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Research of the Farmland Protection Based on Food Security—A Case Study of Anshan City in Liaoning Province, China

YANG Rong-li*

Land and Resources Survey and Design Institute of Anshan City, Anshan 114001, China

Abstract The quantity and quality of farmland is the key factor determining grain production capacity, so protecting farmland has become the key to guaranteeing food security. I take Anshan City in Liaoning Province as the study area which has its own particularity in terms of protecting farmland. Based on the prediction of population, coupled with the relevant data concerning farmland area, the per unit area yield of grain, the prediction and analysis of the balance of supply and demand of farmland in Anshan City are conducted. The results show that in the year 2010, the maximum supply amount of farmland that the city can offer is 239 000 hm², and in the year 2020 the maximum supply amount of farmland that the city can offer will be 238 000 hm²; in the year 2010, the maximum demand amount of farmland is 204 186.02 hm², and in the year 2020 the maximum supply amount of farmland will be 226 409.61 hm². So the supply amount of farmland that the city can offer can meet the need of grain production objective. Some problems concerning farmland protection are pointed out in order to provide beneficial exploration of the farmland protection based on the model of food security.

Key words Food security, Farmland protection, Production capacity, Anshan City, China

The farmland resources are the source of clothing and food, foundation of development, and the most fundamental condition of food security^[1–2]. The meagre farmland per capita, the serious degeneration of quality, the scant reserve resources, and manifold restricted factors of development in China and other features, determine that the problem of farmland will be one restricted factor in China's national economic development in the long run. So protecting reasonably and cherishing every inch of farmland become the key to solving the problems of food security in the future^[3–5]. Based on the population prediction, coupled with related data analysis of the area of farmland and the per unit area yield of grain, this study selects Anshan City as the study area, and projects the demand amount of farmland in the year 2010 and the years 2020, in order to provide useful explorations for farmland production on the basis of food security model.

1 The overview of study area

Anshan City (called An) is the third biggest city of Liaoning Province in China, which has three urban districts of Tiedong, Tiexi and Lishan, and the suburb of Qianshan District. It has jurisdiction over Haicheng City, Taian County and Xiuyan Manchu Autonomous Region. The population of Anshan City is about 3.5 million with 1.46 million city population. The south and the north of Anshan City border on Liaoyang County, the south of Anshan City is adjacent to Fengcheng City and Zhuanghe City, the southeast of Anshan City borders on Dashiqiao City, and the west of Anshan City borders on Panshan County and Liaozhong County. The geographical coordinate is 122°10' E – 123°41' E, longitude and 40°27' N – 41°34' N, latitude. The longest distance between the southeastern and the

north is 175 kilometers, and the longest distance between the east and the west is 133 kilometers.

According to the statistics of the surveyed data in the year 2005, the area of farmland in Anshan City is 239 360.26 hm², accounting for 32.45% of the agricultural use land and 25.87% of the total area of land in Anshan City. The irrigated field is 46 399.44 hm², accounting for 19.38% of the total area of farmland; the flooded field is 60.40 hm², accounting for 0.03% of the total area of farmland; the arid land is 188 811.94 hm², accounting for 78.88% of the total area of farmland; the vegetable plot is 4 088.48 hm², accounting for 1.71% of the total area of farmland.

2 The prediction of demand and supply amount of farmland in Anshan City

2.1 The prediction of farmland available

2.1.1 The prediction of decrease amount of farmland.

2.1.1.1 Damage due to calamity. Because of the uncertainty of damage due to calamity, the study conducts the prediction by using the average damaged farmland by calamity annually from 1997 to 2005. According to average 48.00 hm² damaged farmland by calamity from 2006 to 2010, and average 30.00 hm² damaged farmland by calamity due to further improvement of water conservancy and effective governance of pollution and damage of industrial mine from 2011 to 2020, we predict that there is 240.00 hm² damaged farmland by calamity in the aggregate, and there is 300.00 hm² damaged farmland by calamity in the aggregate from 2011 to 2020.

2.1.1.2 Adjustment of agricultural structure. In the process of adjustment of agricultural structure from 1997 to 2005 in Anshan City, there was 1 422.23 hm² farmland in the aggregate, which was occupied and transformed into garden land with 158.03 hm² every year. Considering the complexity and randomness of agricultural structure adjustment in the city, we use the method

of average change to predict. China begins to pay attention to the work of farmland protection, and normalize the adjustment of agricultural structure. We predict that if 158.00 hm² farmland is adjusted every year from 2006 to 2010, and 100.00 hm² farmland is adjusted every year from 2011 to 2020, it will decrease by 790.00 hm² farmland from 2006 to 2010, and decrease by 1 000.00 hm² farmland from 2011 to 2020.

Table 1 Prediction of the damaged area in Anshan from 2006 to 2020

County(city and district)	Damaged farmlands hm ²	Proportion %
Haicheng	107.88	19.98
Taian County	—	—
Xiuyan County	413.86	76.64
Urban area	18.26	3.38
Total	540.00	100.00

2.1.1.3 Non-agricultural construction farmland. According to the calculated average occupied farmland coefficient on the basis of occupied farmland area of new added urban construction use land, town construction use land, independent industrial mine use land, special use land, transportation use land and water conservancy use land from 1997 to 2005 in Anshan City, we predict the situation of new added construction use farmland on the premise that non-agricultural construction occupies little or no land. Coupled with the achievement of *Optimization of Urban-rural Land Use Structure and Layout in Anshan City*, we predict that there is new added 3 451.00 hm² occupied land for constructing use in 2010, and there is new added 6 305.00 hm² occupied land for construction use in Anshan City from 2011 to 2020.

2.1.1.2 Prediction of amount of new added farmland. The new added farmland mainly comes from land adjustment, reclamation and development. 10 725.74 hm² new added farmland can be realized in the period of planning. 6 677.12 hm² new added land can be realized by adjusting land in whole city in the period of planning, accounting for 62.25% of the total added amount of farmland; it is planned that 269.14 hm² new added farmland by adjusting rural residential area from 2006 to 2010; 760.48 hm² new added farmland can be realized in some rural residential areas in Haicheng City of Anshan City from 2011 to 2020; 2 286.44 hm² reclaimable farmland within the period of planning is predicted, accounting for 21.32% of the total amount farmland, and 629.58 hm² farmland is reclaimed from 2006 to 2010; within the period of planning, 1 762.18 hm² farmland can be reclaimed in the aggregate, accounting for 16.43% of the total amount of added farmland. 846.03 hm² farmland can be reclaimed from 2006 to 2010.

2.1.1.3 Calculation of amount of farmland available. The calculation formula of amount of farmland available in Anshan City is as follows: The supply ability of farmland = Amount of farmland in 2005 - Construction occupation - Adjustment of agricultural structure - Calamitous damage + (Returning farmland, development, adjustment, increasing reclamation).

The area of farmland was 239 360.26 hm² in Anshan City in the year 2005. We predict that the biggest amount of farm-

land available is 239 000.00 hm² in the year 2010, and the biggest amount of farmland available is 238 000.00 hm² in the year 2020.

2.2 Prediction of demand amount of farmland

2.2.1 Prediction model of farmland demand amount. According to the prediction model of farmland demand amount, the smallest area of the farmland which needs protection for food security of Anshan City is calculated. The specific formula is as follows:

The demand amount of farmland = The total demand amount of food/ Yield per unit of grain farmland/ The ratio of area of grain crops and the total area of all crops = The total demand amount of grain × self-supporting rate of food/ Yield per unit of grain farmland × multiple crop index × The ratio of area of grain crops and the total area of all crops (The total demand amount of food is the products of the predicted population and the demand amount of food per capita).

2.2.1.1 Population. The prediction of the future population in Anshan City mainly adopts the method of natural growth rate to predict. The method of natural growth rate is to assume that the future population is to increase according to a certain growth rate or increase in the light of average growth rate in several years in a certain administrative area. The specific formula is as follows: $P = B(1 + Y)^n + \Delta G$. (P is the total population at the end of planning period; B is the population in base period; Y is the natural growth rate of population in the period of planning; n is the years from planning period to the base period; ΔG is mechanical growth rate of population).

According to the analysis of the natural growth rate of population in recent years of Anshan City and net migration variation of population, coupled with the opinions of the relevant experts in some departments, we predict that the total population is 3.748 6 million in the year 2010 in Anshan City and the total population is 4.321 5 million in the year 2020.

2.2.1.2 The demand amount of food per capita. Considering the practical situation of the economic developmental level and food consumption nowadays in Anshan City, and after consult the opinions of relevant experts, the food per capita 400 kilograms /year (about 11 297 kJ calorie and 75 g protein) can be as the standard of consumption levels of simply having adequate food and clothing, and also the lowest standard of food demand per capita to guarantee food security; we select the food per capita 450 kilograms /year (about 11 715 kJ calorie and 85 g protein) as the well off standard; the food per capita 500 kilograms /year (about 11 924 kJ calorie and 90 g protein) is as the affluence standard. As can be shown in Fig. 1, the food consumption level per capita undergoes the quick increase, and the level is around 500 kilograms /year to 600 kilograms /year. Considering the practical situation and developmental tendency of the economic developmental level and food consumption nowadays in Anshan City, and after consult the opinions of relevant experts, we predict that the food demand amount per capita in the year 2010 will take 520 kilograms /year as standard, and the food demand amount per capita in the year 2020 will take 550 kilograms /year as standard. According to the formula: The demand amount of food = Population × Food demand amount per capita, we can deduce that

the total demand amount of food of Anshan City in the year 2010 is 1.949 3 million tons and the total demand amount of food of Anshan City in the year 2020 is 2.376 8 million tons

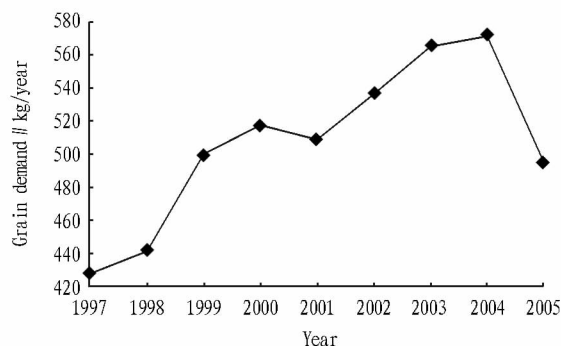


Fig. 1 Per capita grain demand of Anshan from 1997 to 2005

2.2.1.3 The self-supporting rate of food. From 1997 to 2005, the self-supporting rate of food in Anshan City hovered at 50% – 80%, and the maximum value was in 1998, namely 79.33%; the minimum value was in 2000, namely 54.49%. In this planning period, the demand amount of food, fodder and industrial grain will increase comprehensively in Anshan City, and the self-supporting rate of food in Anshan City in 2010 and 2020 will be difficult to surpass the maximum value of the previous planning period, even if we take the agricultural technological progress, and the improvement of farmland quality into consideration; for food security, the self-supporting rate of food cannot lower than the minimum value of 54.49%. The self-supporting rate of food is determined according to three schemes. Scheme A is to assume that the demand amount of food and industrial grain of Anshan City in the planning period increases obviously, but the food production level is invariable basically, then we predict that the self-supporting rate of food adopts 55%; Scheme B is to assume that the demand amount of food and industrial grain of Anshan City in the planning period increases incessantly, and the food production level is improved step by step, then we predict that the self-supporting rate of food adopts the average of the previous planning period, namely 64%; Scheme C is to assume that the speed of food demand increase in Anshan City is smaller than the speed of increased production of food, then we predict that the self-supporting rate of food adopts 79%.

2.2.1.4 Multiple crop index and the per unit area yield of grain. Due to the restriction of climate conditions, multiple crop index of agricultural production in Anshan City basically is 1.0. The food production of Anshan City, adopts different technological measures in different periods, resulting in different effects of production increase. Apart from the natural conditions, the food production levels from now on will generate different results due to different input levels and technological progress. Consequently, 2 schemes are selected according to different situations as follows:

Scheme 1: As can be seen in Fig. 2, the per unit area yield of grain in Anshan City increases on the whole in the past thirty years. From 4 000 – 5 000 kilogram/hm² 30 years ago to 6 000 – 7 000 kilogram/hm² in the period of the Tenth Five –

Year Plan, the per unit area yield of grain increases by 67.00 kilogram/hm² everything year. Taking the per unit area yield of grain of 6 391.37 kilogram/hm² in the period of the Tenth Five-Year Plan as a base, and according to annual increase of 67.00 kilogram/hm² on average, we predict that the per unit area yield of grain in 2010 is 6 726.37 kilogram/hm², and the per unit area yield of grain in 2020 is 7 396.37 kilogram/hm².

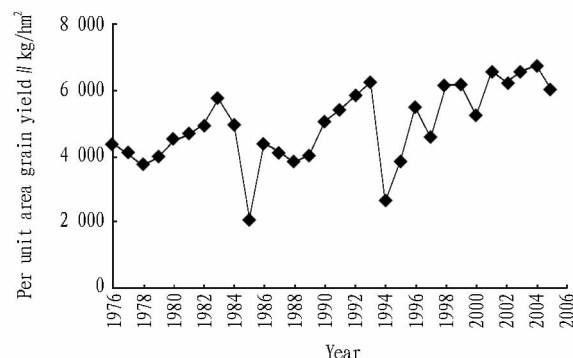


Fig. 2 Variation of per unit area grain yield in Anshan from 1976 to 2005

Scheme 2: Transforming with great exertion the medium and low production farmland, perfecting the infrastructure such as water conservancy, using organic fertilizer and elevating the level of agricultural technology, can increase the per unit area yield of grain quickly. In the period of planning, Anshan City can transform 26 073.92 hm² medium and low production farmland by means of land adjustment. Transforming 1 hm² medium and low production farmland can get 1 500 kilograms production increase, so the per unit area yield of grain in the period of planning increases from the existing level 67.00 kilogram/hm² to 78 kilogram/hm², then the per unit area yield of grain in 2010 is 6 781.37 kilogram/hm² and 7 561.37 kilogram/hm² in 2020.

2.2.1.5 The ratio of grain planting area and the total planting area of agricultural crops. For ensuring food security, the ratio of grain planting area and the total planting area of agricultural crops should not be decreased substantially in Anshan City afterwards. According to the practical situation and developmental tendency of the economic developmental level and food consumption nowadays in Anshan City as well as the opinions of relevant experts, we can deduce that the ratio of grain planting area and the total planting area of agricultural crops from now on should not be lower than 75%. Referring to the recent ratio of grain planting area and the total planting area of agricultural crops, we determine three schemes. Scheme 1: 84.16% (equivalent to the average level during the period of the Ninth Five-Year Plan); Scheme 2: 78.06% (equivalent to the average level during the period of the Tenth Five-Year Plan); Scheme 3: 75.00% (The new planning should not be lower than this ratio).

2.2.2 The demand amount of farmland based on food security. According to the preceding analytical data, using prediction model of farmland demand amount and coupled with the indices, after combination, each target year generates 18 demand schemes of farmland. The calculation results is shown in the following tables.

Table 2 Farmland demand portfolio of Anshan in 2010hm²

No.	Portfolio	Farmland demand	No.	Portfolio	Farmland demand	No.	Portfolio	Farmland demand
1	A11	189 386.41	7	B11	220 388.48	13	C11	272 023.26
2	A12	204 186.02	8	B12	237 610.74	14	C12	293 280.52
3	A13	212 516.81	9	B13	247 305.26	15	C13	305 246.37
4	A21	187 850.40	10	B21	218 601.03	16	C21	269 817.03
5	A22	202 529.97	11	B22	235 683.61	17	C22	290 901.88
6	A23	210 793.20	12	B23	245 299.50	18	C23	302 770.68

Table 3 Farmland demand portfolio of Anshan in 2020hm²

No.	Portfolio	Farmland demand	No.	Portfolio	Farmland demand	No.	Portfolio	Farmland demand
1	A11	209 999.22	7	B11	244 377.92	13	C11	301 648.97
2	A12	226 409.61	8	B12	263 474.84	14	C12	325 221.34
3	A13	235 647.13	9	B13	274 224.61	15	C13	338 490.37
4	A21	205 416.74	10	B21	239 045.24	16	C21	295 066.56
5	A22	221 469.03	11	B22	257 725.43	17	C22	318 124.54
6	A23	230 504.97	12	B23	268 240.63	18	C23	331 104.02

Considering the importance of protecting farmland, especially along with the increasingly outstanding problem of food security, Anshan City improves farmland quality vigorously, increases the agricultural technological content, the future food production level will increase to much extent, but the space for increasing yield per unit is limited. So, the assumption of Scheme A is identical with the future developmental tendency. The predicted increase of yield per unit of grain in Scheme 1 conforms to the realities of Anshan City, and the ratio of grain planting area and the total planting area of agricultural crops selects Scheme 2. Based on these, the demand amount of farmland in 2010 and 2020 both selects Scheme A and Scheme 2. The combination of two schemes takes fully the socio-economic development, population increase, agricultural technological progress and the improvement of farmland quality into consideration, and predicts objectively the demand amount of farmland in the target year, namely the demand amount of farmland of Anshan City in 2010 is 204 186.02 hm²; the demand amount of farmland of Anshan City in 2020 is 226 409.61 hm².

3 Determination of the protection scale of farmland in Anshan City

After comparison, we can find that the demand amount of farmland base on food security is smaller than the amount of farmland available. Consequently, the amount of farmland available of Anshan City can satisfy the future grain production objective. Considering population variation, socio-economic development and the status quo of agricultural industrial structure and tendency of change, for protecting farmland and guaranteeing national food security better, when determining the amount of farmland, it tends to move toward the upper limit within the interval. So we determine that the protection scale of farmland in 2010 is 239 000.00 hm² and the protection scale of farmland in 2020 is 238 000.00 hm². Although Anshan City has abundant supply amount of farmland, it is necessary to retain A large number of farmland. Firstly, after meeting the need of food demand of Anshan City, it should meet the food demand

of Dandong City to a certain extent. Secondly, Anshan City, as the key grain protection areas of Dandong City, has advantageous climate and geographical conditions. It has high yield of grain, and the agricultural income is still one of the important farmers' income sources. Farmland protection also can fulfill the function of using economy and production to increase income, so retaining a large number of farmland is significant to ensuring farmers' income.

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