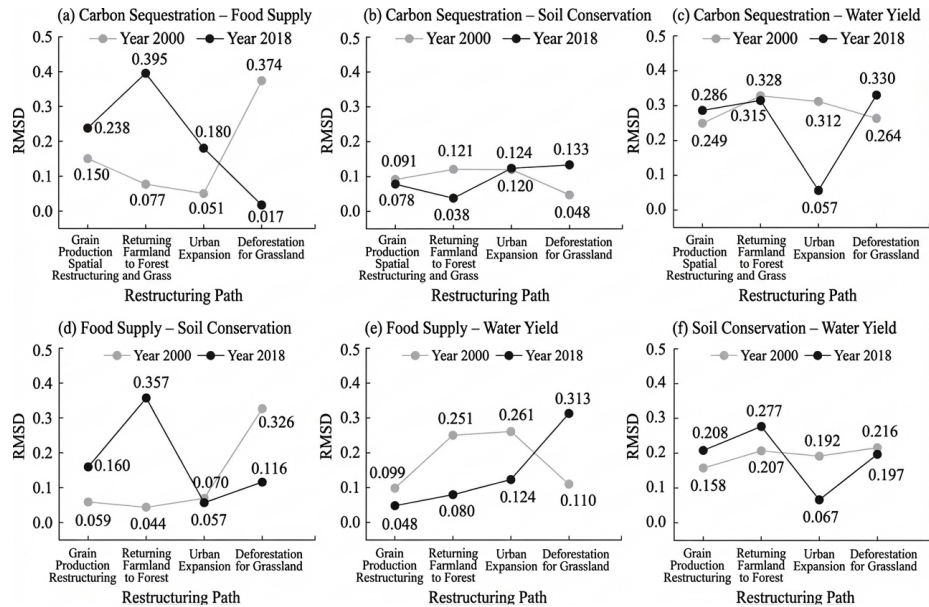


Figure 4: Figure 4

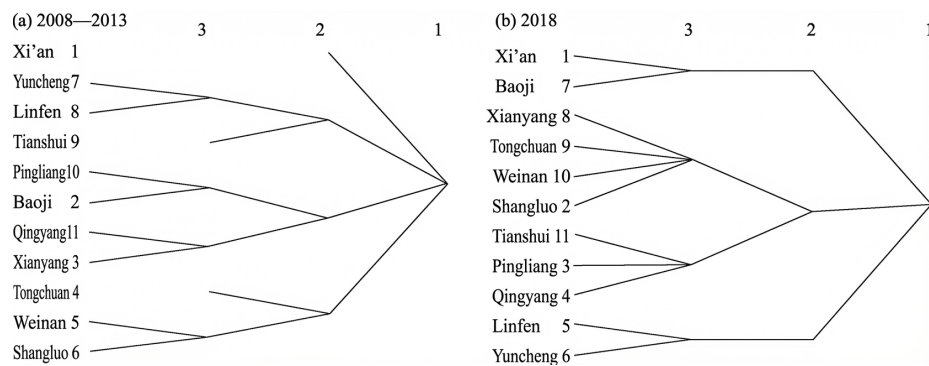


Figure 5: Figure 5