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Analysis and Prediction of the Supply and Demand for China's Major Agricultural Products

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Abstract: Food security is, and always has been, a major strategic issue related to national economic development, social stability, and national independence. Clarifying the degree of food security and scientifically estimating the future national food demand are the basis for formulating food security policies. In 2015, the supply and demand of rice and wheat in China were basically balanced: corn supply exceeded demand; the demand for soybean could only be met through heavy imports; and cotton, oil, and sugar also depended on imports. In addition, the self-sufficiency rate in relation to edible vegetable oil was only 36.9%, while that for cotton and sugar was 87.7% and 74.4%, respectively; supply and demand of livestock products were basically balanced, and the variety of milk needed regulation. Based on factors such as population growth, urbanization rate, and dining-out habits, this study estimates that the Chinese demand for grain consumption will reach 6.37×10^8 t in 2025 and 6.85×10^8 t in 2030, and the demand for meat will reach 8.1×10^7 t and 9.5×10^7 t, respectively. To ensure food security and the effective supply of major agricultural products, we propose that China should increase its input into comprehensive agricultural production capacity, implement a grain saving strategy, strengthen innovation in agricultural science and technology, and reform the subsidy system for agricultural production.
Keywords: food supply and demand; demand forecast; food security

1 Introduction

As the saying goes, "Food is the paramount necessity of the people." Ensuring food security and a stable supply of agricultural products are always important goals for any government. China has a large population, so it has a great demand for agricultural products, which is difficult to meet through global trade [1]. This means that China should depend only on domestic supply rather than imports to achieve food sovereignty, unlike Japan and Korea [2]. The Central Rural Work Conference was held at the end of 2013, and proposed a national food security strategy for the new period summarized by "Be self-centered, rely mainly on domestic production, ensure production capacity, import moderately, and support by technical means," which highlighted that "Chinese people should ensure their food supply themselves." In this case, we must ask to what extent domestic agricultural production provides food security. With the sustained economic development and dramatic changes in urban and rural structure, how will the demand for food and other agricultural products change in the coming decade? This study uses statistical data to comprehensively analyze the current supply and demand for agricultural products, such as grain, cotton, oil, meat, eggs, milk, aquatic products, and so on. It also estimates China's major agricultural

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product consumption for 2025 and 2030 and puts forward directions and proposals for ensuring the basic balance between supply and demand.

2 Current supply and demand of China's major agricultural products

2.1 Grains

2.1.1 The three major grains can achieve self-sufficiency

In recent years, total production of the three major grains (wheat, rice, and corn) has increased continuously. The self-sufficiency rate has always remained above 95%. Although domestic supply was ensured, the trend of net imports with variable levies was evident. Between 2005 and 2015, the total production of China's three major grains increased from 4.013×10^8 t to 5.63×10^8 t, while domestic consumption increased from 4.072×10^8 t to 4.693×10^8 t (Table 1). Influenced by different prices, domestic and international, the three major grains showed an overall net import position, which has increased continuously since 2009. By 2015 the net import of the three major products was 1.069×10^7 t.

Rice supply exceeded demand. China's rice production has increased year by year, encouraged by national food support policies, especially the Lowest Rice Purchase Pricing Policy implemented in 2004. China's total rice production in 2015 was 2.082×10^8 t. As the population has continued to grow, human consumption of rice has maintained a fixed growth rate. The total rice consumption in 2015 was 1.895×10^8 t, of which human consumption was 1.69×10^8 t, while consumption for animal feed and industrial use was 1.92×10^7 t, respectively accounting for 89.2% and 10.1% of the total. The rice self-sufficiency rate was 109.9% in 2015.

Table 1. The Supply and demand of China's major agricultural products in 2015.

Type	Total production ($\times10^4$ t)	Domestic consumption ($\times10^4$ t)	Demand-supply gap[a] ($\times10^4$ t)	Self-sufficiency rate[b] (%)
The three major grains	56 304	46 928	−9 376	120.0
Rice	20 823	18 950	−1 873	109.9
Wheat	13 019	10 977	−2 042	118.6
Corn	22 463	17 001	−5 462	132.1
Soybean	1 179	8 775	7 597	13.4
Edible vegetable oil	1 126	3 280	2 154	34.3
Soybean oil	41	1 410	1 369	2.9
Rapeseed oil	462	630	168	73.3
Peanut oil	252	260	8	96.9
Palm oil	0	570	570	0.0
Cotton	522	716	194	72.9
Sugar	1 160	1 560	400	74.4
Meat	8 454	8 610	156	98.2
Pork	5 487	5 557	70	98.7
Beef	700	747	47	93.7
Mutton	441	463	22	95.2
Poultry	1 826	1 842	16	99.1
Milk	3 870	4 355	485	88.9
Aquatic products	6 700	6 702	2	100.0

Source: *China Agriculture Statistical Report*; *China Grain Development Report*; China National Grain and Oils Information Center; National Cotton Market Monitoring System; and China Sugar Association.

[a]Demand-supply gap = Domestic consumption − Total production

[b]Self-sufficiency rate = Total production/Domestic consumption.

The supply and demand for wheat were tightly balanced. In 2015, wheat consumption in China was 1.098×10^8 t.

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Human wheat consumption was 9×10^7 t, while feed consumption was 6.5×10^6 t, respectively accounting for 82% and 5.9% of the total wheat consumption. China's total wheat production was 1.302×10^8 t, which had been increasing for twelve consecutive years and the wheat self-sufficiency rate was 118.6%.

Corn supply exceeded demand. Encouraged by national grain production support policies, the area under corn cultivation and the yield have increased rapidly since 2004, making corn a major crop and contributing to the increasing grain yield. During 2003−2015, the corn yield increased from 1.158×10^8 t to 2.246×10^8 t. The increased yield was 9.982×10^7 t, which accounted for 56.6% of the total increased grain production in the same period. In 2015, corn consumption was 1.7×10^8 t. Feed consumption was 1×10^8 t, which accounted for 58.8% of the total corn consumption. Industrial consumption was 5.05×10^7 t, accounting for 29.7%. The self-sufficiency rate was 132.1%.

2.1.2 Soybean was heavily dependent on imports

China's soybean acreage and production both decreased because of overwhelming soybean imports and the domestic benefit margin between soybean and corn. The area under cultivation decreased from 1.439×10^8 *mu* (1 *mu* ≈ 666.67 m^2) in 2005 to 9.759×10^7 *mu* in 2015, while production decreased from 1.635×10^7 t in 2005 to 1.179×10^7 t in 2015, reducing annually by 3.8% and 3.2% on average, respectively. Meanwhile, the rapidly increasing quantity of imported soybean made it a major import grain in China. In 2015, the total quantity of imported soybean reached 8.169×10^7 t, which accounted for 65.5% of the total grain import. In 2015, domestic soybean consumption was 8.775×10^7 t, among which pressed oil consumption was 7.6×10^7 t, accounting for 86.6% of the total consumption; and edible and industrial consumption was 1.08×10^7 t, accounting for 12.9%. The demand-supply gap of soybeans reached 7.597×10^7 t, while the self-sufficiency rate was only 13.4%.

2.1.3 The import quantity of alternatives for feed corn increased rapidly.

In recent years, the import quantities of alternatives for feed corn, such as barley, sorghum, DDGS (distillers dried grains with soluble), and dry cassava, have increased rapidly. This has affected the marketing and fiscal stock of domestic corn, leading to overstocking. In 2015, China's excess production of corn reached 5.462×10^7 t, while, the net quantity of imported barley, sorghum, DDGS, and cassava reached 3.761×10^7 t in the same period (Fig. 1).

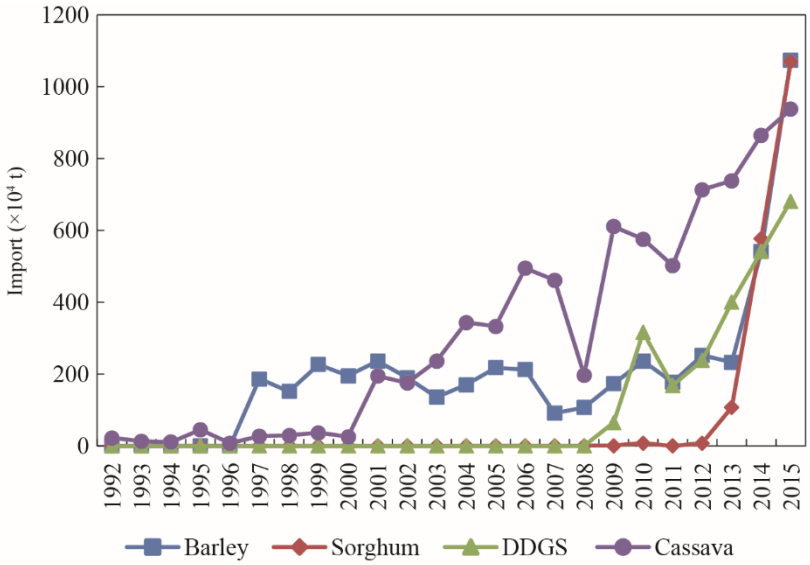

Fig 1. Chinese imports of barley, sorghum, DDGS and cassava from 1992 to 2015.

Note: DDGS: Distillers dried grains with soluble.

2.2 Cotton, oilseed, and sugar

2.2.1 Imports of oilseed increased continuously

China is the largest oilseed producer in the world. The gross production of the eight major oilseeds (namely cotton seed, soybean, rapeseed, peanuts, sunflower seed, sesame seed, flaxseed, and amellia oleifera seed) maintained to be approximately 6×10^7 t [3]. In 2015, the total production of China's eight major oilseeds was 5.944×10^7 t. Among them, the production of cotton seed, soybean, rapeseed, and peanuts accounted for

approximately 90% of the total oilseed production. The oil and fat produced by these four crops, together with palm oil, make up the major portion of the Chinese people's edible oil consumption.

To meet the requirements of China's edible oil demand and the development of the breeding industry, China's oilseed import quantities have seen rapid growth in the past decade. In 2015, China imported 8.757×10^7 t of oilseed (converted to 1.560×10^7 t of oil). This was an increase of 1.005×10^7 t, which was about 13% higher than the previous year. Among these, the import quantity and proportion of soybean and rapeseed increased faster, being the largest proportion in the total oilseed import quantity. In 2015, China's soybean import reached 8.174×10^7 t, which accounted for 93.3% of the total oilseed import. Before 2008, the rapeseed import was usually no more than 1×10^6 t. By 2015, it had rapidly increased to 4.47×10^6 t, which accounted for 5.1% of the total oilseed import.

2.2.2 Supply of edible vegetable oil was heavily dependent on imports

Since 2004, China's edible vegetable oil sector has mainly been in a state of net import [4]. In 2015, China imported 8.39×10^6 t of edible vegetable oil. Of that, palm oil was 5.91×10^6 t, which accounted for 70.4% of the total import quantity. Soybean oil was 8.2×10^5 t, which accounted for 9.7%. Rapeseed oil was 8.2×10^5 t, which also accounted for 9.7% of the total. The import quantity of other edible vegetable oil was 8.5×10^5 t, which accounted for 10.1%. China's total quantity of import edible vegetable oil and oil converted from imported materials in 2015 was approximately 2.4×10^7 t (Fig. 2). In terms of varieties, palm oil was totally dependent on imports, while the self-sufficiency rate of soybean oil was approximately 3.8%, that of rapeseed oil was 73.3%, and peanut oil, 96.9%.

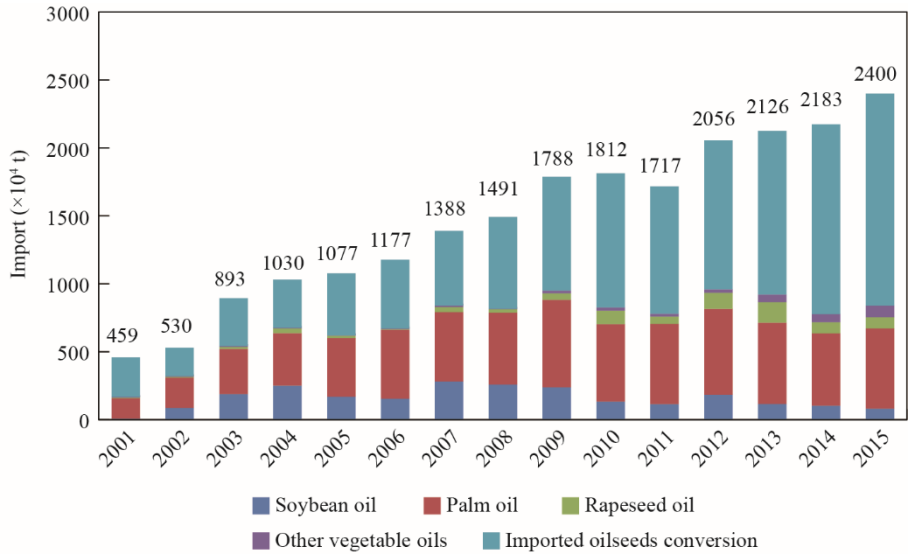

Fig 2. Chinese import of edible vegetable oil from 2001 to 2015.

Source: Data from Chinese Customs.

2.2.3 The supply-demand gap of cotton increased

The area under cotton cultivation and cotton production have both declined in recent years, influenced by several factors, such as the downturn of textile clothing consumption, the shift of the textile industry from domestic to overseas, and the low profit from planting cotton. In 2015, the area under cotton cultivation was 5.695×10^7 *mu*, which had decreased by 3.194×10^7 *mu* since 2007, reducing annually by 5.4% on average. The production of cotton was 5.6×10^6 t, 2.02×10^6 t less than that of 2007. The annual decline was, on average, 3.8%. According to the statistics, the stock of cotton reached 1.306×10^7 t at the end of the 2015/2016 cotton season. The stock consumption rate reached 182.1%. The consumption of cotton was 7.16×10^6 t and the production was 5.22×10^6 t, making the self-sufficiency rate 72.9%.

2.2.4 The total production and consumption of edible sugar have increased

Sugar material production has increased in volatility. In 2015, China's total production of sugar materials was 1.25×10^8 t. Compared with that of 2014, the production increased by 3.048×10^7 t, making the increase rate 32.2%. Among them, the production of sugarcane was 1.67×10^8 t, which accounted for 93.6% of the total sugar material production. Sugar beet was 8×10^6 t, which accounted for 6.4% of the total sugar material production. At present,

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China's total sugar material production has remained steady between 1.2×10^8 t and 1.4×10^8 t.

The production and consumption of edible sugar have increased generally. With changes in the Chinese diet structure, the consumption of edible sugar has maintained a fixed growth rate. According to statistics from the China Sugar Association, China's edible sugar consumption was 1.56×10^7 t in the 2014/2015 grinding season. The year-on-year growth was 5.4%, while the production of edible sugar in the grinding season was 1.16×10^7 t. The self-sufficiency rate was 74.4%.

2.3 Livestock, poultry, dairy, and aquatic products

2.3.1 The import quantity of meat increased, but the consumption proportion was small

In 2015, China's total consumption of pork, beef, mutton, and poultry was 8.454×10^7 t. Compared with that of 2006, consumption increased by 1.50×10^7 t. The annual increase was 2.2% on average. The apparent consumption (the consumption of livestock, poultry, dairy, and aquatic products are all apparent consumption. Apparent consumption = production + import quantity − export quantity) was 8.61×10^7 t. Compared with that of 2006, the consumption increased by 1.637×10^7 t. The annual increase was 2.4% on average. The self-sufficiency rate was 98.2%. Before 1998, China's pork, beef, mutton, and poultry products were essentially exported. However, the export quantity was maintained below 2×10^5 t. In 1999, they became net importers, with an import quantity of 4.54×10^5 t. After 2000, the net import quantity increased. In 2015, the net import quantity was 1.56×10^6 t, which accounted for 1.8% of the domestic consumption.

2.3.2 The consumption and production of dairy products has increased continuously

In 2015, China's consumption of dairy products was 4.355×10^7 t, which had increased by 9.74×10^6 t compared with that of 2006. The annual increase was 2.9% on average. The annual domestic production was 3.87×10^7 t. Compared with that of 2006, the production had increased by 5.68×10^6 t, which was an average increase of 1.8%. The self-sufficiency rate of dairy products was 88.9%. In recent years, the quantity of imported dairy products increased rapidly. Among them, the quantity of imported fresh milk increased from 7×10^3 t in 2008 to 4.6×10^5 t in 2015. The quantity of imported milk powder increased rapidly from 1×10^5 t in 2008 to 5.6×10^5 t in 2015 (converted using the rate of 1:8, the quantity of imported liquid milk was 4.47×10^6 t.)

2.3.3 The consumption of aquatic products has increased steadily

In 2015, China's apparent consumption of aquatic products was 6.702×10^7 t, an increase of 2.087×10^7 t compared with that of 2006. The annual increase was 4.2% on average. The domestic production of aquatic products was 6.7×10^7 t. Compared with that of 2006, the production had increased by 2.116×10^7 t. The annual increase was 4.3% on average. The self-sufficiency rate was 100.0%. From the trade perspective, the import and export quantities had increased rapidly. Among them, the export quantity increased from 3.02×10^6 t in 2006 to 4.06×10^6 t in 2015. The import quantity increased from 3.32×10^6 t in 2006 to 4.08×10^6 t in 2015. The trade surplus increased from $5.06 billion in 2006 to $11.35 billion in 2015.

3 Prediction of domestic major agricultural production in 2025 and 2030

3.1 Methods and data source

3.1.1 Methods

Domestic and foreign research has achieved fruitful results with regard to the prediction of the future demand for agricultural products (Table 2). The forecasting methods can be divided into calculation of personal nutrient intake [5−9], estimation of trend and experience [10−15], and predictions based on structural models [16−19]. Considering the influence of the promotion of consumption structure, urbanization rate, and other factors, we should take the most commonly used and feasible timing model to predict domestic future demand for major agricultural products.

3.1.2 Data source

The data of consumption per capita of these agricultural products are from the *China Statistical Yearbook*, *Chinese Rural Household Survey Yearbook*, and *Chinese Residents Survey Yearbook* over the years. The proportion of eating out is based on data from the China Health and Nutrition Survey. The conversion ratio of raw grain and finished grain is obtained by combining the average yields of rice, wheat, maize, millet, sorghum, pulses, and potatoes, which are referred to in the *Agricultural Technology Economy Manual*, with the ratio of their yields in

the past years. Consumption per capita of edible vegetable oils, sugar, and cotton are calculated by their total consumption over the years. Data of total consumption are from the *China Food Development Report*, *China Sugar Wine Yearbook*, and *China Cotton Yearbook* over the years. The population projections colligates the relevant research findings of the China Population and Development Research Centre and the Population Division of the United Nations Department of Economic and Social Affairs. It is believed that China's urbanization rate will have reached 65% by 2025 and 70% by 2030, and the population will be between 1.42 and 1.45 billion [24]. The coefficients of the feed conversion rate are related to the feed efficiency, conversion of a living animal and its carcass, and conversion of processed and raw grain [25,26].

Table 2. Review of the quantitative predictions for major agricultural production. Unit: $\times 10^8$ t

Sources	Year of prediction	Methods	Grain	Meat	Eggs	Milk	Aquatics	Plant oils	Sugar	Cotton
OECD and FAO	2025	Simultaneous equation model	7.19[a]	1.0[b]	0.21	/	0.7034	0.37	0.19	0.069
Agri. Info. Inst. of CAAS [20]	2025	Simultaneous equation model	6.82[a]	1.0[b]	0.21	0.63	0.7542	0.33	0.18	0.07
Liu Jiang [21]	2030	Qualitative prediction	6.6	1.11	0.4	0.32	0.55	0.35	0.17	0.065
Mei Fangquan	2030	/	6.45–7.2	0.8	0.38	0.56	0.58	/	/	/
Soft Sci. Committee of MOA	2030	/	6.82	0.56	0.28	0.48	/	/	/	/
Cheng Yu [22]	2030	/	7.18, feed grains 5.20	1.23 4[b]	0.44 1	/	/	/	/	/
Chen Yongfu [23]	2025	Simultaneous equation model	5.69–6.47[c]	/	/	/	/	0.31–0.36	/	/
	2030	Simultaneous equation model	5.96–7.22[c]	/	/	/	/	0.31–0.37	/	/
Cheng Guoqiang [16]	2022	GTAP model	6.58[d]	1.15	/	0.47	/	/	/	0.14
	2027	GTAP model	7.17[d]	1.29	/	0.49	/	/	/	0.16
	2032	GTAP model	7.77[d]	1.42	/	0.52	/	/	/	0.18

[a]includes rice, wheat, corn, and soybeans.
[b]includes pork, beef, mutton, and poultry.
[c]refers to cereals.
[d]includes rice, wheat, and corn.

3.2 Forecast of consumption of major agricultural products

3.2.1 Consumption per capita

The consumption per capita of major agricultural products of urban and rural residents in 2025 and 2030 is predicted with a time series model (Table 3). In the medium- to long-term, consumption per capita of grain for human consumption in China will decline to 119.3 kg by 2030, which is 13.4% less than in 2015. Edible vegetable oil, edible sugar, milk, and livestock and aquatic products will continue to experience a fixed growth rate. They will respectively reach 32.2 kg, 17.0 kg, 30.1 kg, and 95.8 kg by 2030, which are 49.6%, 49.7%, 130.7% and 85.8% more than in 2015.

3.2.2 Total consumption in China

In the medium- to long-term, China's demand for grain consumption will continue to increase, of which grain for human consumption will see a slight decrease while feed grain will maintain a stable growth (Table 4). By 2030, the total grain demand will reach 6.85×10^8 t, among which the demand for human consumption will decline to 1.72×10^8 t, which is 1.639×10^7 t less than 2015 and the decreasing amplitude is 8.7%. Because of the increase in a fixed demand for meat, the need for feed grain will increase to 4.09×10^8 t, which is 63.4% more than 2015. With the steady development of the national economy, non-food grain, such as industrial grain, will increase to 1.02×10^8 t by 2030, which is 2.513×10^7 t more than 2015.

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Table 3. Prediction of China's consumption per capita of major agricultural products. Unit: kg

Products	Urban residents			Rural residents			Nationwide		
	2015	2025	2030	2015	2025	2030	2015	2025	2030
Grain for human consumption	114.9	111.7	108.9	167.0	159.2	143.6	137.8	128.3	119.3
Cotton	/	/	/	/	/	/	5.5	6.3	5.6
Edible vegetable oil	/	/	/	/	/	/	21.5	28.5	32.2
Edible sugar	/	/	/	/	/	/	11.3	14.8	17.0
Pork	27.5	35.5	39.4	17.0	30.0	34.6	22.9	33.6	38.0
Beef and mutton	5.4	9.1	10.8	2.6	3.5	4.2	4.2	7.1	8.8
Poultry	15.5	19.7	22.0	6.3	9.4	11.7	11.4	16.1	18.9
Eggs	14.8	16.6	17.7	8.3	10.6	12.5	11.9	14.5	16.1
Milk	17.9	30.7	34.4	6.8	15.1	20.1	13.0	25.2	30.1
Aquatic products	20.4	26.1	28.8	6.9	10.1	11.9	14.5	20.5	23.7

Table 4. Prediction of China's agricultural product consumption in 2025 and 2030. Unit: $\times 10^4$ t

Products	2025	2030
Grain	63 709	68 495
Grain for human consumption	18 225	17 297
Feed grain	35 928	40 924
Grain for industrial, seed, and other use[a]	9 556	10 274
Cotton	894	812
Edible vegetable oil	4 054	4 671
Edible sugar	2 099	2 463
Meat	8 066	9 521
Pork	4 765	5 503
Beef and mutton	1 011	1 279
Poultry	2 290	2 739
Eggs	2 055	2 338
Milk	3 585	4 363
Aquatic products	2 913	3 438

[a]Grain for industrial, seed, and other uses accounts for 15% of the total grain consumption.

4 Suggestions for safeguarding the supply and demand balance for agricultural products

4.1 Improve comprehensive agricultural production capacity

With the improvement of urbanization and the income of residents, China's demand for food will continue to increase before 2030. Improving comprehensive agricultural production capacity is vital. First, enhancing the construction of agricultural infrastructure is urgent. Judging from the current rural situation, poor agricultural infrastructure is still the biggest obstacle to increasing agricultural production in China, especially in the western regions with poor natural conditions. Hence, strengthening the agricultural infrastructure construction focusing on farmland and water conservancy is an urgent task. Second, we ought to accelerate the division of food production functional areas and major agricultural production protected areas. By focusing on target lands, cereals, and subjects, we should attempt to transform the food crop production strategy from pursuing the maximum output to farmland management and technological application.

4.2 Guide reasonable consumption

It is estimated that at present, we have the potential to economize by 5.49×10^7t on grain for livestock farming, food, alcohol consumption, food processing, warehousing, and so on, which accounts for about 10% of the total grain production [27]. According to the requirements for a reasonable diet, the food demand in 2030 should be 5.86×10^8 t at most [7]. However, in 2015, the total grain production has reached 6.21×10^8 t, which indicates that there is enough space to optimize and economize within the dietary structure.

To economize on grain, we need to convert three aspects: (1) the concept of food security converts from simply increasing supply to combining increase and economization; (2) policies and measures convert from simply productive policies to combining productive and consumptive policies; and (3) cereal production converts from

focusing on realistic productive capacity to sustainable productive capacity.

As to the concrete measures, first, we should strengthen political guidance. We ought to draw up concrete food-saving plans, mobilizing enthusiasm for scientifically planning links between livestock and poultry breeding, food processing and warehousing, and food consumption, from the aspects of policy, capital, projects, science and technology, and talent. Second, we should improve publicity on economization in consumption through multi-media and community. We can also motivate consumers to drink and waste less through diverse education and supervision. Step by step, their consciousness of economization on food will be enhanced.

4.3 Fully utilize both domestic and international markets and resources

China currently has one of the highest degrees of open agricultural trade globally. The supply and demand for agricultural products has integrated into the international market. Since entering the international market as a new net importer in 2004, China has now become the world's largest importer of agricultural products and the second largest agricultural trade country. On the basis of self-sufficient grain and the absolute safety of grain for human consumption, moderate importation relieves the pressure on resources and the environment, promotes the strategic adjustment of the agricultural structure, and safeguards China's food security. Thus, to make use of international and domestic markets and resources, we should not only make the best of international agricultural trade, but also let our agriculture "go global" and expand the space for our agricultural development.

4.4 Improve agricultural technical innovation and promotion

In view of limited agricultural resources, increasingly prominent environmental problems, and fixed food-demand growth rates, only scientific innovation can ensure national food security. First, we need to focus more on agricultural scientific technology, and strengthen the technology in key fields and central parts. Our focus should be on making a breakthrough in the technologies of economization, environmental protection, and waste utilization. We should also promote the assembly of traditional practical technology, information technology related to the Internet of Things, and agricultural remote sensing technology, to support the sustainable development of agriculture. Second, it is necessary to improve training in agricultural technology application and to cultivate talent. We should focus on basic agricultural technological staff and new subjects of agricultural operation, develop training hierarchically, and accelerate the cultivation of agricultural scientific and technological model households, all to facilitate the demonstration of agricultural technology.

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