

Review article

Food Security of China: The Past, Present and Future

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Abstract

This paper demonstrates the capability of China to feed itself and the effects of the food security of China on the world. In the past two decades, China didn't cause any food crisis; on the contrary, she exports grain, vegetables, fruits and aquatic products. Chinese hybrid rice and other agricultural technologies have greatly promoted the world food security. It is speculated that in the future, China's agriculture development will meet both great challenges and opportunities. Overall, China will not only be self-sufficient but also improve the world food security.

Keywords: China; world; food security; grain; vegetables; fruits

Who will feed China?

China is the most populous country in the world. When the People's Republic of China (PRC) was established in 1949, William Vogt, the then USA Secretary of State stated that China would not be able to feed its population of 500 million (William, 1948; SSTC, 1996). In 1994 Lester Brown, an American agriculture and economy researcher, asked a similar question: Who will feed China? (Brown, 1994). He predicted that China would import more grain and cause world food shortages and that would persist into the future (Brown, 1995; 1998, 2001, 2004a; 2004b, 2005). Some popular media and organizations also professed, directly or indirectly, that income growth and population growth in China and India have played a role in the current food crisis (Spiegel Staff, 2008; PTI, 2008). Overall, there are ingrained doubts on China's food security.

China can feed itself

From 1948 to 2006, China's total grain output (TGO) and the per capita share of grain increased with the population. Over these years, the population increased 2.42 times, changing from 541.67 to 1314.48 million. Meanwhile, the TGO increased 4.33 times from 113.20 to 490 million tons, with an increase greater than that of population. Furthermore, the per capita share of grain increased 1.8 times from 209 to 377 kg, and reached more than 400 kg in recent years (Fig. 1) (Team of countryside social and economy investigation of China national statistics department, 2000; 2006). It is clear that China's grain output can fully satisfy its need (Li, 2005; Huang et al, 2002a, 2002b; Zhang and Xu, 200; Zhang, 2007; Zhang and Duan, 2010). From 1984 to 2007, the TGO of China is always between 400 and 500 million tons. In 1996, the TGO reached 504.54 million

tons, which is a bumper crop year after 1984 (407.3 million tons) and 1990 (446.2 million tons). Other products also had large harvests. 1996 can be considered as a milestone in the history of Chinese agricultural development. Since this year, the supply and demand of agricultural products in China changed from long-term shortage of supply to balance supply and demand. In fact, since 1984, not all of the surplus grains could be sold to the government for storage, and hence most of the surplus were used for livestock feed or as substrates for alcohol and wine fermentation. In 2007, the TGO was 501.5 million tons (Fig. 1) (Li, 2008; Li, 2005; Huang et al, 2002a, 2002b; Zhang and Xu, 2004, Zhang, 2007; Zhang and Duan, 2010). The surplus of grain caused the structural readjustment in agriculture of China. Since 1984, the farmland area gradually increased, whereas the total area of grain crops greatly decreased (Fig. 2). Among the grain crops, the planting areas for rice and wheat greatly decreased, whereas the area planted to maize rapidly increased. The planting areas for oil crops (peanut, rape and sesame), soybean, and sugar crops (sugarcane and beet) also increased rapidly. And, the planting area for cotton remained almost unchanged throughout the past twenty years (Fig. 3). On the other hand, the fraction of area planted to cash crops accounts for 30-50% of the total farmland in many regions of China since 1984, and it reached as high as 60% in some areas such as the developed coastal areas in east-south China (Zhang and Xu, 2004; Zhang, 2007; Zhang and Duan, 2010). For example, high value-added farming such as fish breeding and poultry production developed quickly. Besides, from 1980 to 2004, the planting area for fruits increased 5.5 times from 1.7827 to 9.7682 million ha. Among the fruits, apple production increased four times from 0.738 million in 1980 to 2.9868 million ha in 1996, and then decreased to 1.1 million ha by 2004; orange and pear also greatly increased and other fruits

Table 1. Trades of grain, oil seed, oil, cotton, and sugar of China in the recent years (10000 ton)

Year	Grain		Edible oil seed		Edible oil		Cotton		Sugar	
	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import
2002	1252.0	253.0	107.0	1088.0			13.8	16.5	32.0	116.7
2003	2200.4	208.7	124.0	2097.6	6.0	541.8	11.7	95.4	10.3	77.5
2004	479.5	975.3	116.4	2023.0	6.6	676.4	1.2	198.4	8.5	121.4
2005	1017.5	627.2	136.0	2704.0	22.8	621.3	0.8	265.3	35.8	139.0
2006	609.9	359.5	121.5	2928.0	40.0	671.5	1.5	380.6	15.4	136.5
2007	991.2	155.7	127.1	3285.8	16.8	839.7	2.4	261.5	11.1	119.3

Table 2. Trades of vegetables, fruits, livestock products and aquatic products (U. S Dollars, 0.1 billion, *10000 ton)

Year	Vegetables		Fruits		Livestock products		Aquatic products	
	Export	Import	Export	Import	Export	Import	Export	Import
2002	23.7	0.7	8.5	3.5	25.5	19.2	41.7	20.7
2003	552.7*	9.0*	266.8*	101.9*	272.7	33.6	54.9	24.8
2004	38.0	0.92	16.5	5.9	31.9	40.4	69.7	32.4
2005	44.8	0.82	20.3	6.6	36.0	42.3	78.9	41.2
2006	54.2	0.9	27.4	7.6	37.3	45.6	93.6	43.0
2007	62.1	1.1	37.5	9.6	40.5	64.7	97.4	47.2

Table 3. Correlations coefficient between total grain productions and other traits

Y	X1	X2	X3	X4	X5	X6	X7		
Y	1.00								
X1	0.90**	1.00							
X2	0.93**	0.94**	1.00						
X3	0.92**	0.68**	0.72**	1.00					
X4	0.96**	0.78**	0.84**	0.95**	1.00				
X5	0.96**	0.83**	0.87**	0.91**	0.99**	1.00			
X6	0.91**	0.74**	0.82**	0.89**	0.98**	0.97**	1.00		
X7	0.93**	0.73**	0.79**	0.96**	0.96**	0.92**	0.89**	1.00	
X8	-0.29	-0.02	-0.14	-0.48*	-0.55**	-0.52**	-0.62**	-0.48	
X9	-0.51**	-0.16	-0.31	-0.71**	-0.72**	-0.68**	-0.76**	-0.68**	
X10	-0.08	0.24	0.19	-0.37	-0.32	-0.27	-0.41	-0.25	
X11	0.82**	0.56**	0.59**	0.95**	0.85**	0.81**	0.82**	0.83**	
X12	0.73**	0.45*	0.51**	0.88**	0.87**	0.84**	0.89**	0.80**	
X13	0.77**	0.48*	0.55**	0.91**	0.86**	0.83**	0.85**	0.82**	
X14	0.87**	0.61**	0.69**	0.95**	0.95**	0.92**	0.94**	0.90**	
X15	0.13	-0.25	-0.37	0.64**	0.75**	0.73**	0.83**	0.25	
X16	0.39	0.00	-0.11	0.74**	0.86**	0.88**	0.87**	0.34	

Note: Y = Total grain production, X1 = Total rice production, X2 = Total wheat production, X3 = Total maize production, X4 = Grain production, X5 = Rice production, X6 = Wheat production, X7 = Maize production, X8 = Total area of grain crops, X9 = Rice area, X10 = Wheat area, X11 = Maize area, X12 = Total of agricultural machines, X13 = Irrigated farm land, X14 = Fertilizer, X15 = Plastic film, X16 = Pesticide. * and ** indicate significant at $P \leq 0.05$ and $P \leq 0.01$, respectively.

such as grape and banana increased at a moderate rate (Fig. 4) (Brown, 2004b). From 1984 to 2004, the agricultural economy developed quickly. A great amount of grain products were used for processed food and raw materials for other industrial products. This is the major feature of Chinese agricultural development in the past 20 years (Zhang and Xu, 2004; Zhang, 2007; Zhang and Duan, 2010). The percentage of total agricultural value (PTAV) in the total value of agriculture and forest and stock raising and fishing (TVAFSF) decreased rapidly from 74.1% in 1984 to 50.1% in 2004, but the percent of total stock raising value (PTSV) in the TVAFSF increased by three times from 11.2% in 1984 to 33.6% in 2004. Moreover, the percentage of fishing value (PTFIV) in the TVAFHF

increased whereas the percentage of forest value (PTFV) in the TVAFSF did not change appreciably (Fig. 5). There are several reasons for the decrease in grains production in the past decade (1998-2007) (Fig. 1). Firstly, the basic grain needs of the nation had been met and thus the decreased market demand made it less profitable and less desirable for farmers. Secondly, some of the farmland was converted to for high-value crops (oil crops, fruits, vegetables, flowers and herbs, etc.) and for industrial and urban areas. Thirdly, frequent natural disasters, such as droughts and floods impacted overall grain production. However, it can be concluded from the developments in the past 10 years that China is able to stabilize the TGO at the level of 450~500 million tons per year (Fig. 1) (Li, 2008; Li, 2005;

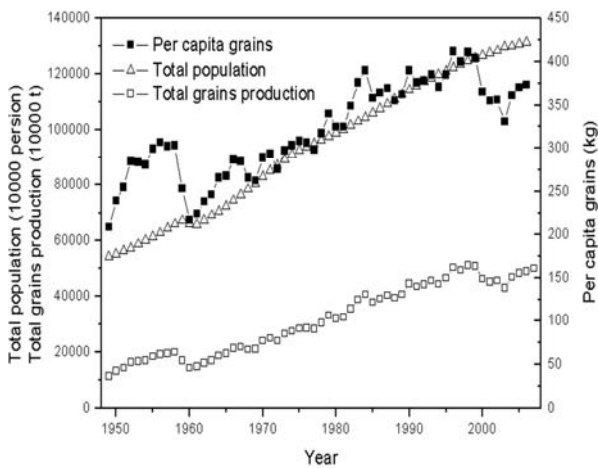


Fig 1. Total population and grains production and per capita share of grains.

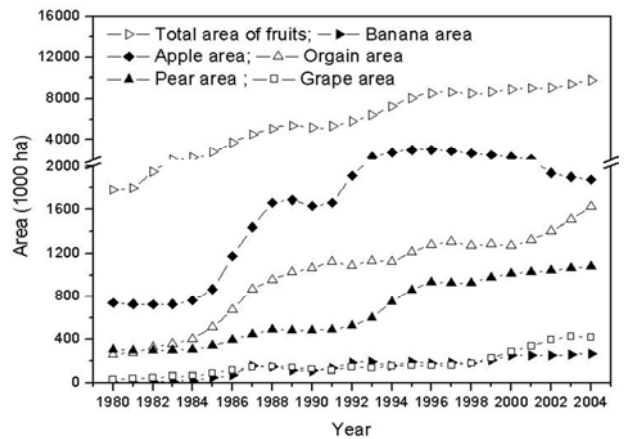


Fig 4. Areas of fruits.

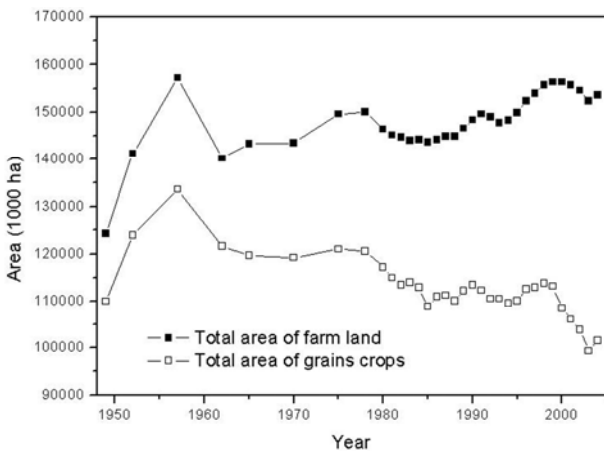


Fig 2. Total areas of farm land and grains crops.

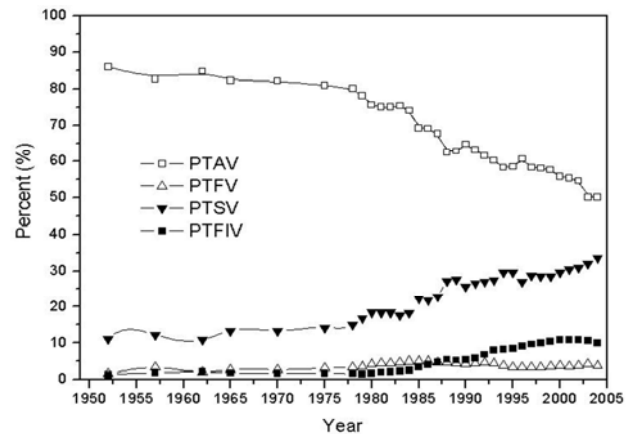


Fig 5. Agriculture constructions.

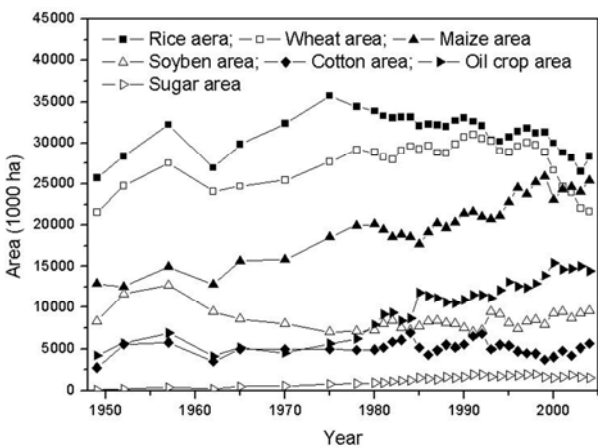


Fig 3. Total areas of different crops.

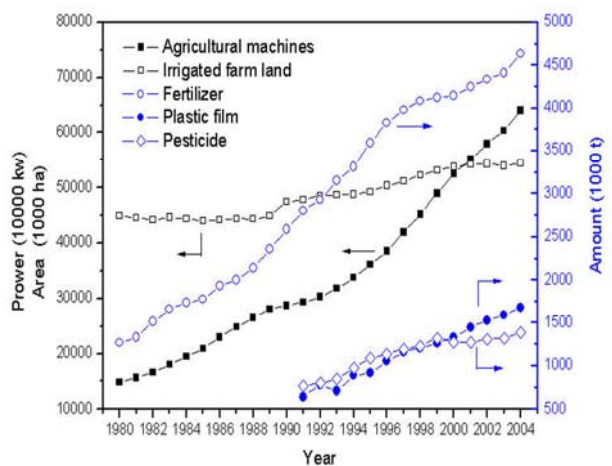


Fig 6. Inputs for agriculture.

Zhang and Xu, 2004; Zhang, 2007; Zhang and Duan, 2010). Since 1980, the area of irrigated land as well as the used fertilizers and agricultural machineries increased; furthermore, new agricultural products and technologies (e.g. plastic film and pesticides) were more and more used (Fig. 6). These changes resulted in a gradual increase in the TGO (Fig. 7) and an obvious increase in the yield per hectare (Fig. 8), although the total area of grain crops greatly decreased (Fig. 2). All of these points are the key reasons why the grain outputs of China have consistently remained at a relative high level for 23 years from 1984 to 2007, without importing large quantities of grain in this time (Zhang, 2006, 2007; Zhang and Duan, 2010). From 1949 to 2004, among the grain crops, the total and per unit area yields of rice, maize, wheat and sugar crops greatly increased. Currently, rice is the largest crop in China, maize is the second, and wheat is the third (Figs. 7 and 8). During this period, the total and per unit area yields of oil crops, soybean and cotton slowly increased (Figs. 7 and 8). At the present time, most Chinese people have shifted from mostly eating grains towards balanced diet including more vegetables, fruits and animal protein (Li, 2005; Huang et al, 2002a, 2002b; Zhang and Xu, 2004; Zhang, 2007; Zhang and Duan, 2010). Since 1980, per capita consumption of grains has decreased, whereas those of fruits, sugar, meat, aquatic products and oils have greatly increased. Per capita consumption of cotton didn't change appreciably (Fig. 9).

Meanwhile, most farmers earned more money from animal husbandry and other high-added value cash crops such as fruits and vegetables and other commodities, increasing their earnings in real terms by 13.7 times from 191.3 (RMB, Yuan) in 1980 to 2622.2 (RMB, Yuan) in 2004 (Fig. 10) according to the China National Bureau of Statistics (2008). Thus the number of farmers living in poverty rapidly decreased from 250 million in 1978 to 29 million in 2003 (Fig. 10) according to the China Statistics Publishing House (2005) and reports of People's Daily (2005).

China exports more grain and other agricultural products to the world

From 1949 to 2004, China's agricultural trade was always a surplus, with a total surplus of 124.38 billion U.S. dollars (Chen, 2004). From 2005 to 2007, there is a balance between the imports and the exports (Fig. 11) according to the reports by Ministry of Agriculture (2002-2007). From 2000 to 2007, the total trade of agricultural products increased 2.8 times from 27.9 to 78.0 billion US dollars, making China becomes one of the largest countries for agricultural products trade. With the acceleration of the pace of structural adjustment of agricultural exports, the exports of grain (Table 1), vegetables, fruits and aquatic products (Table 2) were continually higher than the imports in the same period. Exports of agricultural products have become the main income for farmers in some areas of China. These data show that China is not only a major agricultural food producer but also a major exporter of grains. The rapid development of agricultural economic ensures the tremendous potential for agricultural exports. Meanwhile, China's clothing exports topped 73.88 billion US dollars in 2005, accounting for 24% of the global textile and apparel trade; when the internal trade in EU is excluded, this proportion reaches 31%. Moreover, to meet the consumption balance and improve the living standards, China imported more edible oil and livestock products and sugar for improving the quality of

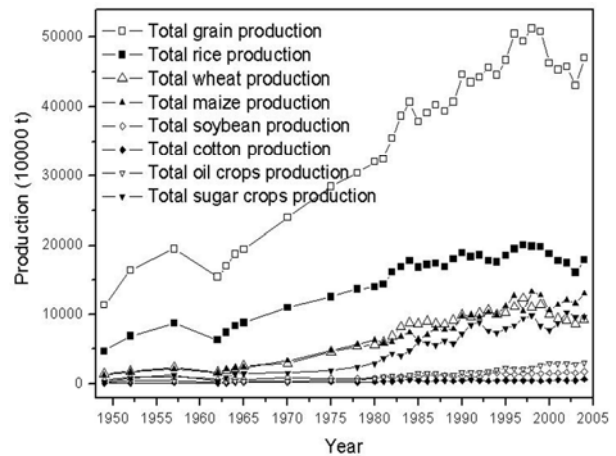


Fig 7. Total productions of grains and different crops.

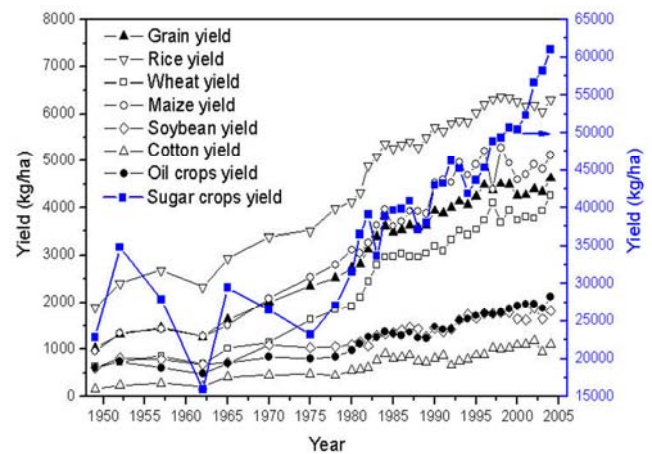


Fig 8. Crop yields.

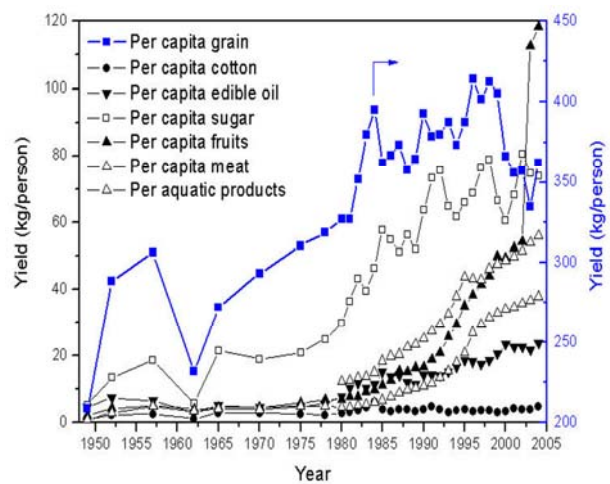


Fig 9. Per capita shares of foods.

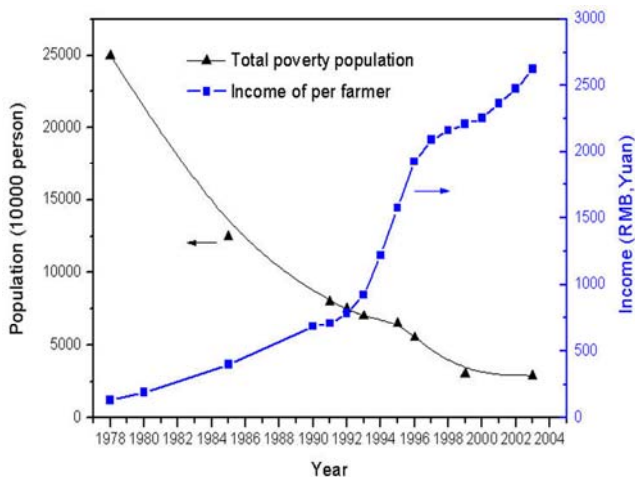


Fig 10. Total poverty population and the income of per farmer.

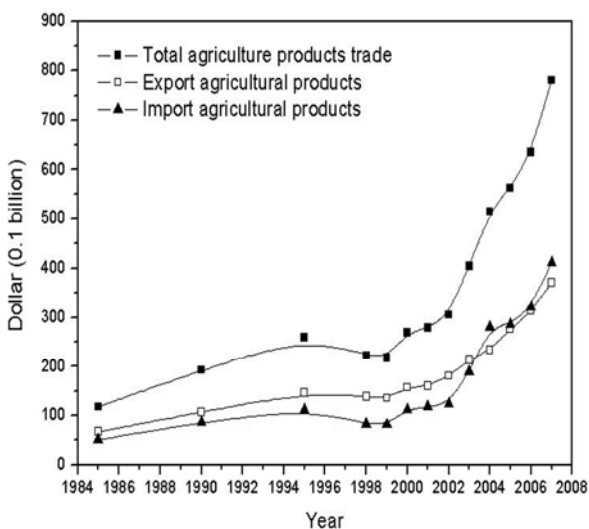


Fig 11. Agricultural trade of China.

life, as well as more edible oil crops seed and cotton (Tables 1 and 2). This import promotes the agricultural economic developments of other countries and also provides employment opportunities for these countries. For example, China imports much high-protein quality wheat for improving the processing quality needed for making breads and other foods. Many companies, in cooperation with China imported edible oil crops seeds for processing into edible oil, for both domestic and foreign consumption. Therefore, to some extent China is not only an indispensable engine to the development of the world economy but also an important engine of the world's agricultural development. Both the imports and the exports of agricultural products of China have major impacts on the world food security (Li, 2008; Zhang, 2007; Zhang and Duan, 2010). Besides, the grain reserves in China are 35% of the total consumed grain, this is twice the food security line (17%-18%) suggested by the Food and Agriculture Organization of the United Nations (FAO). China yields 450-500 million tons of grains every year, and the degree of self-sufficiency in grain is

consistently more than 95% (Li, 2008; Wen, 2008).

China promotes the world food security

In 2005, the World Food Program (WFP), after aiding China for over 25 years, ceased the aid. It is stated that China is self-sufficient and will not bring the world to panic and anxiety. Instead, the WFP urged China to play a larger role as an international food donor, arguing that China now has the resources to provide food aid to needy countries in Asia and Africa (Yang, 2006). Less than 50 years after some devastating famines, China has emerged as the world's third largest food donor, following the United States and the European Union. Since 1981, China has donated a total of 19.47 million U.S. dollars to the WFP. According to the FAO and reports of People's Daily (2005a; 2005b), in the past 25 years, more than 20% of the world's major agricultural products came from China (Pallavi, 2006). China's experience in attaining food security and reducing poverty could be shared and applied to improve food security and nutritional levels elsewhere in the world (Xiao and Nie, 2009). The development of science and technology is important to the food security (Islam, 2010; Goyal et al 2009). In the fields of rice science and technology, Chinese rice breeding and genetic technology have increasingly gained world attention (World Food Prize, 2004; Xinhua, 2006). China has not only solved its own food problem but also the problems of hunger and food shortages for some other developing countries. Since 1979, China presented 1.5 kg of hybrid rice seeds to the Western oil company in the United States, sent rice experts to more than 40 countries, and provided hybrid rice technology training and other related technical services. The planting area for hybrid rice in those countries has now reached 1.5 million hectares. Vietnam was a major importer of rice in Asia until the 1990s. When 40,000 hectares of hybrid rice from China were introduced in 1993, the rice yield increased to 100 million kilograms in the same year. At present, Vietnam has planted 6.5 millions ha of hybrid rice and has become the second largest rice exporter in Asia after Thailand. In addition, India was assisted by China to develop hybrid rice breeding programs to adapt the crops to local conditions. Philippines have enhanced hybrid rice yields two to three times and changed the situation of the import of grain from other countries. Longping Yuan, the World Food Prize laureate in 2004 and the foreign academician of America academy of science in 2006, hopes that the hybrid rice area abroad will increase from 1.5 million hectares to 15 million hectares. This would result in a total output of 30 million tons assuming a 2-ton per hectare output. In 2006, China expressed its intent to provide the services of at least 3000 experts and technicians over a six-year period to improve the productivity of small-scale farmers and fishers in developing countries. China continually aids other countries in improving their food security, which represents a major contribution towards the achievement of the World Food Summit and Millennium Development Goals of halving hunger by 2015 (Xinhua, 2008).

Challenges and opportunities of agricultural development in China

China hold an annual TGO of 400-500 million tons and the grain yield pre hectare has continually increased from 1980 to 2004. The relationship between the TGO and sixteen other agricultural traits is analyzed in the following text. Results

show that the TGO (Y) is significantly negatively correlated with total rice area (X_9) (-0.51**), not significantly correlated with total wheat area (X_{10}) (-0.08), and significantly positive correlated with total maize area (X_{11}) (0.82**). The highest significant correlations with TGO are grain yield per hectare (X_4) and rice yield per hectare (X_5) (0.96**). There is high positive correlation between TGO and total rice production (X_1), total wheat production (X_2), total maize production (X_3), wheat yield per hectare (X_6), and maize yield per hectare (X_7) (0.9** - 0.93**). These results indicate that total and per hectare productions of rice, wheat and maize are mainly responsible for the increase of the TGO in China in the past 24 years (Figs. 1, 7, 8). TGO (Y) and grain yield per hectare (X_4), total and per hectare rice yield (X_1 , X_5), total and per hectare wheat (X_2 , X_6), total and per hectare maize yield (X_3 , X_7) are significantly positively correlated with agricultural machines (X_{12}), irrigated farm land (X_{13}) and fertilizer (X_{14}). Total maize yield (X_3), grain yield per hectare (X_4), rice yield per hectare (X_5) and wheat yield per hectare (X_6) are significantly positively correlated with plastic film (X_{15}) and pesticide (X_{16}) (Figs. 1, 6, 7, 8). These results show that invest on agricultural machines, irrigated land area, fertilizers, plastic film and pesticides is an important factor for the increase of the TGO and the yield per hectare. It is important to analyze the fluctuation of the TGO in China over the past 24 years, and to predict the TGO in the future. Stepwise regression analysis was made with the TGO and the sixteen other agricultural traits:

$$Y = -48759.6 + 10.904X_4 + 0.474X_8 - 0.096X_9$$

This equation indicates that the TGO is positively determined by grain yield per hectare (X_4) and total area of grain crops (X_8). Total rice area (X_9) decreases considerably over the past 24 years and has negative effect on the TGO. Thus, these three factors are identified as the key factors for the TGO in China. In other words, yield per hectare is the most important intrinsic factor determining the TGO, and total area for grain crops is the second important factor. Total rice area may be the third important determinant. Effects of total rice area may result from three aspects: the flooding over these 24 years; the expansion of cities and towns; and the replacement of rice paddies with other high-added value crops such as fruit trees. It is reasonable because the economy and industries of southern China develop more quickly than those of northern China. Thus, China should pay more attention on planting rice in southern China, which is the key factor for keeping or further improving the TGO in China. At present, agricultural development in China has great challenges. Arable land is decreasing. However, the nation's population is expected to increase to 1.5 billion by 2033, needing more food and water. Drought occurs frequently in northern China and seasonal drought occurs in summer and autumn in southern China, where also suffers frequent floods resulting in shortages of unpolluted water resources. Consequently, farmers want to earn more money by planting other high-added value crops. Large snowfalls and freezing temperatures occurred in southern China in early 2008, and this may have some influence on rice and the TGO in China (Ajmal, 2008; Paio, 2010). On the other hand, agricultural development in China is faced with many new opportunities. The first opportunity is the policy support. In recent years, the Chinese government attaches great importance to agriculture development (Xinhua, 2008), and the key phrases were increasing farmers' income (2004), improving agricultural production capacity (2005), pushing forward the "new countryside" scheme (2006), developing modern agriculture

(2007), calling for greater efforts to address rural problems (2008), and improving agriculture development and farmers' income consistently (2009). Since 2004, China has forgiven agricultural fees, purchased grains from farmers at much high prices, provided subsidies to farmers, and invested on building water conservation projects. Another opportunity is based on the fact that China's GDP and the financial revenue have increased quickly in the past twenty years, allowing for more money to be invested on agriculture and food productions. It was reported that China's trade surplus reached 196.1 billion US dollars in 2009. Due to its low-cost labor forces, China has become the manufacturing center for the world. Therefore, it may be predicted that the trade surplus in China may persist long into the future according to the China General Administration of Customs (2008). China is also the largest foreign exchange reserves in the world according to the China National Bureau of Statistics (2008). Thus, China has the ability to re-invest on agriculture through industry, and promote the development of countryside. Furthermore, some other factors will enhance the grain production, which include wide planted areas for super rice, maize and wheat varieties, advanced culture technologies, utilization of agricultural machines, fertilizers, plastic film, and pesticides, and cultivation of land. In summary, recently China's grains production is almost one-fourth of the globe grain production. In the past five years the annual average net export amount of grains (including maize, rice and wheat) reaches more than 8 million tones (Yang, 2008). Also, some factors will further improve the food security of China. Therefore, it can be speculated that China made and will make a great contribution to the globe food security.

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