Unified Analysis and Dynamic Model of the Joint Allocation of Cultivated Land and Ecological Land

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Abstract: Cultivated land is the material basis and condition for human survival and development. Ecological land is an important guarantee to maintain ecological balance and meet people's yearning for a good ecological environment and a good life. With the increase of population and the need of social and economic development, the cultivated land resources are becoming increasingly tense. Unreasonable farming is an important reason for the degradation of cultivated land, which not only seriously affects the effective supply of food, but also brings great pressure on the environment. As a heavy industry base in China, it is still early to use sewage for farmland irrigation, which makes the heavy metal content of farmland in sewage irrigation area exceed the standard and seriously threatens the food security. It is of great significance to scientifically promote the rotation system of polluted farmland, promote the ecological restoration of farmland through the conversion of farmland and ecological land, and ensure the sustainable utilization of land resources.

1. Introduction

The rapid development of industrialization and urbanization has put pressure on land resources and ecological environment, especially in Beijing, Tianjin and Hebei areas with high economic and population density. With 8.1% and 10.0% of GDP, such high economic density and population density, the land development and utilization intensity in Beijing Tianjin Hebei region is very strong, which has a strong impact on natural production and natural material cycle (such as water cycle), and brings great pressure on the ecological environment [1]. The high density of population means that the population base of this area is also very large. With the growth of population, the demand for land resources will continue to increase, and the limited and mobility of land resources aggravate the contradiction between supply and demand of land resources in Beijing.

2. Dynamic Model Construction of Joint Allocation System of Cultivated Land and Ecological Land

2.1 System Dynamics by MIT

The professor put forward in 1956, it uses system theory, cybernetics, information feedback theory, decision theory, system dynamics and computer simulation technology to solve the simulation problem of large system and simulate the development trend of things. Starting from the analysis of system elements, relations and structure, the system dynamics method studies the development trend and function of the system. It is applicable to the system with multi-element, multi-level and complex feedback relationship. It is called the strategy and decision lab. Using system dynamics method to solve this problem can be divided into the following five steps: first, determine modeling boundary, identify system, determine modeling purpose, delimit system boundary; second, system structure analysis. The hierarchical structure and sub modules (or sub-systems) of the system are divided, the variables are defined, the overall and local feedback mechanisms are determined, and the causality diagram and system flow chart are constructed. The third dynamic simulation model is established [2]. According to the system flow chart, the standard system dynamic equation is compiled, and the initial value of the model state variable is determined

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according to the historical data of the system and the relevant parameters of the regression model. The fourth model validity test. Verify the validity of the model, and modify the model according to the test results until the model is closer to the reality. The fifth model simulation. By adjusting and controlling the parameters, the development of the system under different conditions is simulated [3]. Through the analysis and comparison of simulation results, reasonable countermeasures and suggestions are put forward.

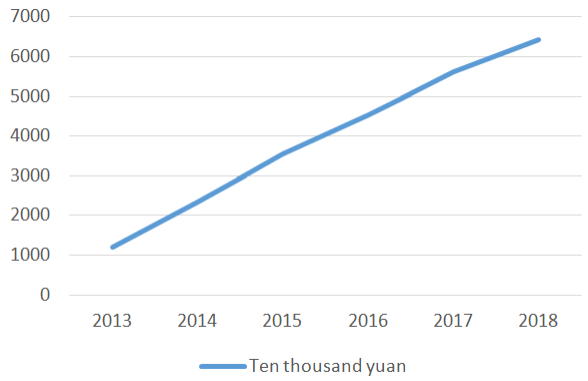

Figure 1 Investment of agricultural fixed assets in Beijing Tianjin Hebei region

2.2 Unified Structure and Feedback Analysis

The joint allocation of agricultural land and ecological land is a complex large system. According to the characteristics of the joint allocation of agricultural land and ecological system and the needs of model design, and considering the social, economic, resource and environmental factors, the joint allocation of agricultural land and ecological system is divided into social subsystem, economic subsystem, resource subsystem and environmental subsystem. Based on the relationship and interaction among the subsystems, this paper analyzes the relationship among the factors in the complex system of society, economy, resources and environment, which is constructed by the joint allocation of cultivated land and ecological land, and puts forward the multi feedback structure of the system [4]. The internal relationship of the joint allocation system of cultivated land and ecological land. It can be seen from that the GDP of the economic subsystem is large, and more funds are used for investment in agricultural infrastructure, pesticides, fertilizers and other aspects, which will have an impact on the output per unit cultivated area of the resource system. With the increase of GDP, more sewage will be discharged into the environment. With the increase of sewage discharge, more sewage will be used for farmland irrigation, resulting in the increase of heavy metal content in farmland soil. The heavy metal content in farmland soil exceeds the standard. In order to maintain farmland security and food security, the cultivated land of resource subsystem will be converted into ecological land, which will further affect food production and agricultural output value of economic subsystem, and will have an impact on economic subsystem. When the content of heavy metals in farmland soil reaches a certain limit, planting and eating crops with high content of heavy metals will have an impact on human health, thus affecting population mortality. The total population in the social subsystem affects the per capita ecological land quantity, which leads to the transformation from the ecological land quantity in the resource subsystem to the cultivated land quantity, and finally affects the economic subsystem and the environmental subsystem [5]. It can be seen that the joint allocation system of cultivated land and ecological land is a complex large system with multiple feedbacks.

2.3 Social Subsystem Analysis

With the development of industrialization and urbanization in our country, as the industrial base of our country, the advantages of employment opportunities and investment environment will attract a large number of immigrants. The social subsystem mainly studies the impact of population change on agricultural population input, food demand, ecological environment demand and cultivated land. For example, the increase of population will increase the pressure on cultivated land

and ecological environment. Population growth will have a greater impact on resources, environment and economy.

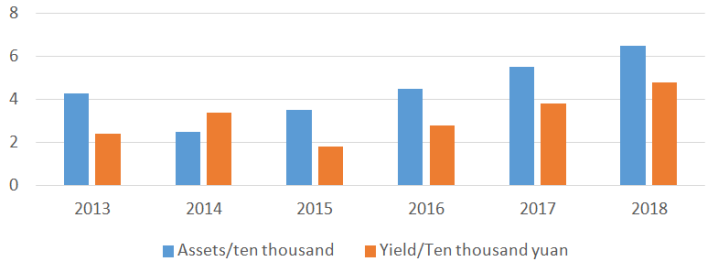

Figure 2 Input of agricultural fixed assets

2.4 Economic Subsystem Analysis

The sustainable development of agriculture can not be separated from capital investment. The higher the regional economic income, the more capital will be used for agriculture. The economic subsystem mainly includes regional GDP, pesticide input, chemical fertilizer input, agricultural output value and agricultural infrastructure input [6]. The increase of regional GDP will increase the input of pesticide, chemical fertilizer and agricultural infrastructure, promote the growth of agricultural output value and continue the growth of regional GDP.

2.5 Environment Subsystem Analysis

In the environmental subsystem, long-term cultivation will affect the soil environment and cultivated land yield. As one of the irrigation areas, sewage irrigation will increase the content of heavy metals in soil. The environmental subsystem mainly includes soil heavy metal content, sewage irrigation, plant heavy metal enrichment rate and soil heavy metal reduction. As a water shortage area, in order to meet the needs of agricultural production, the use of sewage irrigation, soil heavy metal content increased. In order to protect the safety of cultivated land and food security, planting plants with high concentration rate of heavy metals on the cultivated land with high content of heavy metals can reduce the content of heavy metals in the soil to a certain extent.

2.6 Resource Subsystem Analysis

The resource subsystem mainly studies the effect of sewage irrigation on the content of heavy metals in soil. When the standard limit is reached, according to the theory of soil phytoremediation, cultivated land is transformed into ecological land with high plant enrichment [7]. When the yield of cultivated land is lower than the basic bearing capacity of soil, it will turn to ecological leisure. When the cultivated land resource is less or the grain yield is low, the ecological land with heavy metal content reaching the production standard and grain yield per unit area will be converted into cultivated land.

Table 1 Agricultural output value and capital investment

Particular year	2014	2015	2016	2017	2018
Yield	110.05	117.6	127.67	139.7	168.25
Capital investment	195.99	217.16	230.74	238.02	244.31

3. Model System Flow Chart

According to the relationship between the subsystems in the above system and the relationship within the system, the causality feedback diagram of farmland and ecological land allocation system is obtained.

3.1 System Dynamics Model Parameter Setting

When setting the parameters in the system dynamics model, Using the statistical yearbook

(2007-2017), national economic and social development statistical bulletin (2007-2017), China Agricultural Resources Information System of the Chinese Academy of Sciences, land survey results sharing application service platform of the Ministry of natural resources, crop database of the Ministry of agriculture and rural areas, relevant government regulations and other documents and other relevant data, Set the parameters and functions of the paper.

3.2 System Dynamics Model Test

After the system dynamics model is established, the validity of the model needs to be tested to verify whether the simulation results can accurately describe the current situation and solve the research problem [8]. The dynamic model of the system is modified and improved by experiments. Only the model which has passed the test can be used in the system strategy simulation experiment and optimization. Generally speaking, system dynamics model test includes visualization test, running test and history test.

4. Preliminary Construction of the Dynamic Model of the Joint Allocation System of Cultivated Land and Ecological Land

The system dynamics boundary of the joint allocation of cultivated land and ecological land is determined by using the system dynamics method [9]. The joint allocation of cultivated land and ecological land is divided into four systems: society, economy, environment and resources. By analyzing the feedback relationship among the four systems, the dynamic feedback graph of the joint allocation system of cultivated land and ecological land is constructed. Based on the dynamic feedback chart, the dynamic flow chart of cultivated land allocation system and ecological land is constructed. On the basis of correlation analysis, trend analysis, trial and error method and fuzzy comprehensive evaluation, the system dynamic model elements are formulated, and the dynamic model of joint allocation of agricultural land and ecological system is preliminarily established [10]. The key variables such as cultivated land, ecological land and population were selected to test the model. By comparing the simulated and historical values of cultivated land, ecological land and population, the maximum relative error of the three is 0.879%, less than 1%. Within the allowable error range, the model is effective and can simulate the object system well.

5. Conclusion

Through the analysis of the interaction between cultivated land and ecological land, the dynamic model of cultivated land ecological restoration system is established, and the influence of the joint allocation strategy of cultivated land and ecological land on the optimal allocation of cultivated land and ecological land is studied by setting different scene models.

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