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Comparative Analysis of the Utilization Efficiency of Major Agricultural Resources in Hebei Province

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Abstract The utilization efficiency of resources is one of the important factors affecting the development of modern agriculture. Using production function method and ratio analysis method, we carry out the horizontal comparison of the utilization efficiency of major agricultural resources such as arable land, agricultural machinery power and chemical fertilizer in Hebei Province and the national level, and the vertical comparison of the utilization efficiency of major agricultural resources between the prefecture-level cities in the province. The results show that the utilization efficiency of agricultural resources in Hebei Province is below the national average, and there are significant differences in the utilization efficiency of agricultural resources between the prefecture-level cities in the province.

Key words Agricultural resource efficiency, Regression analysis, Ratio analysis, Hebei Province

Hebei is a province of the People's Republic of China in the North China region. Most of central and southern Hebei lies within the North China Plain. The western part of Hebei rises into the Taihang Mountains (Taihang Shan), while the Yan Mountains (Yan Shan) run through northern Hebei, beyond which lie the grasslands of Inner Mongolia. Hebei has a continental monsoon climate, with cold, dry winters, and hot, humid summers. Temperatures average -16 to -3 °C (3 to 27 °F) in January and 20 to 27 °C (68 to 81 °F) in July; the annual precipitation ranges from 400 to 800 millimeters (16 to 31 in), concentrated heavily in summer. In 2011, Hebei's GDP was 2.40 trillion yuan (US \$ 379 billion), an increase of 11% over the previous year and ranked 6 th in the PRC. Hebei Province is one of the major producing areas of grain and oil in China. Due to climatic differences in regional conditions, there are a lot of types of crops. Hebei's main agricultural products are cereal crops including wheat, maize, millet, and sorghum. Cash crops like cotton, peanut, soya bean and sesame are also produced. The area of arable land in Hebei Province reaches 6 million hectares, ranking fourth in the country. At the end of 2011, the total power of agricultural machinery was 101.513 million kilowatts, ranking third in the country; the application rate of agricultural chemical fertilizer was 3.229 million tons, ranking fifth in the country. However, the grain yield in Hebei Province was 29.759 million tons in 2011, ranking seventh in China. High input, low output, and low utilization efficiency of agricultural resources, have become a bottleneck restricting agricultural development in Hebei Province.

Therefore, it is necessary to enhance the study of utilization efficiency of agricultural resources, and understand the actual situation of the current agricultural production, to promote agricultural development in Hebei Province.

1 Research methods

Firstly, using Eviews, we carry out linear regression analysis of the factors influencing the grain output value during the period $1990-2010$ in China, and thus identify the main factors influencing the utilization efficiency of agricultural resources.

Then we calculate the production consumption coefficients of various resources as the evaluation indicators for ratio analysis, and carry out the horizontal comparison of the utilization efficiency of major agricultural resources such as arable land, agricultural machinery power and chemical fertilizer in Hebei Province and the national level, and the vertical comparison of the utilization efficiency of major agricultural resources between the prefecture-level cities in the province.

Finally, using the system clustering analysis method, we carry out the comprehensive analysis of overall utilization of agricultural resources in Hebei province.

2 Empirical analysis of the utilization efficiency of agricultural resources in Hebei Province

2.1 Regression analysis The agricultural production function method is as follows;

$$Q = A \times X_1^{\alpha_1} X_2^{\alpha_2} \cdots X_p^{\alpha_p}$$

where Q represents the agricultural output amount; A represents the conversion coefficient efficiency of agriculture; X_i represents the amount of agricultural input i ; α_i represents the coefficient of elasticity of agricultural input; P represents the total number of input factors.

Taking logarithm of both sides, it is linearly transformed into multivariate linear model:

$$\ln(Q) = \ln(A) + \alpha_1 \ln(X_1) + \alpha_2 \ln(X_2) + \cdots + \alpha_p \ln(X_p) + \mu$$

Then we select total national agricultural output value Q during the period $1990-2010$ (10^8 yuan), total power of agricultural machinery X_1 (10^4 kw), application rate of chemical fertilizer X_2

(10^4 t), growing area of crop X_4 (10^3 hm^2), agricultural power consumption X_3 (10^8 kwh), to carry out regression analysis, in order to explore the factors affecting the utilization efficiency of agricultural resources.

After Eviews calculation, we get the following regression results:

$$\ln(Y) = -1.68\ln(X_1) + 1.27\ln(X_2) + 1.18\ln(X_3) + 7.00\ln(X_4) - 75.57 \quad R^2 = 0.98$$

$$\text{Se: } (0.66) \quad (0.53) \quad (0.78) \quad (2.81) \quad (26.36)$$

$$P(\ln(X_1)) = 0.02 \quad P(\ln(X_2)) = 0.03 \quad P(\ln(X_3)) = 0.15 \quad P(\ln(X_4)) = 0.02$$

At the 0.05 significance level, X_3 does not pass test, that is, the impact of agricultural power consumption on grain yield is not significant. The regression is carried out after removing this factor. We get the following follows:

$$\ln(Y) = -2.34\ln(X_1) + 1.96\ln(X_2) + 10.45\ln(X_4) - 105.14 \quad R^2 = 0.98$$

$$\text{Se: } (0.52) \quad (0.28) \quad (1.73) \quad (18.41)$$

The probability of application rate of total power of agricultural machinery X_1 (10^4 kw), chemical fertilizer X_2 (10^4 t), and growing area of crop X_4 (10^3 hm^2), is less than the significance

level of 0.05. And the adjusted $R^2 = 0.974 \ 941$, and the fitting degree of the model is good.

It can be seen that the agricultural resources of agricultural machinery, chemical fertilizer and arable land have a significant impact on agricultural output value, so we use arable land resources, application rate of chemical fertilizer, and total power of agricultural machinery as the main factors, to carry out the comparative analysis of the utilization efficiency of agricultural resources.

2.2 Ratio analysis The consumption coefficient of various resources is used as comparative indicator to analyze the utilization efficiency of resources.

Consumption coefficient of one resource = Input of this resource/Total output of agriculture.

Total grain output is selected as the total agricultural output indicator, to calculate the consumption coefficient of various resources of the entire country, and Hebei Province in the period 2000 – 2009, as well as the consumption coefficient of various resources of various prefecture-level cities in Hebei Province in 2009. Then we carry out comparative analysis. The results are shown in Table 1 and Table 2.

Table 1 The consumption coefficient of major agricultural resources in the entire country and Hebei Province in the period 2000 – 2009

Year	Consumption coefficient of arable land resource		Consumption coefficient of chemical fertilizer resource		Consumption coefficient of machinery power resource	
	Nationwide	Hebei	Nationwide	Hebei	Nationwide	Hebei
2000	3.38	3.54	0.09	0.11	1.14	2.74
2001	3.44	3.61	0.09	0.11	1.22	2.91
2002	3.38	3.67	0.09	0.11	1.27	3.06
2003	3.54	3.62	0.10	0.12	1.40	3.25
2004	3.27	3.51	0.10	0.12	1.36	3.28
2005	3.21	3.38	0.10	0.12	1.41	3.27
2006	3.05	3.13	0.10	0.11	1.46	3.16
2007	3.06	3.05	0.10	0.11	1.53	3.21
2008	2.95	3.00	0.10	0.11	1.55	3.28
2009	2.98	2.98	0.10	0.11	1.65	3.39

Table 2 The consumption coefficient of major agricultural resources in the prefecture-level cities of Hebei Province in 2009

Region	Consumption coefficient of arable land resource	Consumption coefficient of chemical fertilizer resource	Consumption coefficient of machinery power resource
Shijiazhuang City	1.999 391	0.096 161	3.880 200
Chengde City	3.855 346	0.117 699	3.168 187
Zhangjiakou City	8.298 705	0.115 126	3.435 085
Qinhuangdao City	2.605 096	0.161 273	3.597 338
Tangshan City	2.585 880	0.124 942	3.393 857
Langfang City	2.646 328	0.088 741	3.551 782
Baoding City	2.144 665	0.078 673	2.039 302
Cangzhou City	2.440 149	0.069 137	2.538 965
Hengshui City	2.445 219	0.074 851	2.523 064
Xingtai City	2.486 823	0.083 746	2.228 644
Handan City	2.369 029	0.102 097	2.942 157

2.2.1 Analysis of the utilization efficiency of arable land resources. In geography and agriculture, arable land is land

ploughed or tilled regularly, generally under a system of crop rotation. According to definitions and survey recommendations by the Food and Agriculture Organization (FAO), used by for example Eurostat and the World Bank, arable land is agricultural land occupied by crops both sown and harvested during the same agricultural year, sometimes more than once. Land is also considered arable if used as temporary meadows for mowing or pasture, market and kitchen gardens; as well as temporarily fallow land – not seeded for one or more growing seasons, yet not left idle for more than five years.

Permanent crops that occupy the land for a number of years, and don't need replanting after each annual harvest-like coffee, rubber, flowering shrubs, fruit, nut trees and vines – are not counted as existing on arable land, but as existing on permanent cropland. Permanent pastures and meadows used for grazing, land mowed for hay or silage not included in a crop rotation scheme, and abandoned land resulting from shifting cultivation is also not

counted as arable, along with lands with built-on and barren areas, forests and woodlands.

Although constrained by land mass and topology, the amount of arable land, both regionally and globally, fluctuates due to human and climatic factors such as irrigation, deforestation, desertification, terracing, landfill, and urban sprawl. Researchers study the impact of these changes on food production. Arable land is the most important agricultural production materials, whose utilization efficiency can affect the sustainable use of arable land and socio-economic development of China.

The consumption coefficient of arable land resources refers to the acreage of cultivated land occupied for the production of one kg of grain. The smaller the consumption coefficient of arable land resources, the higher the utilization efficiency of arable land resources.

By comparing the consumption coefficient of arable land resources of the entire country and Hebei Province in the period 2000–2009, it can be found that the utilization efficiency of arable land resources in Hebei Province is slightly lower than in the entire country, but the difference is not significant.

In the long run, the trend of change of both is consistent. The consumption coefficient of arable land resources in Hebei Province fluctuates between 2.9 and 3.7. This consumption coefficient of arable land resources underwent a gradual decline after 2002, indicating that the utilization efficiency of arable land resources in Hebei Province is gradually improving.

The reasons for the efficiency improvement are as follows:

(i) The government sticks to the guideline of developing agriculture through science and technology, popularizes the scientific and technical knowledge, promotes efficient agriculture, and mobilizes the enthusiasm of farmers by policies.

(ii) The water conservancy conditions are improved, the farming systems are changed, and the mechanization of agricultural production is improved.

(iii) The quality of chemical fertilizer and other agricultural materials is improved.

Horizontally, the utilization efficiency of arable land resources in Shijiazhuang City is the highest in Hebei Province, followed by Baoding City.

The consumption coefficient of arable land resources of Zhangjiakou City and Chengde City is higher than the provincial average, that is, the utilization efficiency of arable land resources of the two cities is not high.

There is little difference in the utilization efficiency of arable land resources between the remaining cities, and the utilization efficiency of arable land resources is slightly higher than the provincial average.

The reasons for low utilization efficiency of arable land resources in Zhangjiakou City and Chengde City are as follows:

(i) The cities and towns are expanded blindly, the construction goes after what is big and foreign, and the land use structure is irrational, with low output efficiency.

(ii) There are many idle rural houses and empty villages, and the construction land per capita is expanded year by year.

(iii) The terrain is special. Zhangjiakou City has a total area of 3 686 155 hectares, and a total area of arable land is 898 751 hectares.

It is divided into two natural management areas, the areas above dam and the areas below dam. The area of the areas above dam is 12 480 square kilometers, with an elevation of 1300–1600 meters, belonging to the plateau region; in the areas below dam, the terrain is complex, with undulating hills interweaving valleys, and the area is 24 467 square kilometers, mountains accounting for 56.8%.

A high proportion of the plateau and mountainous terrain leads to the low utilization efficiency of arable land resources in Zhangjiakou City.

2.2.2 Analysis of the utilization efficiency of agricultural machinery power resources. The consumption coefficient of agricultural machinery power resources means the agricultural machinery power used for the production of one kilogram of food. The higher the agricultural machinery power coefficient, the higher the utilization efficiency of machinery power resources.

We carry out comparative analysis of the consumption coefficient of agricultural machinery power resources between Hebei Province and the entire country in the period 2000–2009.

It is found that the consumption coefficient of machinery power resources in Hebei Province is 2.5–3.5, and the consumption coefficient of machinery power resources in the entire country is 1–1.7, and we see that the consumption coefficient of machinery power resources in Hebei Province is obviously higher than the consumption coefficient of machinery power resources in the entire country. That is, the utilization efficiency of machinery power in Hebei Province is far below the national average.

We initially conclude the reasons as follows:

(i) The agricultural extension service system is not perfect, and there are a lot of problems to be solved.

(ii) The investment in agricultural mechanization is not enough.

(iii) The infrastructure for agricultural machinery is poor, which needs to be further improved and developed.

Through the horizontal comparison of consumption coefficient of agricultural machinery power in 11 cities of Hebei Province, it is found that the average consumption coefficient of agricultural machinery power in Hebei Province reaches 3.06. The consumption coefficient of agricultural machinery power is the lowest in Baoding City, followed by Xingtai City (2.23).

The cities with the consumption coefficient of agricultural machinery power higher than the provincial average include Shijiazhuang City, Zhangjiakou City, Qinhuangdao City, Tangshan City and Langfang City. So the machinery power of these five cities restricts the improvement of the utilization efficiency of agricultural resources.

The municipal government should popularize the technical

knowledge on agricultural machinery, and increase the maintenance of agricultural machinery.

2.2.3 Analysis of the utilization efficiency of chemical fertilizer resources. Fertilizer (or fertiliser) is any organic or inorganic material of natural or synthetic origin (other than liming materials) that is added to soil to supply one or more plant nutrients essential to the growth of plants. According to FAO statistics, the chemical fertilizer contributes as high as 50% of crop production.

However, the improvement of application rate of chemical fertilizer will damage the soil, decrease air quality, contaminate the groundwater resources, make the crop quality decline, and lead to a bunch of other problems. Therefore, the rational use of chemical fertilizer and the improvement of the utilization efficiency of chemical fertilizer become especially important.

By comparing the consumption coefficient of chemical fertilizer resources between the entire country and Hebei Province in the period 2002–2009, it is found that the consumption coefficient of chemical fertilizer resources in Hebei Province is higher than the national average, that is, the utilization efficiency of chemical fertilizer resources in Hebei Province is slightly lower than the national level.

Thankfully, the average consumption of 0.1186 kg of chemical fertilizer for the production of one kilogram of grain in 2003 was reduced to the average consumption of 0.1086 kg of chemical fertilizer for the production of one kilogram of grain in 2009. The utilization efficiency of chemical fertilizer resources in Hebei Province is improved.

However, from 2006 to 2009, for the entire country or Hebei Province, the utilization efficiency of chemical fertilizer grew slowly, which shows that the single improvement of the utilization efficiency of chemical fertilizer resources is limited, and to ensure food production, it is necessary to improve the comprehensive overall output capacity of agricultural production factors.

Horizontally, the provincial average consumption coefficient of chemical fertilizer is 0.11, namely 0.11 kg of chemical fertilizer will be consumed for the production of one kg of grain.

The city with the lowest consumption coefficient of chemical fertilizer is Cangzhou City (0.069), followed by Hengshui City with the consumption coefficient of chemical fertilizer of 0.075. The cities with the consumption coefficient of chemical fertilizer higher than the provincial average include Chengde City, Zhangjiakou City, Qinhuangdao City and Tangshan City.

The reasons are as follows:

(i) The application rate of chemical fertilizer is too high or too low, the application method is wrong, and the selected type of chemical fertilizer is inappropriate.

(ii) After the application of fertilizer, the fertilizer is soaked in the soil due to inappropriate application time, resulting in volatilization wastage.

2.3 Comprehensive analysis Cluster analysis or clustering is the task of grouping a set of objects in such a way that objects in the same group (called a cluster) are more similar (in some sense

or another) to each other than to those in other groups (clusters). It is a main task of exploratory data mining, and a common technique for statistical data analysis, used in many fields, including machine learning, pattern recognition, image analysis, information retrieval, and bioinformatics. Cluster analysis itself is not one specific algorithm, but the general task to be solved. It can be achieved by various algorithms that differ significantly in their notion of what constitutes a cluster and how to efficiently find them.

In order to better reflect differences in the utilization efficiency of agricultural resources between the 11 cities in Hebei Province, we carry out data standardization of the consumption coefficient of arable land resources, the consumption coefficient of machinery power resources, and the consumption coefficient of chemical fertilizer resources, and then use SPSS software for cluster analysis.

Classification results obtained are as follows:

{1: Baoding City, Cangzhou City, Hengshui City, Xingtai City}; {2: Shijiazhuang City, Chengde City, Qinhuangdao City, Tangshan City, Langfang City, Handan City}; {3: Zhangjiakou City}.

Based on the consumption coefficient of agricultural resources, the consumption coefficient of agricultural resources is negatively correlated with the utilization efficiency of agricultural resources, and the consumption coefficient of agricultural resources is negative in Baoding City, Cangzhou City, Hengshui City, Xingtai City and Handan City.

It indicates that the utilization efficiency of agricultural resources of these cities is higher than the average level of Hebei Province, and they fall within the category of regions with better utilization efficiency of resources.

The utilization of agricultural resources is very close in Shijiazhuang City, Chengde City, Qinhuangdao City, Tangshan City and Langfang City, at the middle level in Hebei Province. The utilization of agricultural resources in Zhangjiakou City is the worst, which needs to be improved. There are prominent regional differences in the utilization efficiency of agricultural resources in the province.

3 Conclusions

Using the ratio analysis and cluster analysis, we analyze the utilization efficiency of three agricultural resources (agricultural machinery, chemical fertilizer and arable land) in Hebei Province, and draw the following conclusions.

(i) The utilization efficiency of agricultural resources in Hebei Province is below the national average, and especially the utilization efficiency of machinery power is obviously lower than the national average, suggesting that there might be surplus in the machinery power of Hebei Province, with serious waste.

This may be associated with the government policy. The go-vaggricultural machinery for farmers, and many farmers fear that this policy will be cancelled in the future, so they are eager to purchase agricultural machinery, without taking into account the

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