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Retraction

Retracted: Research on Spatio-Temporal Complexity Evolution and Influencing Factors of "Nongrain" in Guangxi

Discrete Dynamics in Nature and Society

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] C. Tang, Y. Yi, and Y. Kuang, "Research on Spatio-Temporal Complexity Evolution and Influencing Factors of "Nongrain" in Guangxi," *Discrete Dynamics in Nature and Society*, vol. 2022, Article ID 1181108, 14 pages, 2022.

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Research Article

Research on Spatio-Temporal Complexity Evolution and Influencing Factors of "Nongrain" in Guangxi

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The "nongrain" problem of farmland has an important influence on grain production safety and planting structure stability in China. Using statistical analysis and spatial analysis tools to explore the spatial and temporal distribution characteristics of "nongrain" cultivation trend in Guangxi, and through the geographically weighted regression model to analyze the factors affecting the degree of "nongrain" cultivation trend in Guangxi. The results showed that (1) the proportion of nongrain crops in Guangxi was increasing from 2009 to 2019, and the decrease of rice planting areas and the increase of vegetable planting area were the main reasons for the trend of "nongrain" in Guangxi. (2) the proportion of oil crop planting area increased rapidly in northwest Guangxi, and the overall growth rate was faster in 2009–2014. The proportion of vegetable planting area increased rapidly in the western and central regions, and the overall growth rate was faster in 2014–2019. The proportion of sugarcane and cassava planting area showed a downward trend in most regions, and the sugarcane decreased significantly in the northwest and eastern regions. (3) The effect of urbanization rate on the degree of "nongrain" is positive in southern Guangxi and negative in northern Guangxi. The average annual temperature is positively correlated in the north and negatively correlated in the south. Agricultural population and average annual precipitation are positively correlated in all regions and are the most significant in the northeast and the north, respectively. The ratio of grain production to sowing and the total power of agricultural machinery are negatively correlated in most areas and are most significant in the northeast. Finally, based on the research conclusion, this study puts forward some policy suggestions for preventing "nongrain" and stabilizing grain production in China.

1. Introduction

Food security is an important guarantee for world peace and development. However, global food security is currently facing serious challenges. According to the report released by the Food and Agriculture Organization (FAO) of the United Nations, the world malnutrition rate is stable at 11%. Although the downward trend in the past few decades has ended, the number of global hungry population has grown for three consecutive years, which has exceeded 820 million, and 2 billion people have experienced moderate or severe food insecurity. At the same time, the world's hungry population is unevenly distributed, with more than 500 million people in Asia and nearly 260 million in Africa, of which more than 90% live in sub-Saharan Africa [1]. The trend toward global food security means that achieving the "zero hunger" sustainable development goal by 2030 faces enormous challenges. In recent years, due to the impact of the novel coronavirus pneumonia epidemic, some countries have begun to tighten food exports, raise food export prices, and other factors such as locust plagues in Africa and South Asia will have an impact on global food security.

As a country with large population and scarce land per capita, agricultural development and food security have been the focus of attention in China. Since the founding of the People's Republic of China 70 years ago, China's arable land has increased from 1.468 billion mu to 2.023 billion mu, and grain production has increased from 113.18 million tons to 663.84 million tons. Grain production has achieved a qualitative leap [2]. However, with the development of industrialization and urbanization, capital going to the countryside continues to deepen, the phenomenon of illegal

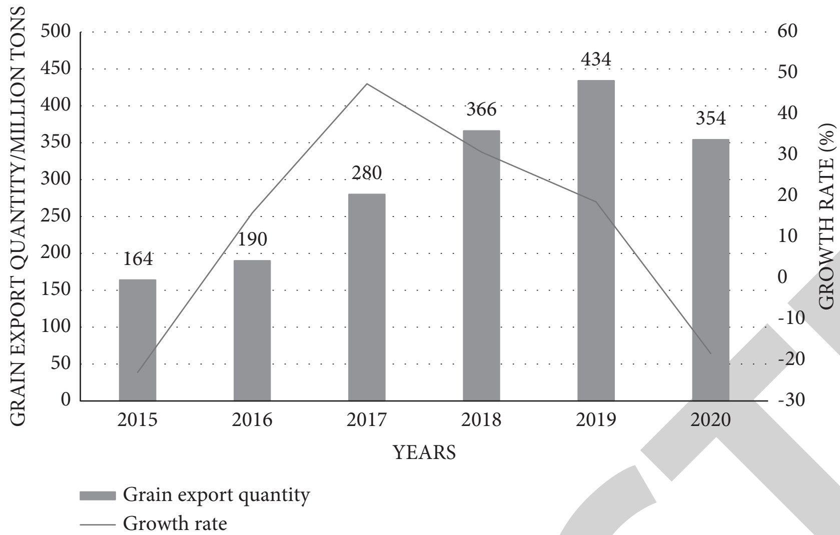

Figure 1: China's grain export quantity and growth rate chart from 2015 to 2020.

planting of permanent basic farmland and the transfer of commercial capital to cultivate nonfood crops has emerged one after another. The phenomenon of "nongrain" cultivated land is becoming more and more serious. The data in recent 10 years show that the proportion of grain crop planting area in China has decreased from 70.12% in 2009 to 69.95% in 2019, the decrease area reached 5.8 million hectares, and China's grain exports in the past five years also showed an inverted "U" trend (as shown in Figure 1). Therefore, in November 2020, the General Office of the State Council issued the "Opinions on preventing 'nongrain' of cultivated land to stabilize grain production," which put forward clear requirements for the understanding, countermeasures, and supervision of the "nongrain" of cultivated land [3].

The so-called "nongrain" refers to a behavioral tendency of farmers to reduce grain planting in the production process of the planting industry. This phenomenon is different from agricultural diversification [4, 5] because this behavior selection process occurs within the cultivated land, it refers specifically to the land used for planting food, not including plantations such as tea and other economic crops [6–8]. The generation of "nongrain" phenomenon is closely related to farmland transfer. Research shows that the "nongrain" ratio of transferred land is five to six times that of original land [9]. Some scholars have found that due to land transfer and large-scale agricultural management, the phenomenon of "nongrain" in major grain depots in coastal and Central China in recent years is particularly obvious [10, 11]. Based on the perspective of regional research, some scholars introduced the current situation of "nongrain" and qualitatively analyzed the potential causes of "nongrain" [9, 10], some scholars examined the factors that affect farmers' willingness to "nongrain" from the microscale, and the subtle differences and complexity of these factors on farmers' decision-making behavior [12, 13]. Other studies focus on the impact of "nongrain" on the environment or social economy, especially its threat to food security [11, 14]. Some scholars found that the expansion of the trend of "nongrain" will lead to the continuous reduction of grain planting area, resulting in fluctuations in grain prices and yields, and thus threatening the food security [15]. In addition, the expansion of the "nongrain" trend will cause damage to the local environment, which will not only accelerate soil erosion [16] and threaten local biodiversity [6], but also aggravate nonpoint source pollution [4] and carbon dioxide emissions [17]. For the influencing factors of "nongrain," some scholars regard the nongrain crop planting ratio as an indicator to measure "nongrain" [18], and some scholars find that factors such as agricultural mechanization level [19] and family labor force [20, 21] will affect the trend of "nongrain"; in addition, scholars consider the impact of urbanization imbalance on "nongrain" [22].

Nevertheless, limited and subjective results were achieved since most investigations were confined to empirical studies based on limited sample survey data. Few studies have analyzed the variability and heterogeneity of "nongrain" from the perspective of time and space. With the increasing number of high spatial resolution remote-sensing images and the wide application of spatial analysis software, the trend of "nongrain" can be quantified timely and effectively. Among them, ArcGIS, as a commonly used spatial analysis software, can present the trend of "nongrain" change through data maps, and explore the influencing factors of "nongrain" change trend through geographical weighted regression.

Through the review of existing literature, it is found that there are still some deficiencies in the research of scholars on the "nongrain" of cultivated land: (1) In the current research on "nongrain," there are a few literature using spatial analysis method to study the evolution trend of "nongrain." Spatial analysis, as a research method to connect time and space with data, can more clearly and intuitively see the trend and evolution characteristics of "nongrain" in the research area. (2) In the current literature on the influencing factors of "nongrain," most of them adopt quantitative research methods, lacking the temporal and spatial presentation of the influencing factors on "nongrain," and it is difficult to see the regional differences of the influencing factors. Based on this, this study takes Guangxi as the research object, using statistical analysis and spatial analysis method to study the spatio-temporal evolution and influencing factors of "nongrain," which provides theoretical reference for the study of spatio-temporal characteristics and mechanism of "nongrain" evolution, curbing "nongrain" phenomenon and adjusting crop planting structure, and makes theoretical contributions to the stability of grain production and sustainable development of agriculture in Guangxi.

2. Research Area and Data Sources

2.1. Overview of the Research Area. Guangxi Zhuang autonomous region is located in South China with a high terrain in the northwest and a low terrain in the southeast. Its longitude and latitude range from 104°28′ E–112°04′ E to 20°54′ N–26°24′ N. It has 14 prefecture-level cities and 111 county-level administrative regions. The climate is dominated by the subtropical monsoon climate, and a few regions are tropical climates. The annual average temperature is between 17°C and 24°C, and the annual rainfall is 1000–3300 mm. The annual sunshine hours are 1213–2135 hours, and the frost-free period is more than 300 days. The unique geographical and climatic conditions make Guangxi have unique advantages in developing pollution-free green vegetables and mountain cloud tea and other characteristic agriculture, with grain and fruit as the main planting industries. In recent years, the development of *Momordica grosvenori*, tomato, Nanshan radish, eggplant, and other economic crops. In 2019, the total output value of Guangxi's primary industry was 549.88 billion yuan, of which the agricultural output value was 310.23 billion yuan. The total arable land area for the year was 4.22 million hectares, and total food production was 13.32 million tons, down 3% from the previous year. Total fruit production was 21.4 million tons, up 19.5% from the previous year, and annual vegetable production was 36.36 million tons, up 6% from the previous year.

Due to the low latitude, sufficient heat, abundant precipitation, and sufficient labor force in Guangxi, close to the densely populated Pearl River Delta, the market is broad, so the value of planting economic crops in agricultural land in Guangxi is higher than that of planting grain crops. The level of income will drive farmers to grow nongrain crops, so the phenomenon of "nongrain" in Guangxi will be more obvious. According to the agricultural statistical data of Guangxi in recent years, the grain planting area is in a state of fluctuation, while the economic crop planting area has an obvious upward trend, and the phenomenon of cultivated land "nongrain" has emerged. Therefore, this study identifies Guangxi as the research area.

2.2. Data Sources. In this study, agricultural data in *Guangxi Statistical Yearbook* and statistical yearbook in Guangxi cities are used as the main data sources. Among them, the meaning of cultivated land in *Guangxi Statistical Yearbook* refers to the land that grows crops, including new development, reclamation, and idle land. The planting area of grain crops refers to the area of grain, beans, potatoes, and other grain crops that are actually sown throughout the year. Whether sown on cultivated land or on noncultivated land, the sowing area should be calculated. Based on the statistics of the cultivated land area and the planting area of various crops in the 2009–2019 *Statistical Yearbook*, the trend and degree of "nongrain" in Guangxi are measured, and the corresponding administrative zoning map is generated by ArcGIS10.2. In the case of missing data on individual indicators, it is supplemented by reference to Guangxi "Statistical Bulletin of National Economy and Social Development" in 2009–2019. In addition, to analyze the main factors affecting the degree of "nongrain" in Guangxi, the sources of the relevant indicators also consult the national land use survey data.

3. Results and Analysis

3.1. Statistical Analysis. The planting area of crops, grain crops, and nongrain crops (including economic crops and other crops) in Guangxi from 2009 to 2019 was counted, and the results were shown in Figure 2. It can be seen that during 2009–2019, the overall trend of the total planting area of crops increased at first and then decreased, but the total amount remained relatively stable. Among them, there was an upward trend from 2009 to 2014, with an increase of 386.7 thousand hectares in five years, an increase of 6.66%. The largest increase was recorded in 2012, at 119.1 thousand hectares, an increase of 1.99% over the previous year. In 2015–2019, the area decreased by 3.27% to 202.7 thousand hectares. Of these, the largest decline in 2018 was 180 thousand hectares, a decrease of 2.92% over the previous year. In 2009–2019, the planting area of grain crops also showed a trend of first increase and then decrease, and the decrease was greater than the increase. In 2009–2013, grain crop acreage increased by 80.6 thousand hectares, an increase of 2.65%. From 2014 to 2019, there was a significant reduction in the area of grain crops, a total of 372.3 thousand hectares, a decrease of 11.94%, of which 202.6 thousand hectares were reduced in 2018 (since the cities adjusted their original planting areas according to the second land survey data in 2018, the actual reduction was smaller than the above), a decrease of 6.76% compared with the previous year. Different from the first two, the nongrain crop planting area showed a continuous upward trend from 2009 to 2019, with an increase of 475.77 thousand hectares in 10 years, an increase of 17.19%. It can be seen from Figure 1 that the proportion of nongrain crops in the total planting area of crops increased year by year in the past 10 years, from 47.66% in 2009 to 54.13% in 2019.

In general, from 2009 to 2019, the changes in the total crop planting area and grain planting area in Guangxi were relatively stable, but the nongrain crop planting area increased rapidly and the proportion continued to increase. The changes showed a certain trend of "nongrain" crops and had a certain impact on grain production in Guangxi.

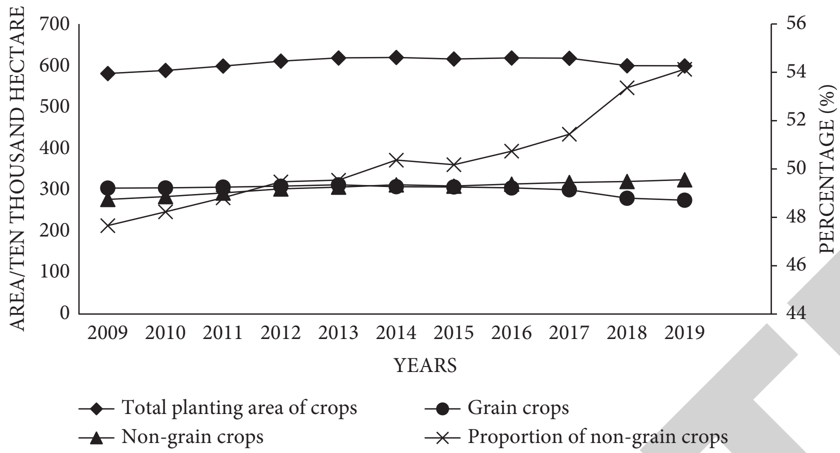

Figure 2: Change of crop area in Guangxi from 2009 to 2019.

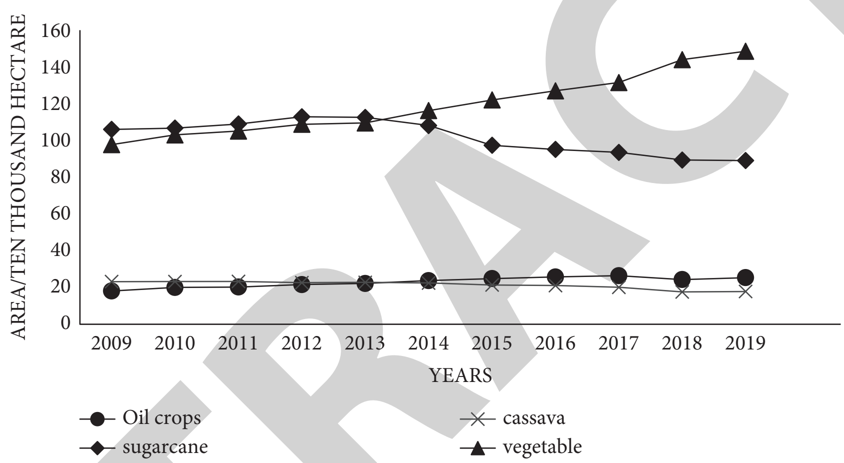

Figure 3: Change of main nongrain crop area in Guangxi from 2009 to 2019.

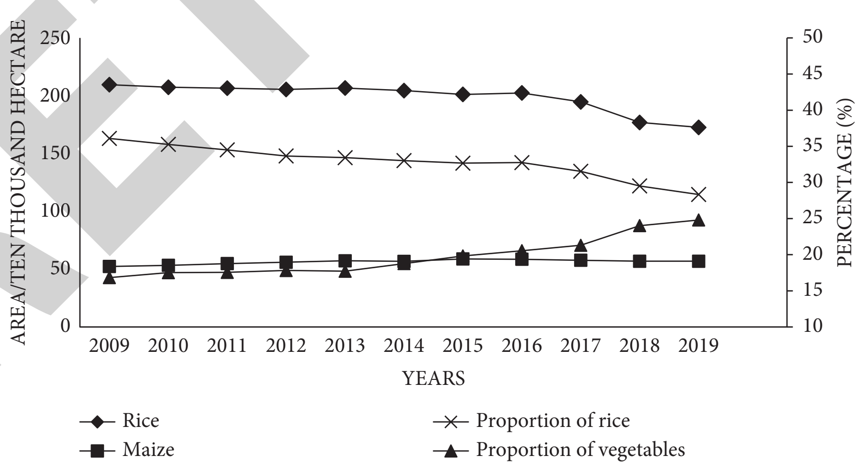

Figure 4: Change of main grain crop area in Guangxi from 2009 to 2019.

After investigating the main cultivated grain crops and nongrain crops in Guangxi, six crops, including rice, maize, oil crops, sugarcane, cassava, and vegetables, were selected and their planting areas and proportions from 2009 to 2019 were counted, as shown in Figures 3 and 4. It can be seen that the planting area of oil crops and cassava showed a stable upward and downward trend from 2009 to 2019, respectively. The area of oil crops increased by 72.8 thousand hectares in the past 10 years, and the planting area of cassava decreased by 53.6 thousand hectares, with an increase of 40.24% and a decrease of 23.13%, respectively. The overall trend of sugarcane planting area increased first and then

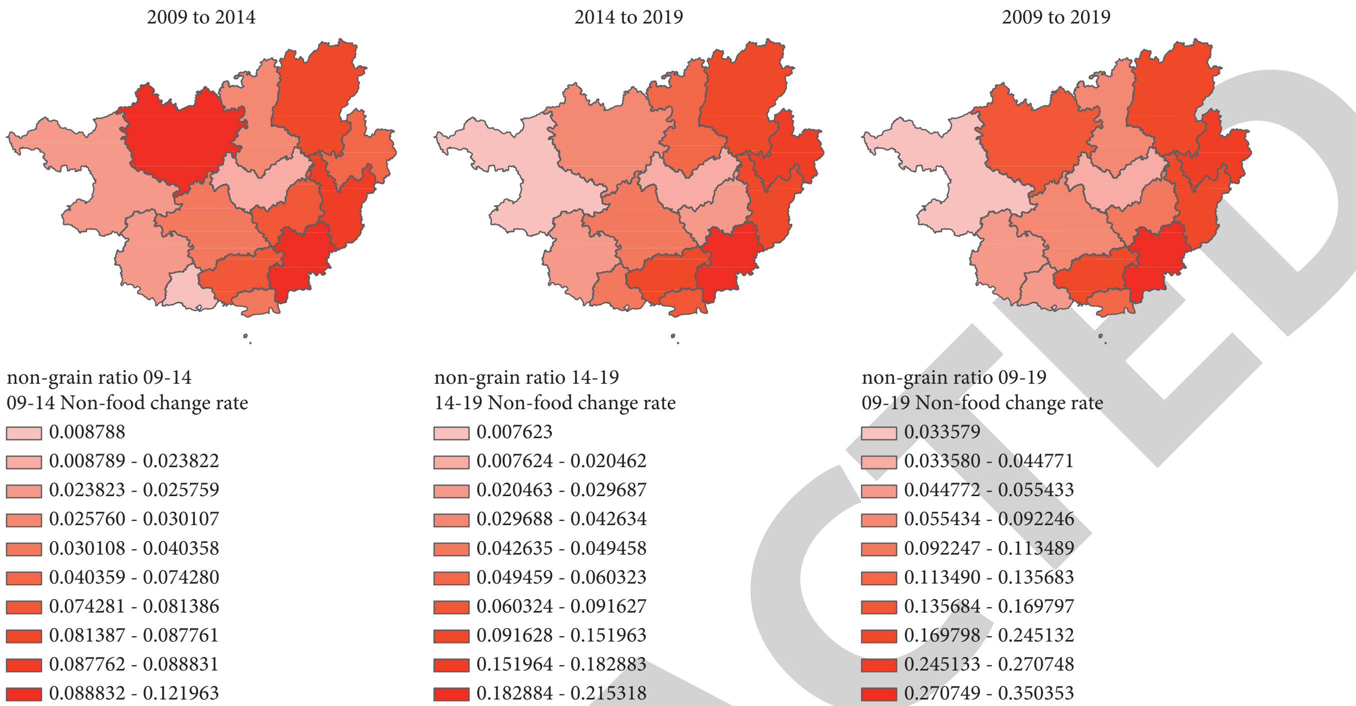

Figure 5: Change rate map of the proportion of nongrain crop planting area in Guangxi from 2009 to 2019.

decreased, with an increase of 6.47%, less than a decrease of 21.13%, and an overall decrease of 16.02%. There was a significant reduction in the area of sowing in 2015, a decrease of 107.6 thousand hectares compared with 2014, a decrease of 9.95%. The vegetable planting area changed most obviously between 2009 and 2019, from 977.3 thousand hectares in 2009 to 1.49 million hectares in 2019, an increase of 51.97%. The growth process can be divided into three stages according to the growth rate. The growth rate of 2014–2017 and 2018–2019 is relatively rapid, and the annual average growth rates are 4.67% and 6.28%, respectively. From Figure 3, it can be seen that the rice planting area continued to decline from 2009 to 2019, with a total decrease of 368.8 thousand hectares in 10 years, a decrease of 17.6%. Among them, the decline in 2017–2019 was more obvious, at 297.6 thousand hectares, with an average annual decline rate of 5.16% (since the cities adjusted their original planting areas according to the second land survey data in 2018, the actual reduction was smaller than the above). The maize planting area showed a small increase and then a decrease trend in 10 years, and the increase was greater than the decrease. From 2010 to 2015, the planting area of maize increased by 65.2 thousand hectares, an increase of 12.46%. From 2016 to 2019, the planting area decreased by 19.5 thousand hectares, a decrease of 3.31%.

Overall, the planting area of major nongrain crops in Guangxi showed an upward trend from 2009 to 2019, while the main grain crop planting area showed a downward trend. It can be seen from Figures 3 and 4 that the continuous decrease of rice planting area and the substantial increase of vegetable planting area are the main reasons for the increase of the proportion of nongrain crop planting area, which makes Guangxi present a “nongrain” crops trend.

3.2. The Spatio-Temporal Evolution of the “Nongrain” Trend in Each City

In order to further explore the change rate of “nongrain area” in Guangxi and its spatial differences, the change rates of the total nongrain planting area and the proportion of the main nongrain crop planting area in the total crop planting area of each city from 2009 to 2019 were calculated. The calculation formula is as follows:

$$v_{ij} = \frac{\left(M_{ij} - M_{ik}\right)}{M_{ij}}. \tag{1}$$

Among them, v represents the change rate, M represents the sowing area, i represents the crop species, j represents the year, and k represents the previous year of the current year. ArcGIS software is used to fill the calculated values into the administrative division map of Guangxi Zhuang autonomous region, as shown in Figures 5–9.

It can be seen from Figure 5 that the cities with the rapid increase in the proportion of nongrain crop planting area from 2009 to 2019 mainly concentrated in the southeast of Guangxi and gradually decreased along the northwest direction. Among them, Qinzhou, Wuzhou, Hezhou, and Guilin all grew by more than 20% in the proportion of nongrain crop planting area within 10 years, and Yulin had the highest growth rate of 35%. In stages, from 2009 to 2014, Hechi and Yulin had a high growth rate, of which the growth rate of Hechi reached 12% in five years, whereas that of Fangchenggang remained low, with only 0.88% growth in 5 years. In 2014–2019, the growth rate of the proportion of

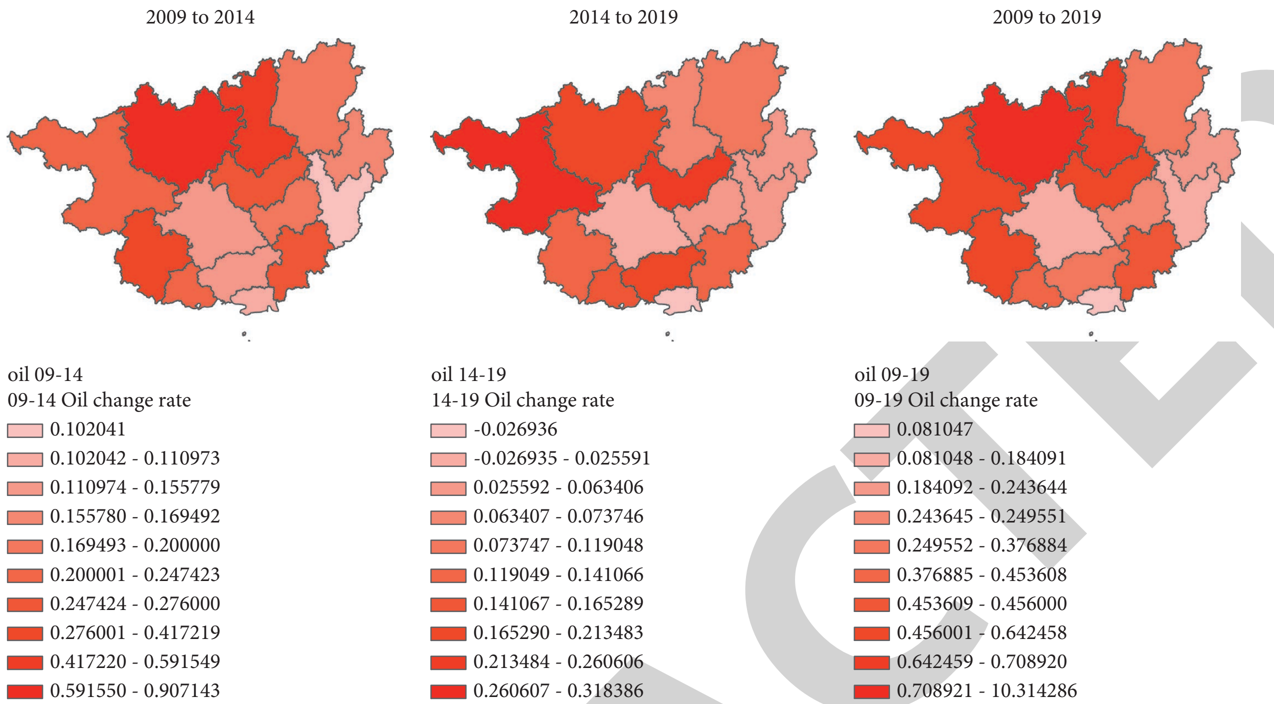

Figure 6: Change rate map of the proportion of oil crop planting area in Guangxi from 2009 to 2019.

nongrain crop planting area in each city of Guangxi was basically the same as that in 2009–2019, with the highest growth rate of 21% in Yulin as the center and decreasing to the northwest. It can be seen that the growth rate of each city from 2014 to 2019 was significantly higher than that from 2009 to 2014, indicating that the proportion of nongrain crop planting area has grown rapidly in recent years, showing a certain trend of "nongrain" crop area.

The change rate of cultivation area proportion of oil crops (mainly peanut and rapeseed) is shown in Figure 6. During the period of 2009–2019, the cities with the fast growth rate of oil crops were mainly concentrated in the northern part of Guangxi. The growth rates of Laibin, Chongzuo, and Baise in the past 10 years reached 60%. The growth rates of Yulin and Fangchenggang in the southern region also reached 45%, while the growth rate of Hechi reached 130%. The proportion growth rate from 2009 to 2014 is basically consistent with the overall trend in the past 10 years, with the growth rate of 90% in Hechi decreasing to 11% in Beihai and 10% in Wuzhou in the southeast. From 2014 to 2019, the change of growth rate decreased from west to east in Baise, the highest, with Beihai accounting for −2.69%, indicating a decrease in the proportion of oil crops. In addition, the images from 2009 to 2014 show that they had a great influence on the changing trend in the past 10 years, indicating that the growth of the proportion of oil crops in the sowing area has slowed down in recent years.

Since sugar crops in Guangxi are mainly sugarcane, the growth rate of the proportion of sugarcane planting area is plotted as shown in Figure 7. From 2009 to 2019, the growth rate of sugarcane planting areas in Guangxi showed an increasing trend from north to south. However, except for 3.13% of the Beihai and 5.71% of Yulin in the south, the growth rates of other regions were negative. The values of Hechi and Wuzhou were lower than −30%, and Baise and Guilin reached below −40%, which indicated that the proportion of sugarcane planting areas in Guangxi showed a significant decrease in 2009–2019. In addition, the changing trends of the proportion of sugarcane planting area in different regions are different at different time stages. From 2009 to 2014, the figures of Liuzhou, Cuigang, and Baise were below −10%, and figures of most of the cities fluctuated slightly between −5% and 5%. The growth rate in Wuzhou during the 5 years was just 0%, which means the share had not changed. The figures for Hezhou in the eastern region and Yulin in the southeastern region were 8.04% and 18.21%, indicating a significant increase in the proportion of sugarcane planting areas in the region from 2009 to 2014. From 2014 to 2019, the proportion of sugarcane planting area in the whole Guangxi region decreased significantly. The values of Baise, Hechi in the northwest, and Wuzhou and Hezhou in the east were all lower than −30%, and only Beihai was 5.4% positive, indicating that the proportion of sugarcane planting area in Guangxi has decreased significantly in the past 5 years. Due to the large overall planting area, the trend of "nongrain" crop area was inhibited to some extent.

The growth rate of cassava planting area in Guangxi from 2009 to 2019 was shown in Figure 8. From 2009 to 2019, the growth rate of cassava planting area was mostly negative, indicating that the overall proportion of cassava planting area showed a downward trend. Only Qinzhou, Fangchenggang, and Yulin in the south maintained a positive growth rate, the highest was 20.12% of Qinzhou, and gradually decreased in the northwest direction. In 2009–2014, Guigang and Wuzhou in the south-eastern region accounted for the main increase in cassava

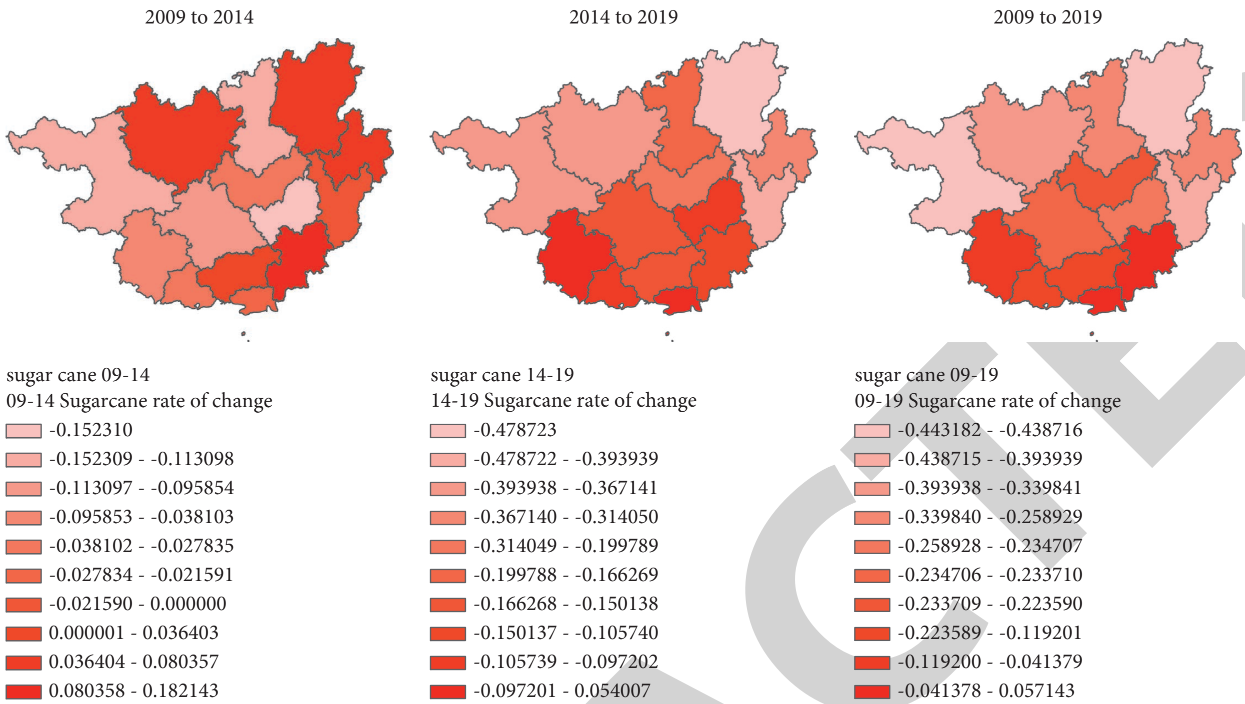

Figure 7: Change rate map of the proportion of sugarcane planting area in Guangxi from 2009 to 2019.

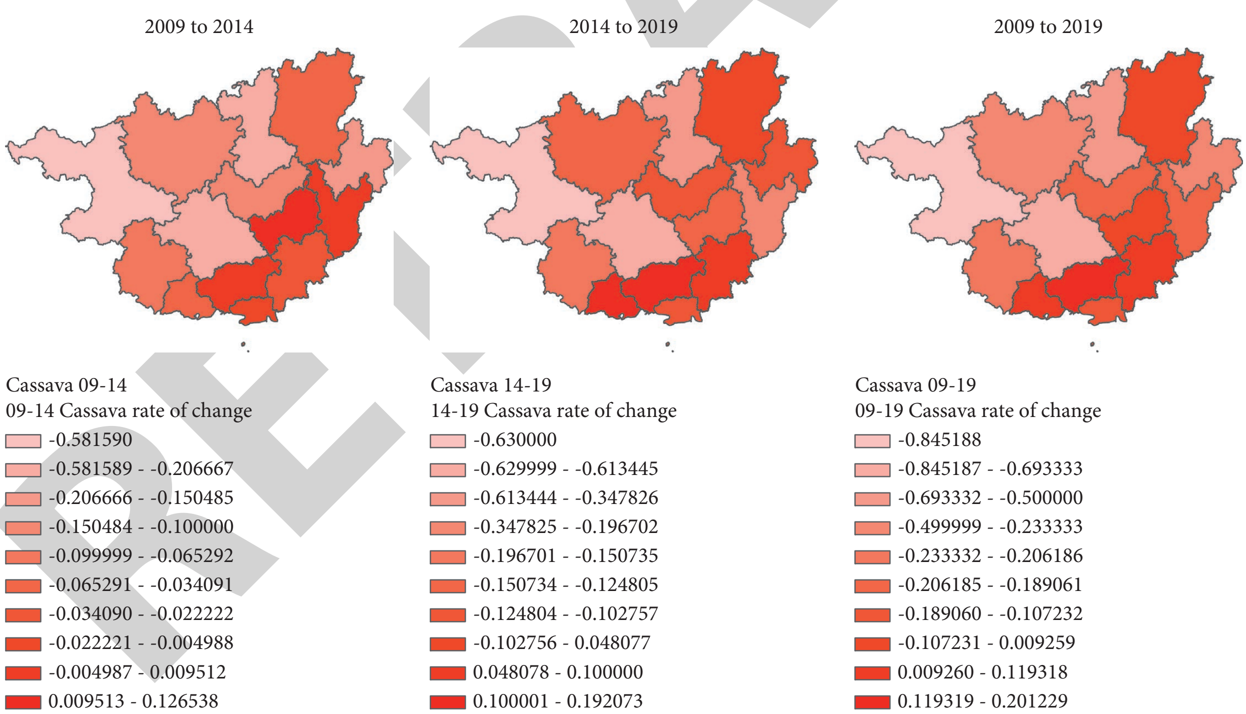

Figure 8: Change rate map of the proportion of cassava planting area in Guangxi from 2009 to 2019.

planting area, but the growth rates did not exceed 10%. The northwest region has a low negative growth rate, such as the growth rate of Baise reaching −58.16%. From 2014 to 2019, only a few southern cities maintained a positive growth rate, and the negative growth rate of most central and northern regions reached below −10%. Among them, the negative growth rate of Baise and Nanning is less than −60%. It can be seen that the proportion of cassava planting area continued to decrease from 2009 to 2019, and the decreasing trend was more obvious in recent years. However, due to the limited overall planting area, there was no significant effect on inhibiting the trend of "nongrain."

The growth rate of the vegetable planting area in Guangxi from 2009 to 2019 was statistically shown in

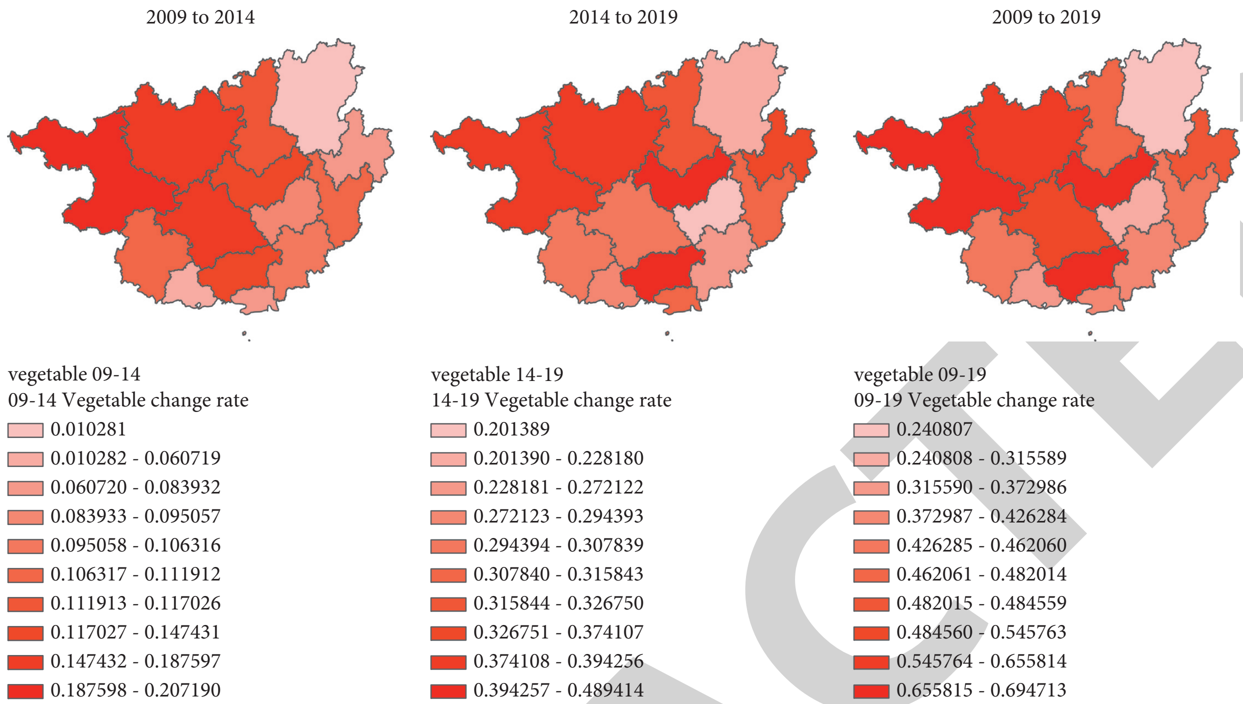

Figure 9: Change rate map of proportion of vegetable planting area in Guangxi from 2009 to 2019.

Figure 9. During the period of 2009–2019, the proportion of vegetable planting area in each city of Guangxi maintained a high growth rate on the whole. Taking Baise in the western region, Laibin city in the central region, and Qinzhou in the southern region as representatives, the growth rate in the past 10 years reached more than 65%, and Guilin in the lowest northeast region also reached 24.08%. From 2009 to 2014, the growth rate of each city showed a gradual upward trend from east to west, and the overall growth rate was relatively low. The highest growth rate was 20.72% in Baise, which was in sharp contrast with the lowest growth rate of 1.03% in Guilin. The growth rate of each city from 2014 to 2019 was between 25 and 50% as a whole and was similar to the trend map from 2009 to 2019, indicating that the vegetable planting area in Guangxi has grown rapidly in the past 5 years. Due to the large overall planting area, the trend of "nongrain" crop area in Guangxi is obvious.

Finally, in order to measure the changing trend of "nongrain" crop area in Guangxi as a whole, the period from 2010 to 2018 is selected as the research object, and the ratio of nongrain crop planting area to the cultivated area of each city (denoted as "nongrain cultivated ratio") is introduced to calculate the growth rate of each year. The calculation formula is as follows:

$$I = \frac{M_i}{M_k}, \quad (2)$$

where I represents the nongrain cultivated ratio of a city, M_i represents the total planting area of nongrain crops in a city, and M_k represents the cultivated area of a city. ArcGIS software is used to draw the data in the administrative division map of Guangxi Zhuang autonomous region, as shown in Figure 10.

From Figure 10, it can be seen that from 2010 to 2018, the growth rate of the nongrain cultivated ratio in Guangxi gradually decreased from northeast to west and southeast, and was divided into three regions. The northeast region represented by Guilin has the highest growth rate, and the nongrain cultivated ratio of growth rate in Guilin has reached 47.06% in eight years. Qinzhou and Yulin as the representatives of the southeast region's growth rate ranks second, are more than 30%, the surrounding city growth rate also reached 20%. The growth rate of the western region represented by Baise and a small number of central cities, such as Laibin, in the past 8 years was negative, indicating that the nongrain crops planted per unit of arable land gradually decreased. From 2010 to 2014, the growth rate of nongrain cultivated ratio in each city was relatively flat, with the highest rate of 36.51% in Qinzhou, the growth rates in the remaining cities were below 20%, and the growth rate in Nanning was negative. From 2014 to 2018, the growth rate of nongrain cultivated ratio in each city is basically the same as that from 2010 to 2018, indicating that the trend of sowing nongrain crops in-unit cultivated land in recent years is rising, and the phenomenon of "nongrain" crop area in the eastern region is more obvious.

3.3. Factors Influencing the Evolution Trend of "Nongrain" Crop Area. The change rate of nongrain cultivated ratio in each city from 2010 to 2018 was a selected trend based on literature review [18–22] as the explained variable to further

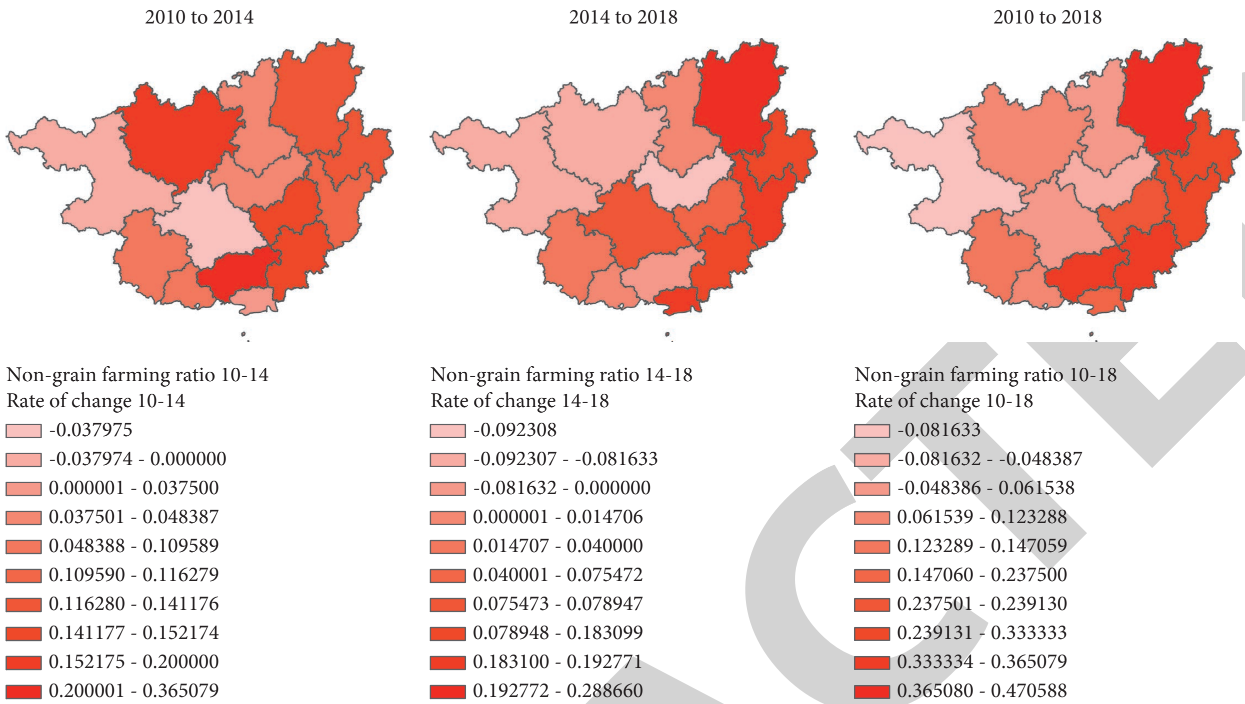

Figure 10: Change rate map of nongrain cultivated ratio in Guangxi from 2010 to 2018.

Model parameters.,	2010-2018.,
Neighbors.,	14.,
Residual Squares.,	0.053303.,
Effective Number.,	11.151984.,
Sigma.,	0.136806.,
AICc.,	111.059949.,
R^2.,	0.853872.,
R^2 *Adjused.,*	0.332989.,

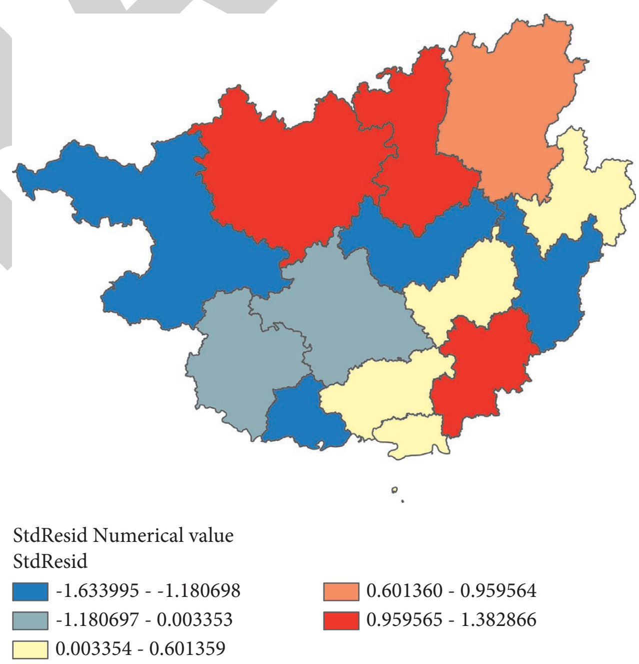

Figure 11: Results diagram of GWR model.

explore the influencing factors of Guangxi's "nongrain" trend. The change rate of urbanization rate, agricultural population, average annual precipitation, average annual temperature, grain production, and grain cultivation area ratio (denoted as "grain production–cultivation ratio"), and total power of agricultural machinery in each city from 2010 to 2018 were selected as explanatory variables. ArcGIS software was used to establish GWR model for geographically weighted regression. The results of the model and the spatial distribution of the regression coefficients of each explanatory variable are shown in Figures 11 and 12.

Using the AIC information criterion method, the parameters of the variable GWR model affecting the trend of "nongrain"cultivated area in Guangxi from 2010 to 2018 are obtained as shown in Figure 11. The overall R^2 value of the model is 0.85, and the goodness of fit of the adjusted model is

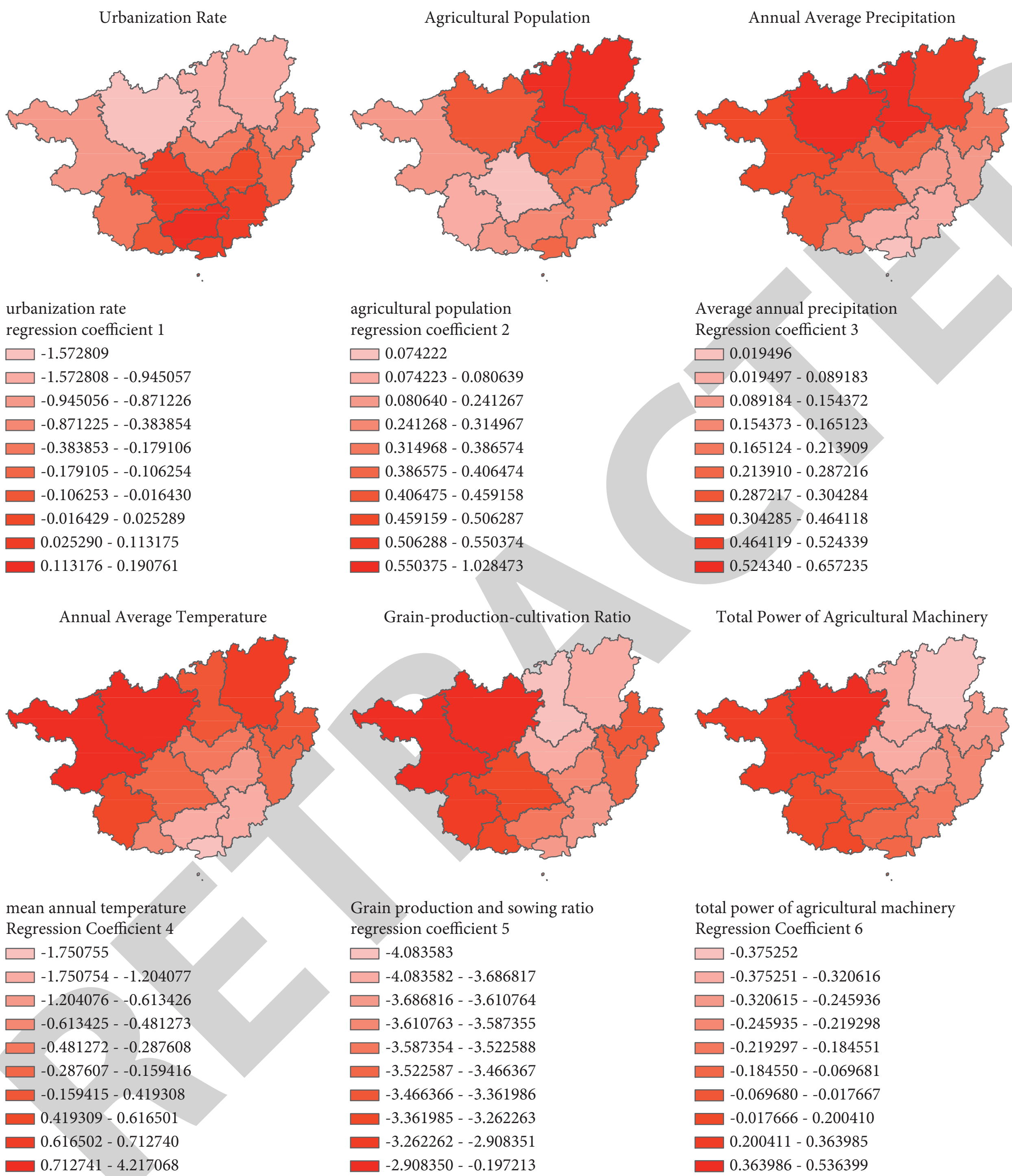

Figure 12: Spatial distribution of regression coefficients of explanatory variables.

also above 33%, and the standard error of the regression coefficients of each city in the map is less than 1.5, indicating that the entire GWR estimation model can better explain the impact of various variables on the trend of "nongrain" cultivated ratio.

The change of urban urbanization rate can not only reflect the flow rate of urban population but also reflect the speed of economic development of a city. It can be seen from the diagram that the regression coefficient of urbanization rate and nongrain cultivated ratio in Guangxi shows a decreasing trend from south to north, and the cities with positive coefficient show agglomeration in the southern region. Among them, the regression coefficients of the surrounding cities centered in Qinzhou are all positive, indicating that the urbanization rate is positively correlated with the growth rate of nongrain cultivated ratio. When the urbanization rate increases faster, the trend of “nongrain” cultivated ratio is more obvious. In addition, the regression coefficient of the rest areas of Guangxi is negative, indicating that it is negatively correlated with the growth rate of nongrain cultivated ratio. The faster the urbanization rate increases, the more obvious the inhibitory effect on “nongrain” cultivated ratio, while the values of Hechi and Baise are the lowest, and the inhibitory effect on “nongrain” is the most obvious. It can be seen that since most cities in the southern region are coastal or offshore cities, the current stage of urban economic development is faster than that of inland cities. The improvement of urbanization level can accelerate the transfer of labor force, increase the price of the rural labor force, and reduce the multiple cropping index of grain crops, which reflects the “nongrain” phenomenon.

Changes in agricultural population will also have an impact on changes in urban planting structure and “nongrain” trends. It can be seen from the figure that the change of regression coefficient between agricultural population and nongrain cultivated ratio in Guangxi shows an increasing trend from southwest to northeast, and the regression coefficients are positive, indicating that the growth rate of agricultural population in each city is positively correlated with the growth rate of nongrain cultivated ratio. The faster the growth rate of the agricultural population is, the more obvious the trend of “nongrain” cultivation in each city is. Among them, the coefficient values of Guilin and Liuzhou are the highest, indicating that they have the most obvious effect on promoting the trend of “nongrain” cultivation. However, the regression coefficient of Nanning in the middle and Chongzuo in the southwest is low, which has no obvious effect on promoting “nongrain” cultivation. It can be seen that when the urban agricultural population increases, farmers tend to plant nongrain crops rather than grain crops, which is related to the base and proportion of urban agricultural population. When the urban agricultural population base is small and the proportion is small, the labor force engaged in grain planting has not reached saturation, so agricultural population increases, there are still some farmers who choose to plant grain crops. When the urban agricultural population base is large, the number of farmers engaged in grain planting first reaches saturation. When the agricultural population continues to increase, more farmers will choose to plant nongrain crops, which are also corresponding to the degree of urban economic development.

Urban precipitation and temperature are natural factors affecting crop planting, and their change rates affect farmers’ choice of planting behavior, thus affecting the “nongrain” phenomenon. It can be seen from the figure that the spatial distribution of the regression coefficients of annual precipitation and annual temperature is roughly the same, showing an increasing trend from south to north. Among them, the regression coefficients of annual precipitation in each city are positive, indicating that the greater the growth rate of precipitation, the more obvious the trend of “nongrain” area. The regression coefficient of average annual temperature is bounded by the central region and is positive in the northern region of Guangxi, showing the promotion effect on “nongrain” area and negative in the southern region, showing the inhibitory effect on “nongrain” area of cultivation. It can be seen that the influence of natural factors on the trend of “nongrain” cultivation is more spatial in the north–south direction, and the influence mechanism of precipitation and temperature on “nongrain” cultivation area is different. The change of precipitation mainly affects the cultivation of nongrain crops in Guangxi, whereas the change of in temperature mainly affects the cultivation of grain crops in Guangxi. Affected by the unique climatic characteristics, Guangxi is rich in precipitation, and vegetables and fruits need adequate water supply in the process of planting. Therefore, the increased rainfall in Guangxi will make farmers grow nongrain crops in large quantities, especially in Hechi, Guilin, and Liuzhou. Temperature has a significant impact on the crops. As the southern part of Guangxi has a relatively high temperature, when the temperature increases, it will increase the multiple cropping index of farmers, reflecting the effect of restraining “nongrain” cultivation, whereas the cooler northern Guangxi shows the promotion of “nongrain” trend.

The ratio of grain production to total planting area can roughly reflect the grain production efficiency of the year, and the change rate can reflect the improvement or reduction of grain production efficiency. It can be seen from the figure that the regression coefficients of the change rates of nongrain cultivated ratio and grain production–cultivation ratio in each city of Guangxi are negative and show a trend of first decreasing and then increasing from west to east, indicating that the change rates of the two are negatively correlated. This shows that in Guangxi, the higher the grain production efficiency is, the lower the growth rate of nongrain cultivated ratio is, or even negative, thus inhibiting the trend of “nongrain” cultivated ratio. Among them, the absolute values of the regression coefficients of Liuzhou and Guilin in the northeastern region are the highest, and the inhibitory effect is the most obvious. Second is that the central and southern cities also show a strong inhibitory effect. In contrast, the absolute value of regression coefficient in Baise and Hechi in the northwest is the lowest, and its inhibitory effect on “nongrain” cultivation ratio is weak. Cost–benefit is one of the important factors affecting agricultural planting structure, which will have a direct impact on farmers’ choice of planting behavior. Although the price of grain crops has still shown a downward trend since 2010, with the improvement of grain production efficiency, the grain yield per unit of sowing area has increased, which makes the income of farmers continue to increase. To a certain extent, it makes up or even covers up the “nongrain” cultivation behavior of farmers that may be caused by the decline in grain prices, and to some extent, it can inhibit the “nongrain” production trend.

The total power of agricultural machinery plays an important role in grain production, and its change rate reflects the total power input in the planting process. It can be seen from the diagram that the spatial distribution of the total power regression coefficient of agricultural machinery is similar to that of grain production–cultivation ratio, and it shows a decreasing trend from southwest to northeast, and the regression coefficient in most areas is negative. This shows that the change rate of the total of agricultural machinery in most cities is negatively correlated with the change rate of nongrain cultivated ratio, and has a certain inhibitory effect on the trend of “nongrain” cultivated area. In the negative correlation area, the regression coefficient value of Guilin is the lowest, indicating that it has the most obvious inhibitory effect on “nongrain” cultivated ratio. Cities in the east, southeast, and central regions also have a certain inhibitory effect on “nongrain” cultivated ratio, whereas cities in the west, such as Nanning and Chongzuo, have the lowest inhibitory effect on “nongrain” cultivated ratio. In Hechi and Baise in the northwest and Fangchenggang in the southwest, the regression coefficient is positive, indicating that the more the total power input of agricultural machinery is, the more obvious the trend of “nongrain” cultivated area is, but the effect is not significant. It can be seen that the improvement of the total power of agricultural machinery is more favorable for grain farmers. On the one hand, the extensive use of agricultural machinery can improve the production efficiency of grain crops. On the other hand, agricultural machinery replaces manual labor, which not only changes the mode of grain farming but also reduces the cost of farmers to plant grain, which has a certain role in inhibiting farmers’ nongrain cultivation behavior.

4. Conclusion, Suggestion, and Prospect

4.1. Conclusion. Based on the statistical analysis, spatial analysis method, and ArcGIS10.2 statistical spatial analysis tool, this study takes the agricultural statistical data of Guangxi from 2009 to 2019 as the research sample, and comprehensively analyzes the spatial distribution characteristics of “nongrain” cultivated area in 14 prefecture-level cities in Guangxi and the influence degree of various influencing factors on “nongrain” cultivated area in each city, and provides clear spatial visualization results. The conclusions are as follows:

In terms of the general trend of “nongrain” production, the planting area of crops in Guangxi showed a general trend of “nongrain” cultivation from 2009 to 2019, especially from 2014 to 2019. In nongrain crops, the increase of vegetable planting area is the main reason for the “nongrain” trend, and the increase of oil crops planting area also promotes the “nongrain” trend to some extent. In addition, the decrease of planting area of sugarcane and cassava inhibited the trend of “nongrain” to some extent, and the inhibitory effect of sugarcane on “nongrain” was more obvious. In grain crops, the continuous decrease of rice planting area is also the main reason for the “nongrain” trend. Although the maize planting area has a trend of first increase and then decrease, the impact on the “nongrain” trend is not obvious.

In terms of the impact of nongrain crops on the trend of “nongrain” in Guangxi, the cities with rapid growth in the proportion of total nongrain crop planting area from 2009 to 2019 were mainly concentrated in the southeast of Guangxi and decreased along the northwest direction, and the overall growth rate was faster from 2014 to 2019. From 2009 to 2019, the cities with the higher growth rate of oil crop planting area were mainly concentrated in the northern part of Guangxi and decreased along the southern and eastern directions, and the overall growth rate was faster from 2009 to 2014. From 2009 to 2019, the growth rate of sugarcane planting area was negative in most areas of Guangxi and decreased along the northern direction. From 2009 to 2014, the growth rate of cities in eastern Guangxi was positive, while from 2014 to 2019, only Beihai was positive, and the remaining cities were negative, the inhibitory effect on “nongrain” trend was more obvious. From 2009 to 2019, the growth rate of cassava acreage proportion was negative in most regions of Guangxi, and only some southern cities were positive, and decreased along the northwest direction. From 2014 to 2019, the inhibitory effect on nongraining was more obvious. The proportion of vegetable area increased rapidly from 2009 to 2019, with Baise in the west, Laibin in the middle, and Qinzhou in the south growing significantly, and the promotion effect on the trend of “nongrain” was the most obvious.

In terms of the influencing factors of Guangxi’s “nongrain” degree, the regression coefficient of urbanization rate to the “nongrain” degree shows a decreasing trend from south to north, and is positively correlated in the southern region, which promotes the “nongrain” trend. The northern region was negatively correlated, inhibiting the trend of “nongrain.” The regression coefficient of agricultural population to the degree of “nongrain” decreases from northeast to southwest, and is positively correlated in all regions, which promotes “nongrain.” In terms of natural factors, the regression coefficient of annual precipitation to the degree of “nongrain” decreases from north to southeast, and is positively correlated in all regions, which promotes the trend of “nongrain.” The effect of annual average temperature on the degree of “nongrain” cultivation was positively correlated in the north and negatively correlated in the south. The regression coefficient of grain production–cultivation ratio on the degree of “nongrain” was negative in all regions, which had an inhibitory effect on the trend of “nongrain,” and the inhibitory effect was obvious in the eastern and northeastern regions. The impact of the total power of agricultural machinery on the degree of “nongrain” is positively correlated in southwest China, promoting the trend of “nongrain.” There is a negative correlation in the rest of the areas, which inhibit the trend of “nongrain,” with the most obvious inhibitory effect in the northeast [15].

5. Suggestion

At present, food security has become one of the hottest issues of global concern. As a big agricultural country, in the context of the increasingly severe trend of “nongrain” in China, how to adjust the planting structure and stabilize grain production requires the central and local governments to formulate effective policies according to local conditions. On the other hand, it requires the academic circles to carry out relevant research on “nongrain” trend to provide theoretical support for the prevention and control of “nongrain” of cultivated land. Based on the above research conclusions, the countermeasures and suggestions of this study are as follows:

The state should do top-level design to curb the trend of "nongrain" from the institutional level. On the basis of an overall grasp of the status quo of "nongrain" trend in China, the state should formulate strategic plans for the prevention and control of "nongrain" cultivation pattern from a macro perspective, optimize and adjust the planting structure, and enhance the awareness of government departments and the public on the issue of "nongrain." At the same time, the government should formulate corresponding grain subsidy policies, refine the types of subsidies, and fully stimulate the enthusiasm of farmers. In addition, relevant government departments should make good urban land planning, improve the utilization of idle and abandoned land, protect high-quality cultivated land resources, refine the types of agricultural land, and strictly delimit the scope of permanent basic farmland. Finally, the early warning mechanism of "nongrain" should be established, and the real-time monitoring system of crop planting area covering the whole country should be constructed to monitor and control the trend of "nongrain" in time. It is necessary to improve the "nongrain" supervision mechanism, strictly control, strengthen supervision, and timely punish illegal occupation of cultivated land.

To balance the relationship between urbanization and agricultural population. It has been proved that the rapid development of regional economy will have a certain impact on the regional food production and stability, and balancing the relationship between urbanization and agricultural population is the key to solving the problem. When the process of urbanization is too fast, it will cause the rapid loss of agricultural population, and the lack of rural labor force will cause the phenomenon of "farmland without planting" in rural areas. When the process of urbanization is too slow, a large number of agricultural population accumulation, surplus labor in rural areas will cause the phenomenon of "people without farmland," will also exacerbate the "nongrain" trend. Therefore, it is necessary to balance the process of urbanization and the transfer of agricultural population, pay attention to the internal relationship between regional economic development rate, urban and rural population change and "nongrain," and give some policy attention to agricultural population while steadily promoting urbanization, so as to realize the win-win situation of economic development and curb "nongrain" cultivation trend.

It is necessary to improve the efficiency of grain production and increase farmers' grain income. The state should pay attention to the development of agricultural science and technology, increase investment in research and development, improve the level of mechanization and science and technology of agriculture in China, and improve the efficiency of grain production by increasing grain yield. It is necessary to adjust the planting structure of grain crops, take actions that suit local circumstances, plant high-quality and high-yield grain crops suitable for local production conditions, and improve the overall quality of grain production. Finally, it is necessary to control the investment in the total power of agricultural machinery and the use of fertilizer and plastic film, reduce the cost of farmers' grain production, attract farmers with the improvement of grain level, so as to fundamentally curb "nongrain" and ensure the safety and stability of grain production.

Strengthen exchanges and collaboration among countries to build a global "nongrain" research system. Affected by new coronal epidemics, global warming, and other factors, the reduction of grain production and the northward movement of farming belt will also exacerbate the global "nongrain" trend, which should be paid attention to by all countries in the world. Therefore, on the basis of the research on China' s "nongrain" issue, we should strengthen the relevant academic exchanges among countries, establish professional research teams in various regions, share academic achievements, and empirical research, and build a global "nongrain" research system to maintain the security and stability of world food production.

6. Prospect

Based on statistical data, this study studies the spatial and temporal evolution and influencing factors of "nongrain" in Guangxi from 2009 to 2019. However, this study still has the following shortcomings. First, the scope of the study area is small, which cannot well prove the general relationship between the trend of "nongrain" and various influencing factors. Second, the statistical data is not accurate enough, as the standard for statistical crop acreage changes around 2018 will lead to inaccurate calculations. Based on this, this study presents the following prospects:

Expand research scope on the basis of existing research areas. This study only selects a coastal province in China to explore the trend of "nongrain," and the conclusion is not universal. In future studies, the study area can be expanded to study the trend of "nongrain" in China's inland provinces, China as a whole, Asia, and even the world, and gradually form a research system to explore the trend of "nongrain" in the region.

Strengthening linkages between "nongrain" research and other areas. At present, most of the "nongrain" studies are related to land transfer, and the influencing factors involved are relatively limited. In future research, we can strengthen the research on the relationship between "nongrain" and other fields, such as the impact of policies on the trend of "nongrain," the relationship between the trend of "nongrain" and the ecological environment, and the impact of farmers' psychological willingness to plant on the trend of "nongrain." We can more comprehensively explore the factors affecting "nongrain" and provide more effective countermeasures and suggestions to curb "nongrain."

Data Availability

The statistical data used were taken from CNKI (https://data.cnki.net/) and the "Statistical Bulletin of National Economic and Social Development" of various cities in Guangxi (http://tjj.gxzf.gov.cn/tjsj/tjgb/). The map data were drawn by ArcGIS software using statistical data and the administrative division map of Guangxi and have been sent to the editorial department by e-mail. In case of doubts about the data, mail yiyongyi123@126.com.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Supplementary Materials

The data of Statistical Analysis part, Spatio-temporal Evolution of the "Nongrain" Trend part, and Factors Influencing the Evolution Trend of "Non-grain" part in this article are referred from the "statistical data" and excel table of supplementary materials. The table contains the specific values of each city's indicators, and the values in each chart of this article are calculated by the data in the table. (*Supplementary Materials*)

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