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Research on the Measurement, Spatiotemporal Variations and Improvement Strategies of Sustainable Intensification of Cultivated Land

-- Taking The Yangtze River As An Example

Rui Duan

School of Public Administration, Sichuan University, Chengdu 610065, China

Abstract

Research on the level of sustainable and intensive arable land use contributes to promoting the sustainable and intensive development of arable land use in China, advancing sustainable agricultural development, and ensuring national food security. Taking the middle and lower reaches of the Yangtze River—a key grain-producing region in China—as a case study, this paper constructs an evaluation index system based on the relevant concepts of sustainable and intensive arable land use. By employing the super-efficiency SBM model and the Moran's I index, the study calculates the level of sustainable and intensive arable land use and examines its spatiotemporal variation across six major provinces in the region. The results indicate that: (1) From 2014 to 2023, the overall level of sustainable and intensive arable land utilization in the middle and lower reaches of the Yangtze River reached 0.77, which is relatively high. It generally showed a steady upward trend, though some provinces still have room for improvement. (2) In terms of temporal evolution trends, significant differences in the levels of sustainable and intensive arable land use were observed across provinces, which gradually narrowed over time, exhibiting the characteristics of "stability at high levels," "fluctuations in the middle," "rising from low levels," and "differences with commonalities." (3) In terms of spatial correlation, there is a certain degree of negative correlation among the sustainable intensive utilization levels of arable land across provinces in the middle and lower reaches of the Yangtze River; regions with high levels are more likely to be adjacent to those with low levels. (4) Targeted strategies for the sustainable and intensive development of arable land utilization—such as increasing the input of green elements into arable land and achieving large-scale agricultural operations—can provide a reference for the green utilization of arable land.

Keywords

Sustainable intensification of cultivated land, Spatial and temporal differentiation, Super efficiency SBM model, Moran's index.

1. Introduction

Food is an important guarantee for China 's economic development and people 's happiness[1]. Food security is also the cornerstone of ensuring national security and social stability[2]. By the end of 2025, China 's population has reached 1.405 billion[3]. Relevant forecast data show that China 's grain consumption demand will reach 685 million tons in 2030[4]. Therefore, we must adhere to the red line of 1.8 billion mu of cultivated land and implement the cultivated land protection measures of ' long teeth '[5]. Under the background of this era, the protection and intensive utilization of cultivated land resources is particularly important[6]. China urgently needs to explore a more environmentally friendly green agricultural development model, and promote the development of the economic output, social benefits and ecological protection of the agricultural sustainable management model[7]. Therefore, it is of practical urgency and importance to study the specific path of sustainable intensive development, which is helpful to further protect cultivated land resources and realize the sustainable intensive development of cultivated land use.

The academic research on the connotation of sustainable development originated earlier. Some scholars believe that the connotation of sustainable development includes the greater freedom of producers in production[21]. Some scholars value the role and contribution of ecological service systems in sustainable intensification[22]. Some scholars believe that sustainable agricultural development should include farmers ' quality training and rural life security[8]. In terms of research methods, the evaluation method of sustainable intensification of cultivated land use includes both qualitative analysis of the theory and quantitative analysis using various methods such as DEA data envelopment analysis[9]. According to the research needs, different scholars choose different levels of division, such as economic benefits, ecological benefits and social benefits, or carry out research from the perspective of input and output of sustainable and intensive cultivated land[10]. Some scholars have explored the spatial pattern and optimization path of sustainable intensive use of cultivated land by calculating the emergy input of the socio-economic system and eco-economic system of cultivated land in the study area through emergy analysis[12]. The spatial and temporal scales of evaluation are also diverse. The time scale is divided into panel data, time series data, etc., and the spatial scale is divided into micro county research, macro provincial research, etc[13].

From the perspective of the sustainable and intensive development path of cultivated land use, some scholars believe that there are differences in the sustainability level of land use intensification among different farmers, so farmers should be guided to transform to a livelihood type with a high level of intensive use[14]. On the other hand, it is necessary to strengthen farmers ' agricultural knowledge education and production technology training, popularize sustainable farming technology and sustainable intensive use awareness[15]. Since sustainable intensive technology is not easily adopted spontaneously by farmers, it is necessary for the government and relevant agricultural organizations to take measures to intervene, such as establishing a sound implementation rules-operation process-assessment indicators and other whole-process guidance systems to improve the overall quality of farmers[16], provide differentiated training services and subsidy policies for farmers, and promote the development of sustainable intensive agriculture[17].

At present, there are some commonalities in the existing literature on the research basis of sustainable intensification of cultivated land use, but the evaluation system and research scale need to be clarified and refined. In addition, domestic related research mostly focuses on provincial or municipal perspectives, and horizontal comparative studies on geospatial scales are rare. Therefore, this paper takes the main provinces in the main grain producing areas in the middle and lower reaches of the Yangtze River as an example, takes the Yangtze River Basin as the horizontal spatial reference and the ten-year vertical time span, analyzes and compares the spatial and temporal differences of sustainable intensification level of cultivated land use among provinces, and puts forward corresponding strategic suggestions.

2. Study Area and Data Sources

2.1. Study Area

The middle and lower reaches of the Yangtze River is one of the main grain producing areas in China. It mainly includes six provinces : Hubei, Hunan, Jiangxi, Anhui, Jiangsu and Zhejiang. It has unique natural conditions. There are many paddy soil and fluvo-aquic soil in this area, the soil layer is soft and the soil quality is high, especially suitable for rice, rape, cotton and other crops, among which the rice planting area and the total yield of rice are among the highest in the country. However, the distribution of water resources in the study area is uneven. The upstream areas such as Hubei and Hunan are abundant in water, while the downstream areas are reduced due to the expansion of urban water demand. At the same time, there are also problems such as water pollution and water quality decline. The region has convenient land and water transportation and developed economy, forming dense urban agglomerations and multiple billion-level industrial clusters. The golden waterway of the Yangtze River and the dense railway and highway networks provide the basis for regional economic integration and facilitate the coordinated development of various provinces, such as the inter-provincial ecological compensation implemented in Zhejiang Province.At the same time, there is also a certain game relationship between provinces and cities in ecological protection and industrial division of labor.

2.2. Data Sources

The data used to evaluate the sustainable intensification of cultivated land were collected from the Jiangxi Statistical Yearbook, Hunan Statistical Yearbook, Hubei Statistical Yearbook, Anhui Statistical Yearbook, Jiangsu Statistical Yearbook, Zhejiang Statistical Yearbook, the China Statistical Yearbook, as well as the official websites of the National Bureau of Statistics of China and the provincial governments. The study covers the period from 2014 to 2023. Missing data were supplemented using the linear interpolation method to ensure the completeness and consistency of the dataset.

3. Research Methods

3.1. Measurement of the Sustainable Intensification of Cultivated Land

This study measures the sustainable intensification of cultivated land using the super-efficiency Slacks-Based Measure (SBM) model proposed by Tone[23,24]. Compared with the conventional SBM model, the super-efficiency SBM model is capable of further ranking decision-making units (DMUs) with efficiency scores greater than or equal to 1, thereby improving the discriminatory power, effectiveness, and reliability of the evaluation results.

Specifically, the super-efficiency SBM model is formulated as follows.

Assume that there are *n* decision-making units (DMUs) involved in the cultivated land use process. Each DMU is characterized by *p* input variables, m_1 desirable outputs, and m_2 undesirable outputs. In this context, the input vector, desirable output vector, and undesirable output vector are defined as follows:

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$$\mathrm{X} = (\mathrm{x}_1, \mathrm{x}_2, \cdots, \mathrm{x}_\mathrm{n}) \in \mathrm{R}^{\mathrm{p}\times\mathrm{n}} \tag{1}$$

$$Y^g = \left(y_1^g, y_2^g, \cdots, y_n^g\right) \in R^{m_1\times n} \tag{2}$$

$$Y^u = (y_1^u, y_2^u, \cdots, y_n^u) \in R^{m_2\times n} \tag{3}$$

Thus, the objective function of the super-efficiency SBM model can be expressed as follows:

$$\mathrm{Min}\varphi = \frac{1-\frac{1}{p}\sum_{i=1}^{p}\frac{s_i}{x_i}}{1+\frac{1}{m_1+m_2}\left(\sum_{r=1}^{m_1}\frac{s_r^g}{y_r^g}+\sum_{r=1}^{m_2}\frac{s_r^u}{y_r^u}\right)} \tag{4}$$

s.t. $X\lambda + s = x_0, Y^g\lambda - S^g = y_r^g, Y^u\lambda + S^u = y_r^u$

$s \geq 0, S^g \geq 0, S^u \geq 0, \lambda > 0$

where φ denotes the level of the sustainable intensification of cultivated land; λ is the weight vector; p, x_i, s, and X represent the number of input indicators, the value of the input indicator, the slack variable associated with the input indicator, and the input indicator matrix, respectively. Similarly, m_1、y_r^g、s_r^g and Y^g denote the number of desirable output indicators, the value of the desirable output indicator, the slack variable associated with the desirable output indicator, and the desirable output matrix, respectively. Likewise, m_2, y_r^u, s_r^u, and Y^u represent the number of undesirable output indicators, the value of the undesirable output indicator, the slack variable associated with the undesirable output indicator, and the undesirable output matrix, respectively. When φ>1, the sustainable intensification of cultivated land is considered to be efficient; when φ< 1, it shows a relatively inefficient level, suggesting that further improvements can be achieved through measures such as optimizing factor inputs.

3.2. Construction of the Evaluation Indicator System

For the measurement of the sustainable intensification of cultivated land, this study constructs the evaluation indicator system based on the input–output framework widely adopted in previous studies [11]. Drawing upon the conceptual connotation of the sustainable intensification of cultivated land, the indicator system is organized into five dimensions: economic intensification, production efficiency, resource conservation, ecological sustainability, and social sustainability[18]. The complete evaluation indicator system is presented in Table 1.

3.3. Spatial Autocorrelation Analysis

Moran 's index is used as the core tool of spatial autocorrelation analysis to measure the distribution pattern of spatial data, including aggregation, dispersion or randomness, which can be further divided into global Moran 's index and local Moran 's index[19]. The global Moran index can show whether there is spatial autocorrelation between the study samples, and the range of Moran index is between (-1,1). The local Moran 's index is helpful to further observe the degree of spatial correlation between local regions[20]. In addition, the corresponding Moran scatter plot can be generated to judge the quadrant type of each region and further analyze its spatial heterogeneity.

4. Results and Analysis

4.1. Temporal Evolution of the Sustainable Intensification of Cultivated Land

Based on the Dearun analysis software, this paper measures the sustainable intensification level of cultivated land use in the main grain producing areas in the middle and lower reaches of the Yangtze River in China from 2014 to 2023 with the help of the super-efficiency SBM model including slack variables. See Table 2 for details, and the trend chart is shown in Figure 1 for details. In general, the overall level of sustainable intensification of cultivated land use in the study area is relatively high. The average level of sustainable intensification of cultivated land use in the past ten years has reached 0.77, and it has shown a steady upward trend. From the perspective of the evolution of the past ten years, the level of sustainable intensification of

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cultivated land use in various provinces shows the characteristics of ' high stability ', ' central fluctuation ', ' low rise ' and ' similarities in differences '.

Table 1. Evaluation Indicator System for the Sustainable Intensification of Cultivated Land

Primary Indicator	Secondary Indicator	Variable Description	Measurement	Unit	Dimension
Inputs	Land input	Crop sown area	Crop sown area	1,000 ha	Resource conservation
	Water resource input	Effective irrigated area of cultivated land	Effective irrigated area of cultivated land	1,000 ha	
	Labor input	Agricultural labor force	Number of employees in the primary industry × proportion of agricultural output value in the total output value of agriculture, forestry, animal husbandry, and fishery	10,000 persons	Economic intensification
	Energy input	Total agricultural machinery power	Total agricultural machinery power × proportion of agricultural output value in the total output value of agriculture, forestry, animal husbandry, and fishery	10,000 kW	
	Fertilizer input	Fertilizer consumption	Fertilizer consumption	10,000 tons	
	Pesticide input	Pesticide consumption	Pesticide consumption	10,000 tons	
Desirable Outputs	Economic output	Gross agricultural output value	Gross agricultural output value	RMB 100 million	Production efficiency
	Social output	Total grain production	Total grain production	10,000 tons	Social sustainability
Undesirable Outputs	Carbon emissions	Total carbon emissions from cultivated land	Carbon emissions from fertilizer, pesticides, agricultural plastic film, agricultural machinery, irrigation, and tillage × corresponding carbon emission coefficients	kg	Ecological sustainability

Among them, ' high stability ' means that the level of sustainable intensification of cultivated land use in Jiangxi Province is always at a relatively stable high level. The level of sustainable intensification of cultivated land use is in the range of (0.9,1), with a ten-year average of 0.99, and the range of change is minimal. The ' central fluctuation ' refers to the fluctuation of the sustainable intensification level of cultivated land use in Zhejiang and Jiangsu provinces. The ' central ' here is relative to other provinces in the study area. In fact, compared with other major grain producing areas in the country, the sustainable intensification level of cultivated land use in Zhejiang and Jiangsu provinces has also reached 0.71 and 0.85, respectively. 'Low rise ' means that in the early 2014, the level of sustainable intensification of cultivated land use in Hubei, Hunan and Anhui was at the end of the middle and lower reaches of the Yangtze River, which was 0.58,0.51 and 0.49 respectively, and then continued to rise until the end of 2023 to catch up with the overall level of the study area. The ' similarities in differences ' refers to the differences in the development trend of sustainable intensification of cultivated land use in various provinces in the study area. For example, Jiangxi has always been stable at a high level, Jiangsu has fluctuated and risen, and Hubei, Hunan, Zhejiang and Anhui have gradually risen steadily.

Table 2. Sustainable Intensification of Cultivated Land in the Provinces of the Middle and Lower Reaches of the Yangtze River, 2014–2023

Year	Hubei	Hunan	Jiangxi	Anhui	Jiangsu	Zhejiang
2014	0.8023	0.5138	1.0079	0.4854	0.7510	0.5069
2015	0.5331	0.5186	1.0002	0.5130	0.7749	0.5272
2016	0.5177	0.5201	1.0025	0.5050	0.7569	0.5579
2017	0.5428	0.5353	0.9785	0.5654	0.7862	0.5999
2018	0.5626	0.5396	1.0024	0.7670	0.8163	0.6701
2019	0.5770	0.5838	0.9537	1.0032	0.8294	0.7281
2020	0.6104	0.6754	1.0033	1.0088	0.8625	0.7891
2021	0.6781	0.7187	1.0110	1.0007	1.0003	0.8344
2022	0.7121	0.9563	0.9755	1.0008	1.0002	0.9218
2023	1.0064	1.0211	1.0256	1.0195	1.0256	1.0507

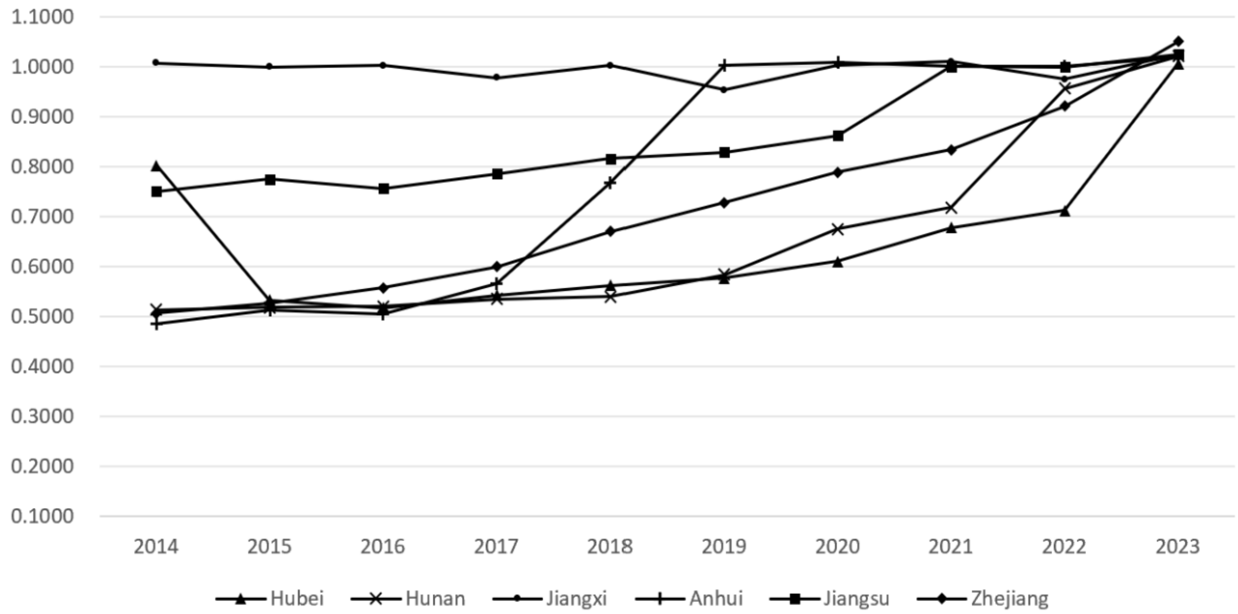

Figure 1. Trends in the Sustainable Intensification of Cultivated Land across the Provinces of the Middle and Lower Reaches of the Yangtze River, 2014–2023

4.2. Spatial Correlation Analysis of the Sustainable Intensification of Cultivated Land

4.2.1. Global Spatial Autocorrelation Analysis

The results presented above reveal clear spatial differences in the sustainable intensification of cultivated land across the middle and lower reaches of the Yangtze River. Considerable variation can be observed not only in the measured values but also in the temporal evolution patterns among provinces. To further investigate whether these differences exhibit spatial dependence, spatial autocorrelation was examined from both global and local perspectives using Moran's I.

Global Moran's I was calculated in Stata 18.0 based on the sustainable intensification values obtained in the previous analysis. The calculation results are summarized in Table 3.

Table 3. Global Moran's I of the Sustainable Intensification of Cultivated Land in the Middle and Lower Reaches of the Yangtze River, 2014–2023

Year	Moran' I	Z-value	P-value
2014	-0.514	-1.363	0.086
2015	-0.497	-1.510	0.065
2016	-0.463	-1.395	0.081
2017	-0.455	-1.268	0.102
2018	-0.328	-0.585	0.279
2019	-0.156	0.180	0.429
2020	-0.185	0.061	0.476
2021	-0.072	0.513	0.304
2022	-0.239	-0.316	0.376
2023	-0.200	0.000	0.500

Table 3 shows that the Global Moran's I values remained negative throughout the study period, indicating that the spatial distribution of sustainable intensification of cultivated land in the middle and lower reaches of the Yangtze River was generally characterized by negative spatial autocorrelation. Statistical significance was observed only during 2014–2016, when the corresponding P-values were below 0.10, whereas the remaining years did not reach the conventional significance threshold.

The lack of statistical significance in most years may be related to the limited number of provincial samples included in this study. In addition, locally significant observations may offset each other, making the overall spatial pattern less apparent. The results point to that spatial autocorrelation among the six provinces was relatively weak and varied over time. Even so, the consistently negative Moran's I values demonstrate that provinces with relatively high levels of sustainable intensification tended to be located next to provinces with comparatively lower levels.

4.2.2. Local Spatial Autocorrelation Analysis

The global Moran 's index is mainly used to analyze whether there is spatial autocorrelation and the degree of spatial autocorrelation in the study area, which cannot indicate the differences and changes between the local areas. In order to further explore the spatial distribution differences such as the scope and location of spatial differentiation or agglomeration in various provinces, Stata18.0 software was used to calculate the local Moran index of the sustainable intensification level of cultivated land use in ten years from 2014 to 2023. The Moran scatter plot distribution area of each province is shown in table 4.

It can be observed that Jiangsu Province fell in the fourth quadrant HL type from 2014 to 2018, and fell in the first quadrant HH type from 2019 to 2023, indicating that the level of sustainable intensification of cultivated land use in Jiangsu Province is always high, and it has regional linkage with surrounding provinces, which has played a certain role in improving the level of sustainable intensification of cultivated land use in surrounding areas. In addition, Anhui Province was located in the second quadrant LH type during 2014-2017 and in the fourth quadrant HL type after 2019, indicating that the level of sustainable intensification of cultivated land use in Anhui Province rose from the original regional low value to the regional high value, reflecting the agricultural development practice and the exploration of sustainable intensification of cultivated land use in Anhui Province from 2014 to 2023.

Table 4. Moran Scatter Plot Quadrant Classification of the Sustainable Intensification of Cultivated Land in the Middle and Lower Reaches of the Yangtze River, 2014–2023

Year	Quadrant I (HH)	Quadrant II (LH)	Quadrant III (LL)	Quadrant IV (HL)
2014	None	Hunan, Anhui, Zhejiang	None	Hubei, Jiangxi, Jiangsu
2015	None	Hunan, Zhejiang, Anhui, Hubei	None	Jiangxi, Jiangsu
2016	None	Hunan, Zhejiang, Anhui, Hubei	None	Jiangxi, Jiangsu
2017	None	Hunan, Zhejiang, Anhui, Hubei	None	Jiangxi, Jiangsu
2018	Anhui	Hunan, Zhejiang, Hubei	None	Jiangxi, Jiangsu
2019	Jiangsu	Hubei, Zhejiang	Hunan	Anhui, Jiangxi
2020	Jiangsu	Hubei, Zhejiang	Hunan	Anhui, Jiangxi
2021	Jiangsu	Hubei, Zhejiang	Hunan	Anhui, Jiangxi
2022	Jiangsu	Hubei, Zhejiang	None	Hunan, Anhui, Jiangxi
2023	Jiangsu, Zhejiang	Hubei	None	Anhui, Jiangxi, Hunan

5. Conclusions

Based on the statistical panel data of six provinces in the middle and lower reaches of the Yangtze River from 2014 to 2023, this paper constructs an input-output index system, selects a super-efficiency SBM model with undesired output for measurement, and uses Moran 's index to analyze the temporal evolution and spatial correlation of the sustainable intensification level of cultivated land use in the middle and lower reaches of the Yangtze River. The following conclusions are drawn:

The main conclusions are as follows: (1) From 2014 to 2023, the total grain output and total agricultural output value in the middle and lower reaches of the Yangtze River increased, the total carbon emissions gradually decreased, and the overall agricultural development was stable.

(2) From 2014 to 2023, the overall level of sustainable intensification of cultivated land use in the middle and lower reaches of the Yangtze River was relatively high. The average level of sustainable intensification of cultivated land use in the past ten years reached 0.77, and it showed a steady upward trend. Although irrigation water, mechanical power and other inputs have promoted the increase of expected output such as total agricultural output value, they have also brought corresponding carbon emissions. There is still room for improvement in the level of sustainable intensification of cultivated land use in some provinces.

(3) In the analysis of time series evolution, the level of sustainable intensification of cultivated land use in each province is quite different, and then gradually decreases, showing the characteristics of ' high stability ', ' central fluctuation ', ' low rise ' and ' similarities in differences '. Among them, the level of sustainable intensification of cultivated land use in Jiangxi Province has always been at a relatively stable high level. The fluctuation of Zhejiang and Jiangsu provinces has risen, and the three provinces of Hubei, Hunan and Anhui have been relatively low in the early stage, and then continue to rise and catch up with the overall level of the study area.

(4) In the spatial correlation analysis, there is a certain negative correlation between the level of sustainable intensification of cultivated land use in the provinces of the middle and lower reaches of the Yangtze River. The areas with high level of sustainable intensification of cultivated land use are more likely to be adjacent to the areas with low level, but the spatial

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distribution has a certain randomness, and the spatial correlation is not stable. And there is a certain regional linkage development between adjacent provinces.

6. Discussion

6.1. Increasing Green Agricultural Input Factors

Through the analysis of the input-output index of cultivated land use and the sustainable intensive level of cultivated land use in the provinces in the middle and lower reaches of the Yangtze River, it can be seen that the carbon emission output in the study area mainly comes from the use of agricultural machinery, agricultural film and pesticide and fertilizer. The use of traditional pesticides and fertilizers and agricultural machinery will increase the yield of cultivated land, but also bring problems such as soil acidification and agricultural non-point source pollution. Therefore, it is necessary to promote the green use of these input factors and increase the proportion of green input factors of cultivated land. In addition, we can increase the research and development of agricultural science and technology, promote the popularization and use of green agricultural machinery and equipment ; strengthen the supervision of the materials and methods of agricultural film use, select more durable and environmentally friendly agricultural film materials such as biodegradable agricultural film, and strictly control the use time and farming rhythm of agricultural film ; encourage and support farmers to choose to apply organic fertilizer, and accurate the use of chemical fertilizers and pesticides, reduce the redundancy of chemical fertilizers and pesticides, improve the quality of cultivated land.

6.2. Promoting Large-Scale Agricultural Operations

The scale of per capita cultivated land in the middle and lower reaches of the Yangtze River is small. On the one hand, due to the mountainous and hilly terrain in some regions and provinces, it is not conducive to the reclamation and concentration of large areas of cultivated land; on the other hand, the reason is that the development and expansion of the city has squeezed the space of cultivated land, and the fragmentation of cultivated land is common. The smaller the scale of cultivated land, the more unfavorable the widespread use of agricultural machinery, resulting in high agricultural production costs, low scale efficiency, the lower the returns to scale and returns to scale, and the lower the income level of farmers, forming a vicious circle. Therefore, we should promote the realization of large-scale operation of agriculture, improve the support of land property right structure and social service system, and improve the efficiency of agricultural production. For example, the development of supporting agricultural machinery leasing, plant protection custody and other producer services, to provide a sound agricultural socialization services; improve the safeguard measures of land transfer and the risk buffer mechanism of part-time farmers, promote the transfer of land management rights so as to realize the reintegration of production factors, and improve the compatibility of scale and farmers ' livelihood.

6.3. Improving Farmers' Disposable Income and Consumption Structure

Farmers ' income level and consumption preference directly affect the allocation efficiency of technology and ecological factors in the process of agricultural production. On the one hand, the increase of farmers ' disposable income can alleviate farmers ' excessive dependence on short-term agricultural income and enhance farmers ' willingness to pay for environmental quality and green technology. On the other hand, the improvement of consumption structure can promote the change of farmers ' own resource allocation priority. If farmers ' consumption structure changes from survival type to quality type, the market demand of agricultural products will also change accordingly, thus guiding the transformation of cultivated land use to high quality. Relevant government departments can strengthen human capital investment by expanding rural e-commerce, agricultural product processing and other employment channels, relying on professional farmers ' training to enhance their ability to connect to high-end markets and increase farmers ' income levels ; improve the quality and price mechanism of agricultural products, such as expanding the coverage of green food certification and strict market supervision, preventing ' bad money driving out good money ', and improving farmers ' consumption structure and consumption quality.

6.4. Strengthening Regional Coordinated Development

Based on the change of the landing point of some provinces in the Moran scatter plot, we found that areas with high levels of sustainable intensification of cultivated land use can play their own demonstration role, radiate and drive the improvement of sustainable intensification of cultivated land use in surrounding areas, and emphasize the principle of " advanced with backward. " For example, regions with low levels of sustainable land use and intensification should actively learn from the advanced experience of surrounding high-level regions, and build sustainable land use and intensification models with unique advantages or characteristics according to local conditions. In areas with high level of sustainable and intensive use of cultivated land, we should actively guide the cultivation of regional factor market, promote the compensation transfer and compensation balance index of cultivated land occupation and inter-provincial carbon emission quota, realize the redistribution of resource factors through market mechanism, and promote regional coordinated development.

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