Prediction of the Cultivated Land Demand Based on Logistic Equation ——A Case of Zhejiang Province, China

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Abstract Regional situation of Zhejiang Province and connotation of Logistic Equation are introduced. According to the relevant statistical data from 1978 to 2006, dynamic change and its driving forces of cultivated land area in Zhejiang Province are analyzed. Firstly, since the year 1978, cultivated land area has shown a significant fluctuant decreasing trend in Zhejiang Province, China. Secondly, cultivated land at the two stages of 1984 -1988 and 1990 -1995 decreases sharply. Large area of cultivated land is occupied by non-agricultural construction. Thirdly, economic development, population growth and agricultural scientific and technological development are the main driving forces. Contradiction between land and human beings becomes more acute; and the load of cultivated land becomes increasingly heavy. Fourthly, cumulative reduction area of cultivated land changes with time, showing a "S"-shaped curve and according with the Logistic Equation. Change of cultivated land of Jiangsu Province in future is forecasted by Logistic Equation. Result shows that the cumulative reduction area of cultivated land will stop increasing until the year 2020 with the total reduction area of 90.91 thousand hectares. Cultivated area of Zhejiang Province will either be stable at the level of 1 498.24 thousand hectares or will fluctuate around it. With the development of industrial structure, encroachment of urbanization and industrialization on cultivated land is not ever-increasing, but will tend to stop at a certain stage. Overall consideration on land use demand for food safety and for urbanization and industrialization may become possible with the advancement of technology and the increase of land inputs.

Key words Logistic Equation; Cultivated land demand; Prediction; Zhejiang Province, China

With the increase of population and the acceleration of urbanization and industrialization, it is an inevitable trend to transform cultivated land to urban land, which is also an inevitable stage in the process of modernization[1-2]. Thus, contradiction between the supply and demand of cultivated land is becoming increasingly conspicuous. Researches on circulation of cultivated land in China are mainly focused on the judgment of cultivated land circulation and its impact on food security, that is, how much cultivated land we have and how to protect it [3-6]. Besides, another important issue is how to meet the need of land use during the rapid development of urbanization and industrialization. So far, there have been few researches on this. Therefore, taking Zhejiang Province as an example, this paper analyzes the change in cultivated land after the reform and opening up, forecasts the future demand of cultivated land, and explains that encroachment of urbanization and industrialization on cultivated land is not ever-increasing, but will tend to stop at a certain stage with the development of industrial structure. Overall consideration on land use demand for food safety and for urbanization and industrialization may become possible with the advancement of technology and the increase of land inputs.

1 Overview of research area

Zhejiang Province is located in the southeast coast of China, the south wing of the Yangtze River Delta. It is one of the smallness provinces in China with only 105.4 thousand square kilometers land area, accounting for 1.06% of the total land area of China. Zhejiang Province is close to the East China Sea in the east, connects Jiangsu and Shanghai in the north, Anhui and Jiangxi in the west, and Fujian in the south. There are rivers, islands, hills, basins, plains and mountains in Zhejiang Province. Among them, mountains and hills account for 70.4% of the province's land area; plains and basins account for 23.2%; and rivers and lakes occupy 6.4%. Zhejiang Province belongs to the sub-tropical monsoon climate with distinct four seasons, abundant sunlight and sufficient rainfall, which is suitable for the growth of crops. Due to the advantageous location, various landform types and suitable climatic condition, Zhejiang Province is a comprehensive high-yield agricultural region, as well as one of the most developed provinces in China. Zhejiang Province has a high population density, but it is covered mainly by the hilly land with very scarce resources of cultivated land. Per capita cultivated land is less than a half the national average, which is less than the warning line of 0.053 hectare per capita by the FAO[7-9]. With the further deepening of reform and opening up, the increasing of population, and the developing of urbanization and industrialization, large area of high-quality farmland will be occupied by non-agricultural construction.

2 Data source and research method

2.1 Data source Data are mainly from the 2007 *Statistical Yearbook of Zhejiang Province* and the *China Statistical Yearbook*[10-11].

2.2 Research method Logistic Equation is used to forecast the future demand for cultivated land in Zhejiang Province[12-13]. Logistic Equation is also called the growth function and the "S" curve, put forward by P. F. Verhust, a mathemati-

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cian and biologist in Germany, in the year 1837. Later, Pearl, an American biologist and demographer, use Logistic Equation to conduct a large number of studies on biological reproduction and growth. Therefore, Logistic Equation is also known as Pearl Curve. Growth curve is a special curve used to describe the process of biological growth. When a given population grows in a limited environment, it grows fast at the beginning. And then the growth rate gradually slows down due to the limited spatial resources and intraspecific competition of other essential conditions. Finally, the growth stabilizes at a certain level, or fluctuates around the level. At this time, individual number of the given population becomes close to, or reaches, the maximum capacity or load quantity of the current environmental condition[14-15]. This process can be extended to the general things, which objectively describes the evolution law of things. It is more reliable to use Logistic Equation to conduct long-term prediction. Therefore, this method is widely used. The equation is $y=\frac{1}{a+be^{-x}}$.

3 Analysis on driving factors and dynamic changes of cultivated land

Since the year 1978, overall change in cultivated land area of Zhejiang Province has shown a significant decreasing trend (Fig.1). Total cultivated land decreases from 1 838 thousand hectares in 1978 to 1 589.15 thousand hectares in 2006, a decrease of 248.85 thousand hectares. Fig.1 illustrates that there are two stages of fast reduction in cultivated area of Jiangsu Province. One stage is 1984 – 1988. During this period, economic development in Zhejiang Province is rapid. GDP increases from 32.207 billion yuan in 1984 to 76.576 billion yuan in 1988. Rapid economic development will inevitably lead to an increase in land use. According to statistics, land use for collective construction, national construction and rural housing construction reaches as high as 4 428.87 hectares in the year 1988, causing rapid decrease in cultivated land. The other stage is 1990 – 1995. The fastest reduction in the total cultivated land occurs during this period. This is mainly due to the increase of population, the continued outward expansion of the city, and the fever of development zones and real estate. Cultivated land decreases sharply and large area of cultivated land is occupied for non-agricultural construction[16].

In a word, after the reform and opening up, driving forces for the change of cultivated land in Zhejiang Province are mainly the following factors.

3.1 Factor of economic development Since the reform and opening up, economic strength has developed rapidly in Zhejiang Province; national capital construction projects have increased; and development mode of urbanization expansion has occupied a large area of cultivated land. Large-scale urban construction leads to the expansion of city and the occupation of fertile field around city. With the acceleration of urbanization in rural areas, there exists the phenomenon of " housing fever" , as well as the construction of Economic and Technological Development Zone and so on, which needs to occupy the land, even fertile farmland.

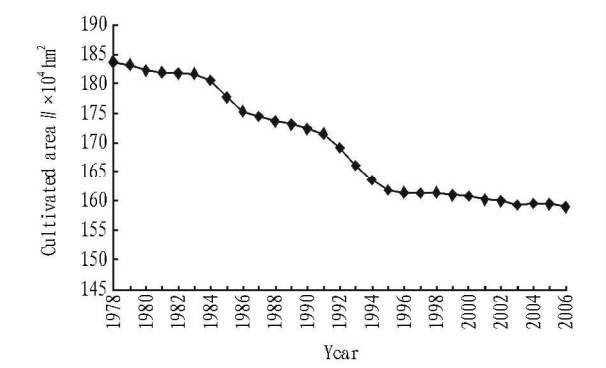


Fig.1 Change of cultivated land area in Zhejiang Province from 1978 to 2006

3.2 Factor of agricultural scientific and technological development According to the course of agricultural development in China, scientific and technological progress is an important parameter of the increase in unit area grain yield. Since the reform and opening up, Zhejiang Province has increased the investment in agriculture, improved the quality of farmland, built water conservancy projects, applied more fertilizers, and brought forward intensive farming, so as to enhance the condition for agricultural production, and to increase the food production and unit yield year by year. In addition, degree of agricultural mechanization has significantly enhanced. And the unit area grain yield has enhanced due to the scientific application of chemical fertilizer and the promotion of improved varieties. However, lured by huge profits, people start to look for land management with high income, to conduct the readjustment of land, and to transfer some cultivated land into garden, woodland and fish pond, which cause a further reduction of cultivated land[16-17].

3.3 Factor of population growth Population, an external pressure, plays a role of bidirectional control in the change of cultivated land quantity. Human being is one of the most dynamic driving forces for the change of land coverage and land use. On the one hand, growth of population needs more living facilities and construction production of cultivated land. On the other hand, growth of population also needs more food and other basic guarantees provided by cultivated land. Moreover, migrant floating population in Zhejiang Province is increasing in recent years. With the development of economy and the improvement of people's living standard, demand for both material civilization and spiritual civilization is increasing. All these stimulate the appearance of service industry and enlarge the land use of tertiary industry. With the further increase in population, area of cultivated land will continue to be reduced. This reverse development has given rise to a more acute contradiction between land and human beings, and the load of cultivated land becomes increasingly heavy[16,18-25].

4 Prediction of cultivated land demand

Taking 1978 – 2006 cumulative reduction area of cultivated land as the ordinate (dependent variable y), and time as the

abscissa (independent variable x), we obtain a scatter diagram (Fig.2). Curve of year and cumulative reduction area of cultivated land is in line with the "S" curve. Hence, we select the equation $y=\frac{1}{a+be^{-x}}$ to forecast the area of cultivated land, where y is the cumulative reduction area of cultivated land, a and b are regression coefficients, and x is year. Reciprocal of the equation is obtained by letting $y'=\frac{1}{y}$, $x'=e^{-x}$. Hence, we have a linear equation $y'=a+bx'$. Use least square method to determine the coefficients a and b in regression linear equation: $a=0.11$, $b=4.275\,2$. Then, Logistic Equation (1) is obtained by equation reduction: $y=\frac{1}{0.11+4.275\,2\,e^{-x}}$.

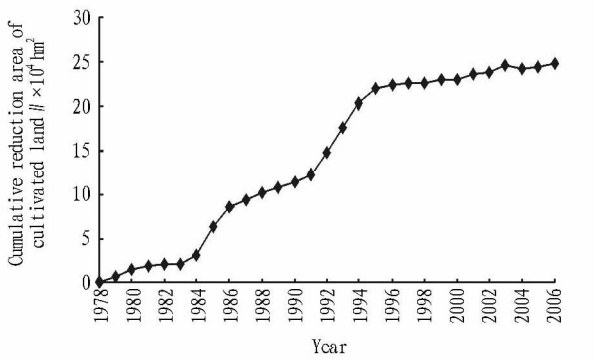
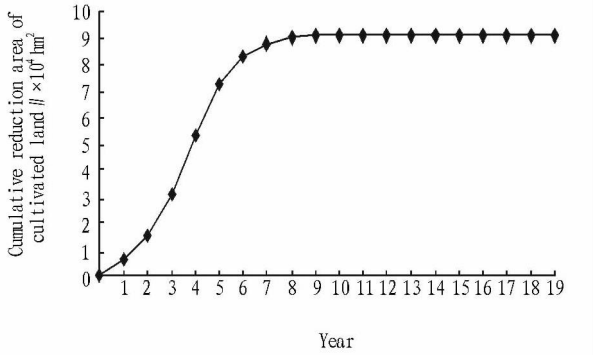


Fig.2 Cumulative reduction area of cultivated land in Zhejiang Province from 1978 to 2006

Relevant index $R=0.938$, indicating that fitting result of Logistic Equation is relatively good and the equation is credible. Finally, based on the equation we established, demand of cultivated land area in future can be forecasted. Fig.3 shows the cumulative reduction area of cultivated land in Jiangsu Province in future by taking the year 2006 as the base year.



Note: 0 – 19 stand for the years 2006 – 2025, respectively.

Fig.3 Logistic curve for cumulative reduction area of cultivated land in Zhejiang Province from 2006 to 2025

Prediction result shows that the cumulative reduction area of cultivated land will stop increasing until the year 2020 with the total reduction area of 90.91 thousand hectares. Cultivated area of Zhejiang Province will either be stable at the level of 1 498.24 thousand hectares or will fluctuate around it.

5 Conclusion and discussion

Analysis result shows that since the reform and opening up, cultivated land area of Zhejiang Province has shown a significant fluctuant decreasing trend. There are two stages with rapid reduction of cultivated area: 1984 – 1988 and 1990 – 1995. Driving factors for the change of cultivated land are economic development factor, population growth factor and agricultural scientific and technological development factor. Cumulative reduction area of cultivated land in Jiangsu Province from 1978 to 2006 changes with time, showing a "S"-shaped curve and according with the Logistic Equation.

Prediction result shows that the cumulative reduction area of cultivated land will stop increasing until the year 2020 with the total reduction area of 90.91 thousand hectares. Cultivated area of Zhejiang Province will either be stable at the level of 1 498.24 thousand hectares or will fluctuate around it. This shows that cultivated land area of Zhejiang Province in the year 2020 will meet the needs of urbanization, industrialization and food safety. Meanwhile, this also indicates that with the development of industrial structure, encroachment of urbanization and industrialization on cultivated land is not ever-increasing, but will tend to stop at a certain stage; and with the advancement of technology and the increase of land inputs, cultivated land for ensuring food safety will decrease. Therefore, we believe that land demand for urbanization-industrialization and for food safety may not always be at conflicting, and overall consideration on the two may become possible.

Conclusion of is obtained based on the current level of productive forces. In the future, prediction result may be changed due to the continuous development of economy, the improvement of productive forces and the increase of population. Therefore, we will pay sustained attention to this issue.

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基于逻辑斯蒂方程的耕地需求预测——以浙江省为例

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摘要 介绍了中国浙江省的区域概况和逻辑斯蒂方程的内涵。根据1978~2006年相关统计数据,分析了浙江省耕地面积的动态变化及其驱动因素。①1978年以来,浙江省耕地面积呈明显的波动减少趋势;②有两个阶段耕地面积减少较快,即1984~1988年和1990~1995年,在此期间,大量耕地被非农建设所占用;③经济发展、农业科技进步、人口增长因素是耕地面积变化的主要驱动因素,人地矛盾日益尖锐,耕地负荷越来越重;④耕地累计减少面积随时间变化的曲线呈"S"形,符合逻辑斯蒂方程。运用逻辑斯蒂方程对浙江省未来耕地变化情况进行了预测。预测结果显示,至2020年,浙江省耕地累计减少面积将不再增加,届时耕地累计减少面积为9.091万 hm^2,浙江省耕地面积将稳定在149.824万 hm^2 水平线上或在该水平线上下波动。研究表明:随着产业结构的高级化,城市化、工业化对耕地的蚕食并非不断增加,而是将在某一阶段趋于停止;随着科技进步和土地投入的增加,为保证粮食安全所需的耕地面积将不断减少;城市化、工业化的用地需求与粮食安全的用地需求是可以兼顾的。
关键词 逻辑斯蒂方程;耕地需求;预测;浙江省

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构建北京市新型农业科技服务体系的探讨

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摘要 首先,在介绍了中国北京市农业科技服务体系发展现状的基础上,阐述了构建北京市新型农业科技服务体系的指导思想和目标。其次,分析了北京市新型农业科技服务体系的6个组成部分:政府主管部门系统、政府公益性农技推广机构系统、村级农技推广员系统、科研院校系统、农民经济合作组织系统和涉农企业系统。再次,提出了农业科技服务传播的3个途径,即公益性农业科技服务途径、经营性农业科技服务途径和农业科技服务支撑途径。其中,经营性农业科技服务途径又可分为政府引导型的产业化传播途径和完全市场化的技术传播途径2种。最后,从机构和组织建设、人才队伍建设、机制与体制建设、支撑与保障4个方面探讨了构建北京市新型农业科技服务体系的具体思路。
关键词 北京市;新型科技服务;体系建设;推广机构