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The Research on Impact Factors and Characteristic of Cultivated Land Resources Use Efficiency---take Henan Province, China as a Case Study

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Abstract

Based on the background of construct the national grain strategy project of Henan province core and construct Zhongyuan Economic Zone, considering the Henan province's cultivated land resources use efficiency and food security, using multiple linear regression model and the principal component analysis to analyze the cultivated land resources' use efficiency between 1999-2008 of Henan province, drew this decade, cultivated area remain basically stable, Cultivated land utilization overall efficiency is high, and established the food production, even in successive years grain output reached a high yield, population density, urbanization rate, per capita GDP, multiple crop index, per hectare fertilizer rate is the greatly influenced factors of influence cultivated land resource utilization efficiency. The main factor that influences grain output has converted from per hectare fertilizer to the quantity and quality of labors in per hectare; the increase of multiple crop index and level of agricultural mechanization are the important factors that influence the grain output. Finally, proposed to improve the cultivated land resource utilization efficiency of Henan province and rational utilization of cultivated land resources countermeasures. Based on the analysis above, this paper indicate that: 1) Promote urbanization, strengthen land management to protect cultivated land resources; 2) Control copulation and improve land use efficiency; 3) Improve water resources in a rational allocation between sectors; 4) Increase input in agriculture, science and technology, to improve land productivity.

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1. Main text

Cultivated land is the scarcest and most valuable resources in the development of China's agriculture and rural economy, which plays an indispensible and foundational role in the sustainable development of the agriculture and domestic economy. As China is a country with the biggest population, its sufficiency rate of grain has important effect on its domestic food production and the development tendency of its consumption and agriculture. Since 1980s, the cultivated land supply of our country has shown a continuous decrease, getting the food demand and cultivated land supply into a tight balance. The contradiction between the balanced quantity and the decreasing quality has become a prominent problem in our country's use of cultivated land resources. The improving of the land resources use benefit, apart from being limited by the natural condition of the region, is also closely related to the regional social economic development, planting patterns, farming habits, investment capability and cultivated land infrastructure construction, etc. The scarcity and shortage of the cultivated land resources in our country have become factors to limit the survival and development in our country. In provinces such as Shandong, Guangdong, Hubei, Guangdong and Guizhou, the use benefit of cultivated land has shown a decreasing tendency. The newly published The Plan of Increasing One Hundred Billion Jin More Grain Production Capability (2009-2020) by the State Council has also stressed the importance of protecting the cultivated land and food security, and set more accurate goals and more detailed measures for the land protection and grain production.

The Henan Province has been one of the major grain producing regions in our country for many years, and makes great contribution to our country's food security. With the quick development of social economy, Henan as an agriculture giant will play an increasingly important role in ensuring the country's food supply and security. As the major grain producing region, the total grain output of which accounts for 10% of the total output in China, Henan not only is very important to ensure the whole country's food security, the problems occurred in the land use are also typical and have representativeness. With the development of social economy in Henan, many relevant factors related to cultivated land resources use change day by day. The grain production is not so steady and varies greatly, which have significant effect on regional food security.

The research and discuss on the factors that will influence the use of cultivated land resources are helpful to recognize and reveal the main problems in regional food production, and have important reference value for making and adjusting policies about the use of cultivated land and improving the ways of land resources use. This paper analyzes the cultivated land use benefit in Henan Province in 1999 and 2008 by means of principal component analysis (PCA), and discusses the main factors that influence the use benefit of cultivated land resources in Henan, as well as the influencing mechanism and relevant measures and suggestions to solve the problems.

2. The general situation of the region under the research

Henan Province is one of the regions which is the earliest to develop and exploit agriculture, so its degree of land exploitation is high, and the use patterns are complex and diversified, the distribution differences of land quality can obviously be seen. According to the land investigation in 2008, Henan Province has a total area of 165,500 square kilometers, including cultivated land118, 895,600 Mu, garden land 4,708,700 Mu, woodland 28,241,500 Mu, grassland 215,700 Mu, other agriculture land 15,122,400 Mu, residential area and independent industrial area 28,241,500 Mu, transportation land 1,825,500 Mu, water conservancy projects land 2,732,400 Mu, other land 8,510,100 Mu, with 1.20 Mu cultivated land per capita. There are 153,800 Mu

cultivated land increased through land developing and reclaiming, while 146,700 Mu of it has been used for construction. All over the province, the unused land which can be suitable to develop into the cultivated land is rare, and the reserve land for cultivated land is badly lacked.

3. The construction of the cultivated land use benefit evaluation index system

3.1. Analysis on factors that influence cultivated land use benefit

Cultivated land use benefit is a general term of the direct and indirect effects gained after the cultivated land ecosystem services are utilized by human beings, including the economic benefit, ecological benefit and social benefit of the cultivated land use. Benefit index is one of the factors that decide the strength of the cultivated land use benefit that can be directly used to evaluate the cultivated land use benefit. Different regions and different levels lead to different influencing factors. Therefore, the factors chosen should be interrelated and interacted, influencing and deciding the degree of cultivated land resources use benefit all together.

3.2. The construction of the evaluation index system

Choose 8 indexes to construct the evaluation index system of cultivated land resources use benefit as is required. Among the 8 indexes, X1 refers to labors on per unit area of the cultivated land; X2 refers to the urbanization rate; X3 refers to the irrigation index; X4 refers to agriculture investment proportion; X5 refers to multiple crop index; X6 refers to the food production of per unit area of the cultivated land; X7 refers to the amount of chemical fertilizer used on per hectare cultivated land; and X8 refers to the agricultural machinery on per hectare cultivated land. (Table 1)

Table 1 Evaluation index system of cultivated land resources use benefit

Name of Index	Formula
Labors on per unit area (X1)	Number of agricultural labors/unit area of the land
Urbanization rate(X2) (%)	The population in the cities and towns/total population
Irrigation index (X3) (%)	Effective irrigation area/total cultivated land area
Agriculture investment proportion (X4) (%)	Agriculture investment/total investment
Multiple crop index (X5) (%)	The index reflecting the degree of cultivated land use, area under crops in a year/ total cultivated land area
Food production of per unit area (X6) (kg/hm^2)	Grain output/actual cultivated land area under crops
The amount of chemical fertilizer used on per hectare (X7) （kg/hm^2）	Net amount of the agricultural chemical fertilizer/area under crops
Agricultural machinery on per hectare (X8) （wkw/hm^2）	Total agricultural machinery/area under crops

4. Quantity evaluation and feature analysis on cultivated land resources use benefit

4.1 Method to analyze the cultivated land resources use benefit

The method of principal component analysis (PCA) is mainly used to analyze the cultivated land resources use benefit of18 level cities in Henan Province in the year of 1999 and 2008.

The core of PCA is to choose n principal components x_1, x_2, …, x_n, among which x_i （i=1，2，…，n）is the score of the ist principal component, and to form overall evaluation function with the weight a_i, calculated according to the variance contribution rate of principal component x_i, by means of analysing the principal components:

$$x = a_1x_2 + a_2x_2 + \cdots + a_nx_n$$

By using PCA to reduce dimensions of the evaluation indexes, we can find the principal component after reconstructing the chosen indexes that are relevant to the cultivated land use degree. This method can not only save as much information collected in the land investigation as possible, but also transform numbers of original factors into very few mutually linear independent principal components by means of mathematical transformation, so that the data structure can be reduced. And according to the variance contribution rate, the weight can be objectively decided, which can avoid the collinearity of the evaluation index and the artificiality when deciding the weight, thus making the evaluation result more reasonable and objective.

4.2 Data sources and model calculation

The data related to each evaluation index in the year of 1999 and 2008 all come from the yearly statistical material of the government and some departments of Henan Province. In order to meet the need of the research, index data such as multiple crop index and amount of chemical fertilizer are necessarily processed and transformed. This paper adopts linear standardization to process the index. The formula is:

$$X_i = x_i \Big/ \max x_i \quad （i=1，2，3，\ldots n）$$

In the formula, $\max x_i$ is the maximum of the x_i, X_i is the number after non-dimensionalization. If the data is reversal index, its reciprocal is needed, and then work out the non-dimensionalization process to get the standardization data. At last, the standardized data should be analysed with the method of PCA.

Use SPSS17.0 to carry out Bartlett sphericity test and KMO test. If the result is 0.655 and 0.637 (all greater than 0.5), the data is suitable for PCA. According to the principle that the accumulated contribution rate should be greater than 75%, choose 3 principal components whose eigenvalue is greater than 1. The accumulated contribution rate of component 1, component 2 and component 3 reaches to 80.495% and 77.963%. Generally speaking, the components whose accumulated contribution rate is above 75% have almost reflected the major information of the original variable quantity.

As is described above, the result of the test is as follows (Table 2).

Table 2 Component Matrix in 1999

Index	Component1	Component2	Component3
Labors on per unit area (X1)	0.302	-0.859	0.206
Urbanization rate (X2)	-0.102	0.134	0.793
Irrigation index (X3)	0.717	0.188	-0.007
Agriculture investment proportion (X4)	0.771	0.571	-0.139

Multiple crop index (X5)	0.840	-0.440	0.142
Food production of per unit area (X6)	-0.029	-0.339	-0.684
The amount of chemical fertilizer used on per hectare (X7)	0.921	-0.129	-0.005
Agricultural machinery on per hectare (X8)	0.196	0.901	-0.021

From the component matrix of the cultivated land resources use benefit (Table 2) it can be seen that the amount of chemical fertilizer used on per hectare has the largest loading contribution rate to the principal component 1, reaching to 0.921, which shows that the increasing of the using amount of fertilizer could increase the production and maximize the cultivated land use benefit at that time. The second is the multi crop index, with its loading contribution rate 0.850. The multi crop index is controlled by the local heat, soil, water conservancy, fertilizer, labor, and science technology. Therefore, adding the multi crop index by adjusting measures to local conditions is an effective way to enlarge seeded area, dig out cultivated land use potential and improve grain production. The agricultural machinery on per hectare has the largest loading contribution rate to the principal component 2, which is 0.901, demonstrating that in 1999, great amount of agricultural machinery was put in to the cultivated land use, and also that the agricultural mechanization had been greatly improved. The improvement of mechanization will improve the cultivated land use benefit. As to the principal component 3, the loading contribution rate of urbanization is 0.793. In 1999, the urbanization began booming, with the cities enlarged and buildings constructed. The flourishing urbanization demanded large quantities of land, encouraging the reasonably use and protection of cultivated land.

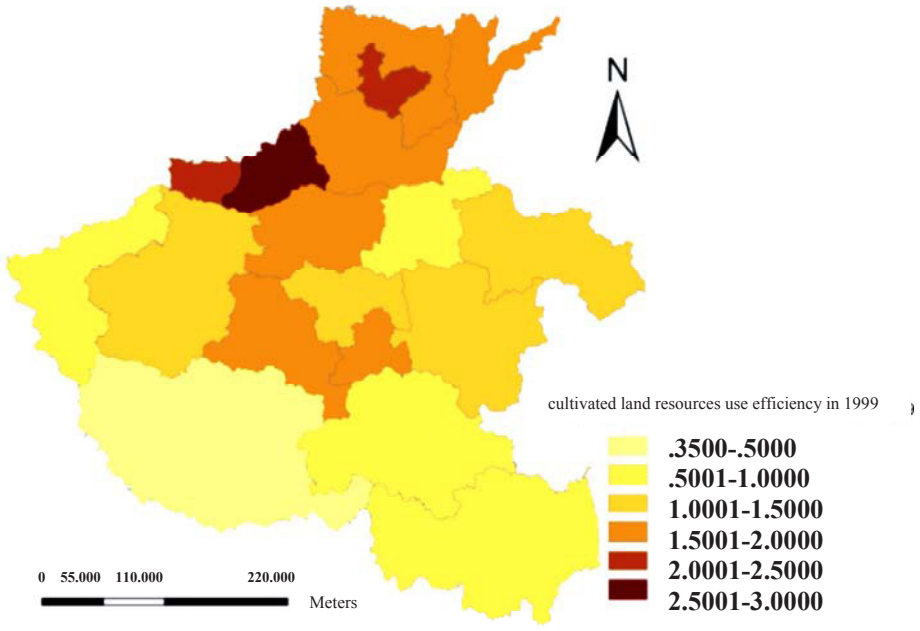
Table3 Component Matrix in 2008

Index	Component1	Component2	Component3
Labors on per unit area (X_1)	0.831	0.028	-0.189
Urbanization rate (X_2)	0.189	-0.157	0.872
Irrigation index (X_3)	0.594	0.220	0.505
Agriculture investment proportion (X_4)	-0.241	0.860	-0.151
Multiple crop index (X_5)	0.766	0.580	-0.044
Food production of per unit area (X_6)	0.520	-0.666	-0.198
The amount of chemical fertilizer used on per hectare (X_7)	-0.693	0.572	0.178
Agricultural machinery on per hectare (X_8)	0.819	0.466	-0.103

From the component matrix in 2008 (Table 3) it can be concluded that labors on per unit area is the one gets the largest loading contribution rate, 0.831, showing that the number and the quality of the farmers played an important part in making use of cultivated land at that time. The second biggest number goes to the agricultural machinery on per hectare area, with the loading contribution rate of 0.819, which just agrees with the cultivation development reality and shows that with the development of society and economy, large quantities of agricultural machinery have been put into the cultivated land use nowadays. It also reflects the improvement of the agricultural mechanization level. The agriculture machinery operation has been extended from food crops to commercial crops, from field agriculture to facility agriculture. Agriculture investment proportion is the biggest contributor to principal component 2, with the contribution rate reaching to 0.86. This demonstrates that the input of the agricultural economic benefit can greatly increase the cultivated land

use benefit. The more the money is invested on the agriculture cultivation, the higher the cultivating efficiency can be, and the higher the food production is. Besides, the amount of chemical fertilizer used on per hectare area, and the multi crop index are also closely related to cultivated land use benefit, with their loading contribution rate of 0.580 and 0.572. The contribution rate of urbanization and irrigation index in principal component 3 are respectively 0.872 and 0.505. The booming of the urbanization accelerates the land utilization, which encourages the intensification of land use; the irrigation index shows that improving the current irrigation and dewatering system, increasing water resource use efficiency can enhance the productivity of the land and help gain the food production.

The paper chooses three principal components, and multiplies them by their respective variance contribution rate to calculate the cultivated land use benefit index of the year in each level city of Henan province. In order to avoid the negative number, the paper will move the coordinate axis. Then the cultivated land use benefit indexes in 1999 and 2008 obtained through the above calculation are classified into 6 levels. The higher the level is, the stronger the cultivated land use benefit can be. At last the data above will be spatially described by using Arcgis9.3(Fig.1).



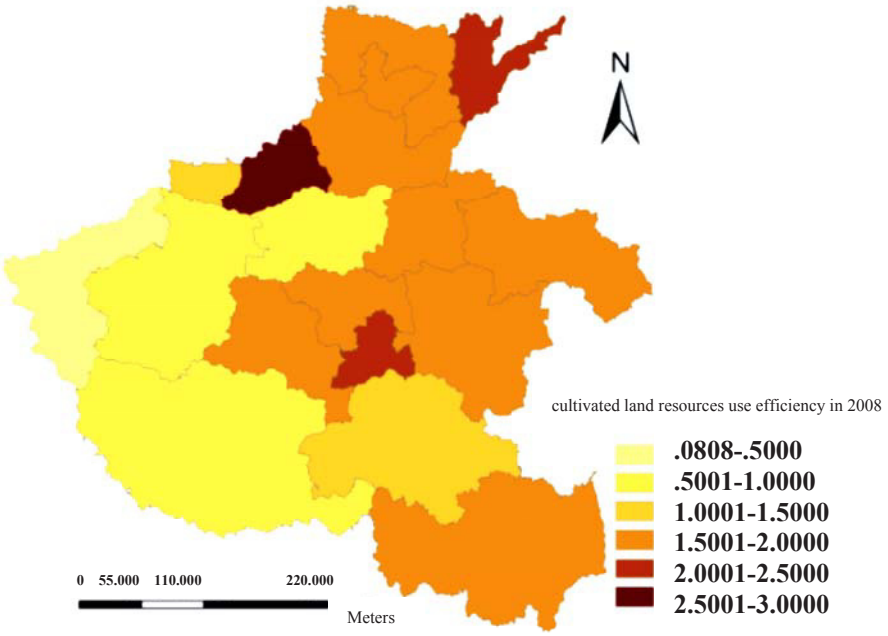


Fig.1 Distributing contrast of cultivated land resources use efficiency in 1999 and 2008

From the tables it can be drawn that in 1999, the cultivated land use benefit index of Henan Province tends to be high in the south and low in the north. The city which has the highest index is Jiaozuo (2.74), the second highest and third are respectively Jiyuan and Hebi (2.26, 2.01). This is because Jiaozuo and Jiyuan, located by the Yellow River, have rich water resources, mature irrigation technology, many skilled famers, reasonable plant conditions and high grain production. It can be said that under the circumstances where urbanization rate and agriculture investment proportion were not high in 1999, the northern part of Henan became the region owning comparatively high cultivated land use benefit index, due to its rich water resource and labors. Nanyang has the worst cultivated land use benefit (0.35), followed by Zhumadian (0.61), Xinyang (0.95), Kaifeng (0.96), and Sanmenxia (0.98). Nanyang is located in the Nanyang Basin, and Xinyang, Zhumadian are in the mountainous and hilly areas, where the science technology was not developed enough, the amount of fertilizer and agricultural machinery degree were not high, and grain production were relatively low at that time, leading to low cultivated land use benefit.

Compared with 1999, 2008 gains totally higher cultivated land use indexes, which tend to be high in the east and low in the west in a ladder form. Jiaozuo still gains the highest cultivated land use benefit index (2.71), followed by Puyang and Luohe, with the number of 2.28 and 2.12. The regions getting higher cultivated land use benefit indexes are mainly in the Low-lying Plain and Huang-huai Plain in the east of Henan. In this area, the cultivated land resources are well protected with greater agriculture investment, complete basic infrastructure, better natural conditions and higher grain production on the unit area of the land, so the area can get good cultivated land use benefit. The city which gets the worst benefit is Sanmenxia (0.08), and then are Luoyang, Zhengzhou and Nanyang, getting indexes of 0.81, 0.91 and 0.92. Sanmenxia is surrounded by mountains and hills with less cultivated land and less numbers of labors on the unit area as well as less agriculture investment, thus getting the lowest cultivated land use index. Zhengzhou, Luoyang is

crowned as economy, culture and technology centers of Henan province. In recent years, these two cities have witnessed a quick urbanization process and booming development of economic zones and development zones. While because more land is used for industrial purpose and their multi crop indexes are low, and also most farmers turn to be workers and service staff, the cultivated land use benefit indexes in the two city decrease compared with those in 1999.

5. Main conclusions

(1) The evaluation result which is tested by PCA clearly shows that as time goes on, the cultivated land use benefit is closely related to the social economic development of a region. Cultivated land use benefit is strongly influenced by social and economic conditions. labours on per unit area of the cultivated land, urbanization rate, agriculture investment proportion, the food production of per unit area of the cultivated land, the amount of chemical fertilizer used on per hectare cultivated land and agricultural machinery on per hectare cultivated land reflect the development level of the overall regional economy, while the irrigation index and multiple crop index belong to natural conditions, reflecting the intensification degree of the cultivation operation and the productivity in natural conditions.

(2) The urban construction and industry occupy lots of cultivated land, and have serious effect on the cultivated land use benefit. Thus, urbanization rate, agriculture investment proportion and the production of the per unit area affect the result of cultivated land use benefit in different aspects. The decrease of numbers of farmers indicates the increase of the urban population; the rise of the urbanization rate shows the acceleration of urbanization and the transition from agriculture to industry. It can also be known that the industrial scale is enlarging, and more cultivated land is occupied. In more and more areas, the action that using land to attract business and investment has caused large areas of land, especially rich cultivated land to be occupied, some occupied land even has never been used. Because of those occupied cultivated land, most is the land with high or medium production, and is mainly located in areas surrounding cities with higher production, the production proportion of the occupied land is much higher than proportion concerning to the area. Meanwhile, with the rapid development of science technology, the amount of fertilizer used and agriculture machinery on per hectare area make the rise of the per unit area yield. In recent years, the country has attached more and more importance to the cultivated land protection and grain production, and brings grain production and food protection into its scientific schedule. However, using chemical fertilizer on a large scale will have side effect on the environment, though it can increase the grain production.

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