Measurement and Spatiotemporal Differentiation of Rural Revitalization Development Level in Gansu Province at the County Scale: Postprint

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Abstract

The Rural Revitalization Strategy constitutes one of the major initiatives for China to comprehensively build a modern socialist strong country. Grounded in the conceptual framework of the Rural Revitalization Strategy, this study constructs an evaluation index system for rural revitalization development levels, employs the entropy weight method to measure the rural revitalization development level across 85 counties (districts) in Gansu Province from 2013 to 2022, and utilizes the Dagum Gini coefficient and kernel density estimation to analyze regional disparities in rural revitalization. The results indicate that: (1) The overall rural revitalization development level in Gansu Province demonstrates an upward trend, with the most pronounced growth rates observed in the two dimensions of industrial prosperity and ecological livability. (2) The development level of county-level rural revitalization in Gansu Province exhibits a spatial distribution characteristic of "high in the northwest and low in the southeast," wherein high-level areas are distributed in the Hexi region, while low-level areas are primarily concentrated in the Hedong region. (3) The overall Gini coefficient of rural revitalization level shows a fluctuating downward trend, with inter-regional differences constituting the primary source of regional disparities; the rural revitalization development level of the 85 counties in Gansu Province demonstrates a gradual convergence trend, exhibiting certain stability. Based on these findings, we propose formulating targeted policies according to regional actual conditions to promote coordinated development of rural revitalization across regions.

Full Text

Measurement and Spatio-Temporal Differentiation of Rural Revitalization Development Levels in Gansu Province Based on County Scale

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Abstract

The rural revitalization strategy represents a major initiative for China to achieve the comprehensive construction of a modern socialist strong country. Grounded in the strategic connotation of rural revitalization, this study constructs an evaluation index system for rural revitalization development levels. Employing the entropy method, we measure the rural revitalization development levels across 85 counties (districts) in Gansu Province from 2013 to 2022. The Dagum Gini coefficient and kernel density estimation methods are utilized to analyze regional disparities in rural revitalization. The results reveal that: (1) The overall rural revitalization development level in Gansu Province demonstrates an upward trend, with the most significant growth observed in the dimensions of industrial prosperity and ecological livability. (2) County-level rural revitalization development levels in Gansu Province exhibit a spatial distribution pattern characterized as "high in the northwest, low in the southeast," with high-level areas concentrated in the Hexi region and low-level areas primarily located in the Hedong region. (3) The overall Dagum Gini coefficient for rural revitalization levels shows a fluctuating downward trend, with inter-regional differences constituting the primary source of regional disparities. The rural revitalization development levels of the 85 counties in Gansu Province display a gradual convergence trend, indicating a certain degree of stability. Based on these findings, we propose that rural revitalization and development efforts in Gansu Province should formulate precise policies tailored to local conditions to promote coordinated regional rural revitalization.

Keywords: rural revitalization; development level; spatio-temporal differentiation; county scale; Gansu Province

1. Introduction

Rural revitalization constitutes the core strategy for addressing the "three rural issues" (agriculture, rural areas, and farmers) and represents a strategic priority for comprehensively advancing the construction of a modern socialist country and promoting balanced socioeconomic development. The Central Rural Work Conference and the No. 1 Central Document have emphasized the critical importance of ensuring national food security and preventing large-scale poverty relapse, which serve not only as the "ballast stone" for safeguarding citizens' basic livelihoods but also as the "anchor" for long-term social stability and sustainable economic development. Furthermore, the *Gansu Province Rural Revitalization Strategic Plan (2018–2022)* explicitly proposes comprehensive promotion strategies across multiple dimensions—including industry and talent—to advance agricultural modernization in the Longyuan region and enhance comprehensive competitiveness in the socioeconomic domain. Under these macro-policy guidelines, objective assessment of regional rural revitalization levels at the county scale can not only facilitate mutual learning and complementary advantages among regions but also provide empirical references for rural revitalization development nationwide.

Existing research on rural revitalization has primarily focused on qualitative studies exploring connotation interpretation, logical relationships, and implementation pathways. Regarding scientific connotation, scholars have clarified that the rural revitalization strategy primarily manifests as the organic integration of five revitalizations: industry, talent, culture, ecology, and organization. Concerning logical relationships, academic research has examined connections between rural revitalization and poverty alleviation, rural governance, industrial integration, and urban-rural development. Regarding implementation pathways, scholars propose constructing harmonious urban-rural relationships as the practical foundation for realizing rural revitalization, with stimulating internal rural development dynamics as the core principle. Differentiated strategies should be adopted according to specific conditions and needs of various villages to avoid uniform "one-size-fits-all" approaches and excessive urbanization of rural landscapes.

As research has deepened, scholars have integrated knowledge systems from geography, management, and economics, focusing on quantitative research around hot topics such as new urbanization and digital village construction. Regarding the construction of rural revitalization evaluation index systems, most scholars adopt the "20-character" guideline of rural revitalization as the criterion level, with secondary indicators varying slightly by region. Some scholars construct relevant indicators from the "five revitalizations" dimensions, while others build index systems from perspectives such as "spiritual affluence, material prosperity, and regional characteristics," "public cultural facilities, cultural activities, and cultural human resource investment,"or "rural civilization construction level, traditional virtues, and accessibility of cultural entertainment facilities." Research methods primarily include the entropy method, principal component analysis,

Delphi method, and comprehensive weighting methods. Research scales encompass national, provincial, and economic belt levels, while temporal dimensions mostly focus on single time nodes, with few studies examining systematic assessments and in-depth research across longer time spans in specific regions.

In summary, current quantitative research on rural revitalization is abundant but has limitations: First, most studies employ short panel data time spans, lacking comparative analysis of spatial differentiation. Second, subjective weighting evaluation methods used in many studies involve unavoidable human interference factors that may bias results. Third, current research predominantly focuses on provincial and municipal scales, with relatively scarce studies measuring rural revitalization development levels at the county scale. Addressing this gap, this paper constructs a county-level evaluation index system for rural revitalization development levels in Gansu Province, employing the entropy method and Dagum Gini coefficient decomposition to analyze the development levels and regional disparities of rural revitalization across 85 counties, thereby providing theoretical support and empirical references for policy formulation.

1.1 Study Area

Gansu Province, located in northwestern China, serves as a critical node on the Silk Road and plays an important role as an ecological security barrier in the upper reaches of the Yellow River basin [Figure 1: see original paper]. The province covers an area of 425,800 km^2, with a total population of 24.98 million, agricultural sowing area of 2,699,800 hectares, and agricultural output value of 180.64 billion yuan. Rural residents' per capita disposable income reaches 13,306 yuan. This study examines 85 counties (districts) in Gansu Province, divided into four regions—Hexi, Longzhong, Longsoutheast, and Gannan-Linxia—based on previous research. Due to missing agricultural household registration data, Chengguan District and Anning District in Lanzhou City are excluded from this study. Additionally, Jiayuguan City is integrated as a single research unit due to missing data in its subordinate districts.

1.2 Data Sources

Research data are primarily sourced from the *China County Statistical Yearbook*, *Gansu Statistical Yearbook*, and *Gansu Rural Yearbook* from 2014 to 2023. Missing data are supplemented using interpolation methods.

1.3 Methodology

1.3.1 Evaluation Index System for County-Level Rural Revitalization in Gansu Province Based on the comprehensive guiding ideology of the rural revitalization strategy and following the five dimensions explicitly defined in the *Plan*: "industrial prosperity, ecological livability, rural civilization, effective governance, and affluent living,"this study constructs an evaluation index system for county-level rural revitalization in Gansu Province (Table 1).

Industrial Prosperity: As the primary task of rural revitalization strategy, promoting productivity development and consolidating the economic foundation is essential. While continuously enhancing comprehensive grain production capacity, agricultural labor efficiency and agricultural mechanization should be simultaneously improved. Accordingly, this paper constructs the industrial prosperity dimension index system from five aspects: grain comprehensive production capacity, agricultural labor productivity, agricultural mechanization level, agricultural industrialization level, and rural employment conditions.

Ecological Livability: Rural livability represents the organic integration of farmers' fundamental demands for living conditions and their needs for a habitable environment. Therefore, this paper constructs the ecological livability dimension index system from four aspects: rural human settlement environment, green development level, electricity consumption conditions, and ecological protection status.

Rural Civilization: Rural civilization construction should address both rural moral construction and cultural development. Regarding rural education, farmers need to acquire continuous learning and innovation capabilities to enhance rural human capital quality. Regarding rural culture, both inheritance of rural culture and stimulation of farmers' enthusiasm are essential. Accordingly, this paper constructs the rural civilization dimension index system from four aspects: rural ideological and moral construction level, cultural construction level, education investment level, and social security level.

Effective Governance: Achieving effective governance requires comprehensive application of self-governance, rule of law, and rule of virtue in governance models. Within governance scope, it covers village affairs, party affairs, villagers' affairs, and convenient services, all operating in an orderly and efficient manner. Therefore, this paper constructs the effective governance dimension index system from four aspects: rural residents' education level, grassroots organization supporting facilities, rural economic governance level, and rural fiscal revenue-expenditure level.

Affluent Living: Affluent living is closely related to farmers' quality of life and sense of happiness. Under the common prosperity goal, strengthening farmers' income and consumption capabilities is particularly important. Accordingly, this paper constructs the affluent living dimension index system from four aspects: rural residents' income level, consumption level, infrastructure conditions, and consumption supply level.

1.3.2 Entropy Method The standardization formula for original data is:

For positive indicators:

$$X'_{ij} = \frac{X_{ij} - \min X_j}{\max X_j - \min X_j}$$

For negative indicators:

$$X'_{ij} = \frac{\max X_j - X_{ij}}{\max X_j - \min X_j}$$

where X'_{ij} represents the standardized value of the jth indicator for the ith county unit; X_{ij} represents the original data; and $\max X_j$ and $\min X_j$ represent the maximum and minimum values of the jth indicator, respectively.

The entropy value and weight are further calculated:

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^{n} P_{ij} \ln P_{ij}$$

$$P_{ij} = \frac{X'_{ij}}{\sum_{i=1}^{n} X'_{ij}}$$

$$W_j = \frac{1 - e_j}{\sum_{j=1}^{m} (1 - e_j)}$$

where e_j is the entropy value of indicator j; m is the total number of indicators; P_{ij} is the proportion of the ith county unit' s jth indicator; n is the sample size; and W_j is the weight of indicator j.

Using the multi-linear weighting method, the comprehensive rural revitalization development index is obtained:

$$S_i = \sum_{j=1}^{m} W_j \times X'_{ij}$$

where S_i is the comprehensive index for the ith county unit.

1.3.3 Dagum Gini Coefficient and Decomposition The Dagum Gini coefficient and its decomposition method are employed to calculate the overall Gini coefficient and inter-county differences in rural revitalization levels in Gansu Province from 2013 to 2022.

The overall Gini coefficient is:

$$G = \frac{1}{2n^2\mu} \sum_{l=1}^{k} \sum_{r=1}^{k} \sum_{i=1}^{n_l} \sum_{j=1}^{n_r} |y_{li} - y_{rj}|$$

where G is the overall Gini coefficient for Gansu Province; y_{li} and y_{rj} are the comprehensive rural revitalization indices for counties i and j in regions l and r, respectively; n is the total number of counties; μ is the mean of the comprehensive rural revitalization indices; and k is the number of regional divisions.

According to the sub-sample decomposition method, the Gini coefficient is divided into three components that must satisfy:

$$G = G_w + G_{nb} + G_t$$

where G_w represents intra-regional differences; G_{nb} represents inter-regional differences; and G_t represents hypervariable density differences.

1.3.4 Kernel Density Estimation Kernel density estimation is employed to analyze the distribution, pattern, and spread of the comprehensive rural revitalization development index across counties in Gansu Province. The Gaussian kernel density function is used to predict the dynamic distribution:

$$f(x) = \frac{1}{Nh} \sum_{i=1}^{N} K\left(\frac{x_i - x}{h}\right)$$

$$K(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}}$$

where $f(x)$ is the density function of rural revitalization development; K is the Gaussian kernel function; N is the number of observations; x_i is the observed value; x is the mean of observed values; and h is the bandwidth (narrower bandwidth yields higher precision).

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2. Results

2.1 Temporal Evolution and Spatial Distribution Characteristics

2.1.1 Temporal Evolution Characteristics Overall, the comprehensive rural revitalization development index in Gansu Province from 2013 to 2022 shows an upward trend, increasing from 0.201 to 0.487 with an average annual growth rate of 14.38%, demonstrating steady year-by-year improvement [Figure 2: see original paper]. The evolution can be divided into three stages: (1) **Slow growth stage (2013–2016)**: The comprehensive index increased from 0.201 to 0.220, with an average annual growth rate of 2.64%, possibly due to Gansu' s relatively lagging economic development and the difficulty of simultaneously developing material and spiritual civilization. (2) **Steady growth stage (2017–2019)**: The index rose from 0.235 to 0.304, with an average annual growth rate of 6.80%, benefiting from the government' s heightened attention to rural revitalization and the continuous expansion of talent pools, which provided ample professional personnel to advance the strategy, ensuring basic agricultural stability while promoting multifaceted rural economic development and prosperity. (3) **Rapid growth stage (2020–2022)**: The comprehensive index increased

from 0.365 to 0.487, with an average annual growth rate of 11.35%. With the rapid development of the digital economy and e-commerce, their benefits have extended to counties and rural areas, enabling Gansu to seize opportunities in new business formats such as internet education, medical care, and agricultural product e-commerce platforms, which have significantly accelerated rural revitalization implementation.

Examining the development indices across dimensions, all show steady improvement but with notable variations. The industrial prosperity and ecological livability dimensions exhibit the most significant growth rates, increasing from 0.028 to 0.070 and from 0.027 to 0.067, respectively, with average annual growth rates of 4.97% and 9.93%. Both rural civilization and affluent living indices show growth rates exceeding 14.38%. However, the effective governance dimension fluctuates between 0.038 and 0.043, indicating that during rural revitalization implementation, counties should focus simultaneously on promoting rural industrial prosperity and optimizing rural administrative management systems.

2.1.2 Spatial Distribution Characteristics Using the natural breaks method, the comprehensive rural revitalization development index for Gansu Province counties is classified into five levels—low, relatively low, medium, relatively high, and high—at three time points (2013, 2017, and 2022) [Figure 3: see original paper]. The spatial pattern reveals a "high in the northwest, low in the southeast" distribution across the study period. During the observation period, all regions show steady upward trends in their comprehensive rural revitalization indices, though inter-county disparities remain evident. Counties ranking in the top 20 are primarily located in the Hexi region, while those ranking in the bottom 20 are concentrated in the Gannan and Linxia regions. This indicates that the Hexi region possesses strong economic radiation and leadership capacity, with high levels of integrated development across primary, secondary, and tertiary industries in rural areas. Counties in Gannan and Linxia with relatively lower rural revitalization levels face more severe challenges. This spatial disparity may be closely related to geographical environment, resource endowments, policy preferences, and economic development foundations. Therefore, to promote overall rural revitalization in Gansu Province, targeted strategies are needed to optimize resource allocation and increase fiscal support for weaker regions to achieve balanced development.

2.2 Regional Differences and Their Sources

2.2.1 Intra-Regional Difference Analysis From 2013 to 2022, the overall Gini coefficient for rural revitalization in Gansu Province shows a fluctuating downward trend, decreasing from 0.238 to 0.204, a reduction of 14.38%, indicating that development gaps among counties are gradually narrowing . Regionally, the Gini coefficients for Longzhong, Hexi, and Gannan-Linxia regions exhibit fluctuating declines, while Longsoutheast shows a clear upward fluctuation. Specifically, Longzhong' s Gini coefficient decreased from 0.187 to 0.147

(a 21.38% reduction); Hexi' s coefficient dropped from 0.155 to 0.147 (a 5.83% reduction); Gannan-Linxia' s coefficient fell from 0.152 to 0.144 (a 5.26% reduction); and Longsoutheast' s coefficient rose from 0.152 to 0.160. This demonstrates that while individual counties experience minor fluctuations, the uneven development among counties is easing. The comprehensive rural revitalization index in Gansu Province shows two characteristics: (1) Significant imbalance: Liangzhou District consistently ranks highest with an average index of 0.671, while Lintan County' s index is only 0.163, representing an approximately fourfold difference that fully reflects unbalanced regional development. (2) Obvious regional disparities: The top 20 counties in comprehensive index are mainly in the Hexi region, while the bottom 20 are concentrated in the Gannan and Linxia regions.

2.2.2 Inter-Regional Difference Analysis The inter-regional differences between Hexi and Gannan-Linxia show the most significant decline, reaching 61.71% . The inter-regional differences between Longzhong and Gannan-Linxia, as well as between Longsoutheast and Gannan-Linxia, show basically consistent change directions, presenting an increasing trend. The inter-regional differences between Longzhong and Longsoutheast, as well as between Hexi and Longsoutheast, show fluctuating increases. The Gini coefficients between Hexi and Longzhong, and between Longzhong and Longsoutheast, show a trend of first decreasing then increasing. This indicates that while regional imbalances in Gansu' s rural revitalization development persist, gaps among regions are gradually converging with the deepening implementation and visible effects of the rural revitalization strategy.

2.2.3 Sources and Contribution Rates of Regional Differences Analysis of the development trends of difference sources reveals that inter-regional differences dominate, with contribution rates fluctuating between 61.75% and 69.51%, averaging 65.40%. Meanwhile, intra-regional difference contribution rates and hypervariable density contribution rates show relatively close numerical ranges. The former varies between 18.17% and 20.09%, averaging 19.02%; the latter fluctuates between 12.32% and 18.16%, averaging 15.57%. This indicates that the overall disparity in Gansu' s rural revitalization development levels primarily stems from differences between regions.

2.3 Distribution Dynamics and Evolution Analysis of Rural Revitalization Development

Examining the trajectory of comprehensive index changes across 85 counties during the rural revitalization process [Figure 4: see original paper] reveals several key characteristics: (1) **Distribution position**: The index curve shifts rightward while clustering on the left, reflecting that counties with relatively low rural revitalization levels constitute the majority in Gansu Province. (2) **Distribution pattern**: The height of the main peak decreases over time while showing a

clear right-skewed characteristic, indicating that disparities in Gansu' s rural revitalization levels are gradually diminishing, with overall development trending toward greater equilibrium and showing obvious convergence. (3) **Number of peaks**: The kernel density curve for Gansu' s rural revitalization comprehensive index shows side peaks, but these peaks are relatively low, indicating that the rural revitalization process does not exhibit obvious polarization. Development levels are relatively evenly distributed across the region, with overall relatively small differences. This reflects that development gaps among counties in Gansu Province are gradually narrowing, with the overall trend showing convergence.

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3. Discussion

The empirical results demonstrate that Gansu' s overall rural revitalization level showed an upward trend from 2013 to 2022, increasing from 0.201 to 0.487, which aligns with the findings of Liu Shujuan et al. Regarding the evaluation scores of each dimension' s development level, all dimensions show steady improvement, but certain differences exist. Industrial prosperity and ecological livability demonstrate the most significant growth rates, while the effective governance dimension requires improvement, which is basically consistent with the research results of Lu Fengying et al. These findings highlight the core role of industrial prosperity in the rural revitalization strategy as a vital indicator of rural revitalization development. Simultaneously, the enhancement of rural civilization and rural governance concerns not only the soft and hard power of rural areas but also constitutes key elements for building a harmonious rural society. Currently, cities and prefectures in Gansu Province need to continue efforts in rural civilization and governance to achieve comprehensive revitalization.

During the observation period, county-level rural revitalization development levels in Gansu Province presented a spatial pattern of "high in the northwest, low in the southeast," consistent with the evaluation results of Lu Fengying et al. and Fu Guangbin et al. regarding various cities and prefectures in Gansu Province. The study reveals that the comprehensive rural revitalization indices of 85 counties show a steady upward trend, with development disparities gradually narrowing. Under the current development scenario, we should thoroughly analyze and comprehensively evaluate the differentiated levels of counties in the rural revitalization process, closely relying on unique rural resources to fully exploit and amplify regional characteristic advantages to enhance overall rural revitalization levels. Analysis of inter-regional and intra-regional differences indicates that imbalance in Gansu' s rural revitalization development persists. Regarding the sources and contributions of differences, inter-regional differences contribute most significantly and represent the main factor causing regional disparities.

The kernel density estimation analysis results show that the rural revitalization development levels of 85 counties in Gansu Province present a gradual convergence trend, indicating that gaps among different regions are continuously

narrowing under the rural revitalization strategy, forming a stable equilibrium state. This further validates the research conclusions obtained using the Dagum Gini coefficient decomposition method. However, this study has limitations. Given data availability constraints, the current evaluation system shows certain restrictions in indicator selection. Future research will continue exploring the synergistic effects and unique differences in rural revitalization strategy implementation across the five dimensions from both macro and micro perspectives. Additionally, we will optimize the rural revitalization evaluation system by refining indicators under each subsystem to ensure scientific and practical evaluation results, providing more detailed research support for rural revitalization.

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4. Conclusions and Recommendations

4.1 Conclusions

This study draws the following conclusions: (1) From 2013 to 2022, Gansu Province' s rural revitalization development comprehensive index showed a continuous upward trend. The evaluation indices for industrial prosperity and ecological livability dimensions grew most significantly, while rural civilization and affluent living indices both increased by more than 14.38%. The effective governance dimension fluctuated between 0.0382 and 0.0432. (2) From 2013 to 2022, the county-level rural revitalization development comprehensive index in Gansu Province exhibited an overall spatial pattern of "high in the northwest, low in the southeast." Regional disparities and intra-regional differences reveal that imbalance in Gansu' s rural revitalization development persists. Regarding sources and contribution rates of differences, inter-regional differences contribute most and constitute the main factor causing regional disparities. (3) Kernel density estimation analysis indicates that the rural revitalization development levels of 85 counties in Gansu Province show a gradual convergence trend, suggesting that gaps among different regions are gradually narrowing under the rural revitalization strategy, demonstrating certain stability.

4.2 Recommendations

Based on these conclusions, we propose the following policy recommendations: (1) Fully consider the spatial correlation characteristics of rural revitalization and design and implement regionally differentiated rural revitalization policies. For the Gannan and Linxia regions, we should further leverage their characteristic advantages, using animal husbandry to lead the optimization and upgrading of agricultural industrial structures to accelerate rural development. For the Hexi region, we must strengthen rural infrastructure construction, optimize and upgrade rural industrial structures, and promote the gradual transition toward intelligent and modern agriculture. For the Longzhong region, we should increase investment in agricultural science and technology research and development, introduce and promote advanced technologies and equipment, and

leverage Lanzhou' s radiating effect on surrounding rural areas. For the Long-southeast region, we should develop characteristic industries, extend industrial chains, and attract external professional and technical personnel to inject new vitality into local development. (2) Comprehensively evaluate the differentiated performance of counties in the rural revitalization process, deeply explore and fully utilize unique rural resource advantages. This will provide theoretical support and empirical references for formulating precise policies tailored to local conditions and promoting coordinated regional rural revitalization development.

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