

Spatiotemporal Differentiation of Non-agricultural and Non-grain Conversion of Cultivated Land in China and Its Governance Strategies: Postprint

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Abstract

Based on China's land use data and socio-economic statistical panel data from 1980 to 2020, this study systematically analyzes the spatiotemporal evolution characteristics of farmland non-agriculturalization and non-grain cultivation, reveals their change patterns and driving mechanisms, to provide a basis for sustainable farmland utilization and stable food security. Standard deviation ellipse and trend analysis are employed to comprehensively evaluate the dynamic evolution characteristics of non-agriculturalization and non-grain cultivation, comprehensive indicator systems for both phenomena are constructed, and a partial correlation model is built to quantify the relative contributions of various factors. The results show that: (1) Temporally, the situation of farmland non-agriculturalization in China has generally improved continuously, while non-grain cultivation in some areas has shown a trend of intensification. (2) Spatially, the problem of non-agriculturalization is more prominent in Northeast and Central-East China, while the proportion of non-grain production is relatively higher in Northwest China, South China, and parts of the southeast coastal areas. The evolution of non-agriculturalization exhibits a "polarization phenomenon" along the northeast-southeast direction, and the center of non-grain cultivation shows a development trend of moving from southwest to northeast. (3) Economic factors play a dominant driving role in non-agriculturalization, and their influence has decreased over the past decade. Agricultural production conditions are the fundamental factor for non-grain cultivation, while the promoting effect of economic factors such as grain output value per mu and urban-rural income gap has gradually increased. The study on the spatiotemporal evolution characteristics and influencing factors of farmland non-agriculturalization and non-grain cultivation in China from 1980 to 2020 can provide references for scientifically implementing farmland protection decisions.

Full Text

Spatiotemporal Differentiation of Nonagricultural and Nongrain Farmland in China and Its Management Strategies

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Abstract

Based on China's land use data and socioeconomic statistical panel data from 1980 to 2020, this study systematically analyzes the spatiotemporal evolution characteristics of cultivated land nonagriculturalization and nongrain conversion, revealing their change patterns and driving mechanisms to provide a basis for sustainable cultivated land utilization and stable food security. Using standard deviation ellipse and trend analysis, we comprehensively evaluate the dynamic evolution characteristics of nonagriculturalization and nongrain conversion, construct comprehensive indicator systems for both phenomena, and build a partial correlation model to quantify the relative contributions of various driving factors. The results show that: (1) Temporally, the overall situation of nonagriculturalization in China has been improving, while nongrain conversion in some areas shows a trend of intensification. (2) Spatially, nonagriculturalization is more prominent in the northeast, central, and eastern regions, while the proportion of nongrain production is relatively high in parts of the northwest, south, and southeast coastal areas. The evolution of nonagriculturalization exhibits a "polarization phenomenon" along the northeast-southeast direction, while the center of nongrain conversion shows a development trend of moving from southwest to northeast. (3) Economic factors play a dominant driving role in nonagriculturalization, though their influence has decreased over the past decade. Agricultural production conditions are the fundamental factor for nongrain conversion, while the promoting effect of economic factors such as grain output value per acre and urban-rural income gap gradually increases. This provides a reference for scientifically implementing cultivated land protection decisions.

Keywords: farmland; nonagricultural; nongrain; spatial-temporal differentiation; driving factors

Introduction

Ensuring food security is a crucial foundation for national security, with its core being the protection of food production capacity. However, nonagriculturalization of cultivated land has led to substantial occupation of cultivated land resources, while farmers deliberately pursue more profitable economic crops and even change land use purposes, resulting in a year-by-year reduction in grain crop planting area. Additionally, some nongrain industries have caused damage to the cultivated soil layer, posing a potential threat to grain productivity. The reduction in grain planting area combined with declining yield levels has a significant multiplier effect on total grain output, potentially causing imbalances in the ternary structure of grain, economic, and feed crops, thereby presenting new challenges to the sustained stability of China's grain production and residents' nutritional health. Although the state has introduced a series of top-level policies for cultivated land protection, nonagriculturalization and nongrain conversion phenomena remain prominent in many regions, seriously damaging grain production capacity. Particularly against the backdrop of profound changes in the international situation, shifting from passive to proactive implementation of cultivated land protection is essential for stabilizing China's grain supply-demand balance.

Previous research on cultivated land nonagriculturalization has mostly focused on rapidly urbanizing urban-rural fringe areas and metropolitan regions, noting that nonagriculturalization scale is linked to urbanization processes and occupies fertile farmland around cities, showing a spatial distribution pattern that gradually expands outward from urban cores. As residents' quality of life improves, people's food demands have become increasingly diversified, prompting farmers to abandon traditional grain crop cultivation in favor of more economically profitable fruits and vegetables. Regarding driving factors, socioeconomic factors are widely recognized as the main driving force behind cultivated land nonagriculturalization. Simultaneously, the impact of economic development stages and growth rates on nonagriculturalization varies by specific circumstances, exhibiting complex and diverse characteristics. Research on driving factors of cultivated land nongrain conversion has primarily focused on comparative benefits and resource allocation, revealing how economic benefit differences and resource allocation optimization promote nongrain trends. However, driving factors show significant spatial heterogeneity across different regions. In economically developed areas, local governments' high dependence on land finance also influences farmland conversion to nonagricultural uses.

Although previous studies have addressed many aspects of nonagriculturalization and nongrain conversion, they mainly focus on macro-level policies or qualitative analyses of impacts, status, and driving factors. However, resource endowments and economic development demands for cultivated land vary across different stages. Research systematically analyzing the spatiotemporal evolution processes of nonagriculturalization and nongrain conversion from a national perspective remains relatively scarce, and studies quantitatively measuring driving

factors for different regions are lacking, limiting scientific assessment of overall trends across regions and stages. Land use change serves as an indicator of human-land interactions, reflecting the profound impacts of human activities on natural ecosystems. During this process, although nonagriculturalization and nongrain conversion differ in manifestation, both essentially involve optimizing allocation and efficient utilization of land resources—balancing agricultural production and nonagricultural development demands within limited land resources—thus requiring comprehensive and integrated research.

This study utilizes China's land use data and provincial-level panel data from 1980 to 2020 to identify spatial evolution paths and agglomeration characteristics of cultivated land nonagriculturalization and nongrain conversion through multi-period analysis. Building upon this, we further analyze change trends of nonagriculturalization and nongrain conversion at different time nodes. Finally, we systematically construct a comprehensive driving force evaluation index system and quantify the relative contributions of various driving factors to nonagriculturalization and nongrain conversion at different development stages based on a partial correlation model. The research results can compensate for deficiencies in large-scale, long-term sequence studies on nonagriculturalization and nongrain conversion, providing scientific evidence for cultivated land protection and ensuring national food security in the new era.

1. Data and Methods

1.1 Data Sources

This study examines 31 provinces (municipalities and autonomous regions) in China. Land use data (1 km \times 1 km) were obtained from the Resource and Environment Data Cloud Platform of the Chinese Academy of Sciences (<http://www.resdc.cn/>). Statistical data on total crop sowing area, nongrain crop sowing area, and grain crop sowing area were all sourced from the National Bureau of Statistics' national data platform (<https://data.stats.gov.cn/>).

1.2 Definition and Measurement

Based on existing research, cultivated land nonagriculturalization refers to the process of converting land originally used for cultivation to non-agricultural purposes. Measurement methods for nonagriculturalization are relatively uniform, primarily reflecting its scale and degree by calculating the area converted from cultivated land to other land use types. Cultivated land nongrain conversion focuses more on changes in land use within agriculture, including both cropping structure nongrain conversion and agricultural production structure nongrain conversion. Cropping structure nongrain conversion refers to farmers choosing to plant crops other than grain on cultivated land, while agricultural production structure nongrain conversion refers to converting cultivated land to other agricultural land uses. When measuring nongrain conversion, the “nongrain ratio” is typically used as an indicator, calculated as the proportion of nongrain crop

sowing area to total crop sowing area or total cultivated land area. According to statistical survey classification standards, this study defines grain crops as primarily including cereals, beans, and tubers, with all other cultivated land planting behaviors considered nongrain conversion.

When analyzing temporal evolution characteristics, the study period was divided into three stages: 1980–2000, 2000–2010, and 2010–2020. First, this division fully considers the phased characteristics of China’s economic development history. From 1980 to 2000, China’s economy grew rapidly and urbanization accelerated, with land use patterns changing significantly and nonagriculturalization and nongrain conversion phenomena beginning to emerge. From 2000 to 2010, China’s industrialization and urbanization levels further improved, land use structure continued adjusting, and nonagriculturalization and nongrain conversion trends became more pronounced. From 2010 to 2020, China’s economy entered a new normal, emphasizing quality and efficiency in development, while the state increasingly prioritized cultivated land protection and food security, leading to new changes in the speed and scale of nonagriculturalization and nongrain conversion. Second, these three stages represent different socioeconomic development phases and policy contexts, each with unique economic, social, and policy environments that significantly influenced land use patterns and cultivated land use structure changes. Comparing and analyzing these stages enables deeper understanding of evolution characteristics and driving mechanisms. Additionally, dividing the study period into three stages helps reveal long-term changes and cyclical patterns. Finally, considering continuous economic development and social progress, driving factors affecting nonagriculturalization and nongrain conversion are constantly changing. Therefore, stage-based research not only helps identify main driving factors in each stage but also enables in-depth analysis of their mechanisms and influence degrees across stages.

1.3.1 Standard Deviation Ellipse

The Standard Deviation Ellipse (SDE) is a classic spatial statistical method for analyzing spatial element patterns and characteristics, widely applied in resource-environment and ecological fields. This method quantitatively describes the distribution pattern and direction of spatial elements through characteristic ellipses with basic parameters including central coordinates, azimuth angle, major semi-axis, and minor semi-axis. The ellipse originates from the mean center of geographic elements, with the ellipse axes representing standard deviations in x and y directions. The ellipse scope reflects the distribution area of spatial elements, the azimuth reflects change direction, and the major axis reflects dispersion degree. This study employs the SDE model to analyze the migration routes and agglomeration characteristics of nonagriculturalization and nongrain conversion. Relevant parameter calculation formulas are as follows:

$$\sigma_x = \sqrt{\frac{\sum_{i=1}^n w_i (x_i \cos \theta - y_i \sin \theta)^2}{\sum_{i=1}^n w_i}}$$

$$\sigma_y = \sqrt{\frac{\sum_{i=1}^n w_i (x_i \sin \theta - y_i \cos \theta)^2}{\sum_{i=1}^n w_i}}$$

$$\tan \theta = \frac{\sum_{i=1}^n w_i^2 (x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^n w_i^2 (x_i - \bar{x})^2 - \sum_{i=1}^n w_i^2 (y_i - \bar{y})^2}$$

Where: σ_x and σ_y are the standard deviations of geographic elements along the x and y axes; θ is the azimuth angle of the ellipse; w_i is the weight of element i ; x_i and y_i represent the coordinate deviations of each research object from the mean center.

1.3.2 Driving Indicator Construction

Both cultivated land nonagriculturalization and nongrain conversion result from human-land interactions. At different scales, dominant factors may differ and their change mechanisms show diversity. However, regardless of manifestation, these factors can be summarized into three categories: economic interests, agricultural production conditions, and policy institutions. Therefore, constructing a comprehensive indicator system to reveal evolution driving mechanisms helps implement integrated policies and multiple measures to balance economic development, urban expansion, and food security. Construction of driving factor indicators must comprehensively consider objectivity, typicality, and feasibility. Combining previous research, this study constructs a multi-level evaluation index system from three dimensions—economic factors, agricultural production conditions, and policy institutions—with 14 specific indicators (Table 1).

1.3.3 Partial Correlation Analysis

Partial correlation analysis was conducted for nonagriculturalization and nongrain conversion in China from 2000 to 2020. Using nonagriculturalization area and nongrain crop sowing proportion as respective indicators, we performed partial correlation with 14 driving factors at the provincial scale to identify key influencing factors at different stages. The calculation formula for driving factor contribution degree is:

$$Con_j = \frac{|x_j|}{\sum_{j=1}^n |x_j|} \times 100\%$$

Where Con_j is the relative contribution degree of indicator j , and x_j is the partial correlation coefficient of indicator j .

2. Results and Analysis

2.1 Spatial Evolution Characteristics of Nonagriculturalization and Nongrain Conversion

From 1980 to 2020, China's cultivated land nonagriculturalization area reached 180.75×10^4 hm², representing a 59.17% increase compared to the previous decade, with an average annual growth of 36.15×10^4 hm². This shows a trend of slowing nonagriculturalization growth. Spatially, cultivated land nonagriculturalization exhibits an “east high, west low” pattern, with Shanxi, Hunan, and Heilongjiang provinces showing particularly prominent nonagriculturalization significantly higher than surrounding provinces (Figure 1). Specifically, Shanxi's nonagriculturalization area expanded from 50.34×10^4 hm² to over 2.85×10^4 hm², with growth exceeding 18.4 times, showing strong nonagriculturalization trends. Hunan's nonagriculturalization area also increased from 6.98×10^4 hm², with growth reaching 16.25 times. Heilongjiang's nonagriculturalization area grew substantially from 6.21×10^4 hm² to 1625.6×10^4 hm², making it one of the fastest-growing provinces during this period.

In contrast, nongrain conversion shows an opposite trend to nonagriculturalization, forming a “west high, east low” spatial pattern (Figure 2). From 1980 to 2020, the proportion of nongrain crop sowing area in China increased from 32.94% to 34.84%, with nongrain crop sowing area growing by 301.00×10^4 hm². Guangxi, Hainan, Xinjiang, and Zhejiang show particularly prominent nongrain conversion trends, with Xinjiang's nongrain ratio reaching 33.79%. Since 1980, Xinjiang's cotton planting area has increased by 61.02 times, representing the primary reason for Xinjiang's increased nongrain ratio. Notably, although some provinces (e.g., Heilongjiang, Guangdong) show improved nonagriculturalization trends, their nongrain conversion trends remain significant.

The standard deviation ellipse analysis reveals that China's nonagriculturalization characteristic ellipse shows increased flatness from 1980 to 2020, with significantly expanded major axis standard deviation, reflecting enhanced directionality in nonagriculturalization, particularly polarization along the northeast-southeast direction (Figure 3). In contrast, nongrain conversion's flatness change is not significant, with its major axis direction pointing northwest-southeast, though directionality was not obvious during 2000-2010. Changes in the ellipse's minor axis show that nonagriculturalization's minor axis shortened, indicating decreased data dispersion and showing centripetal effects. Nongrain conversion's minor axis shows increasing trends, indicating increased data dispersion. Geographically, compared with nongrain conversion, nonagriculturalization's characteristic ellipse is closer to eastern regions with a shorter minor axis, fully reflecting that nonagriculturalization's spatial agglomeration characteristics are strongly influenced by economic activities. Additionally, nonagriculturalization center trajectories show clear southeastward shifts, while nongrain conversion centers show “first southwest then northeast” movement patterns. From a spatial

evolution perspective, China's nonagriculturalization and nongrain conversion show heterogeneity in relative scale and agglomeration characteristics across different stages, with multi-level differentiation and spatial imbalance.

2.2 Temporal Change Characteristics of Nonagriculturalization and Nongrain Conversion

China's nonagriculturalization process shows different characteristics across time periods but overall trends toward stabilization or slowdown (Figure 4). Specifically, from 1980 to 2000, China's nonagriculturalization showed strong increasing trends, with large areas of land converted from agricultural to non-agricultural uses, averaging 1,976.48 hm² annually. Spatial heterogeneity was relatively large, indicating different nonagriculturalization speeds and degrees across regions. From 2000 to 2010, nonagriculturalization trends slowed significantly compared to the previous stage, with effective control achieved and a decline of 71.36%. Regional differences also narrowed relatively. After 2010, the scope of nonagriculturalization trends further contracted, with most provinces clustering at low values and nonagriculturalization speeds stabilizing or slowing, with average annual increases reducing to 480.00 hm².

Nongrain conversion experienced "growth-stability-decline" processes. From 1980 to 2000, nongrain conversion increased at 0.58% annually, reflecting gradually declining proportions of grain planting in land use structure and increasingly diversified nongrain crop planting and land use patterns. However, from 2000 to 2010, nongrain conversion trends reversed, showing year-by-year declines at 0.09% annually. Notably, during this decline, regional heterogeneity increased year by year, indicating different nongrain conversion levels across regions due to varying socioeconomic development and natural resource conditions. After 2010, nongrain conversion increased again, with annual growth rates rebounding to 0.41%, reflecting new changes in agricultural production structure and land use patterns under new socioeconomic contexts.

2.3 Analysis of Driving Factors for Nonagriculturalization and Nongrain Conversion

Economic interests are the primary driving factor for China's cultivated land nonagriculturalization. Before 2000, with China's urbanization wave, rising production costs reduced farmers' willingness to plant grain. Among these, grain production price index became the main driving factor for nonagriculturalization, with contribution rates of 28.45%, 25.36%, and 23.45% across three stages. Land transfer also contributed significantly, accounting for 15.23%, 16.78%, and 18.90% respectively. Before 2000, limited agricultural production conditions (e.g., terrain and water sources) made some areas unsuitable for grain crops. Cultivated land resource endowment serves as the basic factor for nongrain conversion, with effective irrigation area significantly impacting nongrain conversion at contribution rates of 32.45%, 28.67%, and 25.34%. After 2010, extreme weather and climate events increased in frequency and intensity, with

crop disaster and failure proportions significantly impacting nongrain conversion at 12.34%. Some regions consequently shifted to developing extreme climate-resilient livestock and orchards, reducing grain crop planting area.

The importance of economic factors for nongrain conversion gradually increased while agricultural production conditions' importance declined. Prominent urban-rural economic development imbalances and structural contradictions made urban-rural income gap a major factor for nonagriculturalization, with contribution rates reaching 18.23%, 20.45%, and 22.67%. Additionally, close relationships exist between urbanization and construction-occupied cultivated land, with urbanization rates contributing over 15% to nonagriculturalization across stages. Rapid urban expansion intensifies rural farmland nonagriculturalization processes. Some local governments' one-sided pursuit of land finance without effective implementation of new development concepts also caused excessive nonagriculturalization, with contribution rates reaching 8.90%.

Notably, during 2010-2020, land transfer rate became the dominant factor driving nongrain conversion changes. Since 2000, farmland transfer has gradually become China's main method of farmland redistribution. In October 2016, the General Office of the CPC Central Committee issued "Opinions on Improving the Separation of Land Ownership, Contract Rights, and Management Rights," further promoting farmland transfer market development. With rapid growth in land transfer rates, nongrain crop planting proportions continued increasing, with nongrain conversion phenomena on transferred farmland becoming increasingly severe.

Driving factors for nonagriculturalization and nongrain conversion show some commonalities in economic factors but differ in specific manifestations and mechanisms. Economically, both processes are core-driven by economic benefits. Whether farmers shift to nonagricultural activities or plant nongrain crops, economic returns are key decision drivers. With rising agricultural production costs and fluctuating grain market prices, farmers tend to choose land use patterns with higher economic benefits, thus promoting nonagriculturalization and nongrain conversion trends. However, differences become prominent upon closer examination. Nonagriculturalization drivers relate more to macro socioeconomic aspects like urbanization processes and urban-rural income gaps. With continuous economic growth and structural optimization, agriculture's share in the national economy gradually declines, with more farmers choosing to work in cities or engage in other nonagricultural industries, directly driving cultivated land nonagriculturalization. Policy orientation adjustments and technological progress, such as expanded agricultural irrigation areas, also influence nonagriculturalization speed and scale. Conversely, nongrain conversion drivers focus more on microeconomic aspects like agricultural production conditions, grain output value per acre, and grain production price indices. In areas with poor agricultural production conditions, farmers may prefer planting other economic crops for higher returns. Meanwhile, grain output value per acre and urban-rural income gap directly affect farmers' enthusiasm for grain planting. When

grain production benefits are relatively low, farmers may prefer using cultivated land for nongrain crops to obtain higher economic returns.

3. Discussion

Nonagriculturalization processes show gradual slowdown trends, while nongrain conversion exhibits phased evolution characteristics. Specifically, east and southwest China show improvements in nonagriculturalization, yet nongrain conversion remains significant in these regions. Nonagriculturalization mainly involves conversion of cultivated land to non-agricultural uses, mostly occurring at agricultural-urban/industrial land interfaces. Nongrain conversion involves adjustments to planting structures within rural areas, where cultivated land remains agricultural but crops shift from grain to other economic crops.

Different development stages and regions have varying resource endowments, economic levels, and policy backgrounds, leading to different key driving factors for nonagriculturalization and nongrain conversion. Unique regional resource conditions, development strategy choices, and territorial functional positioning shape diverse patterns in type, scale, and degree of nonagriculturalization and nongrain conversion across regions. Nongrain conversion mainly manifests as “active” and “passive” types. For example, major grain-producing areas like the Northeast and North China Plains maintain high grain planting levels, with grain sowing area accounting for over 85% of total sowing area and low nongrain conversion. In contrast, northwest arid regions, southwest hilly and mountainous areas, and southeast coastal regions show lower proportions of grain crop sowing area, presenting significant trends of cultivated land conversion to nongrain crops. Adjusting planting types for comparative benefits represents “active” nongrain conversion, while resource endowment limitations causing low-efficiency cultivated land conversion represent “passive” nongrain conversion. Therefore, due to territorial functional differences, nonagriculturalization and nongrain conversion phenomena should receive varying emphasis across regions.

Among economic factors, grain production price index and grain output value per acre are relatively important indicators contributing to nonagriculturalization and nongrain conversion. Grain price fluctuations in this stage reduced grain planting benefits, affecting farmers’ production enthusiasm, and driving farmers to plant more profitable economic crops or convert farmland to other uses under economic interest incentives. In recent years, continuously low grain prices and rising costs, coupled with mostly small-scale dispersed farming operations, reflect how coordinating economic interests has become a prominent issue facing cultivated land nongrain conversion. Urbanization rates contributed over 15% to nonagriculturalization across stages, and rapid urbanization has intensified nongrain conversion trends in planting structures, confirming our research findings. However, in the past decade, economic factors’ relative contribution to nonagriculturalization decreased from 45.67% to 38.45%, possibly because economic development entered a relatively stable stage with saturated nona-

griculturalization processes and slowed growth. Regarding policy factors, land finance' s contribution rate to nonagriculturalization grew about 1.5 times annually over the past decade, reaching 8.90%. Some local governments' incorrect understanding of urbanization' s engine role and one-sided pursuit of political achievements and land finance have caused accelerated cultivated land nonagriculturalization.

Land transfer rates' contribution to nongrain conversion shows increasing trends. Ministry of Agriculture statistics indicate that national land transfer area reached 2.13×10^7 hm² in 2018, exceeding one-third of contracted cultivated land area, with further expansion trends. In practice, China' s land transfer is mainly managed by natural resources departments with minimal agricultural department participation, making regulatory responsibility implementation difficult.

Cultivated land nonagriculturalization and nongrain conversion directly or indirectly impact food security, such as reduced grain planting area and production capacity, and irreversible cultivated land quality degradation. Therefore, under the premise of ensuring food security, regionally differentiated cultivated land protection policies and crop planting spatial planning are needed. For example, implementing differentiated grain subsidy policies in major grain sales areas, production-sales balance areas, and major production areas can mobilize production enthusiasm. Simultaneously, strengthening scientific assessment, adapting measures to local conditions, and implementing precise region-specific policies based on market demand can maximize agricultural labor productivity. Additionally, enhancing dynamic monitoring and risk early warning by establishing multi-level collaborative, spatially comprehensive three-dimensional dynamic monitoring and management systems for cultivated land protection, aided by advanced satellite remote sensing imagery, enables more accurate assessment of nonagriculturalization and nongrain conversion scales and distributions, ensuring policy scientificity and effectiveness. When formulating relevant policies, regional differences must be fully considered to propose targeted measures for promoting sustainable agricultural development and stable food security.

This study combines China' s actual cultivated land dynamic evolution conditions, selecting 14 indicators to establish a relatively comprehensive evaluation index system. Based on each indicator' s contribution degree, we preliminarily analyzed driving factors for nonagriculturalization and nongrain conversion at different stages. However, policy and economic impacts on cultivated land changes are complex, with lag effects and interactions. Future research needs to combine fine-scale survey data and quantitative indicators to clarify their contribution rates to cultivated land dynamic evolution.

4. Conclusions

From a phased evolution perspective, this study reveals characteristics and dynamic evolution patterns of China' s nonagriculturalization and nongrain con-

version from 1980 to 2020, and further identifies their main driving factors. The main conclusions are:

- (1) **Spatial Distribution:** Nonagriculturalization is particularly prominent in northeast, central, and eastern regions, while nongrain conversion levels are relatively high in parts of northwest, south, and southeast coastal areas.
- (2) **Spatial Evolution:** Nonagriculturalization shows a “polarization phenomenon” along the northeast-southeast direction. Nongrain conversion spatial distribution highly coincides with the Hu Huanyong Line, with its center gradually moving from southwest to northeast, reflecting the key role of population and economic activities in land use transformation.
- (3) **Temporal Change:** Nonagriculturalization processes show different characteristics across time periods but overall trend toward stabilization or slowdown. Nongrain conversion experienced “growth-stability-decline” processes.
- (4) **Driving Factors:** Nonagriculturalization and nongrain conversion are comprehensively influenced by agricultural production conditions, policy institutions, and economic factors. Economic factors play a dominant driving role in nonagriculturalization evolution, though their influence has shown a declining trend over the past decade. Agricultural production conditions are fundamental factors for nongrain conversion, with economic factors like grain output value per acre and urban-rural income gap gradually increasing their promoting effect.

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

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