

RESEARCH ON THE POPULATION CARRYING CAPACITY OF THE LAND RESOURCES IN THE ECONOMIC AREA OF ZHUJIANG DELTA

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ABSTRACT: The authors once made a preliminary research on population carrying capacity of the land in the Economic Area of Zhujiang Delta (EAZD for short) in 1995, and reckoned that the ultimate population in this region will be 23 550 thousand by year of 2000. While the population in being in EAZD was 22.62 million in 1999. This accords with the prefigured result in the rough from the point of view of development. According to the data of plow land resources from the 2000 Statistical Yearbook of EAZD and the study on the population-foodstuff-plow land relationship, this paper calculates the productive potential of plow land and the population carrying capacity of land by year of 2010, and puts forward the countermeasures for improving the population carrying capacity of land in this region.

KEY WORDS: land resources; land production potential; population carrying capacity of land; the Economic Area of Zhujiang Delta

CLC number: F301

Document code: A

Article ID: 1002-0063(2001)02-0174-07

The Economic Area of Zhujiang Delta (EAZD for short) includes 14 cities and counties: Guangzhou, Shenzhen, Zhuhai, Foshan, Jiangmen, Dongguan, Zhongshan, Huizhou, Huiyang, Huidong, Boluo, Zhaoqing, Gaohui and Sihui. In 1999, the population of EAZD is 22.62 million, 30.99% of the total population of Guangdong Province, and the land area is 41 698km², 23.36% of the total area of Guangdong Province (Guangdong Province Statistics Bureau, 2000).

EAZD is the important base of many productions such as food, sugarcane and fish. However, in recent decades, with the economic reform and the rapid development of commodity economy, the area of the non-agricultural land use increases constantly and the area of the arable land decreases. For example, the

area of the arable land was 693 640ha in 1994 and decreased to 660 306ha in 1999 (Guangdong Province Statistics Bureau, 2000). The annually decrease rate is 0.98%. However, the annually increase rate of the population is 1.54% in the same period. Because of the increasing of population, the decreasing of the arable land and the constant decaying of the production capacity of food, the conflict between the population and the arable land resources is obvious day by day. Therefore, it is an important practice to discuss the problem of population carrying capacity of EAZD in 2010 and this will provide scientific basis to establish the policies of population, land and food.

There are two definitions of the land carrying capacity on population, in narrow and broad sense. In the

Received date: 2000-04-25

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narrow sense, it only indicates to guarantee the potentiality of food supplies, that is to say, the land carrying capacity refers to the production potentiality of the agricultural land and the supported population in a certain period in a country or a region. This paper mainly discusses the land carrying capacity in the narrow sense.

1 TO PREDICT THE POPULATION AND THE DEMAND OF GRAIN

1.1 To Predict the Population

The population prediction is to analyze the fluctuation and determine the dynamic trend of the population in a certain future period. This paper uses the physical accretion and mechanical accretion methods to predict the population of EAZD.

According to the special research on Prediction of Population Development of Guangdong Province, the development trend of society and economy of Guangdong Province and the goal of population control, the natural growth rate of population of Guangdong Province in future should be controlled under 1.08%, and the registered population should be controlled within 80 000 thousand. The natural growth rate of the population of Zhujiang Delta decrease year-to-year, for example, from the period of 1994 – 1995 to the period of 1996 – 1998 and 1998 – 1999, natural growth rate of the population decreased from 2% to 1.53% and 1.1% respectively. In fact, during the period of 2000 to 2001, people born in the late 1970s will marry and procreate. But due to that this part of population is considerably less than that of previous, natural growth rate of the population will decrease markedly. Therefore, we assume that natural growth rate of the population in Zhujiang Delta will be 8‰, and based on the registered population of late 1999, then we can predict that population of this region will increase naturally to 24 690 thousand by year of 2010. Additionally, according to the concerned data, during recent ten years, there were about 80 thousand people immigrated into EAZD each year (Guangdong Province Construction Committee, 1996). While the development of cap-

ital-technology-intensive industry will need a great number of persons with ability, but the people in being and in future hardly meet this requirement. And some cities such as Shenzhen are taking in temporary population step by step. All these factors will increase the immigrated population; the immigration rate will increase to 200 thousand each year. So the practical increment of population in this region will be up to 2200 thousand by year of 2010. Thus the total registered population of EAZD will be 26 890 thousand, which will account for 33.75% of the total population of Guangdong Province in year of 2010. This shows that the population of Guangdong Province will centralize towards EAZD gradually in the coming 10 years. As EAZD is the pioneer of Guangdong Province during the realization of basic modernization, this phenomenon is natural. In order to make the plan of land utilization tally with the economic development of the whole province, in the following concerned predictions, we all assume the population to be 27 000 thousand.

1.2 To Determine the Standard of Average Per Capita Nutrition in 2010

The standard of average per capita nutrition is the minimum level of nutrition to guarantee the normal life. It can be represented by the quantity of heat, protein and fat needed everyday. EAZD is one of the richest regions of China and the residents' consumption level is higher than that of others. When determining the standard of nutrition in 2010, we adopted two standards, the moderate well-off standard and the rich standard. The consumption structure is shown in Table 1.

Table 1 The population nutrition level and food structure in 2010 (kg/person · a)

Item	The moderately well-off standard	The rich standard
Meat	21	24
Fowl	12	16
Milk	15	30
Egg	12	30
Aquatic product	21	24
Bean	13	18
Vegetable oil	8	10
Vegetable	135	135
Fruit	20	25
Melon	60	70
Processing grain ration	180	165

1.3 To Predict the Demand of Grain in 2010

The grain is not only an important food but also the materials of the animal husbandry and food processing industry. It can meet many demands. To analyze the amount of the population supported by land can approximately show the population carrying capacity of land. The demand of grain of EAZD includes many aspects shown as follows:

(1) The grain to guarantee the basic living. This refers to the demand of grain (including the grain ration and the grain used as forage) based on different nutrition standards in 2010. According to the different types of the nutrition standards, food structure and the transformation rate of grain, the demand of grain at the different nutrition standards can be figured out. The results are shown in Table 2.

Table 2 The total amount of grain to guarantee the basic living of EAZD in 2010

The nutrition standard	The standard of average grain per person(kg)	The total amount of demand(kg)
The moderately well-off standard	480	1.296×10^{10}
The rich standard	520	1.404×10^{10}

(2) The grain to meet other needs. According to the prediction of the related department, in EAZD in 2010 the grain to meet other needs is 5.4×10^8 kg (including 2.2×10^8 kg for seeds, 2×10^8 kg for industry and 1.2×10^8 kg to supply Hong Kong and Macao). By summing up the amount of the grain to guarantee the basic living and the grain to meet other needs, the total

demand of grain of EAZD in 2010 can be worked out. It will be 1.350×10^{10} kg on the moderate well-off standard and 1.458×10^{10} kg on the rich standard. The average demand per capita will be 500kg and 540kg respectively.

2 TO DISCUSS THE LAND PRODUCTION POTENTIALITY AND PREDICT THE DEMAND OF LAND

The amount of the population supported by the land in a certain region is mainly determined by the land production potentiality. Agriculturally, the land production potentiality refers to the land production capability of the energy and the protein used by people in a certain region in a given period (WANG, 1994). As for the arable land and the grain, it refers to grain production capability per area. Therefore, to estimate the land production potentiality is not only indicates to estimate the grain production potentiality per area, but also estimate the area of the land used as agriculture production.

2.1 To Estimate the Crops Production Potentiality Per Unit Area

To estimate the land production potentiality per area is mainly to get the crop output per area. The crop production potentiality per area in EAZD was estimated by the method of the trend prediction, by which the law and trend of historical change of the crops output is analyzed and the future crops output estimated. The results are shown in Table 3.

Table 3 The predicted production per area of primary crops in 2010 using the method of trend

The average production per unit area from 1989 to 1999(kg/ha)	The annually increased rate(%)		The crop production per unit area in 2010 (kg/ha)
	Lower limit	Upper limit	
5700	1	2	6359 - 7087 (the average is 6723)

2.2 Primary Calculation of the Sown Area of Grain

According to the two nutrition standards, we can estimate the sown area of grain of EAZD in 2010 at the level of 6723kg/ha of grain output per area. The sown

area of grain will be 2.008×10^6 ha at the moderate well-off standard, and 2.169×10^6 ha at the rich standard.

The sown area of grain of EAZD was 9.130×10^5 ha in 1999 (Guangdong Province Statistics Bureau, 2000),

which account for only 45.5% of the area demand at the moderate well-off standard in 2010. In recent years, because of the influence of the market economy, the comparative benefit of grain of EAZD was so low that farmers wouldn't like to plant the crops. Under the market economy, farmers have consciously adjusted the crop distribution and industry structure. Therefore the sown area of grain decreased greatly. Because of the higher economic benefits, the aquiculture industry, the animal husbandry, the high quality fruit and the vegetable production have developed rapidly. At present, EAZD has been one of the most developed regions of the agricultural commodity economy in Guangdong, and even in China. In order to exert the predominance of the exchange agriculture, the land use of the economic crops and grain must be arranged rationally based on the reality. According to the plantation plan of Guangdong province, the self-sufficient rate of grain will reach 65% in 2010. Based on this rate, the predicted sown area of grain in 2010 can be calculated. The results are 1.305×10^6 ha at the moderate well-off standard and 1.410×10^6 ha at the rich standard. And if the sown

area of grain did not decrease and the multiple planted indexes did not increase in 2010 against that in 1999, the area would not meet the demand at the moderate well-off standard. We can conclude that the development of agriculture must rely on the increasing the sown area of grain by all means in the future.

2.3 Plan of Sown Area of the Crops

In recent years, the agricultural production structure has tended to be rational through several adjustments. The sown area of grain is approximately 60% - 65% of the total sown area of crops. According to this proportion, the total sown area of crops of EAZD in 2010 can be worked out. It will be 2.088×10^6 ha at the moderate well-off standard and 2.255×10^6 ha at the rich standard. Referring to this and with the data of the planned area of Guangdong referred, the sown area of crops of EAZD in 2010 can be redistributed. The results are shown in Table 4.

Compared with demanded area of crops planting by population, the area in this scheme shown in Table 4 is

Table 4 The area plan of crop planting of EAZD

Crop	The plant area			
	1999		2010	
	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Grain	9.130×10^5	57.7	1.357×10^6	65.0
Economic crops	1.485×10^5	9.4	1.670×10^5	8.0
Others	5.203×10^5	32.9	5.638×10^5	27.0
The total sown area	1.582×10^6	100.0	2.088×10^6	100.0

at the moderate well-off standard. As Zhujiang Delta is the important production base of crop, sugarcane and fruitage and vegetable of Guandong Province, and rice is the major agriculture production of this region, crop produced here by year of 2010 will account for 35% of the total amount of the whole province. So the redistributed land area for agricultural production will make 36% the total planned area of the whole province, and the crop planting area will account for 65% of that of the whole region.

The above crop distribution accorded with the ecological environment and development trend of agri-

culture of EAZD. Therefore, the data in Table 4 can be the basic data to predict the land production potentiality.

2.4 To Predict the Demanded Amount of the Arable Land

The multiple planting index of the arable land of EAZD was 239% in 1999. In the next 11 years, by fully using the superior ecological environment and adjusting the system of crop maturing, the multiple planting indexes of crops can be expected to reach

260%. According to the index, the minimum demand of the arable land in 2010 can be worked out, as shown in Table 5.

Table 5 The prediction of the arable land demand of EAZD in 2010

Level	The demand of the arable land (ha)
The moderately well-off standard	8.032×10^5
The rich standard	8.675×10^5

The arable area of EAZD was 6.603×10^5 ha in 1999. If the non-agricultural land occupied the arable land with the rate of 0.1%, the arable land in 2010 would decrease to 6.531×10^5 ha. Thus the total amount of the arable land supply will not meet the total demand at the moderate well-off standard. Therefore, we should not only strictly control the amount of the occupied arable land, but also exploit the new resources and enlarge the arable land area in future.

2.5 Calculation of the Land Production Potentiality

According to the prediction of the crop production potentiality per area and the planned area of crops planting in 2010, the land production potentiality can be worked out. The total predicted output of grain of EAZD in 2010 will be $8.63 \times 10^9 - 9.62 \times 10^9$ kg. It

will increase $3.43 \times 10^9 - 4.42 \times 10^9$ kg compared with that in 1999. The average increase rate per year will be 4.7% to 5.8%. At this rate, according to the plan of Guangdong (the self-sufficient rate of grain is 65%), at the moderate well-off standard the grain demand by 27 million population in 2010 will be met, and there also will be some surplus. And at the rich standard 96.3% of the grain demand would be met.

3 TO ESTIMATE THE POPULATION CARRYING POTENTIALITY OF THE LAND

The population carrying potentiality of the land per area on a given condition is the ratio of the land production potentiality and average consumption standard per capita at a given living standard (WANG *et al.*, 1994). Because there is no comparability between all kinds of indexes of the living standard determined in this paper, we can use a comprehensive index at average grain consumption standard per capita to reflect the average living standard when estimating the population carrying potentiality of the land. Having estimated land production potentiality, we can estimate the population carrying potentiality of the land according to the demand of living standard. In 1995, the authors had estimated the potentiality of EAZD in 2000 and 2010. The results are shown in Table 6.

According to Table 6, the maximum population

Table 6 The land carrying capacity on population of EAZD in 2000 and 2010

The living standard	The population carried(10 thousand people)		The ratio of land to population	
	2000	2010	2000	2010
The moderately well-off standard	2198 - 2355	2655 - 2960	0.99 - 0.92	1.02 - 0.91
The rich standard	2041 - 2187	2458 - 2740	1.07 - 1.0	1.09 - 0.98

carried by the land resources of EAZD in 2000 will be 23.55 million, while the population of EAZD in 1999 was 22.62 million. The two data are basically agreed to each other, so the method to estimate the population carrying potentiality of the land is fairly objective. We estimated the population carrying potentiality in 2010 with the same method. The results are shown in Table

6.

As shown in Table 6, if the grain self-sufficient rate of EAZD in 2010 is 65%, the population carried by land resources will be 26.55 - 29.60 million at the moderate well-off standard and 24.58 - 27.40 million at the rich standard. If the population of EAZD in 2010 is 27 million, the ratio of land to population will be

1.02 - 0.91 at the moderate well-off standard and 1.09 - 0.98 at the rich standard. This can illuminate the predicated population of EAZD in 2010. Therefore we can see that according to the present living standard and the grain increasing conditions, the maximum population carried by the land resources of EAZD in 2010 will be 27.40 million, which is the maximum of population.

4 MEASURES OF IMPROVING THE POPULATION CARRYING CAPACITY OF THE LAND

The population carrying capacity of the land is a dynamic process, which is influenced by many factors such as economic development, science and technology progress, population and land resources. Among these factors, the population development rate, the quantity and quality of land resources and land using patterns are dominant. Therefore, if the carrying capacity of land resource is expected to be improved, we must pay much attention to both the population and the land resource.

4.1 Controlling the Increase Rate of Population and Improving the Qualities

In the relationship between human and land, the demand of grain is an important factor. To reconcile the relationship between human and land, we must firstly control the birthrate of population, reduce the increase rate of population and alleviate the population stress on land, food, etc. According to the population plan of this area, the total population will be 27 million in 2010 with the physical annually increase rate is 8‰ and the mechanical increase is 200 thousands per year. If it were not controlled, the amount of population would exceed 27.5 million, even 28 million, which will exceed the maximum population at the rich standard. The situation is still serious. Therefore, we must strengthen management on the family planning by means of law, administration and economy, strictly control the increase rate of population and continuously improve the population quality.

4.2 Using the Land Resources Rationally and Exploring the Production Potentiality Fully

Although EAZD is very short of land resources, the land resources still must support the demand of increasing population. Therefore, we must exploit and use the land resource rationally so that the land production potentiality can be explored fully. The measures are shown as follows:

(1) To increase income and reduce expenditure, and try hard to maintain the relative stability of the arable land area.

The arable land is the most valuable land resource. The certain amount of arable land area will basically guarantee the supplying of many products such as food, cooking oil, sugar and vegetables, which are necessities of life. If the amount of the arable land is not sufficient, the effective supplies of the main agricultural by-products such as grain cannot be guaranteed, and the social stability and economic construction will be affected directly. EAZD is the region that is seriously short of grain. It is impractical to import from other countries and rely on other areas of China. Therefore, to increase income and reduce expenditure, and maintain the relative stability of the arable land area is a chief task to use the local land resource rationally. From 1999 to 2010, the annual index of the land occupied by all kinds of non-agricultural use must be controlled under 0.1% and the total amount of that must be approximately controlled within 7200ha. At the same time, the new cultivated land must be about 9.6×10^4 ha. By 2010, the arable land area of the area must be maintained 7.5×10^5 ha and the average area per capita should be about 0.028ha.

(2) Trying hard to improve the level of land use.

Besides increasing income and reducing expenditure, we should also try hard to improve the level of land use in order to exploit and use the land resources rationally and fully explore the land production potentiality. We must realize the rational structure and distribution of land use, especially the ratio between grain and economic crops, but also continuously increase the agricultural investments, improve the production conditions and expand the area of high-and-stable yield

farmland. At the same time, we must use the advanced technology to increase the multiple planting indexes and improve the rate of land use.

5 CONCLUSION

EAZD is an important base of food, sugarcane and non-staple food production and export-oriented agriculture development. It is also the region in which the conflicts between population and land demand and between agricultural land use and non-agricultural land use are very severe. Therefore, in future we must continuously practice family planning, strictly control the population increase, and save the land resources and improve the rate of land use. The trend of land use should be as follows: 1) to maintain the planting area of grain and sugar, improve the production level per area; 2) to convert the agriculture into the suburb-type and producing-type with the economic development; 3) to construct the production base of fruit, vegetable, aquatic product, fowls and cattle, flowers and so on, in order to supply the fresh and live commodity for cities

and towns of Zhujiang Delta, Hong Kong and Macao; 4) to exploit the bottomlands resources of Zhujiang River mouth actively, expand the area of the arable land and the aquiculture, distribute the non-agricultural land use rationally and strengthen the land use and urban planning.

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