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Full Length Research Paper

Analysis of agricultural input-output based on Cobb–Douglas production function in Hebei Province, North China

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This study is to analyze the temporal and spatial variation of the agricultural input-output and the relation between agricultural output and input factors in Hebei Province by Cobb-Douglas production function in which cultivated area, effective irrigation area, chemical fertilizer usage, agricultural machinery power, rural electricity consumption and manpower are taken as independent variables. It proves that the agricultural output, effective irrigation area, chemical fertilizer usage, agricultural machinery power and rural electricity consumption have an upward trend from 1999 to 2008, but the cultivated area and agricultural manpower have a downward trend. In terms of spatial distribution, the agricultural input and output in the southeastern part of the province are higher than those in northwest. In the 6 input factors, the effective irrigation area has the biggest influence on agricultural output, chemical fertilizer and agricultural machinery power of the second, and other factors have relatively small influence. Therefore, Hebei should pay attention to effective use of water resources and accelerate investment in technology and mechanization to promote agriculture sustainable development.

Key words: Agricultural input-output, temporal and spatial variation, Cobb-Douglas production function.

INTRODUCTION

Agriculture is the human activity in which solar energy is utilized for the production of sugars that are used in the plant to construct carbohydrates, proteins, lipids and other compounds (Van and Rabbinge, 1997). Agricultural activity results in outputs, such as grain, potatoes, nutrient emissions and so on. Thus, agricultural production systems can be characterized by their inputs and outputs, that is, input-output combinations. Agriculture is a significant component of China's economy constitution, accounting for 11.3% it of gross domestic product (GDP) and 23.1% of it employment rate (2008). China now accounts for over 18% of global agricultural production, substantially, more than traditional agricultural production and trade heavyweights such as the European Union, the United States, India and Brazil (Huang et al., 2009).

Some research has been done on the input-output of China's agriculture: Wu et al. (2008) constructed an input-output model for Changde City of Hunan Province using EViews software by choosing the production of agriculture as output factor and labor, fertilizer inputs, dynamic mechanical total, arable land area and the area of effective irrigation as input factor. Dong (2009) analyzed the relationship between input and output of agriculture in China by the partial least squares regression method, and the result showed that: the agricultural output is mainly affected by the expenditure for household management, the financial expenditure for supporting agriculture and the fertilizer input, and is less affected by the input of cultivated area. Jiang and Zhang (2010) established an input-output model about regional agriculture of the southern Xinjiang Province by principal component analysis according to the input and output data in the years 2002 to 2007. Unfortunately, previous studies were based on a single spatial scale (for example, one county, one province or the whole country) in short time series, and less attention has focused on the agricultural input-out of different temporal and spatial scales in China's agriculture.

The main purpose of this paper is to analyze the agricultural input and output in the last 10 years. The objectives of this study are:

1. To analyze temporal and spatial variation of agricultural input-output in Hebei Province;
2. To construct an agricultural input-output potential model based on Cobb-Douglas production function;
3. To analyze the main influence factors to affect the agricultural output in Hebei.

MATERIALS AND METHODS

Hebei Province

Hebei Province (Figure 1) is 190,000 km^2 area with a population of 69 million (2009), and is divided into 11 prefecture level cities (including 138 counties). The topography consists of mountains, hills, and plateaus in the northwest, and a broad plain in the central and southeastern region. A total of 34% of the area is cropland with mainly winter wheat and summer maize double cropping system (winter wheat is cultivated from early October to early June, summer maize is grown from mid-June to late September).

The study area is located in a temperate and continental monsoon climate zone with a mean annual precipitation of 498 mm, 69% of which occurs between June and September (1999 to 2008). Mean annual temperature is 11°C (1999 to 2008). Precipitation and temperature decrease from southeast to northwest.

Data

The economic statistics data for each county from 1999 to 2008, including grain yield, grain price, cultivated area and effective irrigation area, chemical fertilizer usage, agricultural machinery power, rural electricity consumption, and rural manpower, were obtained from Hebei economic statistical yearbooks (2000 to 2009).

Agricultural input-output potential model

Agricultural input factors mainly include labor, irrigation, cultivated land, fertilizer, machinery power and electricity. Accordingly, the agricultural input-output potential model is focused on seven variables: output (*Y*, 10^4 Yuan), cultivated land area (*Ac*, ha), effective irrigation area (*Ai*, ha), rural electricity consumption (*Ce*, 10^4 kWh), agricultural machinery power (*Pm*, KW), chemical fertilizer usage (*Fc*, T) and rural manpower (*Mr*, person). The relation of agricultural output and input can be expressed as,

$$Y(t) = f(Ac(t), Ai(t), Ce(t), Pm(t), Fc(t), Mr(t)) \quad (1)$$

In economics, the Cobb-Douglas functional form of production functions is widely used to represent the relationship of an output to inputs, and it appears to be a good approximation to actual production (Romer, 2001). So Cobb-Douglas production function is used and it is shown as below:

$$Y(t) = A\,Ac(t)^{\alpha}\,Ai(t)^{\beta}\,Ce(t)^{\gamma}\,Pm(t)^{\delta}\,Fc(t)^{\lambda}\,Mr(t)^{\psi} \quad (2)$$

where α, β, γ, δ, λ, and ψ are the output elasticities of cultivated land area, effective irrigation area, rural electricity consumption, agricultural machinery power, chemical fertilizer usage and rural manpower respectively, and 0<α, β, γ, δ, λ, ψ<1.

If

$$A + \beta + \gamma + \delta + \lambda + \psi = 1 \quad (3)$$

The reduction function has constant returns to scale in its six arguments.

However, if

$$A + \beta + \gamma + \delta + \lambda + \psi < 1 \quad (4)$$

returns to scale are decreasing, and if

$$A + \beta + \gamma + \delta + \lambda + \psi > 1 \quad (5)$$

returns to scale are increasing.

Equation 2 can be changed as below:

$$\ln Y(t) = \ln A + \alpha \ln Ac(t) + \beta \ln Ai(t) + \gamma \ln Ce(t) + \delta \ln Pm(t) + \lambda \ln Fc(t) + \psi \ln Mr(t) \quad (6)$$

RESULTS

Temporal variability of agricultural input-output

Trend analysis shows that the agricultural output of Hebei Province has an upward trend in the last ten years, especially after 2003 the output increased rapidly (Figure 2a); in the six input factors, except cultivated land area (Figure 2b) and rural manpower (Figure 2g) are decreasing, the other five factors are increasing (Figure 2c, d, e and f).

Spatial distribution of agricultural input-output

Based on prefecture level city spatial scale, the distribution of agricultural input and output was analyzed (Figure 3) and the results showed that: in 11 cities of Hebei, Baoding City's agricultural output value is the greatest, followed by Shijiazhuang and the least is Zhangjiakou (Figure 3a); Baoding City's cultivated land area is the biggest, followed by Zhangjiakou and the least is Qinhuangdao (Figure 3b); Baoding City's effective irrigation area is the biggest too, followed by Cangzhou and the least is Chengde (Figure 3c); Tangshan City's rural electricity consumption is the most, followed by Shijiazhuang and Zhangjiakou is the least (Figure 3d); Shijiazhuang City' agricultural machinery power is the greatest, followed by Handan and Chengde is the least (Figure 3e); Shijiazhuang City' chemical fertilizer usage is the most, followed by Handan and Baoding and Zhangjiakou is the least (Figure 3f); Baoding City' rural

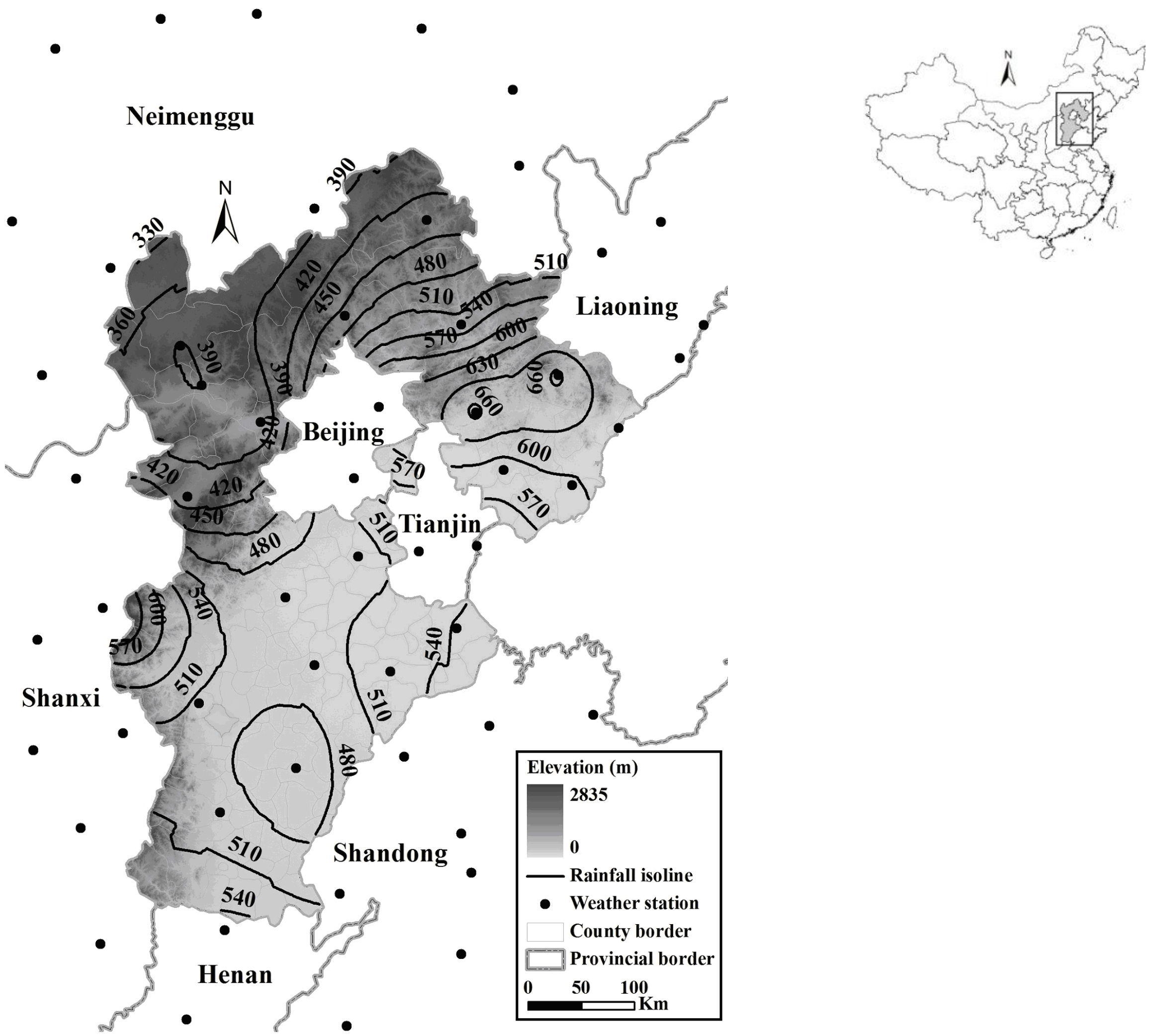

Figure 1. Geographical position of Hebei Province. The contour lines and the points indicate average precipitation (1984 to 2008) and locations of weather stations respectively.

manpower is the most, followed by Handan and Qinhuangdao is the least.

Spatial variability of agricultural input-output

In order to discuss the spatial variability of agricultural input-output, we analyzed the change of agricultural output and the six input factors from the periods of 1999 and 2003 to 2004 and 2008 for 11 cities in Hebei and the results showed that: the agricultural output is increased in all cities and the value of Cangzhou is the largest and with Qinhuangdao is the smallest (Figure 4a); the cultivated land area is decreased except Langfang (Figure 4b); the effective irrigation area is increased except Shijiazhuang, Baoding and Qinhuangdao (Figure 4c); the rural electricity consumption is increased in all cities and the value of Tangshan is the largest (Figure 4d); the agricultural machinery power is increased in all cities and the value of Handan is the largest (Figure 4e); the chemical fertilizer usage is increased except Shijiazhuang and Langfang (Figure 4f); and the rural manpower is decreased except Qinhuangdao and Zhangjiakou (Figure 4g).

Main influence factors to affect the agricultural output

According to Equation 3, an agricultural input-output potential model was constructed by regression analysis based on county spatial scale, and it is shown as follows,

$$\ln Y(t) = 7.87 - 0.14\ln Ac(t) + 0.64\ln Ai(t) - 0.07\ln Ce(t) + 0.01\ln Pm(t) + 0.09\ln Fc(t) + 0.03\ln Mr(t) \qquad F = 122.79 \quad R^2 = 0.85 \quad (n = 138) \tag{7}$$

The elasticity coefficient of effective irrigation area (with0.64) is the highest which indicates that the effective irrigation area is the biggest influent factor on the

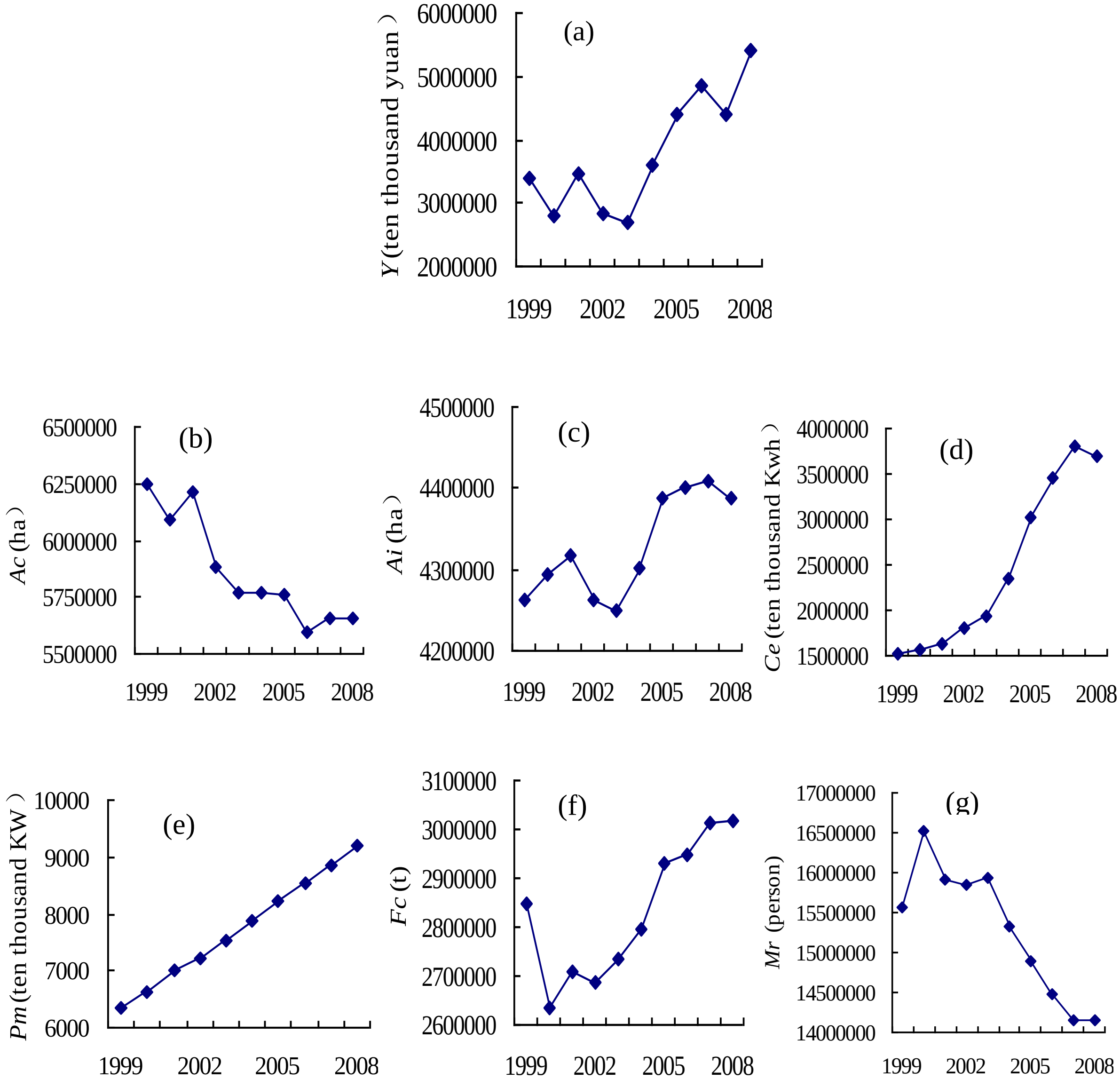

Figure 2. Annual agricultural output (a), cultivated land area (b), effective irrigation area (c), rural electricity consumption (d), agricultural machinery power (e), chemical fertilizer usage (f), and rural manpower (g) from 1999 to 2008 of Hebei Province.

agricultural output in the 6 input factors; followed by chemical fertilizer usage (with 0.09) and rural manpower (with 0.03), while cultivated land area (with -0.14), rural electricity consumption (with -0.07) and agricultural machinery power (with 0.01) have relative small influence on the agricultural output. The sum of elasticity of the six input factors is 0.56 (<1) which showed that the returns to scale is decreasing.

DISCUSSION AND CONCLUSIONS

From 1999 to 2008, the 138 counties in Hebei Province produced a total of 0.26 billion tons of grain which conversed to agricultural output value is 37.84 billion Yuan, and consumed 28.31 million tons chemical fertilizer, 247.76 billion kWh electricity and 0.77 billion KW machinery power. Annual use of cultivated land area is 5.86 million ha with 4.33 million ha is irrigated, and annual human input is 15.28 million persons. In the last ten years, the agricultural output, effective irrigation area, rural electricity consumption, agricultural machinery power and chemical fertilizer usage of Hebei Province have an upward trend, while cultivated land area and rural manpower are decreasing. In terms of spatial distribution, the agricultural input and output in the southeastern part of the province are significantly higher than those in northwest.

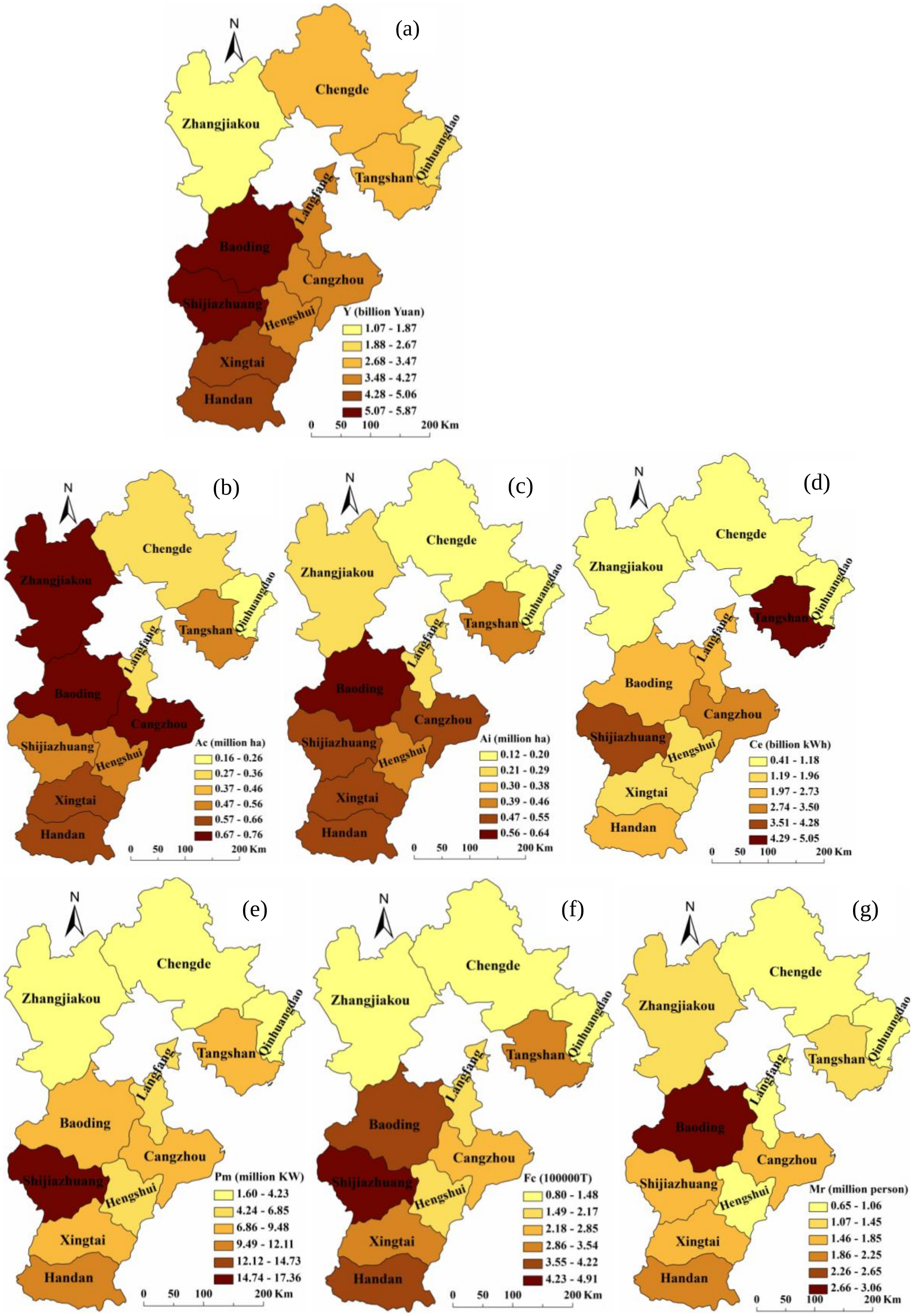

Figure 3. Annual mean agricultural output (a), cultivated land area (b), effective irrigation area (c), rural electricity consumption (d), agricultural machinery power (e), chemical fertilizer usage (f), and rural manpower (g) from 1999 to 2008 of 11 cities in Hebei Province.

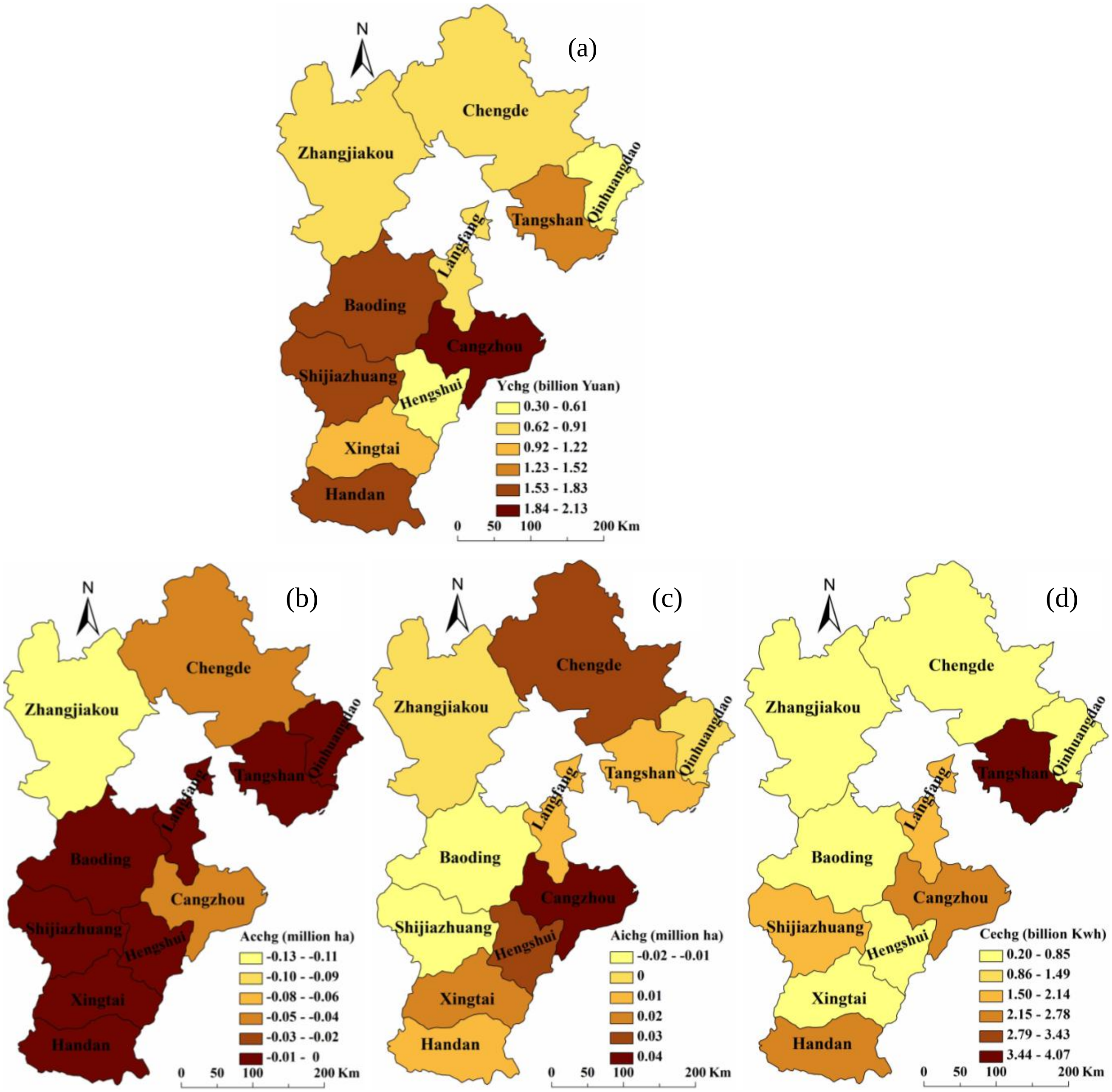

Figure 4. Change of agricultural output (a), cultivated land area (b), effective irrigation area (c), rural electricity consumption (d), agricultural machinery power (e), chemical fertilizer (f) and rural manpower (g) from the periods of 1999 to 2003 and 2004 to 2008 in Hebei Province.

At present, one of the greatest challenges in Hebei is severe water shortage, driven by strong water demands from the huge population, and rapidly expanding irrigated-agriculture, commercial and domestic sectors. Agriculture has been specifically identified as the major water user, accounting for about 70% total water use here. Water-saving especially in agriculture should be promoted by decision makers, irrigation planners and agro-scientists. Water-saving measures such as the adoption of drought-resistant crop varieties, the readjustment of planting patterns, and the use of deficit irrigation and advanced tillage and mulching techniques could reduce water use by limiting soil evaporation and plant transpiration (Zhang et al., 2008). Agricultural water-saving in combination with the long-distance water transfer and optimized water reallocation, are necessary prerequisites for comprehensively redressing the worsening water shortage problems in Hebei.

There are many factors that affect agricultural output except the above six factors, such as temperature, precipitation and crop breed. In this study, we only analyzed the relation of agricultural output and six main input factors and found in the six factors, the effective irrigation area has the biggest influence on agricultural output. This study has provided scientific information for developing efficient irrigation practices to improve crop water productivity and help to maintain sustainable development of agriculture in Hebei.

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REFERENCES

Dong MS (2009). The relationship between input and output of agriculture in China: analysis based on partial least squares regression model. Technol. Econ., 28(1): 37-41 (in Chinese with English abstract).

Huang JK, Liu Y, Martin W, Rozelle S (2009). Changes in trade and domestic distortions affecting China's agriculture. Food Policy, 34: 407-416.

Jiang QS, Zhang XJ (2010). Regional agricultural input-output model and countermeasure for production and income increase of farmers in southern Xinjiang. J. Anhui Agric. Sci., 38(28): 15932-15935 (in Chinese with English abstract).

Van Ittersum MK, Rabbinge R (1997). Concepts in production ecology for analysis and quantification of agricultural input-output combinations. Field Crops Res., 52, 197-208.

Wu HL, He HB (2008). Research on agricultural production input-output model of Changde City. Econ. Res. guide, 11, 53-56 (in Chinese with English abstract).

Zhang XY, Chen SY, Sun HY, Pei D, Wang YM (2008). Dry matter, harvest index, grain yield and water use efficiency as affected by water supply in winter wheat. Irrig. Sci., 27 (1), 1-10.