



## Article

# Identifying the Determinants of Nongrain Farming in China and Its Implications for Agricultural Development

Yuanzhi Guo <sup>1,2,\*</sup>  and Jieyong Wang <sup>1,2</sup> 

<sup>1</sup> Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China; wjy@igsnr.ac.cn

<sup>2</sup> Key Laboratory of Regional Sustainable Development Modeling, Chinese Academy of Sciences, Beijing 100101, China

\* Correspondence: guoyz.16b@igsnr.ac.cn

**Abstract:** Promoted by rapid industrialization and urbanization, the structure and spatial pattern of farming in China has changed greatly, and nongrain farming (NGF) has become more common. However, excessive NGF in some areas is not conducive to sustainable agricultural development and threatens China's food security. In this study, we briefly analyze the stage characteristics of NGF in China and investigate the spatial agglomeration of NGF and its influencing factors from the perspective of spatial econometrics. The results showed that the average annual growth rate of NGF in China from 1985 to 2019 was 0.64%, and there was a growing positive spatial correlation between NGF in each province. Spatial Durbin model (SDM) estimation showed that both the per capita disposable income of local rural residents and the local urbanization rate promoted the development of NGF, while local per capita farmland, road density, and the functional orientation of the main grain-producing areas had a negative impact on NGF. The per capita disposable income of rural households and urbanization rate in neighboring areas had a promoting effect on the development of NGF, while road density in neighboring areas was negatively correlated with NGF. Ultimately, some targeted measures are proposed to promote China's agricultural development in the new era.

**Keywords:** nongrain farming; spatial correlation; spatial Durbin model; food security; agricultural supply-side structural reform



**Citation:** Guo, Y.; Wang, J. Identifying the Determinants of Nongrain Farming in China and Its Implications for Agricultural Development. *Land* **2021**, *10*, 902. <https://doi.org/10.3390/land10090902>

Academic Editor: Le Yu

Received: 19 July 2021

Accepted: 23 August 2021

Published: 27 August 2021

**Publisher's Note:** MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



**Copyright:** © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

Agriculture is the source of food and clothing, the foundation of human survival, and the most basic material for production department in the national economy [1,2]. If the national economy is a building, agriculture is the cornerstone of that building. This status is determined by its own nature and will not change with the development of society and the economy or a decline in its representation in GDP [3]. As an important part of agriculture, farming refers to the social production sector that uses the biological functions of plants to obtain products such as grain, non-staple foods, feed and industrial raw materials through artificial cultivation. Since the transition from a hunting-and-gathering society to an agricultural society, the primary source of nutrients for human survival and development, whether plant or animal, has been farming [4–6]. Therefore, farming is a top priority in social and economic development [7], and due to its unique and important position in agricultural production, a reasonable farming structure is essential to promoting the sustainable development of agriculture.

China has been a large agricultural country since ancient times, and farming plays a significant and unique role in national economic and social development [8]. Since the reform and opening up in 1978, rapid industrialization and urbanization have promoted remarkable changes in China's farming structure [9–11], and the outstanding performance is the continuous decrease in grain crops and the rapid increase in nongrain crops such as vegetable and oil crops [12,13]. However, as the most populous country in the world,

China's per capita grain output has long been hovering right at the standard line of food safety (400 kg/person) set by the FAO for a long time [14–16], which suggests a grim outlook for national food security. In addition, unreasonable nongrain farming (NGF) in some areas has exacerbated this structural imbalance between the supply and demand of agricultural products, which increases the challenges to food security and is not conducive to agricultural development [11,17]. Against this background, NGF has not only become a focus of public attention and government work but also an important object of research by scholars.

In terms of research content, existing studies on China's NGF have mainly focused on analyzing the impacts of industrialization and urbanization [10,11,18,19], economic growth [11,20], the income of rural residents [21,22], and other variables on the development of NGF and have investigated how to protect cultivated land and ensure national food security in a context of growing NGF [11,20,23,24]. With the advancement of land system reform and the improvement of the rural land market, increasing attention has also been given to the role of NGF in the process of land circulation, focusing on investigating the causes of NGF and proposing the appropriate regulatory path to guide agricultural development [19,20,25]. In general, these studies are mainly conducted from a cost-benefit perspective and the factors affecting cost and benefit [26]. Regarding the research methods, most are based on case studies or micro studies at the level of rural households, and analysis of the regional patterns and influencing factors of China's NGF at different spatial scales has been overlooked. Thus, the formulation of regional agricultural development policies lacks sufficient scientific support, which is not conducive to realizing the goal of the modernization of agriculture and the countryside.

With the rapid development of society and the economy, peoples' living standards have greatly improved. As a result, peoples' demand for agricultural products is no longer limited to simply quantity, and increasing attention is being given to the quality and diversification of agricultural products [27]. Corresponding with this change, the Chinese government has actively promoted agricultural supply-side structural reform to ensure that the supply of agricultural products meets the needs of consumers, forming an agricultural product supply system with strong guarantees and reasonable structure [28]. However, agricultural supply-side structural reform in some areas is simply regarded as reducing grain production and increasing nongrain production, which restricts the sustainable development of agriculture. Therefore, a scientific understanding of NGF has become one of the key issues in ensuring national food security and deepening agricultural supply-side structural reform in China. Using a dataset of China's social and economic development during the period of 1985–2019, this study analyzes the spatial-temporal pattern of China's NGF at the national and provincial levels and employs a spatial panel data model to investigate the factors influencing regional differentiation in NGF. These findings not only will deepen understanding of NGF but also merit particular attention from policy makers aiming to ensure national food security and promote agricultural high-quality development in China.

## 2. Materials and Methodology

### 2.1. Methods

#### 2.1.1. Measurement of NGF

Farming refers to the cultivation of farm crops including cereals, beans, tubers, cotton, oil-bearing crops, sugar crops, fiber crops, tobacco, vegetables, orchards, fruits, nuts, beverage and spice crops, medicinal herbs, and others [12]. In China, cereals, beans and tubers are classified as grain crops, and the rest are classified as nongrain crops. Here, NGF refers to the production of nongrain crops in farming, and we use the proportion of sown area of nongrain crops to the total sown area to quantify NGF. Thus, China's NGF can be calculated as follows:

$$NGF = 1 - \frac{Area_{grain}}{Area_{total}} = 1 - \frac{Area_{cereals} + Area_{beans} + Area_{tubers}}{Area_{total}} \quad (1)$$

where  $Area_{grain}$  is the sown area of grain crops, including cereals, beans and tubers; and  $Area_{total}$  denotes the total sown area of crops, which refers to the area of all land sown or transplanted with crops that are harvested within the calendar year. All crops harvested within the year are counted as sown area, regardless of being sown in this year or the previous year, and crops sown this year but will be harvested in the coming year are excluded. In general, the value of NGF ranges from 0 to 1.

### 2.1.2. Spatial Autocorrelation Analysis

According to Tobler's first law of geography, there are agglomeration, random, regular, and other relationships between geographical items or their attributes in spatial distributions [29]. Spatial autocorrelation analysis aims to reveal this potential dependency, and the commonly used indicators include Moran's  $I$  statistic [30], Getis  $G$  [31], and Geary's  $C$  ratio [32]. Drawing lessons from related studies [33–35], this study employs Moran's  $I$  statistic, which includes global and local Moran's  $I$ , to measure the spatial autocorrelation between China's NGF in each province.

The global Moran's  $I$  measures the relationship between the attribute values of adjacent spatial objects. A positive value indicates a positive correlation in the distribution of NGF, a negative value indicates a negative correlation, and zero indicates no spatial correlation. According to existing research, the formula for calculating Moran's  $I$  is as follows [30]:

$$I = \left( n \sum_{i=1}^n \sum_{j=1}^n w_{ij} (y_i - \bar{y})(y_j - \bar{y}) \right) / \left( S^2 \sum_{i=1}^n \sum_{j=1}^n w_{ij} \right) \quad (2)$$

$$S^2 = \frac{1}{n} \sum_{i=1}^n (y_i - \bar{y})^2, \quad \bar{y} = \frac{1}{n} \sum_{i=1}^n y_i \quad (3)$$

where  $y_i$  is the NGF of province  $i$ ,  $n$  is the number of provinces, and  $w_{ij}$  is a component of the spatial weight matrix  $W$  determined by the principle of geographic adjacency; it equals 1 if the two provinces are adjacent, and otherwise equals 0. The value of the global Moran's  $I$  ranges from  $-1$  to  $1$ , where a larger value indicates higher spatial correlation, and a lower value indicates the opposite.

To diagnose the outliers, local Moran's  $I$ , which is also known as the local indicator of spatial association ( $LISA$ ), is used to measure the correlation degree of NGF between province  $i$  and its neighboring provinces and to identify the characteristics of the spatial spillover of NGF. Essentially, the local Moran's  $I$  decomposes the global Moran's  $I$  into a local scale and can be calculated as follows [36]:

$$I_i = z_i \sum_{j=1}^n w_{ij} z_j \quad (4)$$

where  $z_i$  and  $z_j$  are the normalized NGFs of provinces  $i$  and  $j$ , respectively, and  $w_{ij}$  is the spatial weight matrix of row standardization.

### 2.1.3. Spatial Panel Model

The quantitative inspection and estimation methods for general panel models are mature and have been widely used in empirical research [37,38]. However, due to the spatial correlation between geographic things [29], problems such as the deviation of test statistics between levels and inconsistent parameter estimation will be caused if the general panel model is used to study the related scientific problems [39]. Thus, spatial effects should be taken into consideration when investigating the mechanisms of China's NGF; that is, it is necessary to use the spatial panel model to explore the factors influencing regional inequality in China's NGF. In general, the spatial panel model includes spatial autoregression model (SAR) and spatial error model (SEM), where the former indicates that there is a spatial lag term in the explained variable of the model, and the latter

indicates that the error terms of the model are spatially correlated. Additionally, Lesage and Pace [40] proposed the spatial Durbin model (SDM), which contains the spatial lag terms of dependent and independent variables and represents a more generalized form of SAR and SEM, to analyze the mechanism of spatial heterogeneity.

In general, the SAR can be calculated as follows:

$$y_{it} = \delta \sum_{j=1}^N w_{ij} y_{jt} + \alpha + \beta X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (5)$$

where  $y_{it}$  is the dependent variable of province  $i$  at time  $t$ ;  $\sum_j w_{ij} y_{jt}$  denotes the interaction between  $y_{it}$  and  $y_{jt}$  of adjacent province  $j$ ;  $w_{ij}$  is a component of the  $N \times N$  dimensional nonnegative spatial weight matrix  $W$  determined by the features of sample provinces;  $\delta$  is an endogenous parameter that reflects the spatial interaction between dependent variables;  $X_{it}$  is a  $1 \times K$  dimensional exogenous variable;  $\beta$  is the corresponding  $K \times 1$  dimensional coefficient vector;  $\mu_i$  and  $\lambda_t$  are the spatial and temporal specific effects, respectively; and  $\varepsilon_{it}$  is a random error term.

The basic form of the SEM is as follows:

$$y_{it} = \alpha + \beta X_{it} + \mu_i + \lambda_t + \varphi_{it}, \quad \varphi_{it} = \rho \sum_{j=1}^N w_{ij} \varphi_{jt} + \varepsilon_{it} \quad (6)$$

where  $\varphi_{it}$  is a spatial autocorrelation error term,  $\sum_j w_{ij} \varphi_{jt}$  denotes the influence of the error term of adjacent province  $j$  on province  $i$ , and  $\rho$  is the spatial autocorrelation coefficient between error terms.

The formula for the SDM is as follows:

$$y_{it} = \delta \sum_{j=1}^N w_{ij} y_{jt} + \alpha + \beta X_{it} + \sum_{j=1}^N w_{ij} X_{jt} \gamma + \mu_i + \lambda_t + \varepsilon_{it} \quad (7)$$

where  $X_{jt}$  is a  $1 \times K$  dimensional exogenous variable with spatial lag, and  $\gamma$  denotes the corresponding  $K \times 1$  dimensional parameter vector. Under certain conditions, the SDM can be simplified into SAR and SEM.

## 2.2. Variable Selection

Although there are many studies on China's NGF, they have mainly focused on the nongrain of cultivated land. Here, we briefly review research on the nongrain of cultivated land and then select influencing factors of NGF. Based on a rural household survey, Chen et al. [41] discussed the causes of farmers' willingness to grow grain from the perspectives of individual and family characteristics as well as grain price. Additionally, Jin [42] analyzed the factors influencing farmers' willingness to produce grain considering aspects such as market factors, natural conditions and preferential policies. Zhang and Jiang [22] studied the differences of nongrain in land transferred by different types of farmers and investigated the contributing factors from regional economic development, agricultural production conditions and other aspects. Zhao et al. [19] explored the mechanisms of China's NGF based on an analysis of urbanization rate, per capita disposable income of rural households, proportion of nonagricultural industry in GDP, per household cultivated land, number of agricultural employees and other variables. Su et al. [11] analyzed the driving forces of different nongrain production types by using multinomial logistic regression modeling with geophysical, proximate, neighborhood and policy variables.

Reviewing the existing studies, it is obvious that the driving factors of China's NGF can be divided into four types: natural conditions, which mainly refer to the conditions of farmland, such as quantity and fertility; macro socioeconomics, including industrialization, urbanization, and regional economic development; individual characteristics, including labor capacity, age, etc.; and policy systems, such as land transfer and agricultural subsidies. This study focuses on exploring the spatial-temporal pattern of provincial NGF in China

and its influencing factors. Therefore, the micro factors of rural households are not included in the follow-up analysis.

Given the analysis above, the following seven factors are selected to investigate the mechanisms of the regional imbalance of China's NGF (Table 1): ① Per capita farmland. Agriculture has a significant effect on scale economies, and an increase in the agricultural production scale is conducive to improving agricultural total factor productivity and decreasing agricultural production costs [43]; ② urbanization rate, which can reflect the degree to which rural people are transferring to urban areas and the potential market scale of regional agricultural products; ③ per capita GDP, which is an indicator reflecting regional economic development. In general, the higher the level of the regional economy is, the higher people's living standards. As a result, their needs are increasingly diversified and advanced, which promotes the diversification of agricultural production [44]; ④ per capita disposable income of rural households. An increase in farmers' incomes is conducive to improving their production conditions, thus affecting their agricultural production decisions; additionally, farmers gain a stronger ability to meet their various needs; ⑤ road density, which reflects regional traffic situation and has an important impact on the sale of agricultural products; ⑥ rural population aging. Agriculture is a labor-intensive industry, and the aging of rural population directly reduces working populations engaged in agricultural production; and ⑦ function orientation of main grain-producing areas. In the main grain-producing areas, the development of NGF is strictly restricted, and the government has issued a series of policies and measures to encourage grain production. According to the "opinions on the reform and improvement of policies and measures for comprehensive agricultural development" issued in December 2003, Hebei, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Jiangsu, Henan, Shandong, Hubei, Hunan, Jiangxi, Anhui, and Sichuan are identified as the main grain-producing areas in China.

**Table 1.** The selection of influencing factors behind NGF.

Variables	Description
1. Per capita farmland ( <i>PFARM</i> )	Farmland area per person employed in primary industry
2. Urbanization rate ( <i>UR</i> )	Proportion of urban resident population in total resident population
3. Per capita GDP ( <i>PGDP</i> )	Calculated according to the caliber of resident population
4. Per capita disposable income of rural households ( <i>PCDIR</i> )	Excluding migrant workers, but including college students who are supported by the family
5. Road density ( <i>RDEN</i> )	Excluding urban streets, dead end highways, streets built for agricultural production and inside factories
6. Rural population aging ( <i>AGING</i> )	Proportion of rural population aged 65 and above in total rural population
7. Function orientation of main grain-producing areas ( <i>FUNO</i> )	If it is the main grain-producing area, <i>FUNO</i> is as-signed "1", otherwise it is 0.

### 2.3. Materials

This study makes full use of data on the sown areas of farm crops in China at different spatial scales. Sown areas of farm crops come from the China Statistical Yearbook. Administrative divisions and digital elevation models are downloaded from the National Geomatics Center of China and WebGIS, respectively. Data on *PFARM* come from the China Statistical Yearbook on Environment and China Statistical Yearbook on Land and Resources. *UR*, *PGDP*, *PCDIR* and *RDEN* are from the China Statistical Yearbook and the provincial Statistical Yearbooks. *AGING* and *EDU* are derived from the China Population Statistical Yearbook and the China Population and Employment Statistical Yearbook. The missing data are replaced by the data of adjacent years or supplemented through the method of trend extrapolation. According to the research design, Hong Kong, Macao and Taiwan are excluded. Thus, a total of 31 provincial administrative units were obtained.

Because the data of some independent variables before 1990 are difficult to obtain, a dataset from 1990 to 2019 is used for the spatial panel analysis.

### 3. Results Analysis

#### 3.1. Spatiotemporal Pattern of NGF in China

##### 3.1.1. Historical Evolution of NGF in China

Formula (1) is used to calculate China's NGF at the national level (Figure 1). From 1985 to 2019, China's total sown area of farm crops, sown area of grain crops, sown area of nongrain crops and NGF achieved different degrees of growth, with average annual growth rates of 0.43%, 0.19%, 1.07% and 0.64%, respectively. Specifically, the total sown area of farm crops showed a fluctuating rising trend; the sown area of grain crops remained relatively stable before 1999, then declined until 2003, and then increased steadily until shifting to another downward trend after 2016; the sown area of nongrain crops increased steadily before 2003, then had a downward trend until 2006, and remained stable during the period of 2006–2016 before shifting to a rising trend after 2016; the evolutionary trend of NGF was similar to that of the sown area of nongrain crops, but the change was more obvious.

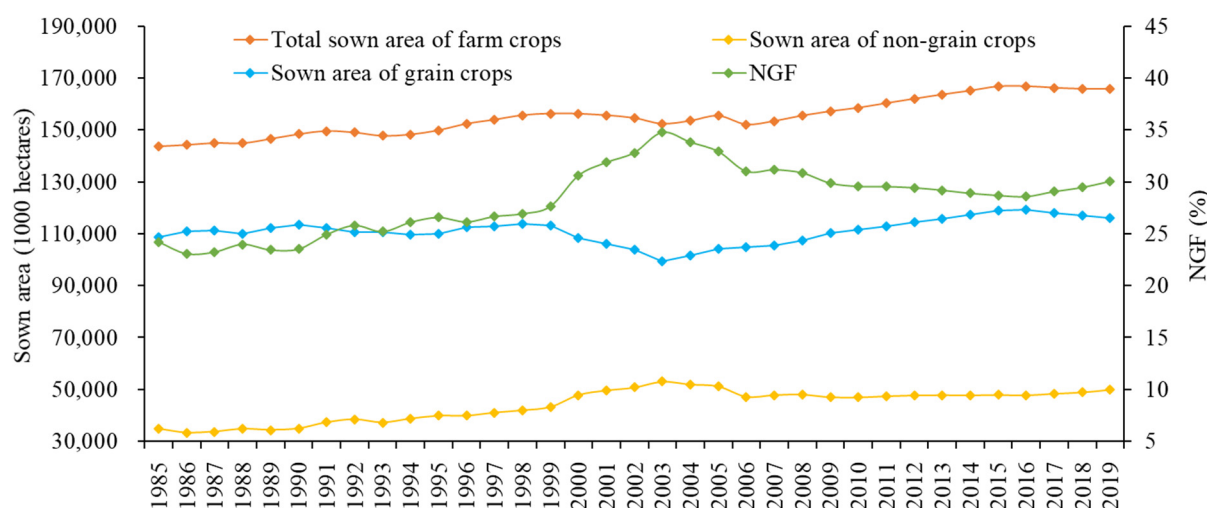
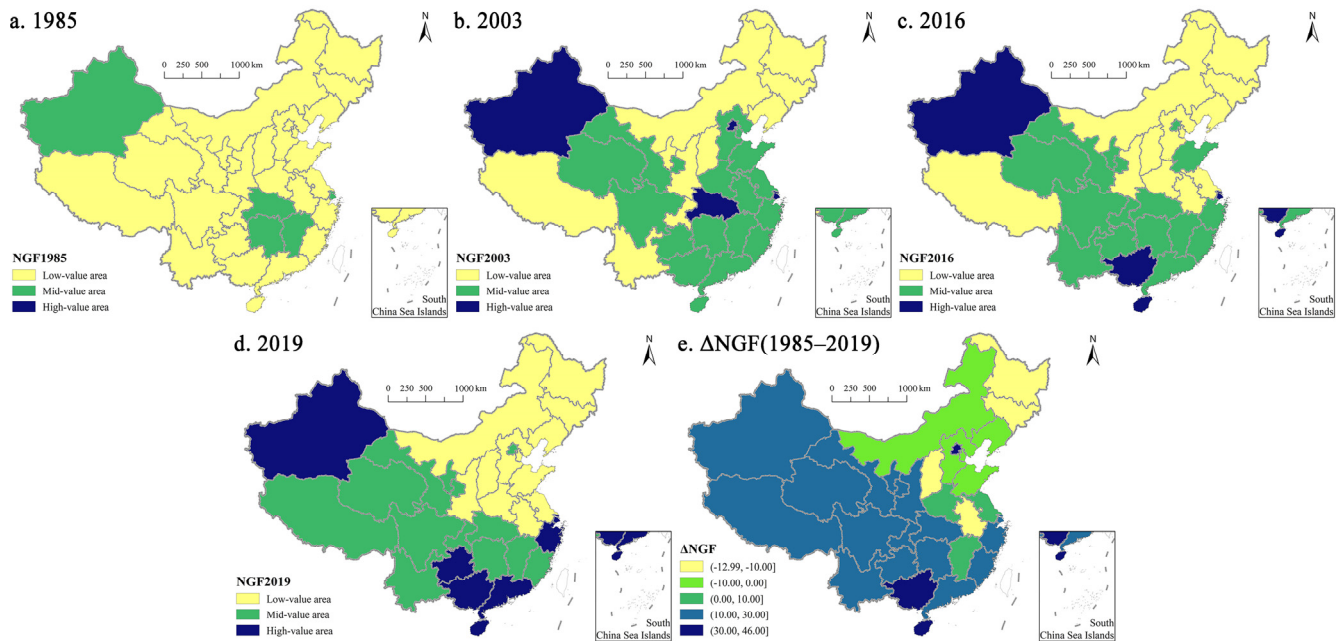


Figure 1. The evolution of NGF and sown areas of farm crops in China from 1985 to 2019.

With the continuous advancement of the reform and opening up, the increasing population in China requires the expansion of the sown areas of farm crops to meet people's needs. In addition, the diversified demand caused by improvements in living standards requires the diversification of agricultural production, which increases the sown area of nongrain crops and their proportion in total farming. By the end of the 20th century, China actively promoted the adjustment of its agricultural structure to cope with the impact of WTO accession on agricultural production. As a result, the sown area of grain crops decreased rapidly while that of nongrain crops increased rapidly. Correspondingly, NGF increased rapidly from 1999 to 2003, seriously threatening national food security. Focusing on the serious decline in grain production and the transformation of its domestic economy, China established the guiding principle of industry supporting agriculture and cities supporting villages in 2004 and issued a series of policies to support and benefit agriculture, including the abolition of agricultural taxes, grain subsidies, comprehensive subsidies for agricultural means of production, a minimum purchase price system for grain, etc. These preferential policies have greatly improved farmers' enthusiasm for growing grain, increased the sown area of grain crops, and caused NGF to decline. With improvement in the guaranteed ability to meet national food security needs, NGF began to rise again in 2016 under the influence of market supply and demand.

### 3.1.2. Regional Pattern of NGF in China

Employing formula (1), NGF at the provincial level from 1985 to 2019 is also calculated, and the results are divided into three grades: low-value area ( $0 < \text{NGF} \leq 30\%$ ), mid-value area ( $30\% < \text{NGF} \leq 50\%$ ), and high-value area ( $50\% < \text{NGF} \leq 70\%$ ). According to previous analysis on the evolution of NGF, the starting and ending years as well as the two transitional years, 2003 and 2016, were selected to reveal the spatial pattern of NGF in China (Figure 2). In 1985, the NGF of most provinces was less than 30%, and only five provinces belonged to the mid-value area, including Shanghai, Jiangxi, Hubei, Hunan and Xinjiang (Figure 2a). In 2003, some provinces had entered the high NGF value group, specifically, Beijing, Shanghai, Hubei and Xinjiang, while the spatial scope of the low-value areas was significantly reduced from 26 provinces to 10 provinces, including Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Chongqing, Yunnan, Tibet, Shaanxi, and Ningxia (Figure 2b). In 2016, Beijing and Hubei dropped out the ranks of the high-value areas and became mid-value areas, while Guangxi and Hainan joined the ranks of high-value areas; the provinces with a low-value of NGF were Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Jiangsu, Anhui, Henan, Tibet and Shanxi (Figure 2c). In 2019, Zhejiang, Guangdong and Guizhou were added to the ranks of high-value areas on the basis of 2016; areas with low-value NGF were concentrated in Northeast and North China, including Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Jiangsu, Anhui, Shandong, Henan, and Shaanxi (Figure 2d).



**Figure 2.** Spatial patterns of NGF and its changes in China from 1985 to 2019 (a–e).

In terms of the changes in NGF from 1985 to 2019, there were only nine provinces with declining NGF, mainly distributed in North and Northeast China, with this decline averaging  $-7.63\%$ . Among them, the provinces with an increase of NGF below  $-10\%$  were Heilongjiang ( $-12.99\%$ ), Shanxi ( $-11.91\%$ ), Jilin ( $-11.49\%$ ) and Anhui ( $-10.92\%$ ). By contrast, there were 22 provinces with a rising NGF, and the average value was  $20.12\%$ . Specifically, the provinces with an increase of NGF greater than  $30\%$  were Hainan ( $45.06\%$ ), Guangxi ( $31.72\%$ ) and Beijing ( $30.29\%$ ); and three provinces had an increase in NGF less than  $10\%$ , that was, Jiangxi ( $0.99\%$ ), Jiangsu ( $2.86\%$ ) and Henan ( $4.32\%$ ) (Figure 2e).

### 3.1.3. Spatial Autocorrelation of NGF in China

Exploratory spatial data analysis (ESDA) is used to explore the spatial correlation of NGF at the provincial level in China. The results show that the global Moran's  $I$  of NGF during the period of 1985–2019 was greater than zero at a 10% significance level, which indicates that there is a significant positive correlation between NGF in different provinces. In other words, the spatial distribution of NGF is not random but indicates that provinces with similar levels of NGF tend to cluster in a specific geographic space. From the perspective of evolutionary trends, the global Moran's  $I$  index has a fluctuating rising trend, from 0.052 in 1985 to 0.434 in 2019, which indicates that the degree of spatial agglomeration among NGFs at the provincial level was gradually increasing. Specifically, it had a trend of first increasing from 1985 to 1996, then decreasing until 2000, then increasing again, and then remaining relatively stable during the period of 2009–2019 (Figure 3).

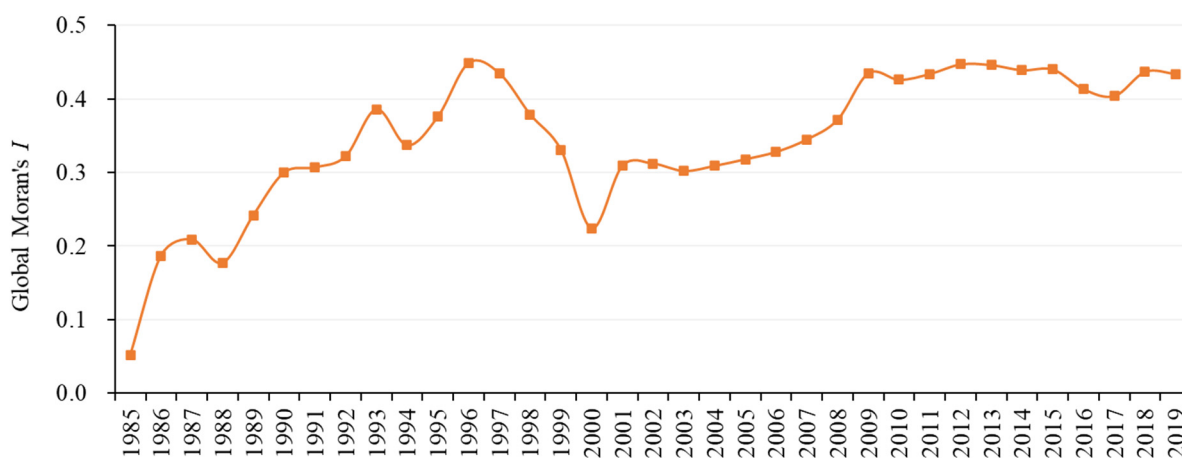
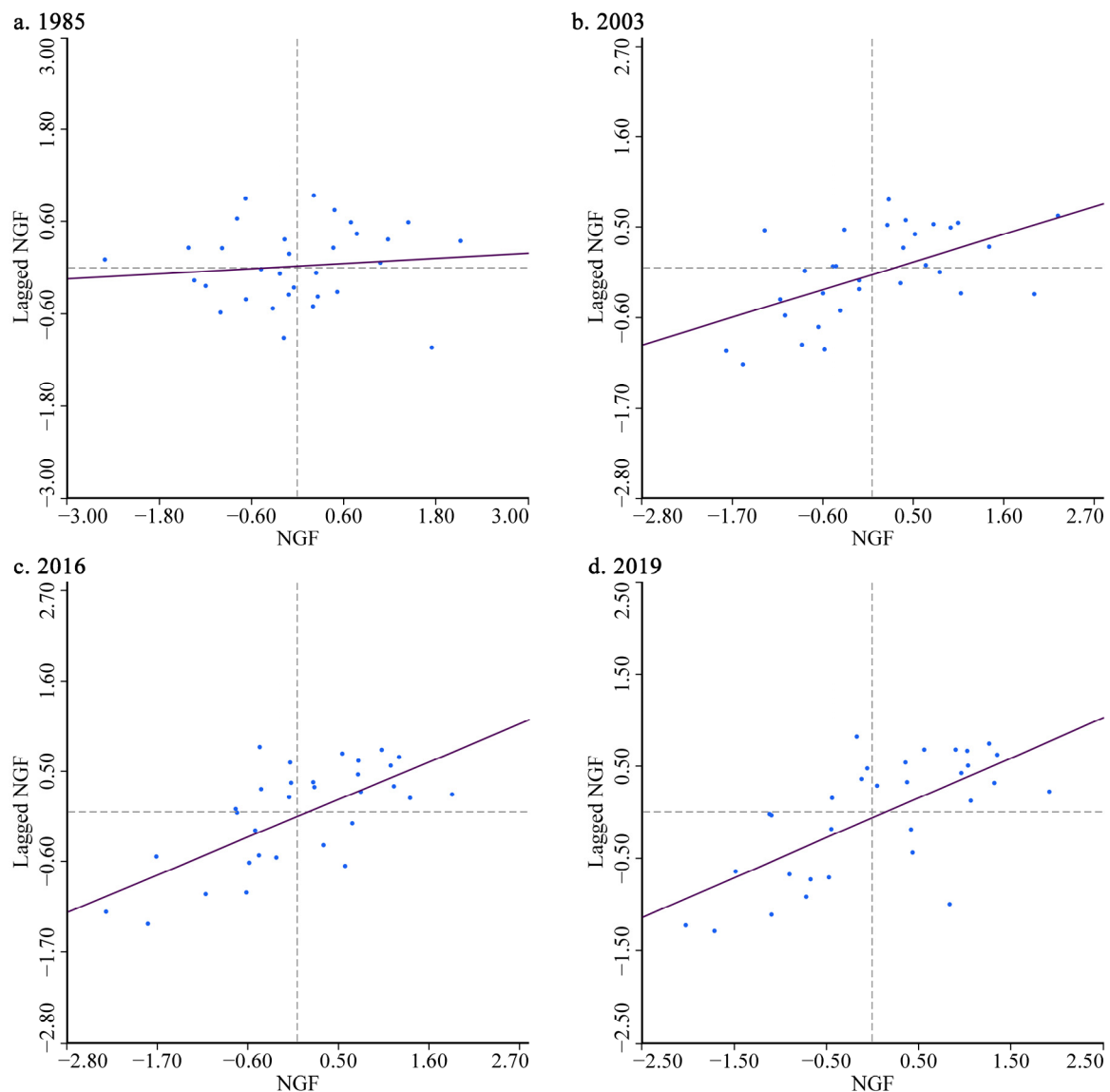


Figure 3. Changes in the global Moran's  $I$  of NGF in China from 1985 to 2019.

To investigate the spatial agglomeration characteristics of NGF, the local Moran's  $I$  is calculated, and the Moran scatter plots in 1985, 2003, 2016 and 2019 are selected to analyze the spatial pattern of NGF for different local areas (Figure 4). In 1985, 2003, 2016 and 2019, there were 9, 11, 12 and 13 provinces in the first quadrant and 10, 12, 10 and 11 provinces in the third quadrant, respectively. Therefore, the number of provinces with positive spatial correlations accounted for 61.29%, 74.19%, 70.97%, and 77.42% of the 31 provinces in 1985, 2003, 2016, and 2019, respectively, indicating that the local spatial agglomeration of NGF in China was mainly characterized by high-high and low-low clusters. Specifically, in 1985, provinces featuring a high-high cluster included Shanghai, Jiangsu, Zhejiang, Anhui, Jiangxi, Shandong, Hubei, Hunan and Guangdong, and those featuring a low-low cluster included Shanxi, Liaoning, Jilin, Heilongjiang, Sichuan, Yunnan, Shaanxi, Gansu, Qinghai and Ningxia (Figure 4a). In 2003, the provinces featuring a high-high cluster included Beijing, Tianjin, Shanghai, Jiangsu, Zhejiang, Fujian, Jiangxi, Hunan, Guangdong, Guangxi and Hainan, and those featuring a low-low cluster included Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Henan, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi and Ningxia (Figure 4b). In 2016, the provinces featuring a high-high cluster included Shanghai, Zhejiang, Fujian, Hunan, Guangdong, Guangxi, Hainan, Chongqing, Guizhou, Yunnan, Qinghai, and Xinjiang, and those featuring a low-low cluster included Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shandong, Henan, and Shaanxi (Figure 4c). In 2019, the provinces featuring a high-high cluster included Shanghai, Zhejiang, Fujian, Hunan, Guangdong, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Qinghai, and Xinjiang, and those featuring a low-low cluster included Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Anhui, Shandong, Henan, and Shaanxi (Figure 4d).





**Figure 4.** Moran scatter plot of NGF in China in 1985, 2003, 2016, and 2019 (a–d).

From the evolution of the different types of spatial agglomeration, it can be seen that the provinces featuring a high-high cluster of NGF became increasingly concentrated in the south, while those featuring a low-low cluster were increasingly concentrated in northeast and north China, which indirectly reflected the northward trend of the center of gravity of China's grain production from 1985 to 2019 [14].

### 3.2. Factors Influencing NGF in China

According to the previous analysis of the spatial agglomeration of NGF, there are obvious spatial correlation characteristics in China's provincial NGF. Therefore, it is necessary to establish a spatial econometric model to analyze its influencing factors. The results of the Lagrange multiplier (*LM*) test show that all statistics reach a 1% significance level (Table 2), which also indicates that the spatial panel is better than the nonspatial panel, and there are spatial error effects and spatial lag effects. Therefore, we reject the mixed multiple regression model. In addition, the *LR* test and *Wald* test are used to analyze the original hypothesis that the SDM is simplified into SAR and SEM:  $H_0^1: \gamma = 0$  and  $H_0^2: \gamma + \delta\beta = 0$ . The results of the *LR* test and *Wald* test show that the SDM should be employed for the empirical analysis of influencing factors (Table 3). The results of the SDM estimation show that model (2) has the largest R-square of (Table 4). Therefore, the SDM with time fixed

effects should be chosen to explore the influencing factors of NGF at the provincial level in China.

**Table 2.** Results of the Lagrange multiplier (*LM*) test.

Test	Spatial Error		Spatial Lag	
	Statistic	<i>p</i> -Value	Statistic	<i>p</i> -Value
Moran's <i>I</i>	12.794	0.000		
Lagrange multiplier	157.831	0.000	270.165	0.000
Robust Lagrange multiplier	53.748	0.000	166.081	0.000

**Table 3.** Results of the likelihood ratio (*LR*) and *Wald* test.

	<i>LR</i> Test		<i>Wald</i> Test		
	LR $\chi^2(7)$	Prob > $\chi^2$	$\chi^2(6)$	Prob > $\chi^2$	
Comparison of SDM and SAR	245.50	0.0000	The first test method	12.44	0.0528
Comparison of SDM and SER	211.44	0.0000	The second test method	16.51	0.0113

**Table 4.** SDM estimation of the influencing factors of NGF in China.

	Model (1)	Model (2)	Model (3)	Model (4)
	NGF	NGF	NGF	NGF
<i>PFARM</i>	−0.713 *** (0.0408)	−0.458 *** (0.0521)	−0.195 *** (0.0587)	−0.112 ** (0.0560)
<i>UR</i>	−0.0999 *** (0.0271)	0.0812 ** (0.0367)	0.114 *** (0.0322)	0.116 *** (0.0307)
<i>lnPGDP</i>	3.974 ** (1.659)	−2.139 (1.911)	9.565 *** (1.238)	7.026 *** (1.453)
<i>lnPCDIR</i>	2.184 (2.085)	12.55 *** (2.414)	−8.411 *** (2.196)	−5.157 ** (2.321)
<i>RDEN</i>	−1.965 (1.235)	−3.634 *** (1.133)	−2.077 ** (0.845)	−3.620 *** (0.882)
<i>AGING</i>	−0.211 (0.183)	−0.109 (0.175)	−0.123 (0.133)	−0.333 ** (0.131)
<i>FUNO</i>	−7.250 *** (0.608)	−9.150 *** (0.705)		
<i>Constant</i>	−7.831 * (4.129)			
<i>PFARM</i> × <i>W</i>		−0.0542 (0.133)	−0.0136 (0.135)	0.107 (0.132)
<i>UR</i> × <i>W</i>		0.628 *** (0.0665)	0.0303 (0.0664)	0.0176 (0.0672)
<i>lnPGDP</i> × <i>W</i>		−3.024 (4.218)	1.227 (1.558)	−4.672 (3.065)
<i>lnPCDIR</i> × <i>W</i>		39.96 *** (4.701)	1.348 (2.523)	10.28 * (5.474)
<i>RDEN</i> × <i>W</i>		−8.208 *** (2.456)	−11.33 *** (1.473)	−15.20 *** (1.902)
<i>AGING</i> × <i>W</i>		−0.215 (0.355)	0.0986 (0.203)	−0.672 *** (0.244)
<i>FUNO</i> × <i>W</i>		−2.369 (1.707)		
<i>Rho</i>		−0.266 *** (0.0452)	0.206 *** (0.0401)	0.0224 (0.0444)
<i>Observations</i>	930	930	930	930
<i>R-square</i>	0.371	0.217	0.154	0.0966

Note: Standard errors in parentheses; \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

According to the model estimation results, regional NGF is not only affected by local factors, such as per capita disposable income and national policy orientation, but also closely related to variables in neighboring areas, such as urban development, road density and other factors. In terms of the influencing degree, the impact of local variables on the development of NGF ranked from highest to lowest is *PCDIR*, *FUNC*, *RDEN*, *PFARM*, and *UR*, while the same ranking of the impact from variables in neighboring areas is *PCDIR*, *RDEN*, and *UR*.

Specifically: ① local *PFARM* has a significant negative effect on NGF, while that in neighboring areas has no significant effect. The fact that a large population with relatively little land causes grain production to have unique significance in regional agriculture, the increase in *PFARM* helps to achieve scale operations, reduce agricultural production costs, improve agricultural production efficiency, boost the development of regional grain production, and ultimately reduce the proportion of nongrain crops in farming. This finding is consistent with the conclusions of existing studies [19,45]; ② *URs* in both local and neighboring areas have a positive effect on NGF, but the degree of their influence is smallest when compared with that of other variables. The development of urbanization consumes much farmland and compresses the space of grain production. On the other hand, demands for various means of production and living caused by the agglomeration of population, industry and other factors promote the development of NGF. In addition, against the background of a rural population flowing to urban areas in China, the relatively low income from grain production causes a large number of transferred lands to be used for nongrain crop production [11,46]; ③ *PCDIRs* in both local and neighboring areas have a significant positive effect on the development of NGF. The increase in farmers' income improves their lives, and their consumption habits and diet structure have also changed correspondingly, gradually shifting from a grain-based diet to a diverse assortment of grain, fruits, vegetables, etc. In addition, the diversified demand for consumption generated by the improvement in living standards of rural residents in surrounding areas also promotes the diversification of regional farming; ④ *RDENs* in both local and neighboring areas have a significant negative effect on the development of NGF. Due to the regional differences in grain production in China, transportation plays an important role in grain circulation. Good internal and external traffic conditions help to promote grain circulation, ensure the income from grain production and reduce the proportion of nongrain crops in farming; and ⑤ local *FUNC* has a significant negative effect on the development of NGF, while that in neighboring areas has no significant effect. The main grain-producing areas are designated by the central government to ensure food security. To ensure the implementation of the national strategy, the government has issued corresponding preferential policies, thus limiting the development of NGF in these areas. However, these policies are exclusive; therefore, whether the neighboring areas are major grain-producing areas has no impact on the local NGF.

#### 4. Discussion and Policy Implications

##### 4.1. Scientific Understanding of China's NGF

Although NGF has challenged the national economy and social development, we should treat this phenomenon objectively. On the one hand, China is a country with a vast territory, and the regional differences in natural conditions such as water and soil require different regions to choose appropriate crops according to local conditions to meet people's needs, which determines the diversity of agricultural production. This kind of diversity is not only manifested in the diversity of crop species and germplasm resources, but also reflected by many varieties and varying performances of the same crop. In addition, the diversification of agricultural planting can improve productivity and resource utilization efficiency by optimizing access to biomass and water resources, thus strengthening the capacity, vitality and competitiveness of agroecosystems [47]. On the other hand, NGF is an inevitable outcome of social and economic development [48]. In the initial stage of agricultural development, people were mainly engaged in grain production, such as

millet and rice; with the development of productivity and the enhancement of interregional links, the types of grain crops in specific areas are becoming increasingly diversified, and vegetable crops, feed crops, cash crops and other crops have gradually become important objects of labor. As a result, the diversification of farming has been greatly improved.

Currently, the completion of the goal of building a well-off society in an all-round way indicates that China's social and economic development has entered a new stage. Accordingly, the principal social contradiction has evolved into the contradiction between people's ever-growing needs for a better life and unbalanced and inadequate development. Against this background, people's demand for agricultural products has transformed from a focus on quantity to one on quality, which indicates higher requirements for the variety and quality of food [49,50]. Compared with the past, when people simply wanted to have sufficient food to eat, they are now more concerned about eating well and eating healthily [27]. At the end of 2015, agricultural supply-side structural reform became an important component of the transformation and upgrading of China's agriculture in the new era, with the aim of improving the quality and efficiency of the agricultural supply system and realizing the transformation of agricultural product supply and demand from simply being a matter of maintaining a low-level total balance to needing to supply high-quality structural coordination [51]. After a period of development, the structure of agricultural production in China continues to be optimized, and the regional pattern tends to be reasonable, which provides not only a guarantee for meeting people's multilevel and diversified needs but also solid support for stabilizing the overall situations of economic and social development. However, in this process, some areas are experiencing excessive NGE, mainly including the nongrain of food production and the nongrain of nonfood production. Additionally, these phenomena show a trend of accelerated development [52] and have brought great challenges to China's fragile grain security.

#### *4.2. Policy Implications for China's Agricultural Development*

Since 2004, grain production in China has had bumper harvests annually, and by the end of 2019, the per capita output of grain had reached 475 kg [12]. However, there are still some serious problems behind this achievement, such as the imbalance between supply and demand, increasing resource use and environmental pressures, which have meant that the balance between grain supply and demand has been tenuous for a long time [53]. Focusing on the transition in the principal social contradiction, the transformation and upgrading of the dietary structure of urban and rural residents in China has become a general trend, and agricultural supply-side structural reform has become the key to agricultural and rural development. In this context, it is critical that the relationship between national grain security and agricultural supply-side structural reform should be scientifically addressed to promote the sustainable development of agriculture, increase farmers' income, and ultimately realize the goal of rural revitalization.

First, a system for protecting farmland must be strictly implemented. The government needs to strictly maintain the red line for farmland, especially basic farmland, strengthen land use control and law enforcement supervision, comprehensively implement strategic tasks for ensuring quantity and improving the quality of farmland, and seriously investigate and punish behaviors that occupy and indiscriminately abuse farmland, thus protecting and optimizing grain production capacity. Second, more attention should be given to developing moderate-scale operations. By adhering to the fundamental rural management system, all regions should vigorously develop new-type agricultural operation subjects and service subjects, and accelerate the development of various forms of moderate-scale operation through the circulation of management rights, joint-stock cooperation, land trusteeship and other methods, thus improving the efficiency of agricultural production. Third, the agricultural subsidy system needs to be improved. The government should further improve current agricultural subsidy policies, focus on the actual operators rather than the owners of contracting rights, and issue preferential policies for major grain-producing areas, entities with moderate-scale operations and green ecological agri-

culture. Fourth, the regional agricultural pattern should be continuously optimized. Based on the national main functional area planning and regional layout planning of superior agricultural products, the government should scientifically and reasonably designate grain production functional areas, such as rice, wheat and corn, and production protection areas for important agricultural products, such as soybean, cotton and rapeseed. On this basis, incentive mechanisms and support policies can be established and improved, thus constantly implementing the responsibilities of construction and management entities. Fifth, the main grain-producing areas need to be further deepened and refined. In some main grain-producing areas, especially economically developed provinces, the grain production function of many counties has been seriously degraded, while there are some counties with large grain output in non-main grain-producing areas, but they lack corresponding policy support. Therefore, delimitation of the main grain-producing areas should be based on the county as the spatial unit to improve policy pertinence. Through multipoint efforts and strategies, an agricultural product supply system with reasonable structure and strong guarantees can be established, and agricultural production will better meet people's demands for variety and quality, enhancing the driving force and ability of sustainable agricultural development.

#### *4.3. Limitations and Future Developments*

Currently, rural China has entered a new historical stage, and the principal contradiction faced by agricultural development has changed from insufficient quantity to structural disequilibrium [54,55]. In terms of the contents, structural disequilibrium is mainly reflected on the supply side, which includes not only an imbalance in the proportion of agriculture, forestry, animal husbandry and fishery, but also disharmony in the internal structure of planting, forestry, animal husbandry and fishery production. In this study, we only focus on farming in the narrow sense. Therefore, more attention should be given to strengthening research on agriculture in the broad sense to provide support for the modernization of agriculture and the countryside in the new era. At the spatial scale, this study analyzes the regional pattern of China's NGF with the provincial administrative region as the spatial unit, which makes the granularity of the spatial analysis slightly coarse. In future research, it is necessary to strengthen research at the county and village scales, thus better revealing the spatial characteristics and internal mechanisms of NGF at the meso and micro levels and enhancing the practical significance of the research. Furthermore, the specific types of NGF are worthy of further study, thus providing scientific support for constructing a modern agricultural industrial system, production system and management system. In addition, NGF in rural China is mainly characterized by the nongrain of cultivated land [56,57]. Therefore, strengthening research on the nongrain of cultivated land is necessary to better guide the implementation of national strategies, such as cultivated land protection and food security.

## **5. Conclusions**

Due to the low comparative benefits of grain crops, farmers' enthusiasm for grain production is declining, and the phenomena of extensive grain production and farmland abandonment are common in rural China [58,59]. Excessive NGF in some areas is not conducive to the high-quality development of agriculture in the new era. To reverse this situation, the central government strictly requires that the amount of farmland should not be reduced. However, compared with a one-sided focus on cultivated land area, sown area, which can reflect the planting situation of different crops, deserves more attention. This study used data on the sown areas of farm crops to analyze the spatial and temporal patterns of NGF in China, explored its influencing factors, and proposed countermeasures to promote sustainable agricultural development.

The results showed that the evolution of China's NGF from 1985 to 2019 had an overall upward trend, where performance first rose, then decreased, and then increased. During the research period, there was a significant positive spatial correlation between NGFs in

different provinces, and this feature had a gradually increasing trend. In terms of the spatial pattern, provinces featuring high-high clusters of NGF were increasingly concentrated in South China, and those featuring low-low clusters were increasingly concentrated in North and Northeast China. The SDM estimation showed that local *PCDIR* and *UR* promoted the development of NGF, while local *PEARM*, *RDEN*, and *FUNO* had a negative impact. In terms of variables in neighboring areas, *PCDIR* and *UR* were positively correlated with the development of NGF, while *RDEN* was negatively correlated with the development of NGF. These findings can serve as a scientific basis for the policy-making of China's high-quality development of agriculture and rural revitalization in the new era, and we hope that this paper will encourage the development of similar studies.

**Author Contributions:** Conceptualization, Y.G. and J.W.; methodology, Y.G. and J.W.; software, Y.G.; validation, Y.G. and J.W.; formal analysis, Y.G.; investigation, Y.G.; resources, Y.G.; data curation, Y.G.; writing—original draft preparation, Y.G.; writing—review and editing, Y.G. and J.W.; visualization, Y.G.; supervision, Y.G. and J.W.; project administration, Y.G.; funding acquisition, Y.G. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was supported by the National Natural Science Foundation of China (Grant No. 42001203) and the Strategic Priority Research Program of the Chinese Academy of Sciences (Grant No. XDA23070300).

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The associated dataset of the study is available upon request to the corresponding author.

**Acknowledgments:** The authors would like to thank the anonymous reviewers for their comments and suggestions which contributed to the further improvement of this paper.

**Conflicts of Interest:** The authors declare that they have no conflict of interest.

## References

- Han, S.; Pan, W.; Zhou, Y.; Liu, Z. Construct the prediction model for China agricultural output value based on the optimization neural network of fruit fly optimization algorithm. *Future Gener. Comput. Syst.* **2018**, *86*, 663–669. [[CrossRef](#)]
- Gepts, P.; Papa, R. *Evolution During Domestication*; ELS Language Centers: Princeton, NJ, USA, 2002.
- Johnston, B.F.; Mellor, J.W. The role of agriculture in economic development. *Am. Econ. Rev.* **1961**, *4*, 566–593.
- Zhao, R.; Wang, E.; Zhang, X.; Liu, J.; Zhou, S.; Li, G.; Han, M. *Human Geography*; Higher Education Press: Beijing, China, 2010.
- Cajete, G. *A People's Ecology: Explorations in Sustainable Living*; Book Marketing Group: Santa Fe, NM, USA, 1999.
- Welch, R.M.; Graham, R.D. Breeding for micronutrients in staple food crops from a human nutrition perspective. *J. Exp. Bot.* **2004**, *396*, 353–364. [[CrossRef](#)]
- Ayanlade, A.; Radeny, M. COVID-19 and food security in Sub-Saharan Africa: Implications of lockdown during agricultural planting seasons. *Npj Sci. Food* **2020**, *4*, 13. [[CrossRef](#)] [[PubMed](#)]
- Guo, Y.; Liu, Y. The process of rural development and paths for rural revitalization in China. *Acta Geogr. Sin.* **2021**, *6*, 1408–1421.
- Chen, J. Rapid urbanization in China: A real challenge to soil protection and food security. *Catena* **2007**, *69*, 1–15. [[CrossRef](#)]
- Long, H.; Tang, G.; Li, X.; Heilig, G.K. Socio-economic driving forces of land-use change in Kunshan, the Yangtze River Delta economic area of China. *J. Environ. Manag.* **2007**, *3*, 351–364. [[CrossRef](#)]
- Su, Y.; Qian, K.; Lin, L.; Wang, K.; Guan, T.; Gan, M. Identifying the driving forces of non-grain production expansion in rural China and its implications for policies on cultivated land protection. *Land Use Policy* **2020**, *92*, 104435. [[CrossRef](#)]
- National Bureau of Statistics of China (NBS). *China Statistics Yearbook*; China Statistics Press: Beijing, China, 2020.
- Johnson, D.G. Does China have a grain problem? *China Econ. Rev.* **1994**, *5*, 1–14. [[CrossRef](#)]
- Wang, J.; Zhang, Z.; Liu, Y. Spatial shifts in grain production increases in China and implications for food security. *Land Use Policy* **2018**, *74*, 204–213. [[CrossRef](#)]
- Wang, Y. The challenges and strategies of food security under rapid urbanization in China. *Sustainability* **2019**, *2*, 542. [[CrossRef](#)]
- Yin, P.; Fang, X.; Tian, Q.; Ma, Y. The changing regional distribution of grain production in China in the 21st century. *J. Geogr. Sci.* **2006**, *4*, 396–404. [[CrossRef](#)]
- Zhang, T. Why are Chinese small farmers planting more grain crops? —Review of the Logic of Grain Planting (2018). *China Agric. Econ. Rev.* **2019**, *1*, 173–175. [[CrossRef](#)]
- Hou, M.; Deng, Y.; Yao, S. Spatial Agglomeration pattern and driving factors of grain production in China since the reform and opening up. *Land* **2021**, *1*, 10. [[CrossRef](#)]

19. Zhao, X.; Zheng, Y.; Huang, X.; Kwan, M.P.; Zhao, Y. The effect of urbanization and farmland transfer on the spatial patterns of non-grain farmland in China. *Sustainability* **2017**, *8*, 1438. [[CrossRef](#)]
20. Qiu, T.; Choy, S.T.B.; Li, S.; He, Q.; Luo, B. Does land renting-in reduce grain production? Evidence from rural China. *Land Use Policy* **2020**, *90*, 104311. [[CrossRef](#)]
21. Zhao, X.; Li, Y.; Zheng, Y.; Jin, Z.; Zhang, X. Impact of industrial structure and farmers' income structure on the non-grain conversion of arable land. *Sci. Technol. Manag. Land Resour.* **2019**, *5*, 66–77.
22. Zhang, O.; Jiang, C. Analysis on differences of 'non-grain' of different types farmers in transfer-in farmland. *J. Financ. Trade Res.* **2016**, *4*, 24–31.
23. Pan, J.; Chen, Y.; Zhang, Y.; Chen, M.; Fennell, S.; Luan, B.; Wang, F.; Meng, D.; Liu, Y.; Jiao, L.; et al. Spatial-temporal dynamics of grain yield and the potential driving factors at the county level in China. *J. Clean. Prod.* **2020**, *255*, 120312. [[CrossRef](#)]
24. Zhong, F.; Zhu, J. Food security in China from a global perspective. *Choices* **2017**, *32*, 1–5.
25. Liu, Y.; Wang, C.; Tang, Z.; Nan, Z. Will farmland transfer reduce grain acreage? Evidence from Gansu province, China. *China Agric. Econ. Rev.* **2018**, *2*, 277–292. [[CrossRef](#)]
26. Wu, S.; Yu, H.; Chu, Y. Limitations and breakthroughs in the study of "non-grain" in cultivated land under agricultural scale management. *J. Northwest A&F Univ.* **2019**, *3*, 142–151.
27. Huang, Y.; Tian, X. Food accessibility, diversity of agricultural production and dietary pattern in rural China. *Food Policy* **2019**, *84*, 92–102. [[CrossRef](#)]
28. Kong, X. The basic connotation and policy suggestions on the structural reform of agricultural supply side. *Reform* **2016**, *2*, 104–115.
29. Tobler, W.R. A computer movie simulating urban growth in the Detroit Region. *Econ. Geogr.* **1970**, *46* (Suppl. 1), 234–240. [[CrossRef](#)]
30. Moran, P.A. Notes on continuous stochastic phenomena. *Biometrika* **1950**, *37*, 17–23. [[CrossRef](#)]
31. Getis, A.; Ord, J.K. The Analysis of Spatial Association by Use of Distance Statistics. *Geogr. Anal.* **1992**, *3*, 89–206. [[CrossRef](#)]
32. Geary, R.C. The contiguity ratio and statistical mapping. *Inc. Stat.* **1954**, *5*, 115–146. [[CrossRef](#)]
33. Wang, J.; Liao, Y.; Liu, X. *Spatial Data Analysis Tutorial*; Science Press: Beijing, China, 2010.
34. Liu, Y.; Liu, J.; Zhou, Y. Spatio-temporal patterns of rural poverty in China and targeted poverty alleviation strategies. *J. Rural Stud.* **2017**, *52*, 66–75. [[CrossRef](#)]
35. Prasannakumar, V.; Vijith, H.; Charutha, R.; Geetha, N. Spatio-temporal clustering of road accidents: GIS based analysis and assessment. *Procedia-Soc. Behav. Sci.* **2011**, *21*, 317–325. [[CrossRef](#)]
36. Anselin, L. Local indicators of spatial association—LISA. *Geogr. Anal.* **1995**, *2*, 93–115. [[CrossRef](#)]
37. Eilat, Y.; Einav, L. Determinants of international tourism: A three-dimensional panel data analysis. *Appl. Econ.* **2004**, *12*, 1315–1327. [[CrossRef](#)]
38. Hsiao, C. Panel data analysis—Advantages and challenges. *Test* **2007**, *16*, 1–22. [[CrossRef](#)]
39. Wang, Z.; Cui, B.; Zhang, Y. *Spatial Econometrics: Modern Models and Methods*; Peking University Press: Beijing, China, 2017.
40. LeSage, J.; Pace, R.K. *Introduction to Spatial Econometrics*; Chapman and Hall/CRC: New York, NY, USA, 2009.
41. Chen, S.; Zeng, F.; Liu, H.; Xu, H. Factors affecting farmers' willingness to grow grain in key grain-producing areas: Based on the investigation of 475 rural households of Hunan Province. *J. Hunan Agric. Univ.* **2012**, *5*, 29–35.
42. Jin, T. Analysis on Farmers' willingness to grow grain and its influencing factors in major grain producing areas. *Stat. Decis.* **2013**, *17*, 91–95.
43. Paul, C.; Nehring, R.; Banker, D.; Somwaru, A. Scale economies and efficiency in US agriculture: Are traditional farms history? *J. Prod. Anal.* **2004**, *3*, 185–205. [[CrossRef](#)]
44. Max-Neef, M. Development and human needs. In *Development Ethics*; Routledge: London, UK, 2017; pp. 169–186.
45. Wu, S. A study of the regional characteristics of China's grain production and its cause of formation: An empirical analysis since the market-oriented reform. *Econ. Res. J.* **2000**, *10*, 38–45.
46. Liu, Y.; Fang, F.; Li, Y. Key issues of land use in China and implications for policy making. *Land Use Policy* **2014**, *40*, 6–12. [[CrossRef](#)]
47. FAO. *The 10 Elements of Agroecology: Guiding the Transition to Sustainable Food and Agricultural Systems*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2018.
48. Long, H.; Tu, S.; Ge, D.; Li, T.; Liu, Y. The allocation and management of critical resources in rural China under restructuring: Problems and prospects. *J. Rural Stud.* **2016**, *47*, 392–412. [[CrossRef](#)]
49. Luo, Z.; Rao, H.; Huang, L.; Liu, M.; Chen, T.; Yao, M.; Li, J. Effect of Cu stress on minerals in rice by analyzing husk based on laser-induced breakdown spectroscopy. *Appl. Phys. B* **2020**, *126*, 8. [[CrossRef](#)]
50. Zhou, Y. Environmental planning and design of pollution-free pig farms in rural areas. *Rev. Científica Fac. Cienc. Vet.* **2019**, *5*, 1345–1354.
51. Fang, F. Seeking the theoretical origins of supply-side structural reform. *Soc. Sci. China* **2018**, *4*, 37–52.
52. Kong, X. Problems, causes and countermeasures of "non grain" of cultivated land. *China Land* **2020**, *11*, 17–19.
53. Shang, Q. Understanding of tight grain balance should be persisted for a long time. *China Grain Econ.* **2014**, *4*, 34–37.
54. Guo, Y.; Liu, Y. Poverty alleviation through land assetization and its implications for rural revitalization in China. *Land Use Policy* **2021**, *105*, 105418. [[CrossRef](#)]

55. Han, H.; Wu, S. Structural change and its impact on the energy intensity of agricultural sector in China. *Sustainability* **2018**, *12*, 4591. [[CrossRef](#)]
56. Wang, Y.; Chen, Y.; Yi, X.; Xiao, B. The non-grain problem in the process of land transfer and the countermeasures. *Chin. J. Agric. Resour. Reg. Plan.* **2011**, *4*, 13–16.
57. Yang, R.; Chen, Y.; Yi, X.; Fang, L. The causes and countermeasures on the excessive “non-food” tendency in the process of land transfer. *Chin. J. Agric. Resour. Reg. Plan.* **2012**, *3*, 14–17.
58. Li, T.; Long, H.; Zhang, Y.; Tu, S.; Ge, D.; Li, Y.; Hu, B. Analysis of the spatial mismatch of grain production and farmland resources in China based on the potential crop rotation system. *Land Use Policy* **2017**, *60*, 26–36. [[CrossRef](#)]
59. Qian, W.; Wang, D.; Zheng, L. The impact of migration on agricultural restructuring: Evidence from Jiangxi Province in China. *J. Rural Stud.* **2016**, *47*, 542–551. [[CrossRef](#)]