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Study on Influencing Factors of Food Security in China Based on Historical Data From 1978 to 2013

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Abstract
Not only food security affects the people's livelihood, but also affects national economic development and social stability. Chinese food security has made remarkable achievements, and it is very important reference value to research on influencing factors for formulating food security policy. This paper summary the literature about influencing factors of food safety, then be established in definition of food security, choose a measurement index, and considers a few factors and conditions, make use of 1978-2013 Chinese macroeconomic data, reveal the main factors affecting food security. Research found that agricultural mechanization, chemical fertilizer, efficient irrigation and food policy have an important contribution to food security, while the contribution of per capita grain acreage decreased year by year, and the agricultural labor force, national financial allocation for agricultural science and technology, rural electricity consumption does not have a statistical significance for food security.

Key words: Food security; Influencing factors; Countermeasures

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INTRODUCTION
China is the most populous country in the world, which has a great demand for grain. According to statistics, sown area of grain in 1978 was 120,587 thousand hectares, but in 2013 this data change into 111,956 thousand hectares, the grain sown area during the period had reduced by 8,631 thousand hectares, while the population at the end of 2013 to reach 1360.72 million people, net increase 398.13 million people compared with the population in 1978. These reduced plantings area and increase population, resulting very prominent contradiction between food demand and supply. From a global perspective, grain exporting country is mainly concentrated in the United States, Canada, Australia and other ten or more countries, while grain importing country is up to more than 100 countries. So there is little effect that China import a small amount of grain from international grain market, but the most Chinese scholars believe that China must adhere to the "self-support as the principle element and trade as the auxiliary one" in order to ensure food security. However, the food security has many influencing factors, and existing research perspective is different, and some conclusions are remarkable differences. It is important to how to find the key factors so as to achieve smaller cost to ensure national food security based on the level of macro-based system.

1. REVIEWS OF LITERATURES ON INFLUENCING FACTORS OF FOOD SECURITY

Food security is a complicated system and it has many influencing factors, so many scholars research this field from different angles. From the view of climate change, some papers showed the impact of agricultural output and economic effects to food security (Schlenker et al., 2006; Bryan et al., 2009; Alpizar et al., 2011), and even further study showed that rainfall is an important factor for food security (Demeke et al., 2011). Some studied the relationship between environmental factors and agricultural production systems, some countries or regions agricultural expansion and intensified, resulting in deterioration of the food production environment, specifically including soil degradation and soil erosion, loss of wildlife diversity, genetic diversity of food crops and loss of climate changes, in turn, these factors also affect agricultural production (Reynolds et al., 2015). Some studied agricultural infrastructure, especially irrigation projects affect the level of food security for peasant household, and the results showed that irrigation projects have a positive impact on the family safe food, recommending collective water management and water-saving technology (Sikhulumile, 2014; Fanadzo, 2012; Hope et al., 2008). For example, Bruce Frayne and Cameron McCordic (2015) assessed the impact of household food insecurity in Kenya with a sample of 6,453 farm households, and the results showed that infrastructure investment has a significant impact on household food safety. Some studied on the impact of technology in food production, the conclusion was that advanced technology has a positive significance to grain production (Sherlund et al., 2002; Suri, 2011; Ogada et al, 2014). Some studied agricultural protection and compensation policies impact on food security, found that government intervention might increase grain output, but would lead to market distortions (Kym et al., 2013; Anderson et al., 2008; Baylis et al., 2008; Croser et al., 2011; Kumar, 1989). Some researched effects of crop diversity for food crop production, showed cropping patterns and crop diversification has a significant impact on crop production (Ogundari, 2013; Bangwayo-Skeete et al., 2012). From countermeasures, the World Bank studied on long-term food security of China, and believed that Chinese grain demand in 2020 will be about 697 million tons of raw trade grain (equivalent to 608 million tons processed food), with 90% solved by increasing the base facilities, agricultural research investment, land and development of water resource facilities in domestic production, the other 10% rely on imports (World Bank, l997); As far as developing countries is concerned, food security not only uses traditional methods, but also apply modern biotechnology (Victor, 2005), and so on.

There is a lot of literature about factors of Chinese grain safety, representative views are as follows: Food policy was closely related to food security, and grain policy on food security had remarkable results, and there were many problems (Zhong, 1995; Huang et al., 2010; Tian & Meng, 2010), but some studies believed that the Policies have no significance for the improvement of food security (Xia et al., 2006); Rapid growth of Chinese grain production mainly was due to the advanced technology, but also caused a waste of resources and destruction of ecological environment, and it need to strengthen the coordination between food security and economic development (Wang et al., 2014; Ma & Zhao, 2006; Xie, 2004); Some studies believed that the land and chemical fertilizer have a significant effect for food production, but it is not significant to affect food production for labor and technology (Zhou, 2003).Some believed that global warming increase natural disasters and threaten Chinese food security, which impact on the global grain trade patterns, therefore, China needs to establish a stable and reliable system to ensure import grain (Gao & Liu, 2014; Qiu et al., 2015; Chen & Xie, 2013; Liu & Lin, 2004).

Overall, foreign researches focus on family food security and community food safety at the micro level, and mainly uses a dynamic simulation model, structural equation or scenario simulation and other advanced methods, while Chinese scholars mostly select statistical analysis and regression models based on the macro-level. However, most studies ignore that food security is a system, which has too many factors and the size of different factors influence is different in the different periods, and has a relationship of mutual promotion or mutual restraint between factors. As Gao (2005) said that the existing literature on food security often discusses issues dispersedly, while ignoring the system characteristics of the object. Based on these reasons, this paper considers more factors about food security such as labor, arable land, mechanization, natural disasters, food policy and so on, building regression model from the macro level, and depending on time series data between 1978-2013, reveal main factors which affect Chinese food security, and put forward countermeasures.

2. DEFINITION AND MEASURE OF FOOD SECURITY

2.1 Definition of Food Security

The concept of Food security first appeared in the early 1970s, which be put forward to solve the problem of hunger. The initial meaning mainly focused on food supply, ensuring availability and price stability. Food security is defined in 1974 on World Food Summit, that is: “In the food supply situation around the world enough to maintain a steady expansion of food consumption and to offset fluctuations in production and prices.” (United Nations, 1975)

Later, this concept was enlarged to access to food, namely how to get food to depend on access to resources, production technologies, environmental conditions, market conditions, non-market food transfers and accumulated food (Sen, 1981). Subsequently, people gradually expanded this definition to these fields such as food processing, circulation and consumption, and also stressed the right to get food for human. In 1996 World Food Summit defined as follows: "All people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life".

Recently, virtually all commentators seem to agree that studies of food security must look at the multi-dimensionality and consider all these aspects, including environmental sustainability (McDonald, 2010). Of course some people definite food security as food systems, stressing all stages from food production to processing, marketing and consumption, and emphasizing that this system has complex sets of interactions factors, which include environmental, economic, political, and social forces, all of which (Lang & Heasman, 2003; Worldwatch, 2011).

To sum up, the definition of food security has experienced developmental stage, including food production, food supply, food right, food center and food system. The concept of food security system expresses the quantity of food security, quality of food safety, sustainable security, access to security, etc..

This paper chooses the concept of food security in the early stage, which is the quantity of food security, namely, food production safety and to provide enough food. The reasons as follows: Firstly, quantity of food security is the basis of other food security. No food production safety, no food trade and distribution, consumption. Now there are many places where have not enough food, leads to malnutrition, and be harmful to people's health (Stone, 2012). So yield increase is still an important goal, and this index is also dominant position in all of the relevant studies (Maxwell & Slater 2003; ESF, 2009). Secondly, the concept of food security system has not reached a consensus, but it is difficult to measure food security system. Because food security systems are very complex, people difficultly capture the information of quality, quantity, vulnerability and sustainability (Barnett et al., 2010). Thirdly, most of national government and the international organization take it as the standard, and formulate the food security goal with the practical application. The international community has accepted these increasingly broad statements of common goals and implied responsibilities. But its practical response has been to focus on narrower, simpler objectives around which to organize international and national public action. The declared primary objective in international development policy discourse is increasingly the reduction and elimination of poverty (FAO, 2003). The Millennium goal of the food security summit to eradicate extreme poverty and hunger has not been achieved (Mark et al., 2012).

2.2 Measurement of Food Security

As far as the index of food security is concerned, there is no accepted public standard. Different studies define food security indicators differently. For example, FAO have taken 17% to 18% of the cereal stocks accounted for the annual consumption as a measure of world food security standards since the mid-1970s. In addition, FAO also proposed rate of grain self-sufficiency, rate of grain stocks and other indicators. Currently, food security metrics are more, not only have a single index, such as the UN Food Organization (FAO), the World Bank, as well as domestic and international economic theorists recently taken mainly for rate of food self-sufficiency, variation coefficient of food production, food reserves level, the level of food security in low-income, per capita share of grain, dependence coefficient of grain trade, but also have index system, including quality, human right, risk and other indicators on food safety. In this paper, the per capita share of grain reflects food security, because it takes into account the population and food production factors, reflecting overall quantity level of national food security. Considered the impact of the international grain trade, it is calculated as follows:

$$P\text{grain} = \frac{T\text{yields} + A\text{imports} - A\text{exports}}{T\text{population}} .$$

Where Pgrain denotes per capita share of grain; Tyields denotes total grain yields; Aimports denotes the amount of imports; Aexports denotes the amount of exports; Tpopulation denotes the total population.

3. MATERIALS AND METHOD

3.1 Data Collection

China is a large developing country with 1.3 billion people, 10% of the world's arable land and 22% of the world population, so Chinese food security affects world's food security. According to the status of food production and resource conditions, the Chinese government formulated a national food security objectives that grain should remain above 95% of the self-sufficiency rate, ration should remain 100% safety. China's food security has made great achievements, and has been food aid donors successfully from the main beneficiaries of food aid since 2005. Other developing countries should learn from the successful experience of food security in China. Therefore, we select China as the study area. China Land Reform has undergone three historical turning points Since 1949, namely land reform in 1949, the people's commune movement in 1958, household contract responsibility system in 1978. As we

all known, China significantly increased food security after 1978. Therefore, this study selects 1978-2013 as research period.

Related data in this study are from books of "China Statistical Yearbook" and "China Rural Statistical Yearbook" in 1978-2014 which were written by the National Bureau of Statistics. Most of data are absolute number, and these data were processed into relative number according to demand of model.

3.2 Method

Based on previous research literature, we take labor, the degree of mechanization, irrigation, natural disasters, agriculture policy and other factors into the model, and build the regression model. Using unit root test judge smoothness of variables, and take JJ test verify whether it exist in cointegration among variables, and other related statistical and econometric test in order to ensure the reliability of the model. The model is established as follows:

$$Y_t = c + \alpha_1 x_{1t} + \alpha_2 x_{2t} + \alpha_3 x_{3t} + \alpha_4 x_{4t} + \alpha_5 x_{5t} + \alpha_6 x_{6t} + \beta_1 x_{7t} + \beta_2 x_{8t} + \theta_1 x_{9t} + \mu_t.$$

Where Y denotes per capita share of grain; X_1 denotes per capita grain sown area, reflect the relative relationship between the amount of arable land and population; X_2-X_6 reflect the factors that affect grain yield, X_2 denotes the agricultural labor force into unit farmland, reflecting labor input factors; X_3 denotes input amount of chemical fertilizer into unit farmland; X_4 denotes the proportion of which effective irrigation area occupy farmland area; X_6 denotes mechanization power of unit area, X_3, X_4 and X_6 reflect capital input and agricultural facilities factors; X_5 denotes disaster area account for proportion of arable land, reflecting factors of natural disasters; X_7-X_9 reflect the impact of external factors on food production, X_7 denotes finance expenditure for agriculture into unit area; X_8 denotes rural electricity consumption in unit area, reflecting the quality of farmers' life; X_9 denotes finance expenditure of technological innovation, reflecting integrated impact of technology and science on food security; c denotes intercept in model, μ denotes random disturbance term.

According to above information, we got the descriptive statistics of variable (Table 1) with Eviews8.0. At the same time, correlation coefficient matrix (Table 2) was obtained. Obviously, it shows the correlation among these variables, the correlation coefficient between Y and X_1, X_3, X_4, X_6, X_7, X_8 and X_9 are more than 0.5, while there are relatively small correlation coefficients between Y and X_2 or X_5. From the correlation between the explanatory variables, some of the correlation coefficients between variables are large, such as between X_1 and X_3, X_4, reflecting multicollinearity may exist in the model. However, multicollinearity of regression model generally isn't strictly considered in practice.

Table 1
Descriptive Statistics of the Variables

Variables	Observations	Mean	Median	Maximum	Minimum	Std. Dev.
X_1	36	1.4098	1.3705	1.8791	1.1539	0.2027
X_2	36	0.1981	0.1979	0.2451	0.1439	0.0271
X_3	36	21.0919	22.2213	35.2037	4.8872	9.7487
X_4	36	46.3339	44.7710	56.6946	37.2884	6.5690
X_5	36	20.5714	20.8632	32.7090	10.3188	5.6293
X_6	36	2.8415	2.2355	6.1874	0.6492	1.7445
X_7	36	1330.0480	281.3674	7949.2900	42.5419	2215.3500
X_8	36	1.5950	1.0383	5.0910	0.1399	1.5077
X_9	36	1112.3440	325.5000	6184.9000	52.9000	1666.4850
Y	36	379.0239	378.4445	442.3673	317.0000	29.0173

Table 2
Correlation Matrix of Variables

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
X_1	1.0000	–0.4047	–0.9492	–0.9163	–0.2508	–0.8562	–0.5265	–0.7722	–0.5622
X_2	–0.4047	1.0000	0.1508	0.1006	0.6577	–0.0846	–0.5052	–0.2226	–0.4712
X_3	–0.9492	0.1508	1.0000	0.9822	0.0874	0.9610	0.7190	0.9131	0.7492
X_4	–0.9163	0.1006	0.9822	1.0000	0.0659	0.9761	0.7493	0.9369	0.7800
X_5	–0.2508	0.6577	0.0874	0.0659	1.0000	–0.0828	–0.4213	–0.1946	–0.3949
X_6	–0.8562	–0.0846	0.9610	0.9761	–0.0828	1.0000	0.8605	0.9859	0.8825
X_7	–0.5265	–0.5052	0.7190	0.7493	–0.4213	0.8605	1.0000	0.9201	0.9971
X_8	–0.7722	–0.2226	0.9131	0.9369	–0.1946	0.9859	0.9201	1.0000	0.9360
X_9	–0.5622	–0.4712	0.7492	0.7800	–0.3949	0.8825	0.9971	0.9360	1.0000
Y	–0.5455	–0.1254	0.5991	0.5124	–0.2914	0.5828	0.6486	0.6008	0.6459

Table 3
ADF Test of Variables

Variables	ADF test statistics	5% critical value	Conclusion	Variables	ADF test statistics	5% critical value	Conclusion
X_1	–0.5441	–3.5629	Instationary	X_6	–0.8948	–3.5443	Instationary
ΔX_1	–3.4362	–3.5629	*Stationary	ΔX_6	–3.6631	–3.5485	Stationary
X_2	–0.6626	–3.5485	Instationary	X_7	2.0998	–3.5950	Instationary
ΔX_2	–4.0112	–3.5485	Stationary	ΔX_7	–4.2840	–3.5950	Stationary
X_3	–0.1038	–3.5443	Instationary	X_8	0.9003	–3.5443	Instationary
ΔX_3	–3.7062	–3.5485	Stationary	ΔX_8	–3.6997	–3.6032	Stationary
X_4	–2.3177	–3.5485	Instationary	X_9	1.9145	–3.5806	Instationary
ΔX_4	–4.5944	–3.5485	Stationary	ΔX_9	–4.2685	–3.6032	Stationary
X_5	0.5437	–3.5684	Instationary	Y	–2.5060	–3.5443	Instationary
ΔX_5	–5.1954	–3.5684	Stationary	ΔY	–6.67127	–3.5485	Stationary

Note. "*" indicates stationary in 10% level of significance.

Table 4
Econometric Estimation Results

Variable	Coefficient	Std. error	*t*-statistic	Prob. ∞
C	919.9228	106.4974	8.637987	0.0000
X_1	–181.4348	48.63792	–3.730317	0.0009
X_2	–185.3399	159.3973	–1.162754	0.2555
X_3	7.113438	1.603852	4.435221	0.0001
X_4	5.586107	2.623987	2.128862	0.0429
X_5	–0.860056	0.695854	–1.235973	0.2275
X_6	61.22079	18.32471	3.340887	0.0025
X_7	0.019047	0.009356	2.035779	0.0521
X_8	17.77815	18.51555	0.960174	0.3458
X_9	–0.001476	0.012334	–0.119672	0.9057

Note. R^2=0.8439, R^2=0.7899, *S.D.* =29.0173, *D.W* =2.2405, F =15.6294, Prob(F)=0.0000.

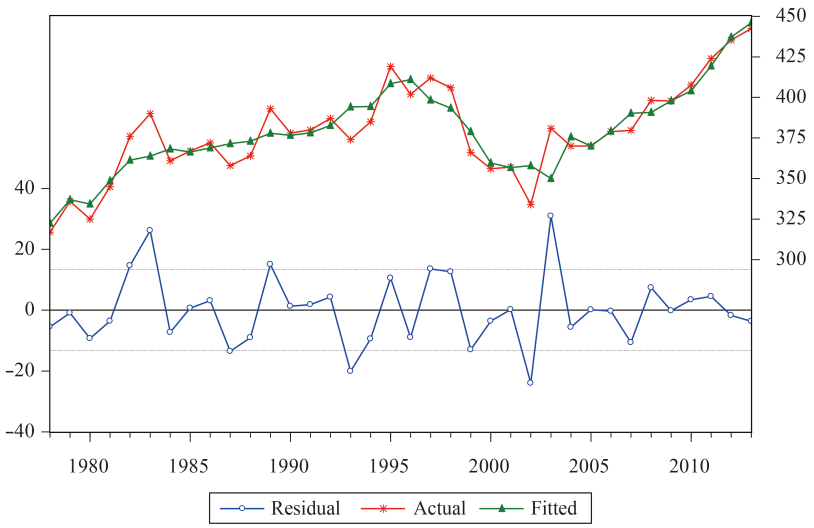
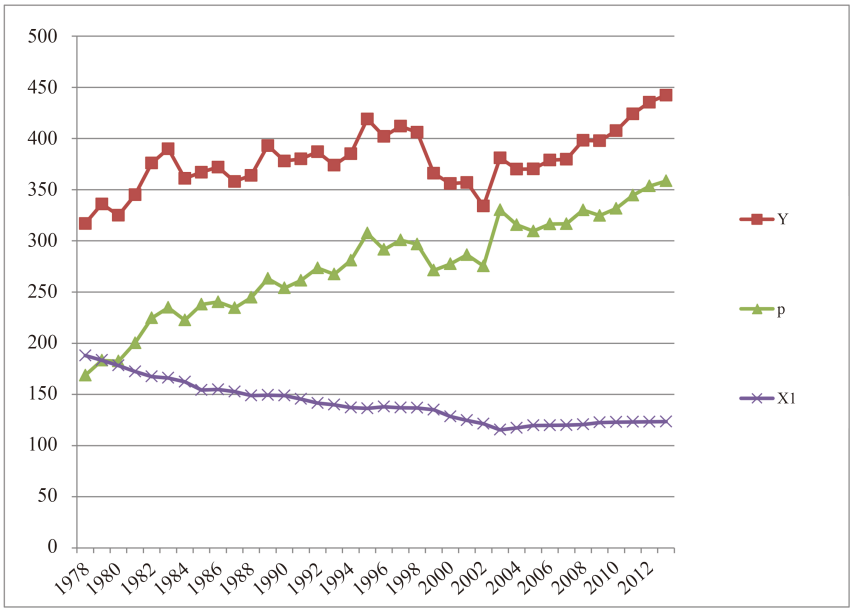


Figure 1
Model Fitting

3.3 Results and Discussion

The unit root test and cointegration test. Time-series variables need to be tested stationary to determine the rationality of the regression equation. Using the ADF (Augmented Dickey-Fuller) unit root test method, Table 3 will be obtained. It shows that all of variables are not stationary, but first difference variables are stationary, reflecting the stability of these variables is the same order. With Johansen Cointegration Test, trace test indicates 1 cointegrating eqn(s) at 0.05 level. Thus, although these variables are instationary series, their linear combinations may stationary series. Therefore, we can construct regression equations with them.

With OLS, we can obtain regression estimation results (Table 4). R^2 can indicate the fitting degree of the model,



(Where Y denotes per capita grain production, P denotes per unit area yields of grain, X_1 denotes per capita sown area of grain)

Figure 2
1978-2013 Per Capita Food Production, Per Unit Area Yields of Grain and Per Capita Sown Area of Grain

and its value is 0.8439, reflecting better fitting the situation (Figure 1). Value of *F* test is 15.6294, and Prob (*F*) is 0.0000, showing that the independent variables can explain the dependent variable easily. *T*-test indicates that the effect X_2, X_5, X_8, X_9 to the dependent variable is not significant, while the rest of the variables are very significant. The White Heteroskedasticity Test results show that the equation does not exist in heteroscedasticity. *DW* value is slightly greater than 2, indicating that the model does not exist in autocorrelation. All of above show that the model passes the relevant statistical and econometric test, and its establishing is reasonable.

CONCLUSION

Mechanization input, fertilizers input, effective irrigation have a significant positive impact on food security. Estimated parameter of three variables is positive, consistent with the expected, which is a positive correlation with food security. From *T* test, the three variables have a significant effect on the dependent variable. These three variables represent actual investment of agricultural capital, agricultural infrastructure and technology respectively to some extent. According to the Beta coefficient calculated, the contribution of three variables to food security add up to 53.92%, influencing order from large to small as follow: chemical fertilizer input> effective irrigation area> degree of mechanization, which is the similar order obtained by Zhou (2003).

Finance Policies to support agriculture have a significant effect on food security. From the results of the estimated model, financial expenditure on agriculture has a significant positive impact on food security, food security contribution of about 12.75%. Because it is the increase in the total annual expenditure of financial support for agriculture, while grain acreage changed little in recent years, and significantly increased the annual fund for agriculture, food subsidies and other policies carried out well during this period, with stimulating agricultural production enthusiasm of the farmers in major grain producing areas. This finding is different with Xia et al. (2006), while support with the conclusion like as Zhong (1995), Huang et al. (2010), empirical evidence indicates that China's financial policy has a positive impact on food security.

Grain sown area has an important role in food security, but the contribution is declining. The variable impacts on food security significantly, which is opposite to conclusion with Chen (2004). But the estimated parameters are negative. We can't conclude that Grain sown area impact negatively on food security, only reflecting the contribution to food security in the fall. The reason is that the per capita grain acreage decline annually, while per capita food production has increased year by year, as shown in Figure 2, reflecting the decline in the explanatory variables isn't helpful to the growth of food security.

Agricultural labor input, natural disasters, rural electricity consumption, financial research funding allocations have not been a statistically significant with food security, namely the relationship is not obvious. As can be seen, the four variables don't pass by *T* test, which

shows that they explain the dependent variable weakly. The reason is that under modern large-scale agricultural conditions, the amount of labor is replaced by machines and thus its role getting smaller and smaller. More agricultural labor force, higher cost, but not necessarily high yield. Therefore, the smaller labor force input, while higher mechanization input in high yield region. Since 1978, China didn't suffer large natural disasters, while strengthening investment in prevention disaster. The ratio of the disaster area of farmland had a small range of change, thus showed statistically weak impact on food production. Rural electricity consumption and the financial allocations for research respectively represent farmers' life quality, support of innovation by finance, both of them don't directly act on food production, and belong to indirect indicators. Empirical results show that two factors aren't significant for the Chinese grain production.

SUGGESTIONS

Strengthen land management and protect farmland effectively. Empirical evidence shows negative influence which farmland area decline annually was covered by increase in unit area yields technology and other factors. Because innovation of grain research is uncertain for per unit area yield, so it is an important countermeasure to prevent decrease of farmland area in order to guarantee food security.

Continue to strengthen rural infrastructure construction, and improve cropping pattern. Enlarging investment and management of agricultural irrigation facilities will help increase of ability which declines adverse effect of natural disasters or abnormal climates. In the short term, within a certain range, more chemical fertilizer, the higher grain yield, but in the long term it will result in soil degradation, pollution of rural ecological environment and disadvantage of grain production. Therefore, improvement of cropping pattern and development of conservation tillage are helpful to sustainable development on food security.

Improve food subsidies and incentive policies. Perfect relevant policies, such as food subsidies, comprehensive agricultural subsidies, seed subsidies and farm machinery purchase subsidy, and expand gradually subsidy standard and scale of grain production in the food price support system which is fit for market requirements and Chinese situation.

Increase scientific and technological innovation and technology on food production. Vigorously promote key technological research in agriculture, further implement technology projects which include breeding of new varieties, high grain yield, and so on, and increase the research ability of biological breeding, achieve new breakthroughs including breeding of high yield varieties, efficient cultivation methods, and efficient use of agricultural resources. Guide and encourage agribusiness, rural specialized cooperative economic organizations to do agricultural technology innovation and promotion activities, and actively provide technology services for farmers. Vigorously develop vocational education in rural areas, and improve farmers "scientific and technological training system, mobilize farmers" enthusiasm to study science, and enhance farmers' grain skills.

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