

# Spatial-Temporal Evolution Characteristics and Driving Factors of Agricultural Space in Jiangnan Plain from the Perspective of “Three-Zone Space”

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## Abstract

Studying the agricultural spatial distribution characteristics of Jiangnan Plain from 2000 to 2018 and its spatial-temporal transformation with ecological space and urban space is of great significance for optimizing the spatial structure of the country, enhancing the supply capacity of agricultural products, and ensuring food security. The research results show that during the period from 2000 to 2018, the agricultural spatial concentration in the area along the “Xiaogan-Jingzhou” link was relatively high, and the areas with large declines were mainly distributed in the flat areas between the Yangtze River and Han River; the space is continuously reduced by the occupation of ecological space and urban space, and ecological space and urban space have been improved respectively; agricultural space has been transformed into ecological space, and the largest urban space has been transformed. Ecological space has been transformed into agricultural space and urban space. Less urban space has been transformed into agricultural space and ecological space.

## Keywords

Three-Zone Space, Jiangnan Plain, Agricultural Space, Spatiotemporal Evolution, Driving Factors

## 1. Introduction

Agricultural space resources are the basic natural conditions for human beings to survive and develop. They are responsible for meeting people’s food needs and are also the basic driving force for urban development [1] [2] [3]. From the perspective of human survival and sustainable development, a reasonable agri-

cultural spatial pattern is an important guarantee for national food security. It is of great significance for optimizing the national spatial pattern, enhancing the supply of agricultural products, and promoting the healthy development of cities [4] [5] [6].

The current literature on agricultural space is mainly focused on three aspects: first, focusing on rural residents' villages, focusing on describing and analyzing the evolution of agricultural village space, and the evolution of the spatial pattern of rural settlements [7] [8] [9] [10]; second, focusing on the development of agricultural modernization, and studying the spatial distribution, types, measures and constraints of agricultural modernization development [11] [12] [13] [14] [15]; third, exploring the relationship between urbanization and cultivated land protection, and studying the root causes of the contradiction between urbanization and cultivated land protection, in order to achieve the protection of cultivated land and comprehensive coordination of urbanization and all land use [16] [17] [18] [19].

This article analyzes the agricultural spatial pattern distribution and spatial-temporal evolution characteristics of the Jiangnan Plain in different periods, and quantifies the mutual transformation between agricultural space, ecological space, and urban space in combination with the "three-zone space" background of the current land space planning, and analyzes and studies the driving force behind it.

## 2. Research Areas and Research Methods

### 2.1. Study Area

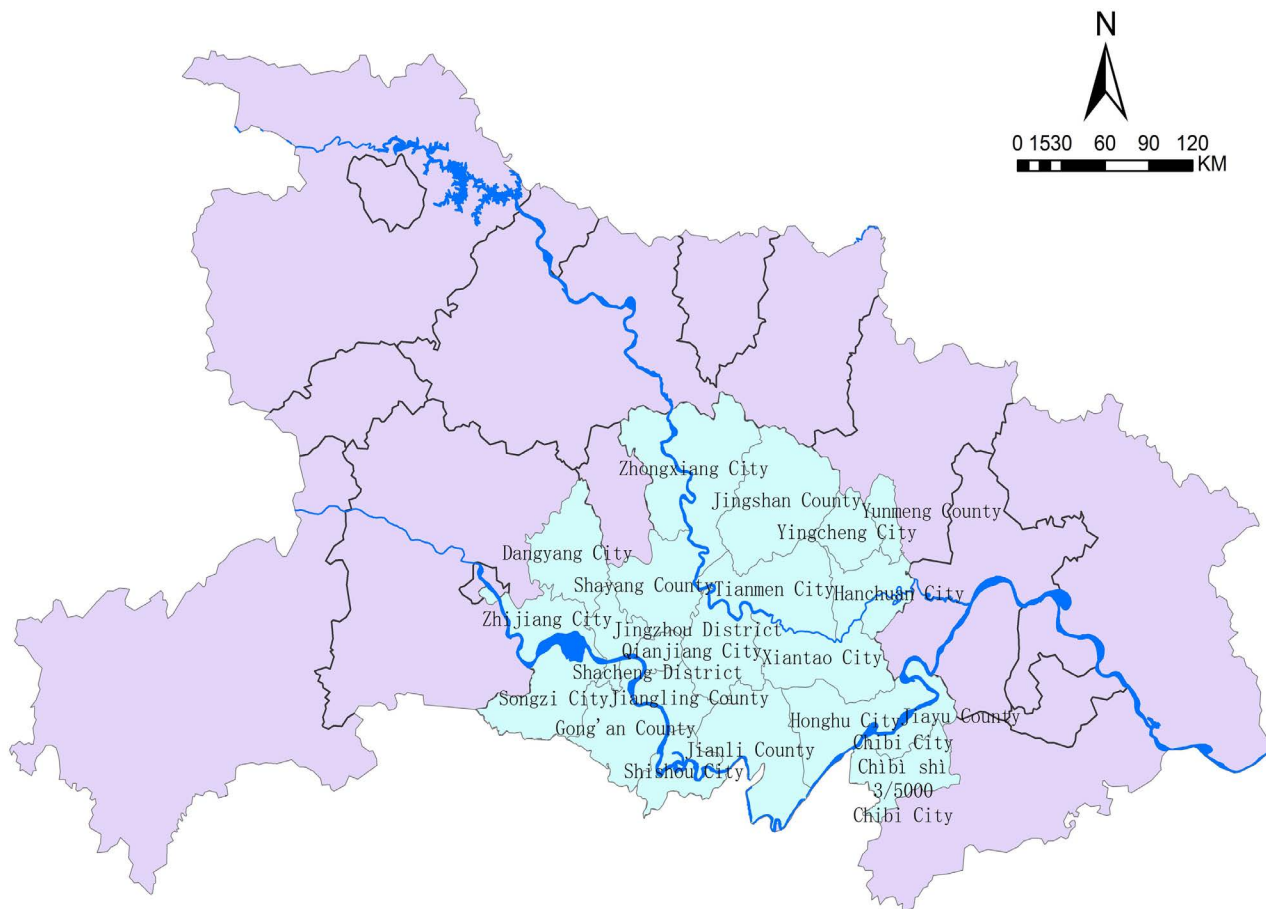
The Jiangnan Plain is located in the middle reaches of the Yangtze River and the central and southern parts of Hubei Province. It has an excellent climate, rich products, and developed agriculture. It is an important food producing area in China. A total of 21 counties (districts) including Jingzhou 2 districts, 3 cities and 3 counties, Yichang 2 cities, Jingmen 2 cities and 1 county, Xiaogan 2 cities and 1 county, Xianning 1 city and 1 county, and 3 cities directly managed by the province As the research object (see **Figure 1**), the total land area is 41,213.03 km<sup>2</sup>, and the total population at the end of 2018 reached 15,128,800.

### 2.2. Data Sources

The land use and "three-zone space" quantitative information involved in this article comes from Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences (RESDC) (<http://www.resdc.cn>) [20], and is obtained through factor extraction and overlay analysis. The demographic and economic data involved are from the Statistical Yearbook of Hubei Province (2000-2018), statistical bulletins of counties (districts) and cities and government work reports.

### 2.3. Research Method

The ArcGIS technology was used to extract remote sensing data for land cover in



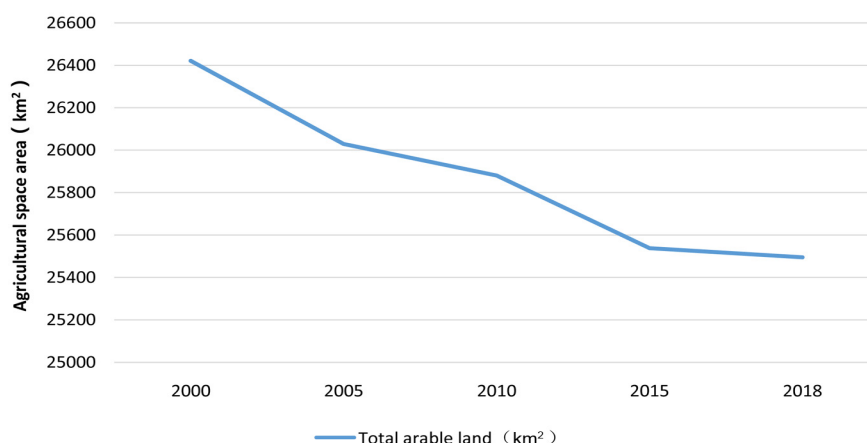
**Figure 1.** Location map of Jiangnan Plain.

the Jiangnan Plain in 2000, 2005, 2010, 2015, and 2018. According to the land use attributes, it was divided into six categories: cultivated land, forest land, grassland, waters, construction land and unused land. According to the “three-zone space” in the land space plan, the six types of space are integrated into three categories: agricultural space, ecological space, and urban space. Among them: agricultural space includes cultivated land, ecological space includes forest land, grassland, and water. Urban space is dominated by construction land. Unused land is included in urban space.

### 3. Change Process Analysis

#### 3.1. Total Change in Different Years

It can be seen from **Figure 2** that the agricultural space area of the Jiangnan Plain continued to decline from 2000 to 2018, from 26,421.20 km<sup>2</sup> in 2000 to 25,495.72 km<sup>2</sup> in 2018, a decrease of 925.48 km<sup>2</sup>. During this period, the most significant changes were in 00 - 05 and 10 - 15 years, which decreased by 391.58 km<sup>2</sup> and 342.73 km<sup>2</sup>, respectively; in 05 - 10, the downward trend was relatively gentle, which decreased by 148.54 km<sup>2</sup>; in 15 - 18, the changes were the smallest and only decreased 42.63 km<sup>2</sup>.



**Figure 2.** Changes in total agricultural space in different years.

### 3.2. Spatial Distribution Map and Area Statistics of Agriculture in Different Regions and Years

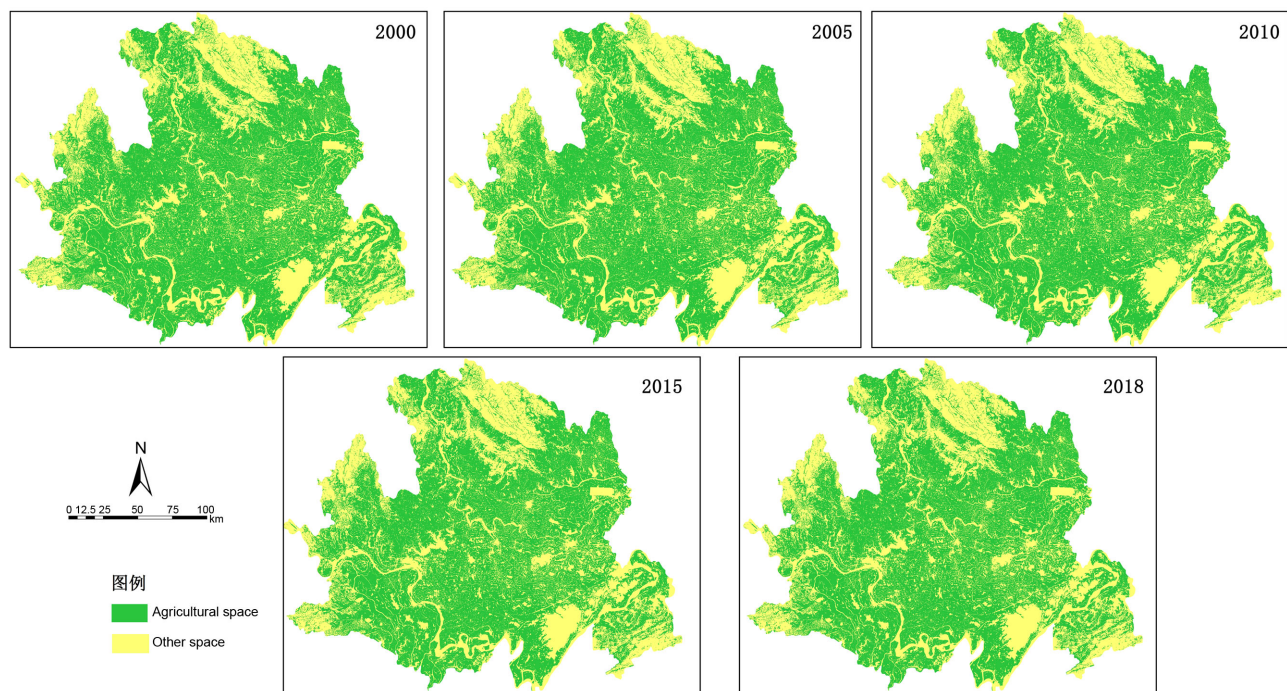
It can be seen from **Figure 3** that the agricultural space in the Jiangnan Plain is mainly concentrated and continuously distributed in Jingzhou District, Jiangling County, Jianli County, Shayang County, and Qianjiang City between the Yangtze River and Hanjiang River, and Gong'an County and Shishou south of the Yangtze River, as well as Tianmen, Hanchuan, Yingcheng and Yunmeng counties north of the Han River. Counties and cities with relatively sparse agricultural spatial distribution, such as Jingshan County and Honghu City, have a large area of non-agricultural space.

As can be seen from **Table 1**, the proportion of agricultural space in the Jiangnan Plain has been decreasing year by year, and the proportion of agricultural space in each county (district) has also shown a gradual decline. Yunmeng, Jiangling, and Shayang counted as three agricultural counties with over 80% of agriculture in 2000. By 2018, only Yunmeng County has more than 80%, and Jiangling and Shayang counties have fallen to 79.49% and 79.26%, respectively. In 2000, 10 counties (districts) and cities accounted for more than 60% of agriculture, including Yingcheng City, Tianmen City, Gongan County, Qianjiang City, Jianli County, Jingzhou District, Hanchuan City, Shishou City, and Xiantao City. And Shacheng District, the Shacheng District will fall to 55.52% by 2018, and other counties (districts) and cities will also show varying degrees of decline.

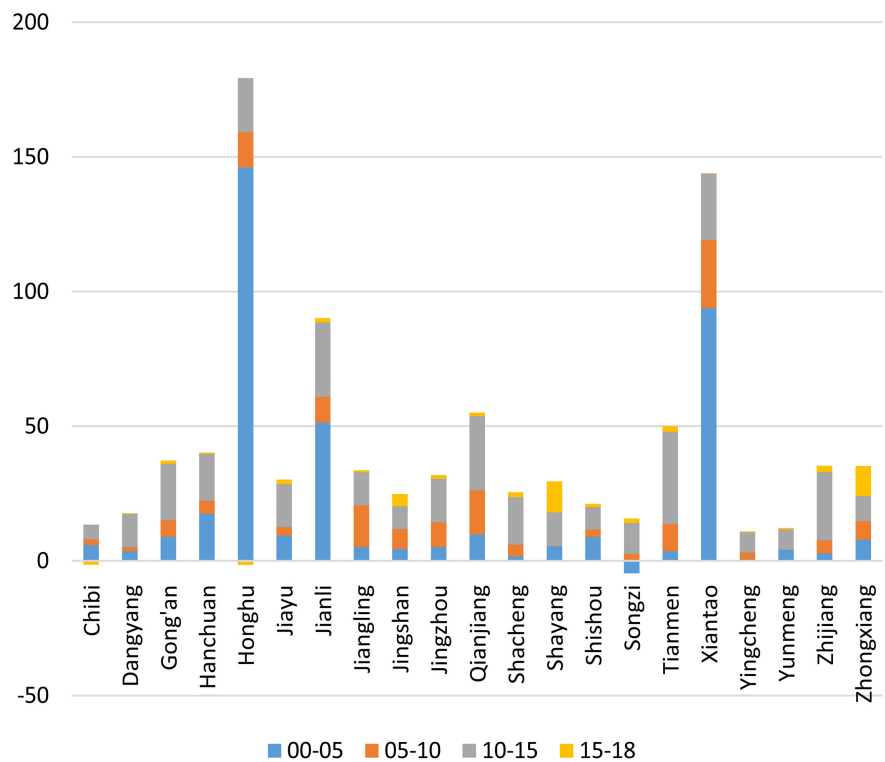
It can be seen from **Figure 4** that from 2000 to 2018, the largest change in agricultural space was in Honghu City, which reached 177.76 km<sup>2</sup>; followed by Xiantao City, which fell by 143.95 km<sup>2</sup>; Jianli County, Qianjiang City, and Tianmen City with a change of more than 50 km<sup>2</sup>. They are 90.13 km<sup>2</sup>, 55.11 km<sup>2</sup>, and 50.04 km<sup>2</sup> respectively; the smallest change is in Yingcheng, which has only decreased by 10.9 km<sup>2</sup>.

### 3.3. Location Quotient of Agricultural Space in Each County and City

Using the concept of location quotient to analyze the degree of agricultural spatial



**Figure 3.** Agricultural spatial distribution of Jiangnan Plain from 2000 to 2018.



**Figure 4.** Spatial changes in agriculture by region, 2000-2018.

agglomeration and professionalization [21] [22], the calculation formula is:

$$Q = \frac{a}{A} / \frac{b}{B}$$

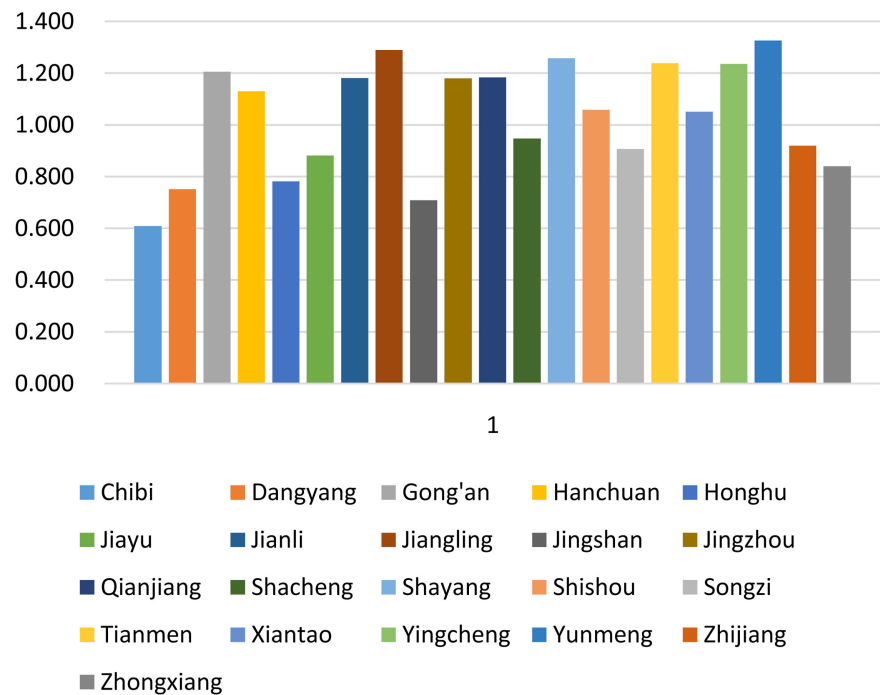
**Table 1.** Spatial data of agriculture in Jiangnan Plain, 2000-2018.

	2000			2005			2010			2015			2018	
Name	The total area	Agricul-tural space area km <sup>2</sup>	Propor-tion	Agricul-tural space area km <sup>2</sup>	Propor-tion	Agricul-tural space area km <sup>2</sup>	Propor-tion	Agricul-tural space area km <sup>2</sup>	Propor-tion	Agricul-tural space area km <sup>2</sup>	Propor-tion			
Chibi	1718.43	671.13	39.06%	665.21	38.71%	663.09	38.59%	657.70	38.27%	659.15	38.36%			
Dangyang	2128.79	1025.30	48.16%	1021.68	47.99%	1020.23	47.93%	1007.78	47.34%	1007.61	47.33%			
Gong'an	2268.14	1752.72	77.28%	1743.82	76.88%	1737.58	76.61%	1716.61	75.68%	1715.51	75.64%			
Hanchuan	1663.66	1205.36	72.45%	1187.84	71.40%	1183.06	71.11%	1165.56	70.06%	1165.14	70.03%			
Honghu	2511.76	1258.10	50.09%	1111.95	44.27%	1098.96	43.75%	1078.85	42.95%	1080.34	43.01%			
Jiayu	1035.66	585.24	56.51%	575.80	55.60%	572.72	55.30%	556.75	53.76%	555.07	53.60%			
Jianli	3133.29	2370.89	75.67%	2319.62	74.03%	2310.03	73.73%	2282.35	72.84%	2280.76	72.79%			
Jiangling	1064.75	879.98	82.65%	874.80	82.16%	859.34	80.71%	847.09	79.56%	846.37	79.49%			
Jingshan	3521.21	1600.73	45.46%	1596.25	45.33%	1588.87	45.12%	1580.42	44.88%	1575.96	44.76%			
Jingzhou	1035.50	783.48	75.66%	778.37	75.17%	769.14	74.28%	752.94	72.71%	751.57	72.58%			
Qianjiang	2024.36	1535.60	75.86%	1525.75	75.37%	1509.35	74.56%	1481.74	73.20%	1480.48	73.13%			
Shacheng	490.08	297.56	60.72%	295.90	60.38%	291.51	59.48%	273.96	55.90%	272.07	55.52%			
Shayang	2166.99	1746.98	80.62%	1741.51	80.37%	1741.37	80.36%	1728.97	79.79%	1717.49	79.26%			
Shishou	1416.15	959.99	67.79%	951.07	67.16%	948.32	66.96%	939.99	66.38%	938.83	66.29%			
Songzi	2173.35	1263.28	58.13%	1267.91	58.34%	1265.30	58.22%	1253.89	57.69%	1252.15	57.61%			
Tianmen	2639.98	2096.41	79.41%	2092.84	79.27%	2082.76	78.89%	2048.47	77.59%	2046.37	77.51%			
Xiantao	2526.23	1701.12	67.34%	1607.26	63.62%	1581.90	62.62%	1557.38	61.65%	1557.17	61.64%			
Yingcheng	1084.02	858.61	79.21%	858.10	79.16%	855.51	78.92%	847.97	78.22%	847.70	78.20%			
Yunmeng	611.21	519.62	85.01%	515.42	84.33%	515.39	84.32%	507.91	83.10%	507.42	83.02%			
Zhijiang	1564.94	921.56	58.89%	918.80	58.71%	913.91	58.40%	888.59	56.78%	886.26	56.63%			
Zhongxiang	4434.53	2387.54	53.84%	2379.74	53.66%	2372.75	53.51%	2363.46	53.30%	2352.31	53.05%			
total	41,213.03	26,421.20	64.11%	26,029.62	63.16%	25,881.03	62.80%	25,538.35	61.97%	25,495.72	61.86%			

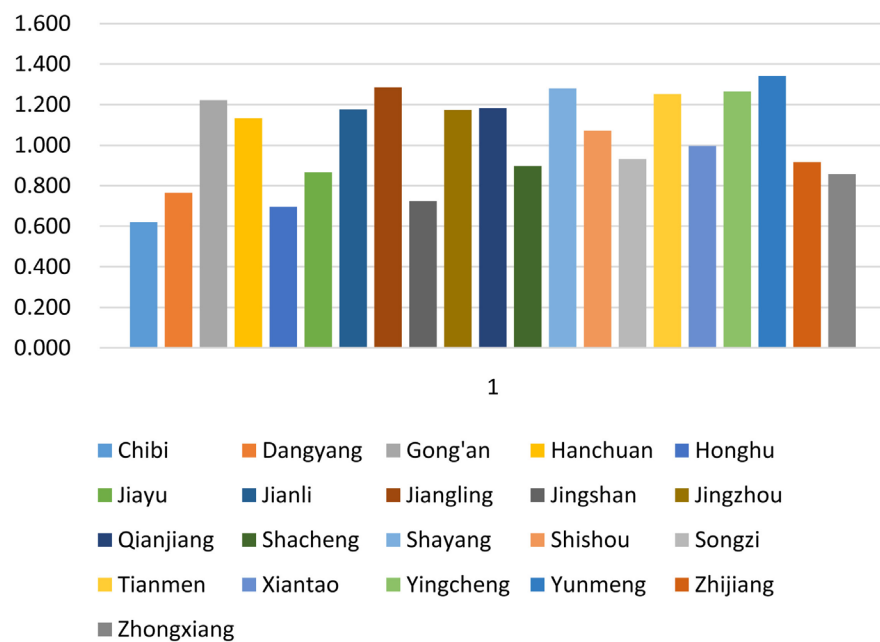
In the formula,  $Q$  represents the location quotient,  $a$  represents the agricultural space area of a county (district) city,  $A$  represents the total land area of the county (district) city,  $b$  represents the agricultural space area of the whole region, and  $B$  represents the total land area of the whole region.

It can be seen from **Figure 5** and **Figure 6** that from 2000 to 2018, Yunmeng County, Jiangling County, and Shayang County have always been in the top three agricultural space quotients, indicating that Yunmeng, Jiangling, and Shayang have a high degree of agricultural spatial concentration. Compared with other counties (districts) and cities in the Jiangnan Plain, it has a comparative advantage; in 2000, there were 9 regions with a location quotient greater than 1, and they were Tianmen City, Yingcheng City, Gong'an County, Qianjiang City, Jianli County, Jingzhou District, Hanchuan City, Shishou City, and Xiantao City





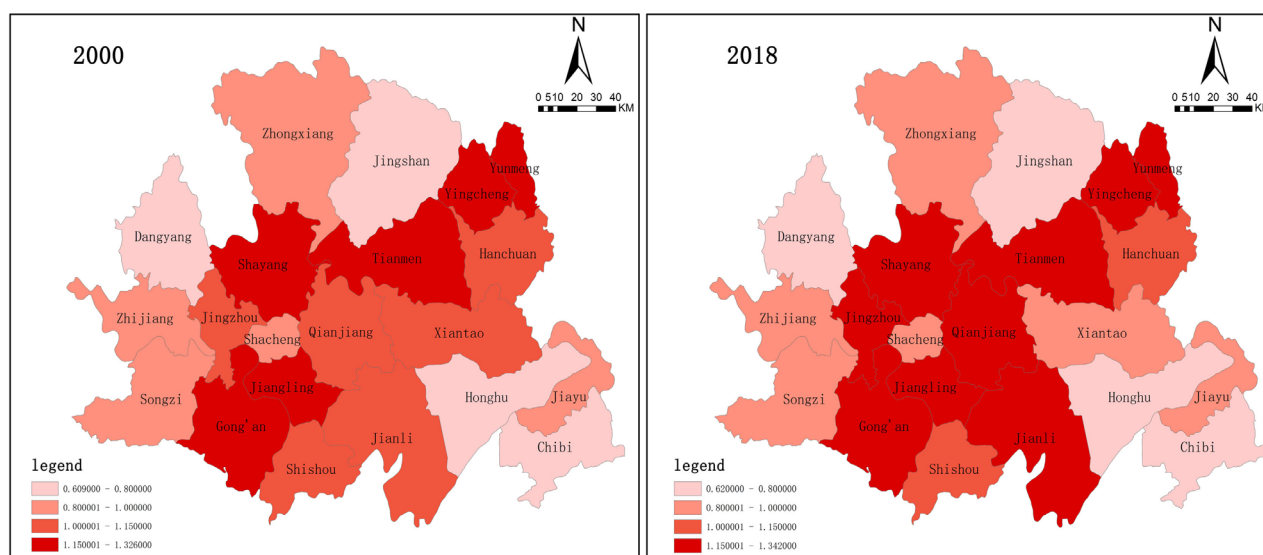
**Figure 5.** Location quotient of agricultural space by region in 2000.



**Figure 6.** Location quotient of agricultural space by region in 2018.

will fall to eight by 2018, of which Xiantao City has dropped below 1, indicating that the agricultural space of Xiantao City has changed significantly; Chibi City, Honghu City, Jingshan, and Dangyang have changed in the past 18 years.

Based on the location quotient, and the analysis of relevant data, using GIS to draw the spatial distribution map of the agricultural space location quotient of the Jiangnan Plain from 2000 to 2018 (Figure 7), we can see that the administrative



**Figure 7.** Spatial distribution map of agricultural spatial location quotients by region in 2000 and 2018.

units with a higher degree of agricultural spatial concentration are distributed in a centralized and continuous pattern. The spatial pattern is belt-shaped, mainly located between the Yangtze River and the Han River and in areas extending northeast and spreading southward, that is, the direction of the “Xiaogan-Jingzhou” connection has the largest agricultural spatial density, and decreases with the spread to both sides small.

### 3.4. “Three-Zone Space” Distribution Characteristics

The land space is divided into three categories: agricultural space, ecological space, and urban space. GIS is used to draw the spatial distribution maps of the three districts in different years in the Jiangnan Plain, and the area of the three types of space is quantified to obtain **Figure 8, Table 2**.

The analysis shows that in the past 18 years, agricultural space has been continuously occupied by ecological space and urban space and has declined; although ecological space has also been continuously occupied by urban space, it has increased due to the simultaneous occupation of agricultural space; urban space has shown an upward trend year by year.

On the whole, the “three-zone space” in the Jiangnan Plain has not risen or fallen violently. After nearly 20 years of rapid economic development, the proportion of various types of space has not changed significantly, and the territorial space structure remains relatively stable.

### 3.5. “Three-Zone Space” Mutual Transformation Characteristics

Based on the “three-zone space” distribution map of the Jiangnan Plain, Arcgis was used to superimpose land properties, and the conversion relationship between the “three-zone space” in each county (district) and city from 2000 to 2018 was obtained and quantified (**Figure 9**).



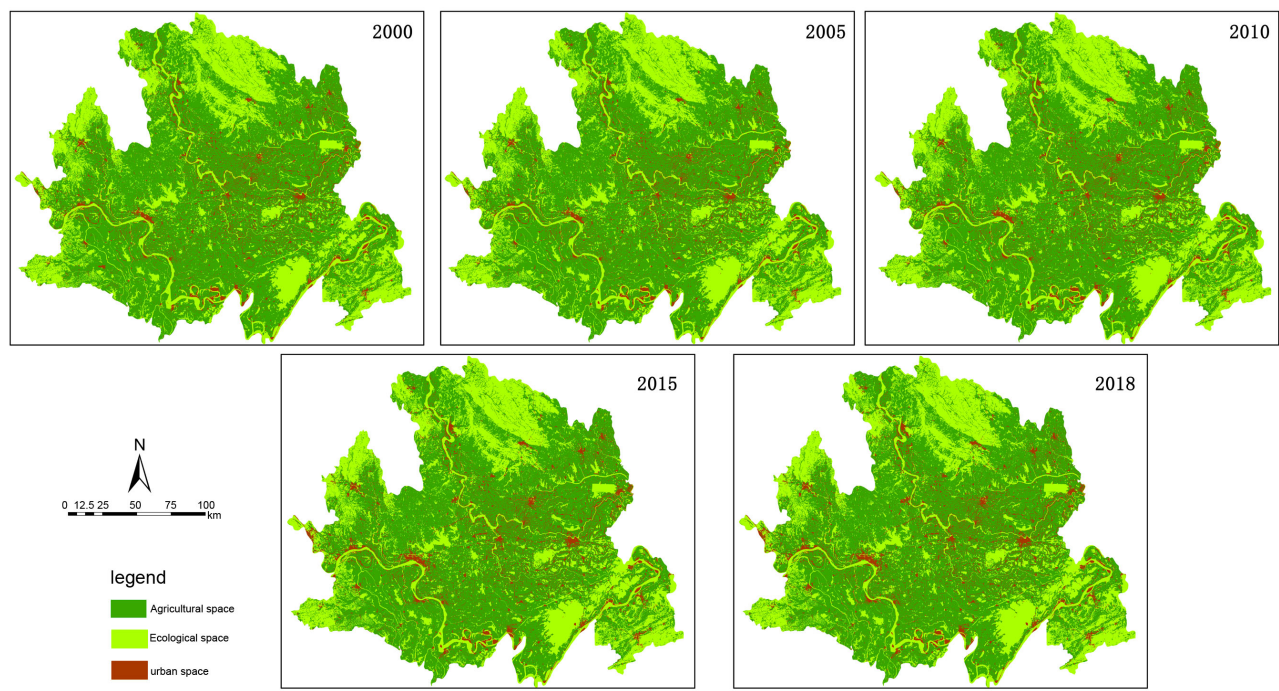


Figure 8. “Three-zone space” distribution map of Jiangnan Plain from 2000 to 2018.

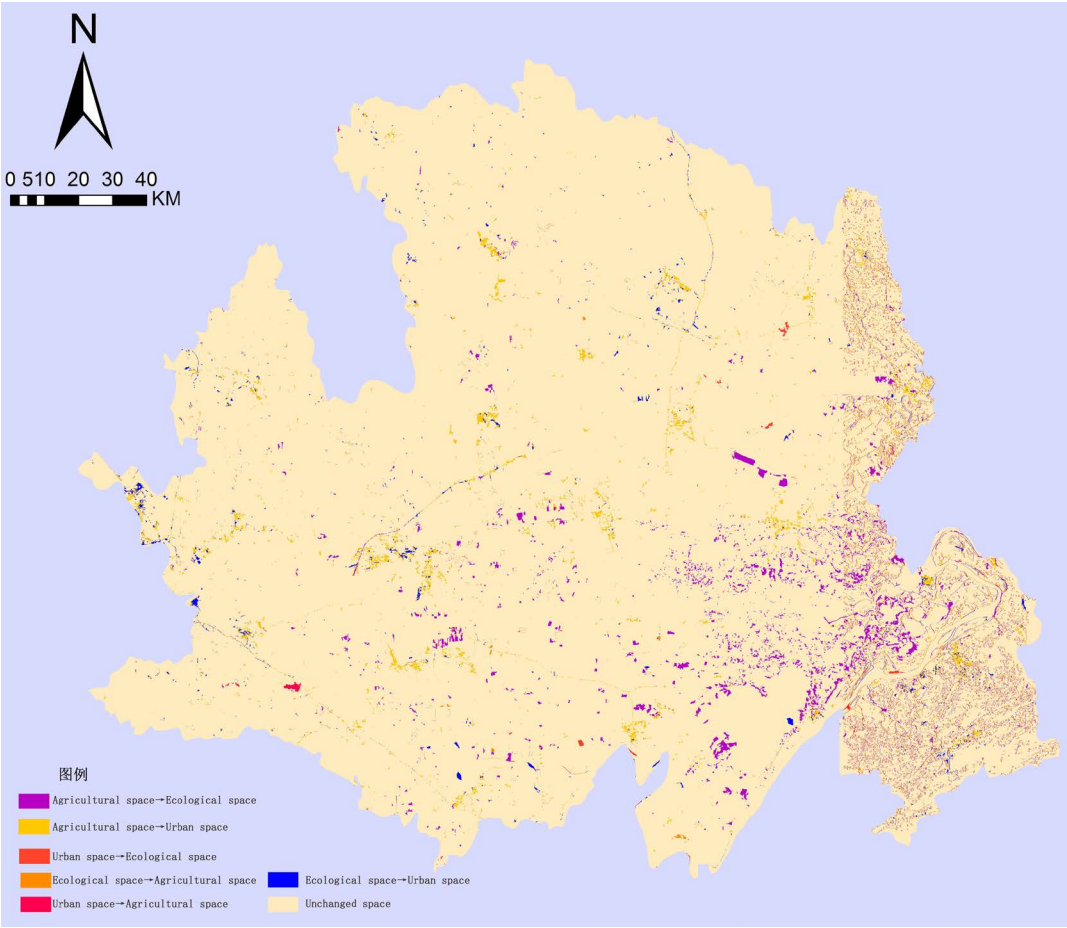


Figure 9. “Three-zone space” conversion map of Jiangnan Plain from 2000 to 2018.

**Table 2.** Data of “three-zone space” in Jiangnan Plain from 2000 to 2018.

	2000		2005		2010		2015		2018	
	Land area (km <sup>2</sup> )	Proportion	Land area (km <sup>2</sup> )	Proportion	Land area (km <sup>2</sup> )	Proportion	Land area (km <sup>2</sup> )	Proportion	Land area (km <sup>2</sup> )	Proportion
Agricultural space	26,421.20	64.11%	26,029.62	63.16%	25,881.07	62.80%	25,538.35	61.97%	25,495.72	61.86%
Ecological space	11,908.10	28.89%	12,265.83	29.76%	12,318.72	29.89%	12,331.16	29.92%	12,322.55	29.90%
Urban space	2883.73	7.00%	2917.58	7.08%	3013.24	7.31%	3343.52	8.11%	3394.77	8.24%
Total	41,213.03	100.00%	41,213.03	100.00%	41,213.03	100.00%	41,213.03	100.00%	41,213.03	100.00%

The analysis shows that: 1) The transformation of agricultural space into the largest ecological space, especially in Honghu City, Xiantao City, Chibi City and Jianli County, the scale of transformation is the most prominent, and has become the largest administrative unit of spatial function transformation in 18 years. These areas are rich in Water resources; 2) The conversion of agricultural space into urban space appears to varying degrees in counties (districts) and cities, and has become the mainstream trend of spatial conversion in most administrative units; 3) The conversion of ecological space into agricultural space Chibi City is the most obvious, followed by Jiayu County and Honghu City; 4) The conversion of ecological space into urban space is also more significant, of which Zhijiang City, Jiayu County, Honghu City, and Jingshan County have a larger increase; 5) The scale of transformation into agricultural space is relatively small, mainly distributed in Hanchuan City, Yunmeng County, Honghu City and other places; 6) Urban space is transformed into the least ecological space, mainly concentrated in Chibi City, Jiayu County, Hanchuan City and other places.

## 4. Driving Factor Analysis

### 4.1. Physical Geography

The natural geographical environment is the foundation that affects the composition and use of land and space, and often combined with factors such as location conditions and human history to determine the distribution characteristics of the “three-zone space” in the Jiangnan Plain: 1) Jingzhou has been the main production area of grain, cotton, and aquatic products. 2) Zhongxiang City, Jingshan County in the north of the Jiangnan Plain, and the western and southeastern areas are mostly mountainous and hilly, its functions are more significant; 3) Hanchuan City, Xiantao City, and Jiayu County in the eastern part of the Jiangnan Plain are located in the Wuhan City Circle, which is driven and affected by the regional growth poles; Zhijiang City and Dangyang City are located in Yichang Provincial Deputy Center has unique advantages in infrastructure construction and industrial structure optimization. Urban spatial expansion

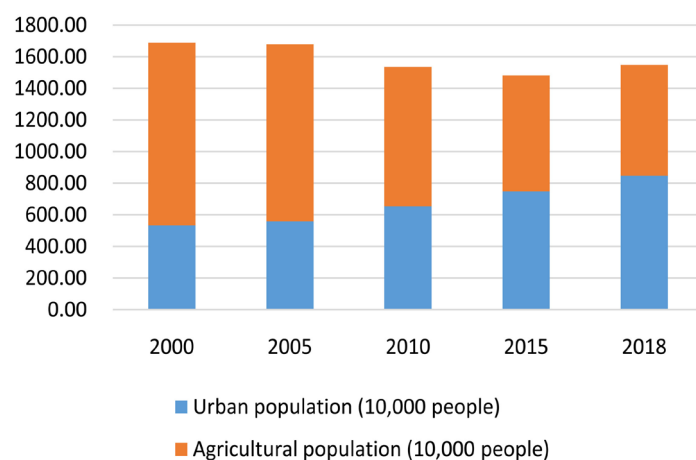
trend is more pronounced.

## 4.2. Policy Promotion

From the 18th National Congress of the People's Republic of China to respecting nature, complying with nature, and protecting nature, the idea of ecological civilization, to the 19th National Congress of the Communist Party of China, insisting on the harmonious coexistence of man and nature, in this context, Hubei Province promulgated more Policy articles such as "Plan for Hubei Province's Main Function Areas" (2012), "Outline of Hubei Ecological Province Construction Plan (2014-2030)" (2014), "Hubei Hanjiang Ecological Economic Belt Open Development Master Plan (2014-2025)" (2015), "Special Plan for Industrial Green Development of the Yangtze River Economic Belt in Hubei" (2017), etc. These policies provide institutional guarantees and management tools for the expansion of ecological space and urban space in the Jiangnan Plain from aspects of ecological environmental protection and transformation of industrial development methods.

## 4.3. Population Migration and Accelerated Urbanization

According to the statistics of the population of Jiangnan Plain from 2000 to 2018, we obtained the population change trend chart (Figure 10). The analysis shows that the total population of Jiangnan Plain has been decreasing year by year, a decrease of 10.47%, from 29.93% of the total population of Hubei Province in 2000 to 25.57% in 2018, but the number of urban population increased by 3,292,100, an increase of 59%, exceeding the 56% increase in urban population in Hubei Province during the same period, and the urbanization rate also increased from 31.62% in 2000 to 56.00% in 2018. Therefore, during this period, a large number of people flooded into towns, the urban construction land continued to expand, and the increase in urban space was a significant phenomenon. At the same time, the rural population in the Jiangnan Plain fell by 39.27%,



**Figure 10.** Trend of population change in Jiangnan Plain from 2000 to 2018.

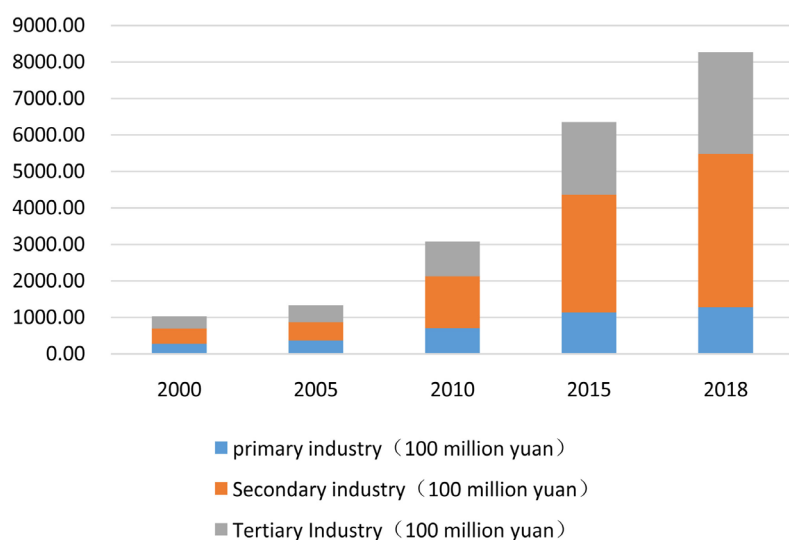
far exceeding the 30.11% decline in rural population in Hubei Province during the same period. The outward migration of the population has led to the emergence of wasteland and wasteland in many places, coupled with the increase in agricultural output and production efficiency, leading to the constant shrinking of agricultural space.

#### 4.4. Economic Development and Industrial Structure Transformation

Statistics on the industrial development of the Jiangnan Plain from 2000 to 2018 can be found in **Figure 11**. The analysis shows that: 1) In terms of industrial structure changes, the growth rates of the primary, secondary, and tertiary industries have reached 368.90%, 894.14%, and 738.14%, respectively. The development is more than twice that of the primary industry, and the proportion of tertiary industry has also changed from 26.5:41.1:32.4 in 2000 to 15.4:50.8:33.8 in 2018. This is in line with the increase in urban space and ecological space in the Jiangnan Plain. Consistent with the trend; 2) Compared with Hubei Province's tertiary industry ratios of 18.7:40.5:40.8 and 9.0:43.4:47.6 in 2000 and 2018, the proportion of the primary industry in the Jiangnan Plain is always much higher than the provincial average. This is determined by the positioning of the main grain producing areas of the Jiangnan Plain and good geographical conditions, natural environment, and historical development; the proportion of the secondary industry and the province's average ratio have gradually increased, indicating that the Jiangnan Plain actively optimizes and adjusts its industries Structure and achieved certain results.

### 5. Conclusions

Taking the agricultural space of Jiangnan Plain as an object, the spatial distribution and evolution rules of 2000, 2005, 2010, 2015, and 2018 were analyzed, and



**Figure 11.** Trend of industrial changes in Jiangnan Plain from 2000 to 2018.

the spatial and temporal evolution of agricultural space, ecological space, and urban space were analyzed from the perspective of “three-zone space”. The relationship between the three regions is analyzed from the aspects of physical geography, policy promotion, population migration and acceleration of urbanization, economic development and industrial structure transformation. The main conclusions are as follows:

1) The regions with a high degree of agricultural spatial concentration are distributed in the direction of the “Xiaogan-Jingzhou” connection; the areas with relatively small changes in agricultural space, that is, the regions with a large decline, are mainly distributed in the relatively flat terrain between the Yangtze and Han;

2) Agricultural space continues to be occupied by ecological space and urban space and declines. Although ecological space is also continuously occupied by urban space, it is increasing due to the simultaneous occupation of agricultural space, and urban space continues to expand and shows a rising trend year by year;

3) The transformation of agricultural space into ecological space has the largest scale; the transformation of agricultural space into urban space has appeared to varying degrees in each administrative unit and has become the mainstream trend of spatial transformation in most administrative units; the conversion of ecological space into agricultural space and towns space is also significant; less urban space is transformed into agricultural space and ecological space;

4) Natural geography conditions, location conditions, human history, and other factors work together to determine the distribution characteristics of the “three-zone space” in the Jiangnan Plain; the national and provincial governments have issued a series of policies to provide for the expansion of the ecological space and urban space in the Jiangnan Plain. But institutional safeguards and management methods still need to be further explored in terms of bottom-line control; the sharp increase in urban and rural population has become a powerful driving force for urban space expansion and agricultural space compression; changes in the industrial structure. The correlation mechanism between the change of industrial structure and the spatial structural adjustment it brings is very obvious. The adjustment of the proportion of the three industries provides a strong guide for the expansion of urban space and ecological space.

## Conflicts of Interest

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

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