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# Target Prediction of Cultivated Land Resources Based on Influencing Factors and Time Series Model

—A Case of Anqiu City, China

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**Abstract** Taking Anqiu City, Shandong Province, China as an example, dynamic change of cultivated land resources of Anqiu City is analyzed from the aspects of the quantitative change of cultivated land resources, the structural change of cultivated land resources, and the regional differences of cultivated land change. Based on the land demand prediction of grain demand, the land demand prediction of economic crop production, and the land requirement goal, factors affecting the requirement goals of cultivated land resources are discussed. Linear Prediction Model and Polynomial Forecasting Model are used to discuss the goal forecast of cultivated land resources based on time series, which provides basis for decision making of land use in Anqiu City within planning period. Result shows that total area of cultivated land increases year by year and the per capita cultivated land is relatively stable. Proportion of irrigated cultivated land in cultivated land is decreasing gradually and that of dryland is increasing. Dynamic change of cultivated among township streets shows no significant regional differences. Due to the increase of population, per capita cultivated land will be under great pressure and the situation of cultivated land is still not optimistic.

**Key words** Land resources; Influencing factor; Time series; Anqiu City; China

Sustainable utilization of land resources is the basis of sustainable development of human social economy. Cultivated land is the most basic of natural resources, and keeping a certain quantity of cultivated land is the basic conditions for the survival of mankind<sup>[1-2]</sup>. In recent years, due to construction use, ecological cropland conversion, agricultural structure adjustment, natural disaster damage and etc., the retaining amount of cultivated land in our country is decreasing rapidly, the state's food security is threatened<sup>[3]</sup>. Therefore, strengthening cultivated land dynamic change research and the prediction of quantity of cultivated land during the planning period provides a reference for rational utilization of cultivated land resources, controlling further reductions of the cultivated land area, ensuring dynamic balance of cultivated land in quantity and quality, enhancing sustainable utilization of cultivated land resources and scientific development of regional social economy<sup>[4]</sup>.

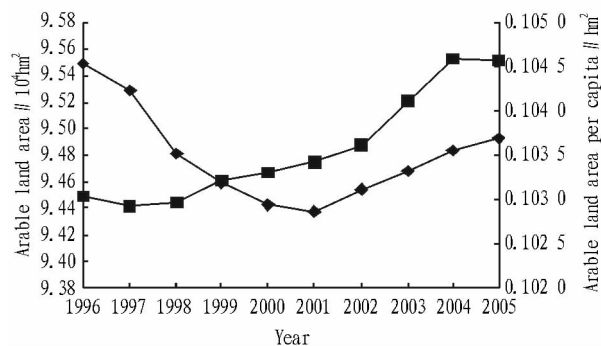
## 1 General information of research area

Anqiu City is located in the middle east of Shandong Province, south-central Weifang City, 118°44' – 119°27' E, 36°05' – 36°34' N. The city is bounded in the east by Weifang River to Xiashan District, separated from Yishui County by Qu River, next to Fangzi District and Chanle County in the north and neighbored with several cities. Plain, hills and mountain areas occupy one third of the city's area respectively. It has 10 towns, 2 streets and 1 217 administrative villages. Till the end of the year 2005, the city's total population is 921 200, the total land area is 1 712 km<sup>2</sup>, the total cultivated land area is 95 500

hm<sup>2</sup>, the cultivated land per capita is 0.104 hm<sup>2</sup>.

## 2 Dynamic change of cultivated land resources of Anqiu City

**2.1 The quantity change of cultivated land resources** As shown in Fig. 1, Anqiu's cultivated land area is 94 500 hm<sup>2</sup> in 1996, and increases 1 000 hm<sup>2</sup> to 95 500 hm<sup>2</sup> in 2005, with an average annual increasing of 100 hm<sup>2</sup>. Through analyzing the ten-year cultivated change situation in Anqiu, we find that the city's total cultivated land area is about 94 000 – 95 000 hm<sup>2</sup> and with a rising trend. Per capita cultivated land area in 2005 of the city is 0.104 hm<sup>2</sup>, 0.023 hm<sup>2</sup> more than that of Shandong Province which is 0.081 hm<sup>2</sup><sup>[5]</sup>. Change among years is little<sup>[5]</sup>.



Note: The information are from investigation data of land use change in Anqiu City, China.

**Fig.1 The variation of arable land area in Anqiu City, China during 1996 – 2005**

**2.2 Structural change of cultivated land resources** In 2005, Anqiu has a total cultivated land area of 95 500 hm<sup>2</sup>, with

44 800 hm<sup>2</sup> irrigated cultivated land an 50 700 hm<sup>2</sup> dryland of it, and they respectively take 48.08% and 51.92% of the total cultivated land area. The proportion of irrigated land in cultivated land is decreasing gradually and that of dryland is continuously increasing. The former has decreased by 600 hm<sup>2</sup>, and the latter has increased by 1 000 hm<sup>2</sup>. The change situation of the structure of cultivated land in ten years reflects that the quality of cultivated land descends slightly.

**2.3 Regional differences in dynamic change of cultivated land** Using relative rate of land use type to study the regional differences of the dynamic change of cultivated land in Anqiu City. We get a formula:  $R = (K_a/K_b)/(C_b/C_a)$ .

In the formula,  $K_a$ ,  $K_b$  respectively delegates the area of the beginning and the end of the study of one particular land use type in one region;  $C_a$ ,  $C_b$  respectively delegates the area of the beginning and the end of the study of one particular land use type in the whole study region.

In one region, if the relative rate of one land use type- $R > 1$ , then it shows that in this region the land use type changes a lot. Through calculating, we find that the  $R$  value of each township and street is in the scope of 0.94 – 10.5, it reflects that the regional differences of the dynamic change of cultivated land of townships and streets in Anqiu is little.

### 3 Target prediction of the demand of cultivated land resources

In recent years, many scholars have adopted various forecasting methods to predict different regional scale of cultivated land resources. For example, SunYan *et al.* use the exponential model and dynamic prediction model to predict the retaining amount of cultivated land in China, Gao Xuesong *et al.* predict the cultivated land area of Sichuan province based on the balance of the system, Sun Guojun *et al.* predict the cultivated land in Jiuquan city based on the multivariate linear regression,

and so on<sup>[6-9]</sup>. Current research is building mathematical model according to the quantity of cultivated land, rarely predicts the quantity of cultivated land from the angle of logical relationship between cultivated land change and its influencing factors. The author predicts the quantity of cultivated land from the angle of logical relationship between cultivated land change and its influencing factors and uses the time series model to finally get the amount of cultivated land in the planning period with small errors by taking weighted value from the two kinds of forecasting methods.

#### 3.1 Target prediction of the demand of cultivated land resource based on the influencing factors

**3.1.1** The prediction of the cultivated land demand based on the demand for food. For reasonably predicting the cultivated land demand and meeting the future demand for food during the planning period of Anqiu, the model of prediction of the cultivated land demand is built by four factors related to the cultivated land demand area, including total population in planning period, per capita occupying food index, grain crop output per unit and cultivated land replanting index.

$$S = \frac{P \times I}{D \times \alpha}$$

In the formula,  $S$  delegates the cultivated land demand area,  $P$  indicates the population in the year of planning period,  $I$  is the per capita food demand in planning year,  $D$  delegates the output per unit in the year,  $\alpha$  is the replanting index in the year.

**3.1.1.1** Population size prediction. Population prediction is the important foundation work of general land using plan, it is the important basis of determining the index of various types of land, adjusting the land use structure, achieving the balance of supply and demand of cultivated land and solving the contradiction between man and land. Choose population data of Anqiu city from 1996 to 2005 as the based data of population prediction. (Table 1).

**Table 1** The change of population in Anqiu City during 1996 – 2005

Year	Total population × 10 <sup>4</sup>	atural growth rate of population ‰	Birth population	Birth rate ‰	Death population	Mortality ‰
1996	90.38	5.72	109 811	12.15	58 114	6.43
1997	90.58	5.66	113 859	12.57	62 590	6.91
1998	91.22	6.82	119 863	13.14	57 651	6.32
1999	91.67	4.18	90 753	9.90	52 435	5.72
2000	91.96	4.51	104 282	11.34	62 808	6.83
2001	92.11	3.22	83 267	9.04	53 608	5.82
2002	92.00	-1.95	80 500	8.75	62 560	6.80
2003	92.15	2.17	83 580	9.07	63 583	6.90
2004	92.26	4.08	88 477	9.59	50 835	5.51
2005	92.12	-2.32	83 829	9.10	62 457	6.78

Note: Data are from *Anqiu Statistical Yearbook* during 1996 – 2005. The same as Fig.2.

From Table 1, Anqiu's had the lowest birth rate 8.75‰ in 2002, and 12.57‰ in 1997 as the highest, the birth rate of each year did not exceed 10‰ after 2001 and maintained a steady level. We firstly forecast Anqiu's total population in future planning period by using the method of average growth rate, then choose other methods to predict population and make a comprehensive analysis of population prediction refer to

other population forecast of relevant planning, finally determine the total population in planning period. Specific forecasting formula is  $P = P_0 \times (1 + K)^n$ , where  $P$  is the total population in planning period,  $P_0$  is the population in based period,  $K$  is the natural population growth rate in planning period(‰),  $n$  is the planning years.

From determining the growth rate at each period by consid-

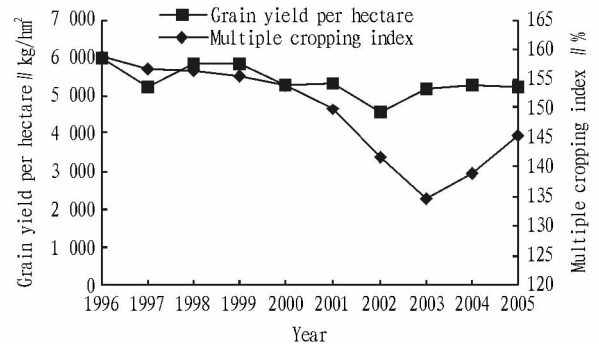
ering the cyclical variation of population growth, we can see that from 1996 to 2000, Anqiu's total population is at an ascending period, taking the end of the year 1996 as the based period, the four years compound growth rate is 4.33‰, comes to the maximum. From 2001 to 2005, Anqiu's total population mainly unchanged, this period is a preparing period for the ascending period from 2005 to 2010. Taking the 919 600 population at the end of 2000 as the based data, we estimate that the annual compound growth rate in new population cycle in Anqiu is 3.88‰. The prediction of population in 2010 is 955 900, the annual compound growth rate is 3.88‰ from 2000 to 2010. With the development of economy and further improved living standard, the compound growth rate is estimated higher than 3.88‰ from 2010 to 2020 but lower than four-year compound growth rate 4.33‰. Take average 4.20‰ of the two and make the population prediction at the end of 2010 as the based data, through calculating, the population prediction is 996 800 in 2020. The prediction result is basically the same by using the regression analysis method or the growth rate method. Meanwhile it corresponds with the prediction of each plan in Anqiu. For this we determine the population prediction in 2010 is 955 900 and 996 800 in 2020.

**3.1.1.2** The prediction of grain occupying per capita. The grain demand should be analyzed systematically brought into the whole situation of total food demand. With the improvement of people's living standard, the proportion of per capita consumption of grain in the total consumption of grain (including food ration, feed grains and other uses) appears a slowly downward trend. At the same time, people's demand in animal food plays a quickly growing trend. The two kinds of growing trends increase the demand of feed grain. Anqiu is located in the middle east of Shandong province, the per capita cultivated land area is small, middle-and-low-yielding fields make a big proportion of the cultivated land, the output of the grain can't meet the local needs. Wheat and corn are mostly from local production, little shortage is filled by outside, corn and sweet potatoes all use to meet local needs. Therefore, prediction of grain of Anqiu city should mainly meet the local requirements. Anqiu is an agricultural city, its per capita grain occupancy is 661 kg in 1997 and 417 kg in 2005, has already exceeded 400 kg per capita which is the food safety standards. Combining with the actual situation, for insuring the food safety, the per capital grain occupancy should be 550 kg.

**3.1.1.3** The prediction of grain output per unit. According to statistical yearbook data of Anqiu from 1996 to 2005, its grain output per unit is shown in Fig. 2. From the figure, the grain output per unit in Anqiu in the past ten years presents stable with a slight decline and changes little. In 2010, using the average annual grain output 5 395 kg/hm<sup>2</sup> as the recent grain output level. After completing agricultural infrastructure and improving the quality of cultivated land, the grain output per unit in 2020 is predicted to 5 500 kg/hm<sup>2</sup>.

**3.1.1.4** The prediction of replanting index. Replanting index is the ratio of total sown area and total cultivated land area in a region. It is an important index to measure cultivated land utilization, it often expresses as percentage<sup>[10]</sup>. The replanting index of the past ten years in Anqiu is shown in Fig. 2. From

1996 to 2005, the replanting index in Anqiu is decreasing first then increasing according to the Fig. 2. It is influenced by regional position, climate change, agricultural policy and agricultural market. Among the ten years, the replanting index was 158.78% in 1996, and decreased to 145.14% in 2005. It is predicted to increase somehow with the improvement of farmland infrastructure and development of interplanting technology. In this planning the average replanting index 150% from 1996 to 2005 is used. According to the above analysis, using the grain prediction model to calculate, the crop production demand area is 65 000 hm<sup>2</sup> in 2010 and 66 500 hm<sup>2</sup> in 2020.



**Fig.2** The change of grain yield per hectare and multiple cropping index in Anqiu City during 1996 – 2005

**3.1.2** The prediction of cultivated land demand for economic crop production Anqiu's economic crops mainly focuses on oil plants and cotton. Cotton production changes according to the market demand. It needs rationally adjust the planting area and promote new varieties with high quality and high resistance and formulate a reasonable agricultural development planning at the same time. The oil plant production should mainly relies on geographical advantages, quicken the new varieties development, meet the market demand of Anqiu with the condition of agricultural development as the basis. With the development of chemical fiber industry, the market demand for cotton will gradually decrease. Per capita occupancy of cotton in 2005 is 4.25 kg, and predicts 4.20 kg in 2010 and 4.00 kg in 2020. And that of fuel in 2005 is 38.80 kg, and predicts 40.00 kg in 2010 and 41.20 kg in 2020. Calculating with the output in unit of oil plants and cotton respectively as 1 000 kg/hm<sup>2</sup> and 3 400 kg/hm<sup>2</sup> and the replanting index respectively as 100% and 100%, Anqiu needs cultivated land 15 300 hm<sup>2</sup> by 2010, and 16 100 hm<sup>2</sup> by 2020.

**3.1.3** The target of cultivated land demand. In order to ensure food safety of future society, according to the lowest cultivated land demand of Anqiu agricultural production and the strategic positioning as industrialized city, by 2010, the whole city needs 80 300 hm<sup>2</sup> cultivated land, and 82 600 hm<sup>2</sup> by 2020.

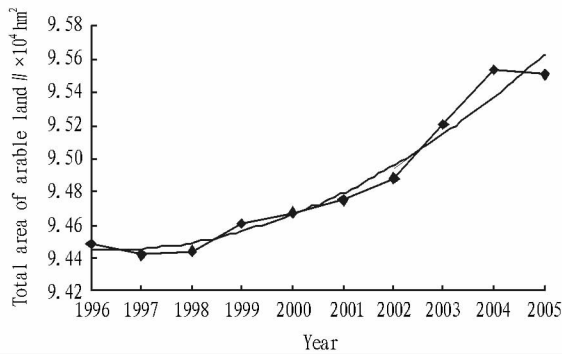
**3.2 The target prediction of cultivated land resource based on time series** Time series prediction method make a judgment based on the variation laws that the cultivated land formed in a long period. It uses historical statistical data and reality investigation data to predict the future and get certain regularity by statistical analyzing these data, supposing the trend formatted in the past continues to exist in the future<sup>[11]</sup>.

**3.2.1** Using the polynomial prediction model build a model as

follow,

$$y = ax^2 + bx + c$$

In the formula,  $y$  is the total cultivated area,  $x$  is the year,  $a$ ,  $b$ ,  $c$  is coefficient. Calculating by the least-square method, we get that,  $a=0.0016$ ,  $b=-6.2614$ ,  $c=6259.3000$ ,  $R^2=0.9632$ . Fitting to significance, as shown in Fig. 3, putting the corresponding numerical in the formula, we get the result that the cultivated land area in 2010 is 97 400  $\text{hm}^2$  and 103 300  $\text{hm}^2$  in 2020.

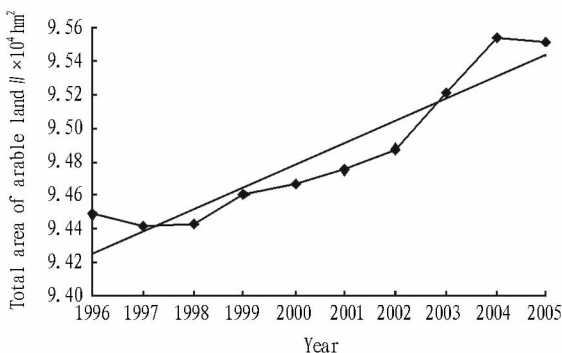


**Fig. 3 Polynomial prediction of arable land in Anqiu City during 1996–2005**

**3.2.2 Using linear prediction model build a model as follow,**

$$y = ax + b$$

In the formula,  $y$  is the total cultivated land area,  $x$  is the year,  $a$ ,  $b$  is the coefficient. Calculating by the least-square method, we get that  $a=0.0132$ ,  $b=-16.9840$ ,  $R^2=0.8838$ . Fitting to significance, as shown in Fig. 4, putting the corresponding numerical in the formula, we get the result that the cultivated land area in 2010 is 95 500  $\text{hm}^2$  and 96 800  $\text{hm}^2$  in 2020.



**Fig. 4 Linear prediction of arable land in Anqiu City during 1996–2005**

**3.3 The results of prediction** On the basis of the predicting values, synthesizing regional development strategy and practical situation in Anqiu, analyzing cultivated land changing trend of Anqiu objectively, and finally using the average method to get the result that the cultivated land area in 2010 is 91 100  $\text{hm}^2$  and 94 200  $\text{hm}^2$  in 2020.

## 4 Conclusion

In recent 10 years, the dynamic change trend of Anqiu's cultivated land resources is mainly embodied in the following

aspects: the total amount of cultivated land has increased gradually and the quantity of cultivated land per capita is relative stability; the proportion of irrigated land in cultivated land reduces and the proportion of dryland in cultivated land increases year by year; the dynamic changes of cultivated land in each township and street show no significant regional differences. Through the prediction, Anqiu's cultivated land will remain at the level of stability with a slightly declining. Due to the increase of population, per capita amount of cultivated land will continue to reduce, cultivated land situation is still not optimistic. Therefore, in the planning period, in order to ensure the total amount of cultivated land and the per capita quantity of cultivated land, improve the quality of cultivated land, achieve the dynamic balance between the quantity and the quality of cultivated land, it is better to take the following measures. Firstly, perfect and refine the basic cultivated land protection system, strictly enforce the balance system of occupation and supplement. Secondly, increase the force of land reclamation and reserve land resources development. Thirdly, strengthen the government management mechanism<sup>[12]</sup>, strict land controls and improve cultivated land management level by using science and technology.

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markable. Although agricultural output value raises with the development of agricultural technology, the increment is balanced out with output value reduction caused by farmland losses. Hence, this result cannot objectively describe its influence on farmland change, because it is difficult to distinguish these two reasons leading to changes of agricultural output values mentioned above (In this case, we remove the variable to maintain fineness of our model).

**4.2 Discussion** Since there are various types of panel data models and model estimation involves huge amount of data informations, Eviews soft is adopted to yield twice the result with half the effort in selecting and estimating models. Although the test on this model and economic significance has obtained good effect, the farmland use and its change are a complicated system under combined actions of society and economy. Therefore, the model in this study has its own limitation with merely main socio-economic factors being chosen. Furthermore, socio-economic factors and natural causes, such as climate and environment, also have great impact on farmland change which requires our further research as well.

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## 基于面板数据的江苏耕地社会经济模型

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**摘要** 在界定了面板数据含义的基础上, 介绍了面板数据回归模型及其具体估计方法。结合江苏省耕地利用现实情况, 选取了总人口、地区生产总值、农业产值、固定资产投资、社会消费品零售总额、城镇居民人均可支配收入、农民人均村收入 7 个对耕地变化有影响的社会经济因子作为解释变量, 耕地作为被解释变量。利用江苏省 13 个市 2000~2008 年的面板数据, 根据 Hausman 检验结果选用了固定系数、变截距的固定效应模型, 并运用该模型构建了江苏省 13 个市的耕地社会经济模型。结果表明, 人口因素是江苏省耕地变化最重要的驱动力因子, 社会经济因素对耕地的固定效应较弱, 农业产值的回归系数不显著, 地区生产总值的模型系数所反映的经济含义与现实不符, 模型从经济意义上来说总体是显著的。

**关键词** 耕地; 面板数据; Eviews; 社会经济模型

(From page 52)

## 基于影响因素角度和时间序列模型的耕地资源目标预测研究

——以山东省安丘市为例

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**摘要** 以山东省安丘市为例, 在介绍研究区概况的基础上, 从耕地资源数量变化、耕地资源结构变化、耕地变化动态的区域差异 3 个方面分析了安丘市耕地资源动态变化状况, 从基于粮食需求的耕地需求预测(人口规模预测、人口粮食占有量、粮食单产预测、复种指数预测)、经济作物生产对耕地需求预测、耕地需求目标 3 个方面探讨了探讨了影响耕地资源需求目标的因素, 采用多项式预测模型和线性预测模型探讨了基于时间序列的耕地资源目标预测, 为安丘市规划期内土地利用提供决策依据。结果表明, 耕地总量呈逐年增多趋势, 人均耕地数量相对稳定; 水浇地占耕地比重逐年减少, 旱地占耕地比重逐年增多; 各乡镇街道耕地动态变化区域差异不大; 安由于人口数量的不断增加, 人均耕地的数量将会面临很大的压力, 耕地形势仍然不容乐观。

**关键词** 耕地资源; 影响因子; 时间序列; 安丘市