

Prediction of Food Consumption and Grain Demand on China's Mainland

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Abstract: Food consumption in Taiwan Province is currently stable, and it is very likely that the China's mainland will follow a similar progressive path of food consumption to that of Taiwan. The total dietary consumption of China's mainland residents will reach its peak in around 2026, as will the consumption of foods with high added value, such as fruit, meat, eggs, seafood, dairy, and oil. Total dietary consumption will be 563 kg per capita, and grain consumption will be 456 kg per capita. The structure of dietary consumption will reach a stable state by 2035, with total dietary consumption and grain consumption at 499 kg per capita and 412 kg per capita, respectively. The dietary consumption of China's mainland residents has great potential to increase, which will exert long-term, continuous pressure on China's limited land and water resources.

Keywords: Taiwan Province; China's mainland; dietary consumption; grain demand

1 Introduction

The China's mainland has seen rapid economic development since the 1980s, with annual average GDP growth exceeding 9% between 1978 and 2015. This has made China one of the world's fastest-growing economies. China's per capita GDP surpassed USD 8 800 in 2017, and is projected to reach USD 14 612 by 2030 (calculated in 2012 constant prices) [1]. Along with rapid economic development, tremendous improvements have been seen in incomes and living standards. China is a developing country, and presently contains the world's largest population; therefore, the evolution of its food structure and the resulting food security issues have attracted the attention of scholars from around the world [2–4].

Scholarly research on food consumption on the China's mainland is essentially unanimous in concluding that significant changes are taking place in the food consumption structure. The traditional grain-based diet is shifting toward a modern diet, with decreased consumption of grain and increased consumption of animal-based foods [5]. Although there is general consensus on the direction in which people's diets are developing, there is much discrepancy among research outcomes regarding mainland grain demand [1,6,7]. An accurate assessment of potential evolutionary trends in mainland grain consumption could serve as an important basis for policies regarding agricultural production, foreign trade, and food security. The process experienced by developed countries and regions is an important frame of reference for determining the characteristics of the China's mainland's potential food consumption. Compared with other developed Asian regions, Taiwan is a more useful reference for forecasting the evolution of mainland food consumption.

Received date: September 10, 2018; **Revised date:** September 20, 2018

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Funding program: CAE Advisory Project "Research on Key Strategic Issues of Agricultural Resource and Environment in China" (2016-ZD-10)

Chinese version: Strategic Study of CAE 2018, 20 (5): 135–141

Cited item: Xin Liangjie. Prediction of Food Consumption and Grain Demand on China's Mainland. *Strategic Study of CAE*, <https://doi.org/10.15302/J-SSCAE-2018.05.020>

There are four reasons for this. First, as one of Asia's "Four Little Dragons," Taiwan began developing economically in the 1960s; accordingly, the rise in its food consumption standards was rapid. After more than three decades of development, the total food consumption of Taiwan's residents essentially stabilized around the beginning of the twenty-first century, with a relatively rational structure and balanced dietary nutrition. Meanwhile, the mainland has also gone through 30 years of rapid development, beginning in the 1980s, so the two have a similar economic background. Second, dietary habits in Taiwan are characteristically Chinese [8]. Third, both Taiwan and the mainland have been influenced by Western eating and drinking culture in the process of their development, causing distinct changes in traditional ideas and behaviors related to food and drink. Fourth, the factors driving the development and transformation of food consumption in the two areas are essentially the same [9].

Thus, this paper assesses the potential food consumption of mainland residents on the basis of analyzing how the diets of Taiwan's residents have changed over time. Furthermore, animal-based foods are converted back to their grain equivalents through conversion factors in order to calculate per capita grain demand. Hopefully this will provide an informative reference for the formulation of the China's mainland's agricultural policy, grain policy, and food-related foreign policy.

2 Taiwan's economy and evolutionary characteristics related to food consumption

Taiwan's rapid economic development really began at the start of the 1970s. By 1976, Taiwan's per capita GDP had broken the USD 1 000 mark and reached USD 1 156, and by 1980 it passed the USD 2 000 mark and hit USD 2 389. By 1990, Taiwan's per capita GDP had reached USD 8 216, and it had officially entered the ranks of developed economies. Taiwan's economic growth rate was 18.8% per year in the 1970s, and 15.0% in the 1980s. Later on, as the economy expanded and adjusted in structure, the growth rate slowed and fluctuated to an extent, but maintained upward momentum overall. By 2016, Taiwan's per capita GDP had reached USD 22 561.

As the economy has developed, Taiwan residents' food consumption has changed significantly. This has primarily manifested in the following two ways: (1) Taiwan's food consumption has essentially stabilized in terms of both structure and total amount, gradually shifting from plant-based foods being predominant to plant- and animal-based foods being equally important. (2) Different categories of food have reached stability points at somewhat different times.

2.1 Taiwan's food consumption has essentially stabilized in terms of both structure and total amount

The main categories of food consumed by residents of Taiwan include cereals, tubers, vegetables, fruit, meat, eggs, seafood, dairy, and oil/fat. In the initial stage of economic development, when the per capita GDP was lower than USD 1 000, food consumption in Taiwan was highly elastic, with consumption increasing significantly with each increment of economic growth. Although food consumption certainly continued to increase after the per capita GDP broke the USD 1 000 mark, the rate of increase was much slower, and it slowed even further once the per capita GDP passed USD 5 000 and residents' food consumption exceeded 500 kg. Food consumption in Taiwan peaked between 1993 and 2004 with an annual average of 547.7 kg. Consumption was highest at 581.0 kg in 1999, when the per capita GDP was USD 13 819. After peaking, food consumption declined slowly, and it has now essentially reached a point of stability. The per capita GDP broke USD 20 000 in 2011, and between 2011 and 2016, per capita food consumption averaged 513.4 kg per year. The point of relative stability for Taiwan's food consumption could be around 510 kg (Fig. 1).

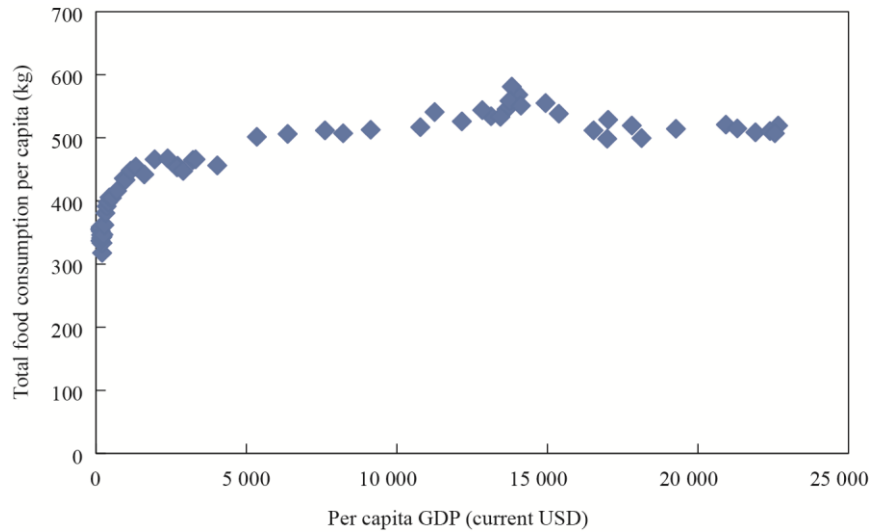


Fig. 1. Food consumption of Taiwan's residents at different economic levels.

In the initial phase of Taiwan's economic development, food consumption was dominated by plant-based foods, with relatively low consumption of animal-based foods. The ratio between grains, fruit/vegetables, and meat/eggs/dairy was 55:25:15. As the economy developed, the structure of Taiwan's food consumption gradually shifted until plant- and animal-based foods became equally important. At present, the food consumption structure is essentially stable, as noted. Between 2011 and 2016, the ratio between grains, fruits/vegetables, and meat/eggs/dairy was 20:45:30. In this period, the combined share of cereals and tubers in food consumption was approximately 32.1%. Vegetables accounted for 20.5% and fruit accounted for 24.2%, for a combined share of 44.7%. The proportion of animal-based foods was 28.8%, with 14.8% for meat, 3.4% for eggs, 6.3% for seafood, and 4.4% for dairy. Oil/fat accounted for 4.4% of food consumption (Fig. 2).

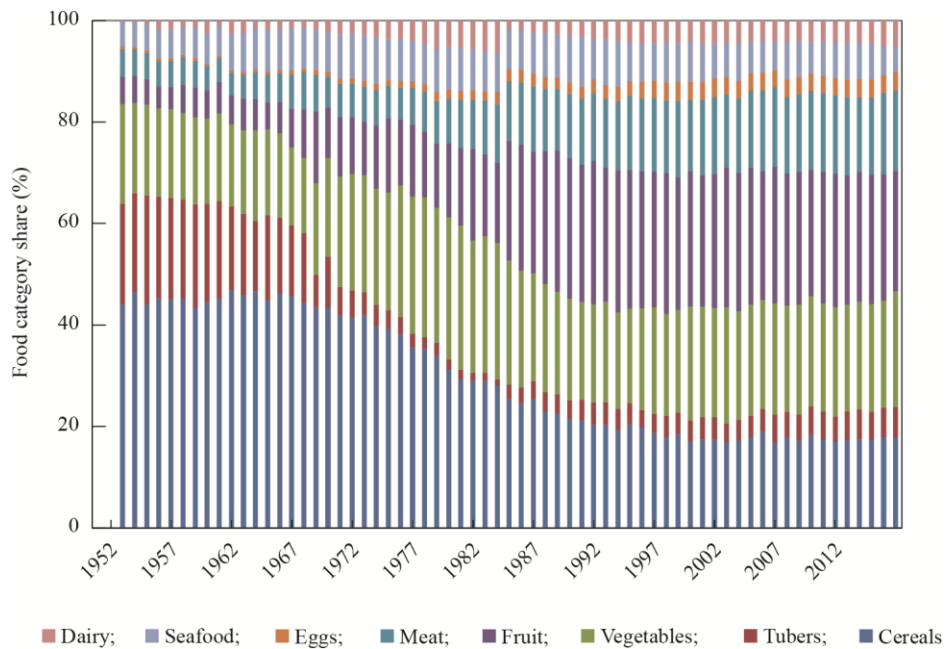


Fig. 2. Evolutionary characteristics of Taiwan's food consumption structure.

2.2 Different categories of food reached points of stability at somewhat different times

In the initial phase of economic development, consumption increased in almost every food category. At that time, the goal was simply to have enough to eat. After a period of time, however, consumption successively peaked in different food categories. Tubers were the first to peak, with per capita consumption growing to 72.1 kg in 1958, then rapidly falling, then bouncing back to an extent in recent years. Cereals were the next to peak after tubers, with per capita consumption reaching 167.8 kg in 1974, at which time per capita GDP was approaching the USD 1 000 level at USD 934. Per capita consumption of vegetables has changed little overall. It reached its peak of 129.6 kg in 1980 and averaged 105.5 kg between 2011 and 2016, a difference of about 25 kg. In the same way, consumption of high-value-added foods such as fruit, meat, eggs, and seafood first increased and then dropped along with economic development. Consumption of these foods was very uniform in the sense that they all peaked between 1997 and 2000, when the per capita GDP was roughly USD 14 000 (Table 1). In contrast with the other categories, dairy consumption has continuously increased, growing from an average of 7.3 kg per person in 1984 to 24.5 kg in 2016.

At present, stability has essentially been reached in the main categories of Taiwan's food consumption. Between 2011 and 2016, residents of Taiwan consumed an average of 85.9 kg of cereals, 75.7 kg of meat, and 17.2 kg of eggs per year (Fig. 3).

Table 1. Peak points of residents' food consumption in Taiwan.

Category	Tubers	Cereals	Vegetables	Seafood	Fruit	Oil/Fat	Eggs	Meat	Dairy
Year	1958	1974	1980	1990	1997	1997	1999	2000	2016
Amount (kg)	72.1	167.8	129.6	47.5	150.1	26.7	19.4	79.0	24.5
Per capita GDP (USD)	185	934	2 389	8 216	14 040	14 040	13 819	14 941	22 561

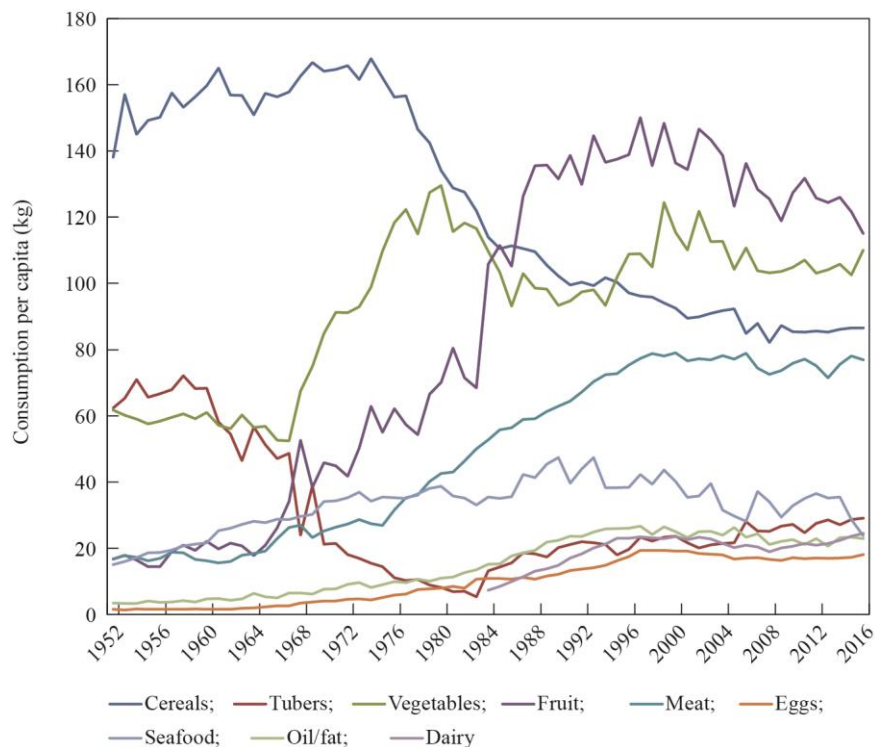


Fig. 3 Changes in Taiwan's food consumption in different categories.

3 Background of potential food consumption on the China's mainland

According to data published by the World Bank, in 2016 the China's mainland had a per capita GDP of USD 8 123, for a level of economic development equivalent to that of Taiwan in 1990. Under a medium-growth scenario, a research group at Tsinghua University's Institute for Contemporary China studies predicted that the mainland's per capita GDP will grow at a rate of 6.15% between 2015 and 2020, 4.74% between 2020 and 2035, and 3.44% between 2035 and 2050 [10]. At this rate, the per capita GDP will reach USD 20 658 by 2035, equivalent to that of Taiwan in 2011.

Assuming that the evolution of China's food consumption, in terms of both total amount and structure, is consistent with the experience of Taiwan, the consumption levels of mainland residents in 2016 will then correspond with the consumption levels of Taiwan's residents in 1990. The per capita GDP on the China's mainland will reach USD 13 617 in 2026, the equivalent of Taiwan's level of economic development in 1999. At that time, the mainland could reach a peak in total food consumption, with consumption of high-value-added foods such as fruit, meat, eggs, and seafood also peaking accordingly. By 2035, the mainland's per capita GDP will reach USD 20 658 [11], roughly equivalent to Taiwan in 2011, at which time the food consumption of its residents may have dropped slightly compared to 2026's peaks and reached a level of stability (Fig. 4).

We selected the average food consumption values of Taiwan from 1997–2000 as the peak values that the China's mainland could reach in 2026, and the average consumption values of Taiwan between 2011 and 2016 as the level of stability that the mainland could reach in 2035. We compared these with the mainland's food consumption levels in 2016 to judge the potential room for growth in consumption. On this basis, we used feed conversion ratios or grain conversion factors [1] to convert animal-based foods back to unprocessed grain, and then determined the average amount that residents of the China's mainland are expected to consume in key years.

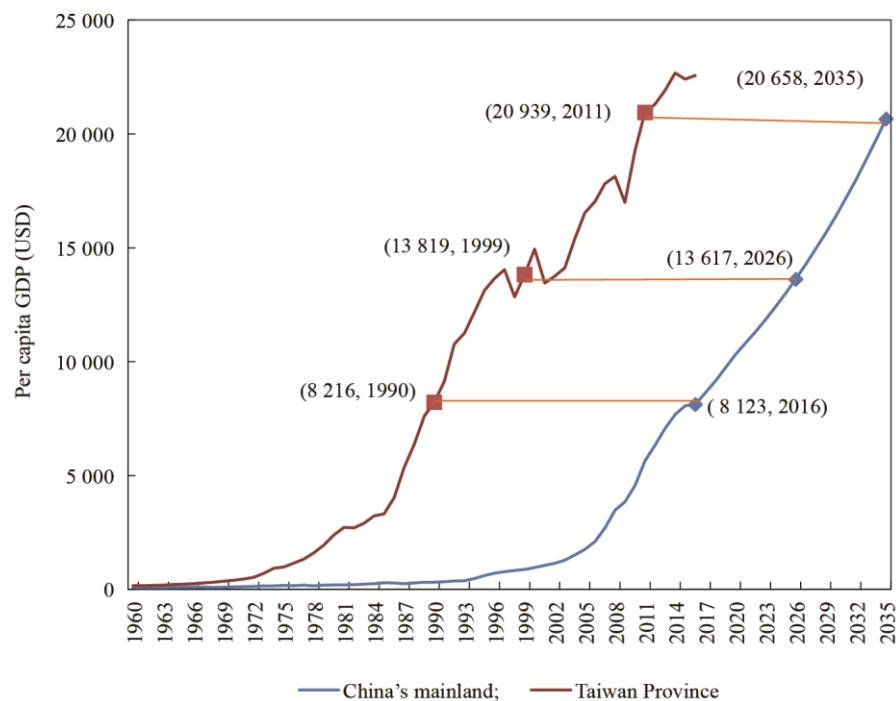


Fig. 4. Potential economic growth of the China's mainland.

From Table 2, it can be seen that the mainland's current food consumption is still quite far from the peak and stable consumption levels. This is particularly true for high-value-added foods like fruit, meat, eggs, seafood, dairy, and oil/fat.

Mainland residents consumed 132.8 kg of unprocessed grain on average in 2016, which may be 13.6 kg from the peak level. Vegetable consumption is not far from peaking, with the 2016 level 13.3 kg below the peak. The gap is largest for fruit, with consumption at 48.3 kg in 2016—only one-third of the 142.6 kg peak, meaning there is significant room for

mainland residents' fruit consumption to grow. In the meat category there is also quite a large gap, with consumption of 35.2 kg in 2016 not even halfway to the 78.3 kg peak. The difference is most striking with regard to poultry, since 2016's consumption of just 9.1 kg represents only 27% of the peak level. Moreover, 2016 levels for mainland residents' consumption of seafood, dairy, and oil/fat amounted to 28%, 51%, and 41% of their respective peaks.

In terms of grain demand, in the year of peak consumption the China's mainland may need 456 kg of grain per person. This includes 119.2 kg of grain for direct human consumption, a proportion of 26.1%, and 227.0 kg of grain consumed to produce meat, a proportion of 49.8%. At the stable level, a total of 412 kg of grain per person may be required, with 99.6 kg of grain (24.2%) for direct consumption and 219.6 kg (53.3%) consumed to produce meat.

Table 2. Potential food consumption and grain demand of mainland residents (kg).

Category	Staple Foods	Cereals	Vegetables	Fruit	Meat	Pork	Poultry	Eggs	Seafood	Dairy	Oil/Fat	Total consumption /demand
2016 Mainland*	132.8	122.0	100.1	48.3	35.2	19.6	9.1	9.7	11.4	12	10.6	360
2026 peak	119.2	94.7	113.4	142.6	78.3	39.9	33.4	19.4	41.4	23.3	25.6	563
Difference from peak	-13.6	-27.3	13.3	94.3	43.1	30.3	24.3	9.7	30.0	11.3	15.0	203
2035 stability	99.6	85.9	105.5	124.1	75.7	36.3	33.3	17.2	32.5	22.4	22.4	499
Difference from stability	-33.2	-36.1	5.4	75.8	40.5	16.7	24.2	7.5	21.1	10.4	11.8	139
Grain conversion factor**	1.0	1.0	/	/	2.9	2.9	2.4	1.7	1.0	0.4	1.0	/
Grain demand in peak year	119.2	94.7	/	/	227.0	115.7	80.2	32.9	41.4	9.3	25.6	456
Grain demand at stability	99.6	85.9	/	/	219.6	105.4	79.8	29.3	32.5	9.0	22.4	412

Sources: *Data come from the National Bureau of Statistics. **Data come from referenced source [1].

Notes: The tubers included in staple foods are converted to unprocessed grain at a 1:5 ratio. Meat includes poultry.

4 Food security strategies to respond to the rapid improvement of diets on the China's mainland

4.1 On the supply side, we must strictly protect agricultural land and ensure that domestic agricultural production is sufficient

In 2016, residents of the China's mainland consumed an average of 360 kg of food each. This figure could potentially peak at 563 kg, a difference of 203 kg. The margins by which high-value-added foods fall short are relatively large, with current fruit consumption as much as 100 kg below its peak. China has a large population and limited agricultural land. In 2016, China's total cultivated land area was only about 135 million hectares, or about one tenth of a hectare per person, while high-quality farmland is even more lacking. Furthermore, as the economy has developed, non-agricultural construction has inevitably encroached on agricultural land, mostly high-quality farmland (hard reduction). Meanwhile, as the economy has developed, agriculture has inevitably shrunk due to its status as a vulnerable industry. In spatial terms, this has taken the form of returning farmland to forests and grasslands, while in temporal terms it has been reflected in the gradual withdrawal of marginal crops and fall of multiple cropping indexes (soft reduction). With limited water resources and rapidly growing demand for agricultural products, we should come to terms with the reality that it will be difficult for our own agricultural resources to guarantee complete self-sufficiency in agricultural products. We should

orient our policies toward strict, long-term protection of our agricultural land resources, especially cultivated land, while also putting emphasis on efforts to enhance soil fertility and composite production capacity.

4.2 On the demand side, we must step up supervision and guidance over consumption

The food consumption of mainland residents has transitioned from strictly quantitative demand to a combination of quantitative, qualitative, structural, and nutritional demands. The dual emphasis on quality and quantity will exert significant, sustained pressure on the mainland's agricultural industry. Guiding citizens toward rational consumption is an important way of easing pressure on the supply side. In this regard, we must continue to carry out thorough studies of balanced dietary models suited to Chinese people and ensure that the *China Food and Nutrition Development Program* is updated and published at regular intervals. We must help change how citizens think about eating, and offer food assistance or nutritional intervention for key groups such as people living in poverty and primary and middle school students. These efforts will guide the people in forming nutritious, healthy, and environmentally friendly eating habits.

4.3 On the level of macro regulation, we must shift the focus of food security from staple foods to a broader range of foodstuffs

In line with Taiwan's experience of food consumption growth, food consumption on the mainland could continue to experience distinct changes over the next 20 years. The most prominent characteristics of these changes will likely be as follows: consumption of grain-dominated staple foods will continue to fall, while consumption of high-value-added foods like fruit, meat, eggs, and dairy will rise sharply. Increased consumption of animal-based foods like meat, eggs, and dairy will lead to a direct increase in the amount of animal feed used. When the grain consumption of mainland residents peaks in 2026, it could reach 456 kg per person, with 49.8% or 227.0 kg of this accounted for by animal feed. This means that animal feed will take up the largest share of mainland grain demand, almost 100 kg larger than the staple food demand of 119.2 kg per person. In response to this consumption trend, we must review the mainland's current staple-focused food security strategy. At the Central Economic Work Conference, on December 10, 2013, it was proposed that we "rely on ourselves to ensure adequate volume of staple foods and concentrate domestic resources in this respect, and work to achieve grain self-sufficiency and absolute staple food security." However, looking at the current state of staple food production on the mainland, there are no major problems with staple food security. On the other hand, as consumption of animal-based foods like meat, eggs, and dairy continues growing vigorously, feed shortages could potentially spread from soy to corn. Therefore, in this scenario, animal feed is what food security policy should be focused on. Furthermore, with fruit consumption bearing enormous potential for growth and fruit cultivation currently lagging, we must be soberly aware of the possibility of fruit consumption growing rapidly. We should make plans in advance and designate suitable growing regions in order to form a fruit production layout in which there is balanced output, ample variety, and regional coordination.

5 Conclusion

The evolution of food consumption in Taiwan is a valuable reference for the mainland. According to the characteristics of food consumption growth in Taiwan, the mainland's total food consumption could peak in around 2026. At that time, food consumption could reach an average of 563 kg per person, with consumption of high-value-added foods like fruit, meat, eggs, seafood, dairy, and oil/fat also reaching corresponding peaks, and meat consumption in particular reaching 78.3 kg. After 2026, food consumption of mainland residents will slowly fall, and could reach a point of essential stability by 2035, by which time food consumption will be 499 kg per person. In terms of grain consumption, each person will consume an average of 456 kg of grain in 2026 and 412 kg of grain in 2035. By comparing 2026 and 2035 consumption levels with that of 2016, it is evident that the food consumption of mainland residents still has significant potential to rise, which will put long-term pressure on China's limited land and water resources. A number of steps should be taken to relieve this pressure. On the supply side, we need to strictly protect agricultural land, especially high-quality farmland, in order to ensure adequate domestic agricultural production; on the demand side, we need to guide citizens to gradually form nutritious, healthy, and environmentally friendly eating habits; and on the macro regulation level, we need to shift the focus of food security from staple foods to a broader range of foodstuffs.

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