Evaluation of Food and Important Agricultural Product Supply Security in Gansu Province under the "Greater Food" Concept and Its Influencing Factors (Postprint)

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Abstract

The concept of the "Greater Food Vision" profoundly interprets the connotation of food security in the new era, transitioning from a singular focus on grain production to the construction of a diversified food supply system. From the perspective of the Greater Food Vision and based on the research hypothesis of "self-sufficiency" for grain and important agricultural products in Gansu Province, this study takes 86 counties and districts in Gansu Province as research units. Utilizing panel data from 2014 to 2023, an evaluation index system for the supply security of grain and important agricultural products in Gansu Province was constructed across three dimensions: supply quantity security, supply structure security, and supply ecological security.

The Entropy Weight-Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method, interannual trend slope analysis, kernel density estimation, and spatial autocorrelation analysis were employed to analyze the spatiotemporal differentiation characteristics of supply security levels. Furthermore, an individual fixed-effects model was introduced to explore the influencing factors.

The results indicate that: (1) The supply security level in Gansu Province fluctuated from 2014 to 2019 and rose steadily from 2019 to 2023; the supply security index of each county continued to extend toward higher value ranges, with the frequency and concentration of dominant regions increasing. (2) Spatially, the supply security level exhibited differentiated evolutionary characteristics described as "overall improvement, local slight decline, faster in the west and slower in the east." In terms of spatial agglomeration, it showed a distribution pattern of "hot-spot clustering in the Hexi Corridor and Longdong regions, and cold-spot correlation in parts of Longzhong and Longnan." (3) High per capita

Gross Regional Product (GRP) and sufficient employment rates in agriculture, animal husbandry, fishery, and forestry are critical supports for ensuring supply security, whereas excessive service loads on rural primary-level organizations weaken the foundation of supply security. Accordingly, policy recommendations are proposed to strengthen regional synergy, promote industry feedback to agriculture, and enhance the efficiency of primary-level governance.

Full Text

Evaluation of Supply Security and Influencing Factors of Grain and Important Agricultural Products in Gansu Province Under the "Greater Food" Concept

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Abstract

The concept of the "Greater Food View" provides a profound interpretation of the connotations of food security in the new era, representing a strategic shift from a focus on singular grain production toward a diversified food supply system. This paradigm shift emphasizes that food security should not be limited to traditional staple crops but should encompass a broader range of nutritional sources derived from forests, rivers, lakes, and seas, as well as from animal husbandry and microbial sources. By expanding the scope of food production and optimizing the structure of the food supply, this approach aims to meet the increasingly diverse and high-quality nutritional needs of the population while ensuring the sustainable use of natural resources.

Under the perspective of the "Greater Food View" and based on the research hypothesis of "self-sufficiency" in grain and essential agricultural products within Gansu Province, this study utilizes 86 counties and districts in Gansu Province as the primary research units. Drawing upon panel data spanning from 2014 to 2023, the evaluation framework is constructed across dimensions including supply quantity security, supply structure security, and supply ecological security. The study employs the Entropy Weight-TOPSIS method, interannual trend slope analysis, Kernel Density Estimation (KDE), and spatial autocorrelation analysis to analyze the spatio-temporal differentiation characteristics of the supply security levels. Furthermore, an individual fixed-effects model is introduced to explore the underlying influencing factors.

The results indicate that: (1) The supply security level in Gansu Province exhibited a fluctuating state from 2014 to 2019, followed by a period of steady growth from 2019 to 2023. (2) Spatially, the supply security level exhibits a differentiated evolutionary pattern characterized by "overall improvement, localized

slight declines, and a faster pace in the west compared to the east." In terms of spatial agglomeration, the distribution follows a pattern of "hotspot clustering in the Hexi Corridor and eastern Gansu (Longdong), with cold-spot correlations in central Gansu (Longzhong) and parts of southern Gansu (Longnan)."(3) High per capita Gross Domestic Product (GDP) and a sufficient employment rate in the agriculture, forestry, animal husbandry, and fishery sectors serve as critical supports for ensuring supply security. Conversely, an excessive service load on rural primary-level organizations tends to weaken the foundation of supply security. Based on these findings, this study proposes policy recommendations focused on strengthening regional synergy, promoting industrial feedback to support agriculture, and enhancing the efficiency of primary-level governance.

Keywords: Greater Food Approach; Food Security; Supply Security Evaluation; Spatiotemporal Differentiation; Influencing Factors; Gansu Province

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1. Introduction

Ensuring food security is a fundamental prerequisite for maintaining national security and achieving sustainable social development. The report of the 20th National Congress of the Communist Party of China emphasized the need to "reinforce the foundations of food security across all aspects" and "ensure that the rice bowls of the Chinese people are held firmly in their own hands." In recent years, the concept of the "Greater Food Approach" has emerged as a critical strategic framework. This approach shifts the focus from traditional staple grains to a more diversified food supply system that encompasses plant, animal, and microbial sources across various ecosystems, seeking to "extract calories and protein from plants, animals, and microorganisms."

Gansu Province, characterized by its complex topography and diverse climatic zones, serves as a significant ecological barrier and an important agricultural production base in Northwest China. However, the region faces substantial challenges, including water scarcity, fragile ecological environments, and uneven regional development. Current research regarding Gansu Province focuses primarily on traditional grain crops. There remains a lack of systematic assessment concerning the supply of grain and essential agricultural products within the framework of the Greater Food perspective, making it difficult to fully reflect the true landscape of regional food supply.

This study is based on the research hypothesis of "self-sufficiency" in grain and essential agricultural products within Gansu Province. It aligns with the objectives outlined in the *Fourteenth Five-Year Plan for Promoting Agricultural and Rural Modernization in Gansu Province*, which aims to achieve basic self-sufficiency. By utilizing the county scale as the primary unit of analysis (86 counties and districts), this study aims to provide a scientific basis for policy

formulation aimed at enhancing food security in Gansu Province and similar arid to semi-arid regions.

2. Materials and Methods

2.1 Construction of the Evaluation Index System

Under the Greater Food Approach, food security extends beyond the self-sufficiency of cereals to include the stable supply of meat, eggs, milk, vegetables, fruits, and aquatic products. Following the principles of scientific rigor, systematicity, and data availability, we selected 21 indicators across three dimensions: supply quantity security, supply structure security, and supply ecological security .

Evaluation index system of the supply security of grain and important agricultural products in Gansu Province under the macro-food concept.

2.2 Data Sources

The data utilized in this study primarily originate from the *Gansu Rural Yearbook*, the *Gansu Development Yearbook*, and the *Gansu Statistical Yearbook* for the years 2015 to 2024. Additional data were obtained from the statistical bulletins of various cities and prefectures. Missing data points were supplemented using linear interpolation.

2.3 Research Methods

2.3.1 Entropy Weight-TOPSIS Method The entropy weight method is used to objectively determine the weights of indicators based on data variability. The TOPSIS method then ranks the research units by calculating their relative closeness to the positive ideal solution (Q_j^+) and negative ideal solution (Q_j^-). The relative closeness C_i is calculated as:

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-}$$

where $C_i \in [0, 1]$. A higher value signifies a superior level of supply security.

2.3.2 Interannual Trend Analysis (Slope) To characterize long-term changes, the linear regression slope is calculated:

$$\text{Slope} = \frac{n\sum_{i=1}^{n}(i \cdot C_i) - \sum_{i=1}^{n} i \sum_{i=1}^{n} C_i}{n\sum_{i=1}^{n} i^2 - (\sum_{i=1}^{n} i)^2}$$

A positive slope indicates an upward trend.

2.3.3 Spatial Autocorrelation and Kernel Density Global Moran' s I is used to test for spatial clustering across the province. Local Getis-Ord G_i^* index is employed to identify "hotspots" and "coldspots." Kernel Density Estimation (KDE) is used to analyze the dynamic evolution of the distribution of security levels.

2.3.4 Individual Fixed-Effects Model To explore influencing factors, the following model is introduced:

$$y_{it} = \alpha_i + X'_{it}\beta + \epsilon_{it}$$

where y_{it} is the supply security index, X'_{it} represents influencing factors, and α_i represents individual fixed effects.

3. Results and Analysis

3.1 Temporal Evolution Characteristics

The overall supply security level in Gansu Province exhibited low-level fluctuations from 2014 to 2019, followed by a continuous upward trend from 2019 to 2023 [Figure 2: see original paper].

- **Quantity Security:** Remained at a low point with significant fluctuations until 2018, followed by a steady upward trend.
- **Structure Security:** Exhibited phased characteristics. The implementation of the "Grain-to-Feed" transition and structural adjustments (e.g., increasing potatoes and medicinal herbs) caused initial fluctuations before stabilizing.
- **Ecological Security:** Showed a sustained upward trend, benefiting from increased effective irrigation areas and soil erosion control measures.

[Figure 2: see original paper] Overall level and each dimensional level of grain and important agricultural products supply security in Gansu Province from 2014 to 2023. [Figure 3: see original paper] Temporal kernel density of the level of grain and important agricultural products supply security in counties and districts of Gansu Province from 2014 to 2023.

3.2 Spatio-temporal Differentiation Characteristics

The spatial distribution exhibits the characteristics of "overall improvement, localized slight declines, and a pattern of 'fast in the west and slow in the east' " [Figure 4: see original paper].

- **Hexi Corridor:** Maintained high and stable security levels. Oasis agriculture, supported by irrigation from the Qilian Mountains, provides a robust foundation.
- **Longdong Region:** Showed fluctuations but generally improved. Areas like Huan County and Huachi County emerged as hotspots due to specialized planting (e.g., apples).

- **Longzhong and Longnan:** Faced challenges due to fragmented land and ecological vulnerability, with some areas in Longnan showing a slight downward trend.

[Figure 4: see original paper] Spatial distributions and changing trends of the overall level of grain and important agricultural products supply security in Gansu Province from 2014 to 2023.

3.3 Spatial Agglomeration Analysis

Global Moran' s I values for all dimensions were greater than 0 ($P < 0.01$), indicating significant positive spatial autocorrelation . Hotspot analysis [Figure 5: see original paper] revealed: - **Hotspots:** Concentrated in the Hexi Corridor (Gaotai, Ganzhou, Minqin) and parts of Longdong. - **Coldspots:** Primarily distributed in the Longzhong and Longnan regions, as well as parts of Gannan (Maqu, Diebu).

Global autocorrelation analysis of the overall level and each dimensional level of grain and important agricultural products supply security in Gansu Province. [Figure 5: see original paper] Spatial hotspot analysis of the overall level and each dimensional level of supply security of grain and important agricultural products in Gansu Province.

3.4 Analysis of Influencing Factors

The fixed-effects model results show that: 1. **Per capita GDP:** Exerts a significant positive impact ($\beta = 0.03, P < 0.05$). A strong economic foundation supports agricultural infrastructure and technological innovation. 2. **Employment Rate in Primary Industry:** Exerts a significant positive impact ($\beta = 0.06, P < 0.01$). Sufficient labor support is critical for maintaining production scales. 3. **Service Load of Grassroots Organizations:** Exerts a significant negative impact ($\beta = -0.07, P < 0.05$). Excessive administrative burdens on village committees weaken policy implementation and public service supply. 4. **Agricultural Machinery and Labor Productivity:** Showed no significant impact in this specific model, suggesting that simply increasing machinery input without optimizing management may not yield immediate security improvements.

Indicators of influencing factors. Regression results of the Fixed Effects (FE) model.

4. Discussion and Conclusion

4.1 Discussion

The study finds that Gansu' s food security has transitioned from a weak foundation to a more resilient system. The "Greater Food View" has encouraged the development of characteristic industries (e.g., silage corn, medicinal herbs,

and facility agriculture). However, the "spatial mismatch" between resource endowment and industrial foundation remains a challenge. The negative impact of grassroots service load highlights the need for digital governance to reduce administrative burdens.

4.2 Conclusion

(1) The supply security level in Gansu Province has improved significantly since 2019, with advantageous regions becoming more concentrated.
(2) Spatial differentiation is prominent, with the Hexi Corridor leading in security levels while southern and central regions lag behind.
(3) Economic strength and labor stability are key drivers, while grassroots governance pressure is a major constraint.

4.3 Policy Recommendations

1. **Strengthen Regional Synergy:** Establish pairing assistance between the Hexi Corridor and the Longzhong/Longnan regions to share water-saving and specialized planting technologies.
2. **Promote Industrial Feedback:** Leverage GDP growth to fund agricultural IoT and infrastructure, particularly in "cold spot" regions.
3. **Enhance Grassroots Efficiency:** Implement digital platforms to reduce the administrative load on village committees, allowing them to focus on agricultural production guidance.
4. **Differentiated Risk Management:** Establish distributed reserve points in Longnan and Gannan to enhance emergency response capabilities in ecologically fragile areas.

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