Impact of land-use induced changes on agricultural productivity in the Huang-Huai-Hai River Basin

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ABSTRACT

The water resource allocation is greatly influenced by the land use, agricultural productivity and farmers' income. Therefore analyzing the impacts of land use changes on agricultural productivity and subsequent effects on farmer's income is an important basis of the further study on the management mechanism and optimal water resource allocation. Taking the Huang-Huai-Hai River Basin as the study area, this study examined the impacts of conversion from cultivated land to built-up land from 2000–2005 and 2005–2008. Then the agricultural productivity was estimated with the Estimation System for Agricultural Productivity model, and the changes in agricultural productivity caused by land conversion were analyzed. Thereafter, Simultaneous Equations Model was used to analyze the impacts of the conversion from cultivated land to built-up land on the agricultural productivity and subsequent effects on farmer's income. The results showed that: (1) The agricultural productivity was stable during the whole period, reaching about 2.84 ton/ha, 3.09 ton/ha and 2.80 ton/ha on average in 2000, 2005 and 2008, respectively, but the conversion from cultivated land to built-up land had important influence on the spatial pattern of agricultural productivity. (2) The land productivity, total power of agricultural machinery and the conversion from cultivated land to built-up land had an overall positive effect on the agricultural productivity. (3) The agricultural productivity and gross domestic product had positive influence on the farmers' income, while the cultivated land area per capita and percentage of farming employee had negative influence, indicating that the farmer's income was mainly contributed by non-agricultural income. These results in this study showed that optimal land use management can play an important role in promoting virtuous ecosystem cycle and sustainable socioeconomic development, which can also lay an important foundation for further research on the optimal allocation of water resources in the Huang-Huai-Hai River Basin.

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1. Introduction

Changes of ecosystem services caused by land use change and consequent impacts on the socioeconomic development have become a hot issue in the research of global environmental changes since the research plan of land use and cover change was jointly put forward by International Geosphere-Biosphere Program (IGBP) and International Human Dimensions Program on Global Environmental Change (IHDP) in 1995 (Jenerette and

Wu, 2001; Gao and Deng, 2002; Liu et al., 2002, 2003; Gutman et al., 2004; Walsh et al., 2004; Veldkamp and Verburg, 2004; Verburg et al., 2004; Liu and Deng, 2010; Deng et al., 2013b; Li et al., 2013; Singh et al., 2014). The current land use change in China is most remarkably characterized by the expansion of urban built-up land and decrease of cultivated land (Yu et al., 2013). On one hand, the continuous decline of the cultivated land has not only restricted the improvement of land productivity, but also influenced the national food security (Liu et al., 2012; Wasilewski and Krukowski, 2004; Zhang et al., 2011, 2014). On the other hand, the land use change interacts with the structural change of industries, while different industries differ greatly in the demand for the water resources, which can consequently have significant impacts on the allocation of water resources. For example, Calder (1998) analyzed the impacts of spatial land use on water allocation to

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comprehensive management of a catchment, and it has been proved that human activities, e.g., land use change, can cause hydrological changes. Besides, the farmers are the major agents of agricultural production, and their income level determines the household utilization of water resources to some degree. Changes in both the land use and the farmers' income will have some impacts on the allocation and management of water resources. Therefore it is very necessary to carry out the research on the change in the agricultural productivity and subsequent impacts on the farmers' income under the background of land use change, which can lay a firm foundation for improving the watershed water resource management and optimizing allocation of water resources.

Agricultural productivity is the capacity of cultivated land to output agricultural products under the conditions of current agricultural facilities, management regulation, and modern agricultural machinery, which is an important foundation for regional sustainable land use and ecological environment construction (Deng et al., 2006; Yan et al., 2009). The change of agricultural productivity is an important indicator of global change and can have important influence on the allocation of watershed water resources. The agricultural production lays a foundation for the socioeconomic development, affects human well-beings and can promote the improvement of agricultural productivity (Yang and Li, 2000; Olesen and Bindi, 2002; Ewert et al., 2005). On one hand, conversion from cultivated land to built-up land can directly lead to the socioeconomic development and migration of urban labor to cities (Deng et al., 2008b). On the other hand, improvement of infrastructure in rural regions and widespread use of agricultural techniques caused by socioeconomic development and urbanization can influence the agricultural productivity, farmers' income and allocation of water resources (Wu et al., 2014a, 2014b; Deng and Bai, 2014). However, much remains unknown about how the change in agricultural productivity caused by conversion from cultivated land to built-up land influences the farmers' income, and there is a lack of relevant research at home and abroad (De Groot et al., 2002; Farber et al., 2002; Tschamtket et al., 2005; Seppelt et al., 2012).

With the Huang-Huai-Hai River Basin as the study area, this study analyzed the spatiotemporal characteristics of the conversion from cultivated land to built-up land in 2000, 2005 and 2008. Then the land productivity in these three periods was estimated with the Estimation System for Agricultural Productivity (ESAP) model based on the data of soil, topography, and regional climatic factors. Thereafter, the agricultural productivity in these periods was estimated through bringing in the constraint factors including the agricultural production input and management policies. Finally, the Simultaneous Equations Model (SEM) was used to analyze the impacts of conversion from cultivated land to built-up land on the farmers' income, and the management implication from water resource utilization was discussed. The results of this study can provide important scientific reference information for the watershed land use planning and assist the decision making on the agricultural production and increase of farmers' income, which is of great importance to improving the watershed water resource management.

2. Data and methodology

2.1. Study area

Huang-Huai-Hai River Basin (HHHRB) lies between 32°08'–40°16'N and 112°10'–122°40'E, covering Shandong Province, including part of Beijing, Tianjin, Hebei Province, Henan Province, and the Huaibei area of Anhui Province and Jiangsu Province

according to administrative division of China. Overall, HHHRB is characterized by kernel geological location with seasonal climate, rich agricultural potentials with ecological resource, adjacent to super cities with industrial diversity and cultural superiority. HHHRB is a typical flood plain and one of the most important grain production regions in China (Fig. 1), where the elevation is generally below 50 m. It is mainly influenced by the warm temperate monsoon climate, with typical observable seasonal changes. South part of HHHRB is located in the transition area to subtropical regions in the Huaihe River Basin, and the average annual temperature and rainfall of the whole basin are about 10–15 °C and 500–900 mm, respectively, which gradually decrease from the south to the north on the whole. With deep and fertile soil, HHHRB is very favorable for agricultural production, producing various grain crops such as wheat, rice, maize, sorghum, millet, and yams; and other economic crops such as cotton, peanuts, sesame, soya bean, and tobacco. However, HHHRB is one of the regions that suffer from serious water shortage in China, especially in the Jing-Jin-Tang region and Shandong Peninsula.

2.2. Data and processing

2.2.1. Climate data

The climate data included the daily mean temperature, precipitation, relative humidity, wind speed, solar radiation, and daily maximum and minimum temperature from January 1st, 2000 to December 31st, 2008. All these data were derived from the daily observation data of meteorological stations maintained by the China Meteorological Administration. The original data were saved in the text format, which were then interpolated into 1 km × 1 km grid data with the coupling-fitted thin-plate interpolation method. In addition, the temperature data were adjusted with the elevation data.

2.2.2. Land use data

The 1 km resolution land use data in 2000, 2005 and 2008 were provided by the Data Center for Resources and Environment Sciences, Chinese Academy of Sciences (<http://www.resdc.cn>), covering six land use classes, i.e., cultivated land, forest land, grassland, water area, built-up land, and unused land (Deng et al., 2013c).

2.2.3. County-level panel data

The county-level panel data included the fertilizer consumption and irrigation coefficient, etc. The irrigation coefficient was calculated with the ratio of irrigated farmland area and all cultivated land for each county. Besides, the county-level panel data of different input levels and management were generated through data format conversion, data link, spatial discretization, spatial sampling, etc.

2.2.4. Other data

The topography data were extracted from the DEM data at a scale of 1:250,000, which were resampled into 1 km × 1 km grid data. The soil data were extracted from the second national soil survey and finally interpreted into 1 km × 1 km grid data using Kriging method. Besides, a number of field survey data were used, including the crop cultivation information, farming practices, crop growth cycle, type and pattern of the main crops, crop residues and byproducts, etc. In addition, some statistical data in 2000, 2005 and 2008 were extracted from statistical yearbooks, e.g., gross domestic products (GDP), rural net income per capita, rural farmer population, the primary industrial output, food production, the total power of agricultural machinery, amount of pesticides usage, ratio of the total population and urban population.

Fig. 1. Location of the Huang-Huai-Hai River Basin.

2.3. Methodology

2.3.1. Estimation of agricultural productivity

Estimation of land productivity, which is carried out with the ESAP model in this study, is the foundation for estimating agricultural productivity. An asymptotic approach was used to estimate the potential land productivity under the control of natural factors such as temperature, precipitation, radiation levels, soil texture and topography. The photosynthetic productivity, light and temperature productivity, climate productivity, and land productivity were estimated step by step (Deng et al., 2008a; Deng, 2011; Yu et al., 2013). The photosynthetic productivity is the potential productivity which is completely determined by the photosynthetic active radiation when the temperature, water, soil, diversity of crops, and other agricultural technology are under optimum conditions. Light and temperature productivity is the potential productivity determined by the natural light and temperature conditions when other factors such as the water, soil, diversity of crops, and other agricultural technology are under the proper conditions (Deng et al., 2013a). In other words, light and temperature productivity can be obtained by temperature correction based on photosynthetic productivity. The climate productivity is estimated on the basis of the light and temperature productivity, taking into account the constraint of precipitation as well irrigation. Thereafter, the land productivity can be estimated on the basis of the climate productivity and the soil effective coefficient.

It is necessary to consider some other factors except for the climate factors and soil factors in the estimation of agricultural productivity, e.g., the management measures and input level, interaction between different kinds of crops. The input factors can be categorized into two aspects, i.e., the fundamental input to improve the land conditions and the regular input in specific production processes (Jiang et al., 2011). The following model estimates agricultural productivity under the assumption of interrelationships between input factors and production outputs in the basic production unit at the county level (Albersen et al., 2002).

$$Q_l(Y_l) = G_l(V_l, A_l, x_l) \quad (1)$$

where $Q_l(Y_l)$ is the productivity of the crop output in county l , which stands for the agricultural productivity determined by land inputs

A_l , non-land inputs V_l , and natural conditions x_l in county l . The constraints of land productivity are further introduced as follows:

$$G_l(V_l, A_l, x_l) = F(V_l, A_l)N(A_l, x_l) \quad (2)$$

where $F(V_l, A_l)$ is the land utilization rate ranging from 0% to 100%, which represents the impacts of input factors on the land productivity, $N(A_l, x_l)$ is the land productivity in county l with the land input A_l .

The agricultural productivity can be further estimated with the following steps. The county-level productivity $Q_l(Y_l)$ is a nonlinear combination of Y_{lc} , the yields of various crops in a county, which can be represented with the constant elasticity of substitution (CES) production function.

$$Q_l(Y_l) = \left[\sum_{c \in C_l} (\alpha_c Y_{lc})^{\alpha_0} \right]^{\frac{1}{\alpha_0}} \quad (3)$$

where C_l is all types of crops in county l , α_c and α_0 are parameters to be estimated.

However, not every county grows all types of crops, and there may be some interactions among different types of crops, which may increase or decrease the estimated productivity. Sometimes, selection of profit-oriented crops also affects the planting plan at county level. Therefore, Eq. (3) was modified by introducing a modification coefficient with a dummy variable which indicates the impacts of types of crops as follows.

$$Q_l(Y_l) = \left(1 + \sum \mu_m M_{lm} \right) \left[\sum_{c \in C_l} (\alpha_c Y_{lc})^{\alpha_0} \right]^{\frac{1}{\alpha_0}} \quad (4)$$

where M_{lm} is a dummy variable which denotes whether there is crops m that compete with the main crop in county l , and it is assumed that $m \leq 4$ since competing crops are less than 4 types in the study area; μ_m is the modification coefficient of the competing crop m .

2.3.2. Simultaneous equations model

Simultaneous Equations Model (SEM) is an equation system for describing simultaneous dependence between variables. Since there may be two-way causality relationships between two variables, the relationship between them cannot be completely described with a single equation model (Goldberger, 1964). We

draw on the concept of SEM to establish a number of interrelated equations, which represents interdependence between socio-economic system and ecosystem. It is necessary to make sure that the newly introduced equations contain at least one variable (endogenous or predetermined variable) that is not included in the previously introduced equations when establishing a SEM (Zellner and Palm, 1974; Greenwood, 1975; Wooldridge, 2012). Meanwhile, for the previously introduced equations, it must contain at least one different variable that is not included in the newly introduced equation. Besides, the number of equations should be not less than that of endogenous variables, otherwise, the SEM cannot be estimated.

This study established a SEM to analyze the influence of the change of agricultural productivity due to conversion from cultivated land to built-up land on the farmers' income. The results of this model can reveal the mutual influence between the ecosystem service provision and socioeconomic development. In the linear SEM, a dependent variable in one equation may appear the right side in another equation. In other words, the dependent variable in one equation can act as the independent variable in other equations. Therefore, it is not necessary to conventionally distinguish between the independent and dependent variables in the linear simultaneous equations. According to the properties of these variables, the variables can be divided into two categories. One is the random variables called endogenous variables (the dependent variable), which are associated with the observation error, and they are denoted by Y_1 , Y_2 , etc. The other is the variables called exogenous variables (the independent variable), which have nothing to do with the observation error and are denoted by X_1 , X_2 , etc.

3. Results

3.1. Conversion of cultivated land to built-up land

The built-up land is increasing rapidly as the urban area expands in China, but with decline of the cultivated land area (Fig. 2). The total area of cultivated land converted to built-up land

in the HHHRB was about 12,100 km² between 2000 and 2005. The loss of cultivated land concentrated in Beijing, Tianjin, Shandong Province, which are undergoing rapid urbanization. Thereafter, the total area of cultivated land in HHHRB continually decreased during 2005–2008, but with a much slower rate under the influence of regulation of the cultivated land protection and land use management policies. The total area of cultivated land converted into built-up land is about 4619 km² during 2005–2008. Besides, the loss of cultivated land showed a very scattered spatial pattern under the influence of national regulation policies.

3.2. Estimation of agricultural productivity

3.2.1. Estimation of land productivity

The land productivity of HHHRB in 2000, 2005 and 2008 was estimated with the ESAP model, the results were shown in Fig. 3. The average land productivity in 2000, 2005 and 2008 reached 8.59 ton/ha, 10.18 ton/ha, and 9.17 ton/ha, respectively. Generally, there is no obvious variation of land productivity over time, and the fluctuation of land productivity is mainly caused by annual variation of natural climatic factors, especially the local climate changes, which have huge impacts on the local land productivity. Besides, the spatial pattern of land productivity in HHHRB suggests that the land productivity showed an increasing trend from the south to the north under the joint influence of natural factors such as solar radiation, zonal air temperature, precipitation and differentiation of soil properties.

3.2.2. Estimation of agricultural productivity

The county-level agricultural productivity in HHHRB in 2000, 2005 and 2008 was estimated on the basis of land productivity through taking into account the agricultural input, management factors and so on (Fig. 4). The estimation results showed that the average agricultural productivity in HHHRB in 2000, 2005 and 2008 reached 2.84 ton/ha, 3.09 ton/ha and 2.80 ton/ha, respectively, showing some time-series fluctuation. The average agricultural productivity showed an increasing trend during 2000–2005.

Fig. 2. Spatial distribution of the conversion of cultivated land into built-up land from 2000–2005 and 2005–2008 in the Huang-Huai-Hai River Basin.

Fig. 3. Spatial distribution of land productivity in Huang-Huai-Hai River Basin in 2000, 2005, 2008.

Fig. 4. Spatial distribution of agricultural productivity in Huang-Huai-Hai River Basin in 2000, 2005 and 2008.

The agricultural productivity is influenced by not only the change in total cultivated land area, but also other factors such as the cropping area, grain yield per hectare, change in the agricultural policies, all of which may vary greatly in a short period. The agricultural productivity was relatively stable during 2005–2008, showing a slight declining trend. The agricultural productivity declined to some extent due to the influence of conversion from cultivated land to built-up land. However, the agricultural productivity increased slightly due to the implementation of measures such as land reclamation, expansion of irrigated cropland under the influence of policies such as national direct subsidies to grain producers and agricultural tax exemption, which offset the decline of agricultural productivity caused by loss of cultivated land.

The spatial pattern of agricultural productivity is generally consistent with the statistical data (Deng et al., 2006; Jiang et al., 2011). There is obvious regional heterogeneity of the agricultural productivity in HHHRB, showing a declining trend from the south to the north. But the gap of agricultural productivity among counties is gradually narrowing under the influence of change in cultivated land area, factor inputs and management policies. It is notable that the agricultural productivity declined dramatically in some developed areas, which may be caused by the decrease of multiple cropping index. The rapid development of the second and tertiary industries leads to the decline of benefit from agriculture, and as a result the agricultural income is no longer the major income source of farmers. Besides, the agricultural productivity

remained relatively stable with small inter-annual variation compared to the land productivity, which showed dramatic variation. This indicates that it is plausible to offset the adverse influence of natural disasters by increasing the inputs of production factors and improving agricultural production conditions and so on.

3.3. Analysis of influence factors in farmers' income

A SEM was established to explore the influence of change in ecosystem services caused by land use change on the socioeconomic development and the farmers' income. In the SEM model in this study, the endogenous variables of agricultural productivity system and rural socioeconomic development include *rnipc*, the rural net income per capita (Unit: ten thousand yuan), and *ap*, the agricultural productivity (Unit: ton/ha). Besides, six exogenous variables were included as follows. *cclbl* is the conversion area of cultivated land to built-up land in ha; *fclpc* is the farmers' cultivated land per capita in hectares/person; *rfr* is the Rural Farmer ratio in %; *gdp* is the gross domestic product in ten thousand yuan; *tpam* is the total power of agricultural machinery in thousands of watt; and *lp* is the land productivity in t/ha (Table 1). The SEM model was finally established as follows.

$$\begin{cases} lrpni = \alpha_0 + \alpha_1 ap + \alpha_2 fclpc + \alpha_3 rfr + \alpha_4 gdp + u_1 \\ ap = \beta_0 + \beta_1 rnipc + \beta_2 cclbl + \beta_3 lp + \beta_4 tpam + u_2 \end{cases} \quad (5)$$

Table 1

Variables and statistical description (county-level) in Huang-Huai-Hai River Basin.

Variable (units)	Period	Obs	Mean	Std. Dev	Min	Max
<i>rnipc</i> (rural net income per capita: ten thousand yuan)	Δt_1	283	0.091	0.163	−2.523	0.252
	Δt_2	283	0.153	0.063	−0.078	0.355
<i>ap</i> (agricultural productivity: ton/ha)	Δt_1	283	0.259	0.320	−0.345	1.593
	Δt_2	283	−0.287	0.410	−1.154	0.688
<i>gdp</i> (gross domestic product: ten thousand yuan)	Δt_1	283	130393.3	412939.6	−1,139,302	3,001,671
	Δt_2	283	491392.5	437946.3	−186,882	2,445,025
<i>rfr</i> (rural farmer ratio: %)	Δt_1	283	0.540	0.062	0.359	0.709
	Δt_2	283	0.012	0.029	−0.119	0.204
<i>fclpc</i> (farmers' cultivated land per capita: hectares/person)	Δt_1	283	−0.502	8.510	−0.014	0.092
	Δt_2	283	0.001	0.011	−0.041	0.060
<i>tpam</i> (total power of agricultural machinery: thousands of watts)	Δt_1	283	15.121	33.442	−409.6	171.67
	Δt_2	283	10.760	13.362	−33.6	94.3
<i>lp</i> (land productivity: ton/ha)	Δt_1	283	0.809	0.973	−1.143	3.619
	Δt_2	283	−0.938	1.353	−3.124	2.114
<i>cclbl</i> (conversion from cultivated land to built-up land: ha)	Δt_1	283	2202.62	6000.51	11.96	65456.91
	Δt_2	283	951.42	2071.08	1.56	25262.06

 Δt_1 refers to 2000–2005, Δt_2 refers to 2005–2008.

In this study, Three Stage Least Squares (3SLS) was applied to control the impacts of correlation among error and residual terms in consideration of characteristics of the SEM model. The estimation procedures with 3SLS are as follows. First, each of equations was estimated by Two Stage Least Squares. Then the covariance matrix of the disturbances of the whole system was estimated according to the results of the preceding step. Finally, the whole equation system was estimated with the Generalized Least Squares Estimate. The significance of variables and robustness of this model were tested, the results showed that coefficient of determination of the equations was 72% and 91%, respectively, indicating the estimation results of parameters in this model were reliable with high statistical significance. The estimation results of the whole model are as follows.

$$\begin{cases} \widehat{rpni} = 0.1283 + 0.0062ap - 0.0003fclpc - 0.0925rfr + 6.11e08gdp \\ \quad \quad \quad (.0093)^{***} \quad \quad (.0146) \quad \quad (.0008) \quad \quad (.0230)^{***} \quad \quad (1.81e-08)^{***} \\ \widehat{ap} = 0.0200 - 0.2773rnipc + 3.54e06cclbl + 0.2927lp + 0.0010tpam \\ \quad \quad \quad (.1575) \quad \quad (.0196)^{***} \quad \quad (1.36e-06)^{***} \quad \quad (.0046) \quad \quad (.0002)^{***} \end{cases} \quad (6)$$

The empirical analysis results from the first equation in the model indicated that agricultural productivity and GDP have positive impacts on rural net income per capita. But the impacts of the agricultural productivity are not significant, which may be due to the fact that the farmers' income largely depends on the non-agricultural earning. By comparison, the effects of GDP are very significant, indicating that the socioeconomic development level has great influence on the farmers' income and the rural net income per capita can reach a higher reach in regions with higher GDP. In addition, the rural employment ratio and cultivated land area per capita have negative effects on rural net income per capita. The increase of the rural employment ratio may lead to the waste of labor in the agricultural production and decline of the production efficiency and farmers' income. While the decrease of the cultivated land area per capita may promote the shift of rural labor to the second and tertiary industries, which can increase the farmers' income. Moreover, the influence of rural employment ratio is significant, while that of cultivated land area per capita is not significant, which also indicates the farmers' income mainly comes from the non-agricultural earnings.

The results from the second equation in the model show that the land productivity, total power of agricultural machinery and the conversion of cultivated land to built-up land have positive effects on agricultural productivity. The higher the land productivity and the total power of agricultural machinery are, the higher the agricultural productivity will be. Besides, the economic benefit

from the conversion of cultivated land into built-up land can increase the factor inputs for agricultural production, which consequently promote the agricultural productivity. In addition, the high significance of the influence of the land productivity, total power of agricultural machinery and the conversion of cultivated land to built-up land suggests that the change in agricultural productivity largely depends on the natural conditions and the factor input level.

The analysis results mentioned above show that the agricultural productivity has positive impacts on farmers' income, but without high significance. The regional socioeconomic development level largely determines the farmers' income level, in particular development of non-agricultural industries has great influence on the structure of farmers' income. Overall, the farmers' income mainly comes from the non-agricultural earnings, while the income from agricultural production accounts for a small proportion of the farmers' total income. In view of this, special attention should be paid to the adjustment of the industrial structure in the rural area in order to increase the farmers' income. On the one hand, it is necessary to improve the agricultural productivity through optimum scale management and application of advanced scientific technology. On the other hand, it is necessary to optimize the allocation of rural labor among different various industries.

4. Conclusions and discussion

There is a growing ability of human beings to interfere with the natural environment as the urbanization continues. The land use change has led to dramatic change of the ecosystem pattern, which further influences the human well-beings. Analyzing the influence of ecosystem changes caused by land use changes on socioeconomic development can provide scientific foundation for improving the land use management and water resource utilization. This study first analyzed the conversion from cultivated land to built-up land in the HHHRB in 2000, 2005 and 2008, and then estimated the agricultural productivity with the ESAP model. Thereafter, a SEM model was established on the basis of the agricultural productivity, socioeconomic data and so on, the results from which revealed the impacts of change in agricultural productivity caused by conversion from cultivated land to built-up land on the farmers' income, and the management implication for the water resource utilization was discussed.

The results of this study show that the conversion from cultivated land to built-up land exerted great impacts on the level and spatial pattern of agricultural productivity. The agricultural productivity was relatively stable, reach 2.84 ton/ha, 3.09 ton/ha

and 2.80 ton/ha on average in 2000, 2005, and 2008, respectively. The agricultural productivity changed dramatically due to the conversion from cultivated land to built-up land, but the improvement of agricultural machinery and fertilizer use exerted positive significant impacts on agricultural productivity, which led to the slight change in the overall agricultural productivity. Moreover, change in the agricultural productivity had positive impacts on the farmers' income, but its impacts were not significant, which may be due to the fact that the non-agricultural earnings made a major contribution to the farmers' income. The results of this study suggest that optimal land use management can play an important role in promoting the virtuous ecosystem cycle and sustainable socioeconomic development. The change in land use change and agricultural productivity can have significant influence on the water resource utilization, which work through influencing the transformation of the industrial structure and the farmers' income. All these results in this study can provide a foundation for the scientific decision making on the land use management and optimization of water resource management, which is of great significance to improving the water resource utilization.

Conflicts of interest

The authors declare no conflict of interest.

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