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Spatial Distribution Characteristics of Agricultural Development Level in Jianghan Plain Based on Geostatistical Analysis

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Abstract. Based on geostatistical analysis, this paper analyzed the overall and partial spatial layout of the agricultural development level in 21 counties of Jianghan Plain from 2014 to 2016. The results show that: 1) The agricultural development levels of the counties in Jianghan Plain vary greatly and have strong autocorrelation, which means that a region will affect its surrounding areas in terms of agricultural development; 2) The agricultural development level of the Jianghan Plain is generally higher in the west than in the east and slightly higher in the north than in the south. The study of the spatial distribution characteristics of agricultural development level can provide a theoretical basis for the agricultural policy designation in Jianghan Plain.

1. Introduction

The "Planning for Promoting the Rise of Central China" put forward requirements for the development of characteristic agriculture in the middle reaches of the Yangtze River in terms of scale and standardization. Jianghan Plain is an important food production base and its level of agricultural development is not only related to the sustainable economic development in the plains, but also to the sustainable development of the entire middle reaches of the Yangtze River. In recent years, spatial distribution characteristics of regional economic development has become a hot issue in the field of economic geography and attracted widespread attention from many scholars[1]. By introducing geographical factors into economic analysis, we can scientifically explore spatial differences or spatial correlations between economic data, and then provide a theoretical basis for scientific decision-making. At present, scholars' research on the spatial distribution characteristics of agricultural development mainly focuses on the spatial distribution characteristics of leisure agriculture, urban agriculture and agricultural products, and most scholars adopt the methods of location commercial method, coefficient of variation method and spatial agglomeration method[2]. Most of these analysis methods focus on the spatial distribution characteristics of regional agricultural development at different sections of time. However, scholars pay little attention to the overall spatial layout of regional agricultural development and local spatial layout. Geostatistical analysis method refers to using probability theory and mathematical statistics to study geography which is proposed by South African engineer KRIGE in the estimation of gold reserves and gradually extended to the research fields of soil, water resources, agriculture, meteorology, etc[3]. We use this method to analyze the overall spatial distribution characteristics and local spatial distribution characteristics of agricultural development in Jianghan Plain.

2. Materials

2.1 study area

Jianghan Plain is located in the south-central Hubei Province, with latitudes 29°26′-31°10′N and longitudes 111°45′-114°16′E, as shown in figure 1. It covers a total area of approximately 46,000 km^2, an important part of the middle and lower reaches of the Yangtze River. Jianghan Plain is bordered by Zhijiang in the west, Wuhan in the east, Zhongxiang in the north, and Dongting Lake in the south. It includes Zhongxiang, Jingshan, Anlu, Yunmeng and other 17 counties, accounting for 24.7% of land in Hubei Province. The Jianghan Plain is a subtropical monsoon climate with excellent climate and abundant products which can produce rice, wheat, millet, cotton, hemp, oil, sugar, fish, vegetables and other agricultural products. It is known as the "land of fish and rice" and is an important food production base in China[4].

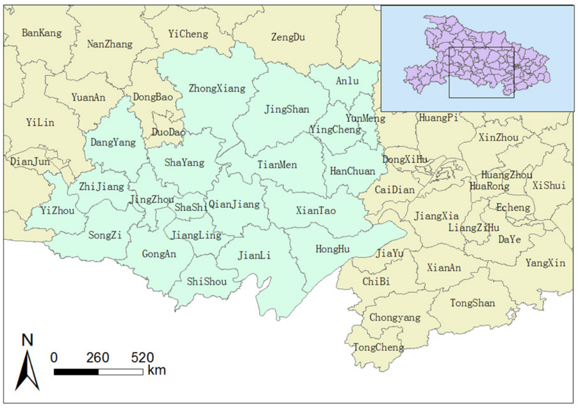


Figure 1. Location of study area.

2.2 Data Description

In this study, the necessary data of the agriculture in 21 counties were collected from *Hubei Statistical Yearbook* (2015-2017) which published by Hubei Provincial Bureau of Statistics. In 2016, the gross agricultural production value of Jianghan Plain was 212.3 billion yuan, Shashi, with the lowest total agricultural production value, had only 2.8 billion yuan, and the highest Jianli had reached 17.5 billion yuan. The gross agricultural production value varies greatly by region. Due to large differences in area and population between regions, the per capita agricultural production value was used to measure the level of agricultural development more accurately. In 2016, the highest per capita agricultural production value of Dangyang reached 29,700 yuan per people, and the lowest, Shashi, was 5300 yuan per people. There is still a big difference in per capita agricultural production.

3. Methodology

3.1 Spatial Weight Matrix

If the spatial econometric model of agricultural development needs to be established, the first step is to establish a matrix of spatial weights. Usually, a spatial weighting matrix W can be set as follows[4]:

$$W = \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1n} \\ w_{21} & w_{22} & \cdots & w_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ w_{n1} & w_{n2} & \cdots & w_{nn} \end{bmatrix}$$

Where, n represents the spatial correlation of n regions in different locations, and w_{ij} represents the proximity relationship between region i and region j. Based on the data of agricultural development in 21 counties of Jianghan Plain, we have established spatial proximity matrix.

3.2 Spatial autocorrelation analysis

3.2.1 Global Spatial Autocorrelation (Moran's I). Global spatial autocorrelation refers to the overall interpretation of the spatial distribution of spatial things. The most frequently used measurement of global spatial autocorrelation is Moran's I statistic[5]. The value of Moran's I ranges from -1 to 1. When Moran's I > 0, it represents that the spatial things are positively correlated in spatial distribution. When Moran's I < 0, it represents that the spatial things are negatively correlated in spatial distribution. The greater the absolute value of Moran's I, the more relevant it is. When Moran's I = 0, it means that spatial things have no correlation in spatial distribution[6]. The formula is expressed as follows:

$$\text{Moran's I} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(y_i - \bar{y})(y_j - \bar{y})}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}}$$

Where, n represents the number of samples, y_i and y_j represent the attribute values of bit region i and region j, respectively, W_{ij} represents the weight matrix that measures the relationship of spatial things, $\bar{y} = \frac{1}{n}\sum y_i$, $S^2 = \frac{1}{n}\sum(y_i - \bar{y})^2$.

3.2.2 Local Indicator of Spatial Association (LISA). LISA is an indicator to confirm the significance of hot spots suggested by Moran's scatterplot and it can indicate the local spatial autocorrelation and the significance of hot spots[7]. Its calculation formula is as follows:

$$I_{i,t} = \frac{(X_{i,t} - \bar{X}_t)}{S^2} \sum_j w_{ij}(X_{j,t} - \bar{X}_t)$$

Where, $X_{i,t}$ represents the number of observation to region i for year t, X_t represents the average value of the observation values of all the regions in the t-th year. w_{ij} represents a weight matrix that measures the interrelationship of spatial things.

4. Empirical analysis

4.1 Spatial Distribution of Agricultural Production Value in Jianghan Plain
The gross agricultural production value in 2014-2016 is shown on figure 2. The agricultural development level in the Jianghan Plain was uneven. The level of agricultural development in each county varies greatly. The three maps show the agricultural situation in 2014-2016. These three maps have the same classification criteria, the deeper the color, the higher the per capita agricultural production. It can be seen that the overall color is deepening year by year, and it shows that the agricultural production in the Jianghan Plain was gradually increasing. Dangyang and Zhijiang had always been the regions with the highest per capita agricultural production, Shashi was the lowest.

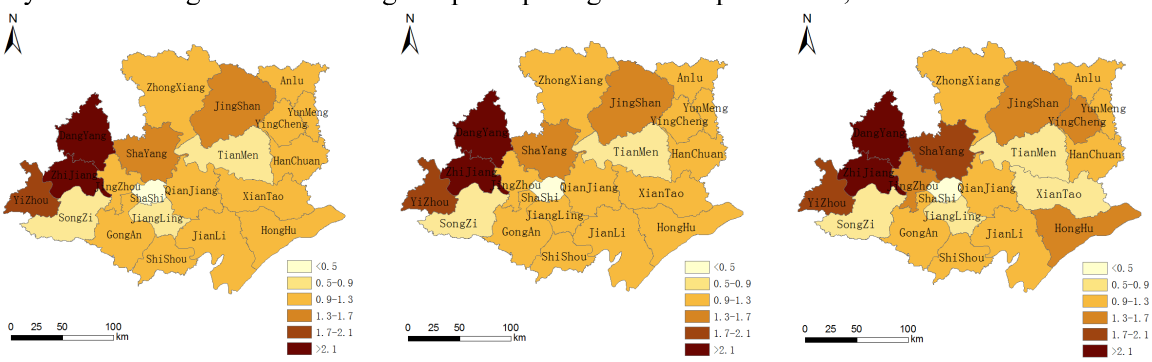
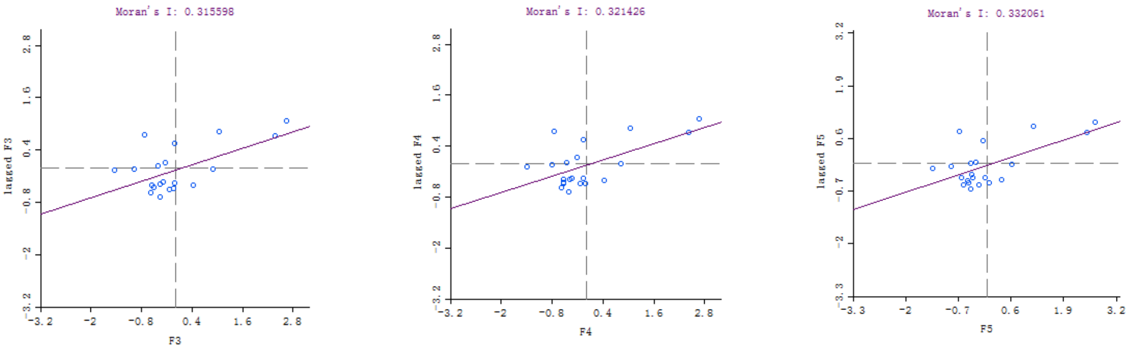


Figure 2. Spatial distribution of per capita agricultural production in Jianghan Plain (2014-2016).

4.2 Overall spatial pattern

4.2.1 Moran's Scatterplot Analysis. To provide more insight into local spatial association between cities, Moran's scatterplot is presented. Figures 3 displays Moran's scatterplots of the gross agricultural production values from 2014 to 2016. The Moran's I values for three years are 0.315598, 0.321426, and 0.332061, respectively. With respect to the evolution of Moran's I statistics over time, it is shown that the values of Moran's I statistics become higher as time goes by. Therefore, the results indicate the existence of significant and positive spatial autocorrelation between counties in agricultural development level. And the spatial autocorrelation had become increasingly noticeable. Positive spatial autocorrelation means that counties with a relatively high (or low) level of agricultural development are located near to cities with relatively high (or low) level of agricultural development, respectively.



Figures 3. Moran's scatterplots of the gross agricultural production values from 2014 to 2016

4.2.2 Overall Trend Chart. In figure 4, the X axis represents the east direction, the Y axis represents the north direction, and the Z axis represents the gross agricultural production value of each sample. Projecting each point value as a scatter plot onto the XZ and YZ planes can represent the trend effect changes in the north-south and east-west directions, respectively. It can be seen from Figure 4: 1) the spatial difference in the level of agricultural development in the Jianghan Plain had not changed much in the past three years. The gross agricultural value of the three years was high in the West and low in the East. That is, the level of agricultural development in the west was high, and the east was weak. 2) In the north-south direction, it shows an inverted U shape, the highest point was in the north-central, the south was higher than the north. In short, the level of agricultural development in the western part of the Jianghan Plain was much higher than that in the east, slightly higher in the central part than in the north and south, and slightly higher in the north than in the south.

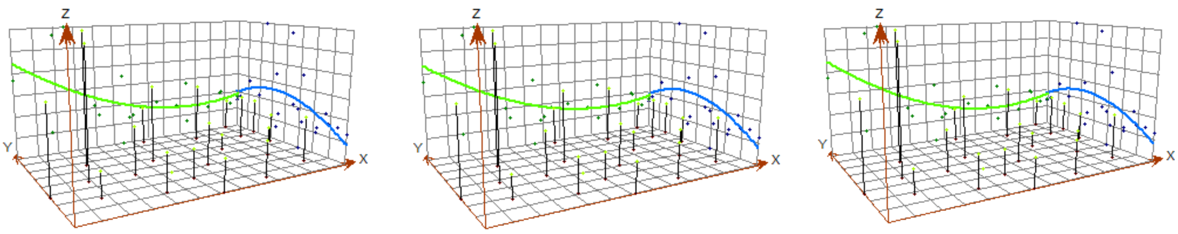


Figure 4. Trend chart of agricultural production in Jianghan Plain.

4.3 Local spatial pattern

The overall spatial pattern explains the level of agricultural development in the Jianghan Plain as a whole. However, there are large differences in the spatial distribution characteristics of the 21 counties in the plain. Therefore, we adopt the LISA statistics to further reveal the local spatial characteristics of agricultural development in Jianghan Plain. The colored region reached 0.05 significant level and different colours are used to represent different categories of spatial autocorrelation in the agricultural level of the Jianghan Plain. The local autocorrelation in the eastern part of the Jianghan Plain is not significant. In the past three years, Dangyang and Zhijiang in the northwest were high-high aggregation types, indicating that the northwest was the most developed part of agriculture. Songzi and Jingzhou were high-low aggregation types, which means that their level of agricultural development was lower than the surrounding areas. Gongan was low-low aggregation with low agricultural levels.

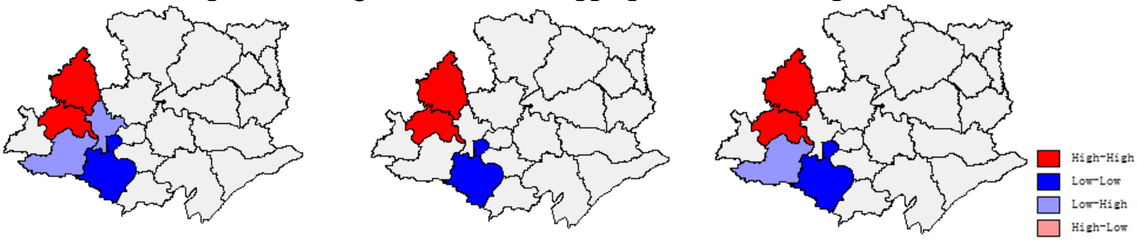


Figure 5. LISA aggregation diagram.

5. Conclusions

This paper uses geostatistical analysis to study the spatial distribution of agricultural development. The agricultural development in Jianghan Plain has a strong spatial correlation and a trend of increasing correlation, suggesting that the development of agriculture will have an impact on the surrounding areas. Areas with high levels of agricultural development will also drive the development of surrounding areas. Therefore, when formulating agricultural policies, policymakers should give full consideration to the spatial correlation of the region, encourage cooperation between regions, and promote the construction of a rural logistics public information platform between regions with strong spatial correlation.

The level of agricultural development in Jianghan Plain is unevenly distributed. The highest level of agricultural development in the Jianghan Plain is in the northwest, and the northern level of agricultural development is higher than in the south, western level is higher than in the eastern. In the formulation of the agricultural policy framework, it is necessary to consider not only the natural distribution characteristics of crops in various regions of the Jianghan Plain, but also the spatial distribution characteristics of agricultural development in various regions. It is necessary to actively guide and carry out inter-regional agricultural cooperation through various means and improve the market cooperation mechanism, so as to promote the formation of agricultural industrial clusters and gradually form a scientific and rational spatial distribution of superior agricultural products.

Acknowledgments

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