

Planting structure adjustment and food security in major food production district: A case study on 10 main food production counties in Gansu Province, China

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Abstract. This paper made an empirical study on planting structure adjustment and food security, in which main data and information came from the questionnaires of 10 main food-production counties in Gansu Province, China. The investigation results showed that: 1) During 1995 and 2014, the cultivated land area per household dropped by 2.40%, in which food crop area declined by 3.16%, yet cash crop area increased by 129% in the survey area. In the same period, the revenue per household increased by 162.99%, while food income from the revenue only increased by 17.42%; 2) In Hexi and Longzhong districts, mean wheat crop area per household shows a downtrend, while cash crop area increased significantly in the past 20 years. Especially, the household food output and income did not appear a simultaneous increase trend. In Longdong district, the household food output and income showed a simultaneous uptrend, and household income came mainly from miscellaneous grain (e.g. sorghum, bean, buckwheat, etc.); 3) In order to pursue higher economic efficiency of cultivated land, the farmers were forced to adjust planting structure and develop characteristics industries, profitable agriculture and cash crop with comparative advantage, which resulted in few food stock and impacted seriously on regional food security.

1. Introduction

In recent years, drought, flood, natural disasters, bio-fuels utilization etc., food prices continuously rose with extreme climate increasing. As a result, food crisis began to appear in the international market. Furthermore, some riots even happened in some countries. Currently, a threat of food insecurity was growing and food security has become a focus national government and economic theorists paid attention to [1-9]. In China, per capita arable land area is 40% less than that of the world average, food security has a great potential threat and has become one of the issues academic community focused on [10,11]. In 2013, food output reached 6.02×10^{11} kg, increased by 58.84% than 1985, and rose to its highest level since 1985. In 2003, food output (4.31×10^{11} kg) reduced to the lowest level since 1990. Therefore, the state began to carry out the policy of food subsidies in order to encourage farmers to expand sown area for food production. Since 2004, food production increased rapidly, far higher than the inter-annual level during 1985-2003 [12]. However, China's industrialization, urbanization and marketing process will accelerate in further and the cultivated land area will also continue to decline year after year, and a potential threat to food security will gradually



emerge in recent years with the economic globalizing and the market internationalizing. In 2008, "National food security and long-term planning framework" stated that China's food self-sufficiency rate will stabilize at more than 95%, as of 2020, the amount of cultivated land will be maintained no less than $1.2 \times 10^9 \text{ hm}^2$, the grain production capacity will reach $5.40 \times 10^{12} \text{ kg}$, which fully showed national emphasis on food security.

Internationally, the strategic measures resolved food security is generally divided into three modes. The first is to achieve food self-sufficiency, the second is to use international trade to reach the balance goal of food supply and demand, and the third is to combine self-sufficiency and international trade for achieving food security. This paper agreed with the regional food supply and demand balance (self-sufficiency) mode, the main reason is that regional food security will seriously affect by extreme weather, industrialization, urbanization, some infectious diseases (e.g. Severe Acute Respiratory Syndromes) and the friendly relations between regions. When the supply and demand balance of regional food reach to self-sufficiency state, food security can be adequately safeguarded, otherwise, food safety will exist in a potential danger.

China's cultivated land resources, food production capacity and food supply-demand varies vastly in the different regions and provinces. Regional and sub-provincial food security is an integral part of national food security system, while food security of the major food production areas is the basis of regional food security, which should be received special attention. The major food production areas cannot only meet own regional food security and resist the threat of major natural disasters, but also maintain the dynamic equilibrium of food supply and demand inside and outside regions. Based on these reasons, this paper took three major food production areas of Gansu Province, China as the research object, analyzed change trend of crop production structure from 1980 to 2014, made a field survey and interviews faced to the farmers in ten major food production counties, investigated some factors and reasons planting structure adjustment affected food security, and brought forward some countermeasures and advice assorted with structural adjustment of crop production and raised the total grain output with a view to benefiting to stabilize China's food safety system and institute food production policy.

2. Study area

Gansu Province lies at the juncture of Qinghai-Tibet, Inner-Mongolia and Loess Plateaus in Northwest, China, and belongs to western inland arid areas (figure 1). Gansu has large land resources, but little precipitation, large evaporation and limited water resources lead to the lower percentage and capacity of utilizable land and cultivated land. Based on the above condition, Gansu's food production mostly focused on wheat crop, and inter-regional food security mainly refers to wheat supply and demand balance. Since the 1990s, Gansu achieved basically an initial balance of food supply and demand with low level, and showed a coexistence phenomenon on the overall balance of supply and demand as well as the structural surplus and shortage [13, 14]. Currently, Gansu is still at a low level of food security, the balance of food supply and demand is not still very stable. In recent years, the depressed food prices and decreased farmer's income resulted in an ironic phenomenon that the benefit to plant grass is more profitable than that to plant wheat, all which resulted in the farmers adjusting dramatically crop production structure and reducing continuously food sown area.

In Gansu, the total sown area showed an insignificant increase trend ($0.01 \times 10^6 \text{ hm}^2/\text{a}$, $P < 0.01$) during 1993-2014, but it increased rapidly after 2006. Food crop area decreased significantly with a rate of $0.07 \times 10^6 \text{ hm}^2/\text{a}$ ($P < 0.0001$) in the past 20 years, but its output increased obviously with a rate of $0.16 \times 10^9 \text{ kg/a}$ ($P < 0.0001$) in the same period. By contrast, cash crop area exhibited a significantly increase with a rate of $0.01 \times 10^6 \text{ hm}^2/\text{a}$ ($P < 0.001$) in the same period (figure 2).

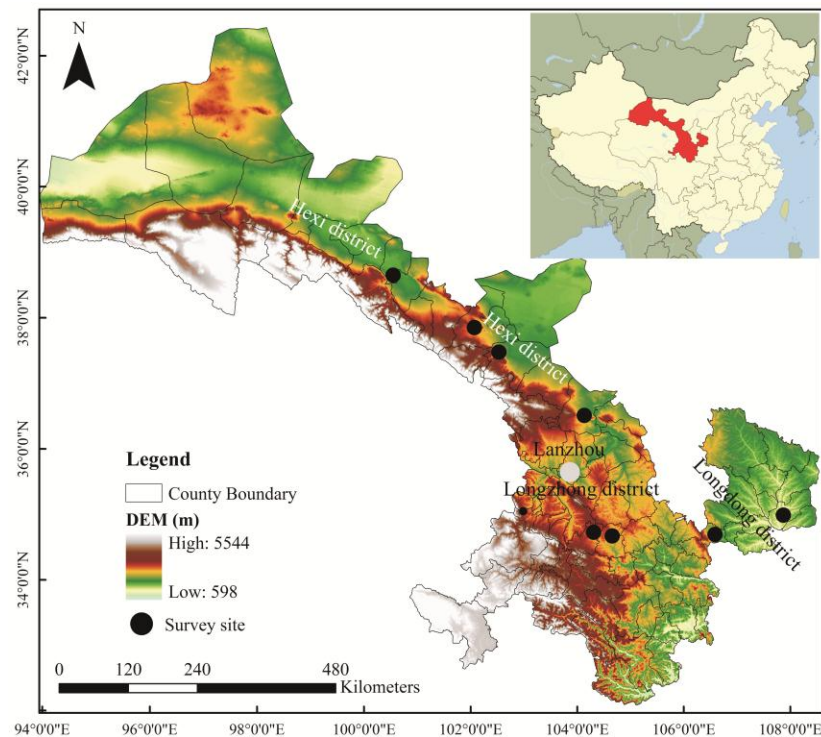


Figure 1. Location and distribution of the study area.

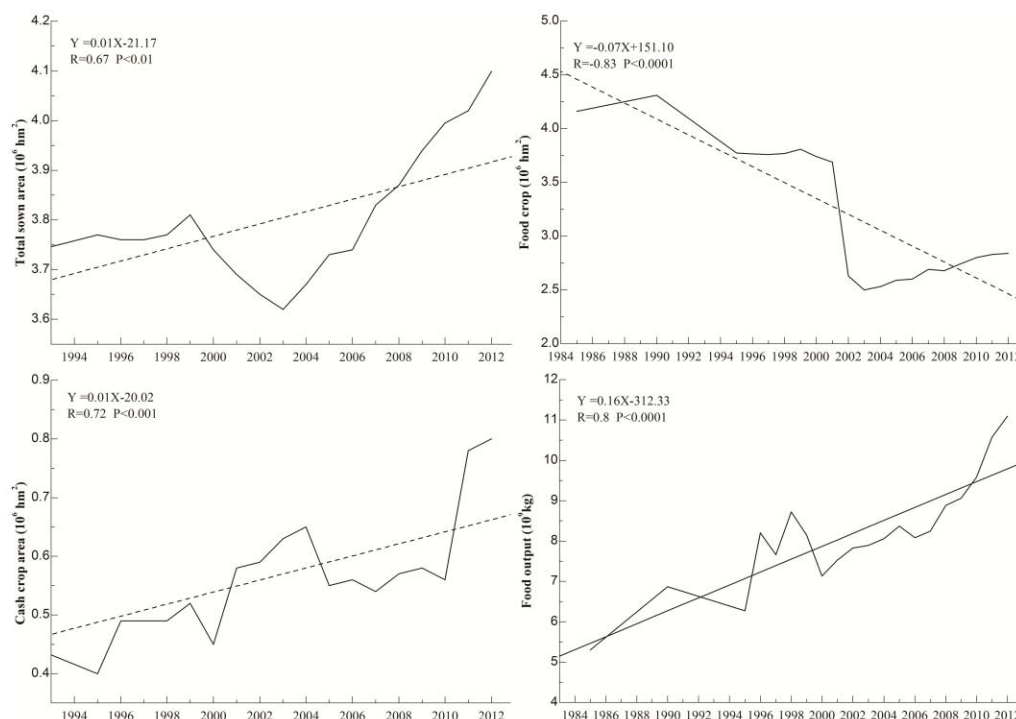


Figure 2. Change trend of crop sown area and food crop output in Gansu Province in 1985-2012.

(Source: Gansu Statistical Yearbook and Rural Economics Yearbook, 1986-2013)

Of food crop area, the sown area of wheat showed a significant decrease ($P < 0.001$) from 1985 to 2012, but the sown area of corn increased significantly by 7.63% ($P < 0.001$). The decreasing part of

wheat sown area, on the one hand, shifted corn area, on the other hand, turned into cash crops and other crop area, in which the sown area of soybean occupied small percentage in food crop area and remained about 3.0% (table 1). In 2004, Gansu province implemented entirely nation policies to exempt taxes of special agricultural products and increase subsidies for food, high quality seed and farm machinery. These policies got really farmers more benefits, and mobilized their enthusiasm to grow food crop, especially wheat. After 2004, the total sown area slightly increased, whereas food output increased significantly. By 2012, food output increased to 11.39×10^6 kg, rose by 65.89%, compared with 1990 (Figure 2(a)). However, with population increasing and industry and fodder food (especially wheat) consumption increasing, at present, Gansu has appeared a phenomenon on food supply less than demand in 8 years and food security problems gradually emerged.

Table 1. Sown area change of the main food crop in Gansu in 1985-2012.

Unit: $1 \times 10^6 \text{ hm}^2$					
Year	food crop	wheat	corn	soybean	other
1985	4.16	1.49	0.28	0.05	0.96
1990	4.31	1.46	0.30	0.06	1.06
1995	3.77	1.36	0.35	0.07	1.16
1999	3.76	1.22	0.53	0.09	1.07
2000	3.76	1.19	0.46	0.09	1.05
2001	3.77	1.12	0.47	0.08	1.02
2002	3.81	1.07	0.50	0.08	0.98
2003	3.74	0.96	0.49	0.08	0.97
2004	3.69	0.93	0.50	0.09	1.02
2005	2.63	0.96	0.50	0.09	1.03
2006	2.50	0.94	0.52	0.09	1.06
2007	2.53	0.92	0.50	0.10	1.17
2008	2.59	0.90	0.56	0.10	1.12
2009	2.60	0.92	0.70	0.09	1.03
2010	2.69	0.88	0.84	0.09	0.99
2011	2.68	0.86	0.84	0.08	1.02
2012	2.74	0.82	0.92	0.06	1.00

Source: Gansu Statistical Yearbook and Rural Economics Yearbook, 1986-2013.

3. Date source and method

The preliminary survey was carried out from July to August in 2014. For understanding the interrelationship among structure adjustment of food crop, food production and food security, the research team chose 500 farmers as a survey sample and spent two months to make a field research and direct visit to them from 10 counties in three main food production districts (i.e. Hexi, Longzhong and Longdong city) (figure 1). Finally, the research team issued and returned 300 survey questionnaires, consisting of 486 completed questionnaires and 14 uncompleted. The effective response rate reached 97%. The survey methods chose relative open form [15].

During the investigation, the team visited the village committee, the retired director, and some senior farmers, inquired them in detail on the development status of agricultural economy, structural adjustment of crop production and food security etc. Meanwhile, the research team surveyed some farmers in the form of the interview, the investigation contents included the basic farmers' situation that impacted food security, like crop production, crop area change, planting structure adjustment, the constitute of the household income and crop yield change during 20 years from 1995 to 2014. After investigating, the research team verified the survey contents with the village committee again and did

some necessary complement. At the same time, the research team explained some data to be inconsistent with reality and made some error correction. Finally, the research team aggregated and processed the survey data by statistical software EXCEL, and analyzed some correlative problems on structural adjustment of crop production, annual household income, and food yield and food security in three major food production areas.

4. Results and analyses

4.1. An empirical study of Hexi district

Hexi district locates in the west of the Yellow River in Gansu, including Jiuquan, Zhangye, Wuwei, Jiayuguan and Jinchang city (figure 1). Hexi district, relatively developed area in the rural economy, is once one of China's 10 main food production bases, the rural population accounts for 16.46% of Gansu's population and per capita income ranks first in Gansu. The 180 rural families were surveyed in Wangjiabao village, Dangzhai town in Ganzhou district, Zhangye City, Fazhan village, Qingyuan town in Liangzhou district, Wuwei City, and Beihaizi village, Chengguan town in Yongchang County, Jinchang City in Gansu. The survey results showed that the cultivated land per household surveyed reached to 0.57 hm² in 2014, increased by 5.26%, compared with 1995, in which the sown area of food crop decreased significantly ($R^2=0.91$) with a rate of 0.14 hm²/10a ($P < 0.001$) during 1995-2014, yet cash crop showed a significant increase trend with a rate of 0.16 hm²/10a ($P < 0.001$) ($R^2=0.94$). Survey shows that 80% of respondents said all edible wheat is purchased by the market. These factors resulted in food output reduction and made it loses the overwhelming superiority status of main food product base in the past (figure 3).

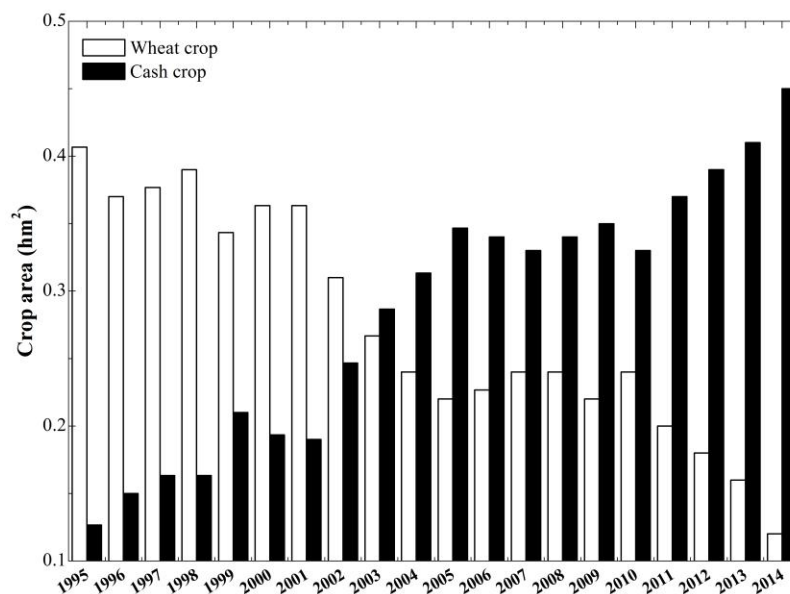


Figure 3. Crop production structure change of the households surveyed in Hexi district during 1995-2014.

The main reasons appeared these phenomena are as follows: over the past 10 years, national food policy took on a contraction status, and the comparative benefits of food industry decreased in most regions. In view of these reasons, the farmers changed the conventional behaviors to grow and reserve food, all which resulted in the sustaining downtrend of food planting area and food output per household. In addition, with cash crop (e.g. malting barley, wine grape planting, corn seed production, medicinal materials, vegetable in greenhouses and *Medicago sativa*, etc.) fast development relying on better soil and light-heat resources and temperature difference of day and night in Hexi corridor, wheat

area downtrend will be inevitable under self-regulation influence of supply and demand balance in regional food market in the future.

In the previous period, Hexi district with 30% arable land of Gansu provided 70% commodity grain for Gansu province. However, food contribution rate decreased year by year, and now it has transferred to the main sales area from once the main producing area. At the same time, Hexi region has become the largest and most advantageous production base of corn seed in China. In 2013, the income per household investigated reached 38,000 RMB, increased 70.59%, while food income dropped to 1200 RMB, the reduction extent reached 40%, compared with 1995 (figure 4). Therefore, Hexi region should stabilize wheat crop area, develop food production, and implement innovation projects of agricultural science and technology in order to increase wheat production and ensure food stock goal and food supply and demand balance.

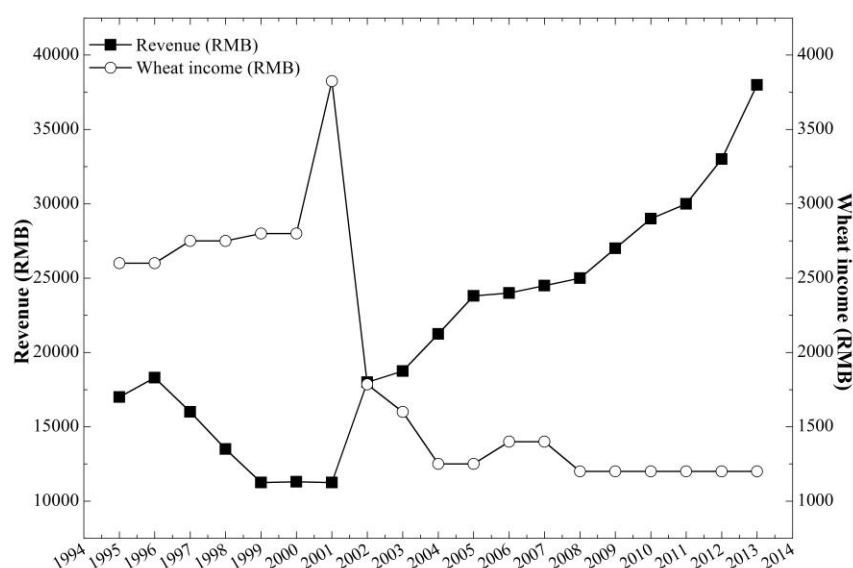


Figure 4. Revenue and wheat income per household change in Hexi district during 1995-2013.

4.2. An empirical study of Longzhong district

Longzhong locates in the abdominal region of Gansu, including Baiyin, Dingxi city and Linxia Huimin autonomous prefecture (figure 1), the rural population accounts for 34.19% of Gansu. Longzhong has larger dry land area and lower food production level, and is also a concentration region of the agricultural population. In Longzhong district, the research team surveyed 160 rural families of four villages, including Hanji village, Hanji town in Linxia Huimin autonomous prefecture, Linxia county, Fansiping village, Yujing town in Lintao county and Jiudianzi village, Pingxiang town in Tongwei county in Dingxi city, and Chenzhuang village, Xiquan town in Baiyin City, Jingta i county. During 20 years from 1995 to 2014, the cultivated land area per household surveyed appeared small uptrend. The mean area of wheat crop per household appeared a slight downtrend ($0.06 \text{ hm}^2/\text{decade}$), especially, the downtrend increased clearly after 2000. The mean area of cash crop per household reached to 0.26 hm^2 in 2014, increased significantly by 420% ($P < 0.001$), compared with 1995 (figure 5). At present, Longzhong has become the largest potato seed breeding base in Northwest, China.

During the period of 1995-2014, per household revenue showed a continuing upward trend (670.75 RMB/a) in Longzhong. Especially, per household revenue reached to 17000 RMB in 2014, and increased by 240%, compared with 1995. However, per household wheat income indicated a decrease with a rate of 276.5 RMB/decade ($P < 0.001$, $R^2 = 0.55$) during the past 20 years. Especially, wheat income showed some increase trend after 2007 (figure 6). In contrast, income share from non-agricultural and cash crop appeared uptrend. As a whole, the agricultural structure increasingly changed towards the regional nature resources advantage and economic benefit. Similarly, Longzhong

existed also a phenomenon that food output increased without income from wheat crop increasing.

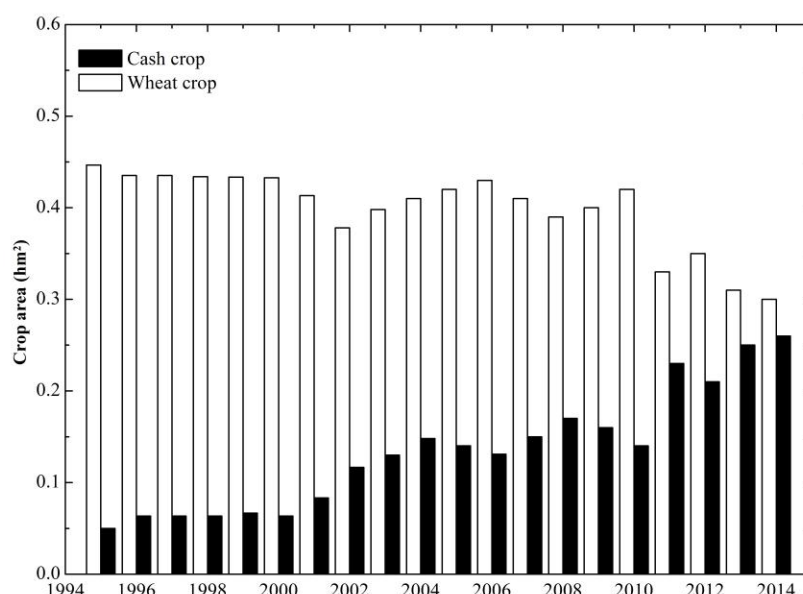


Figure 5. Crop production structure change of the households surveyed in Longzhong district during 1995-2014.

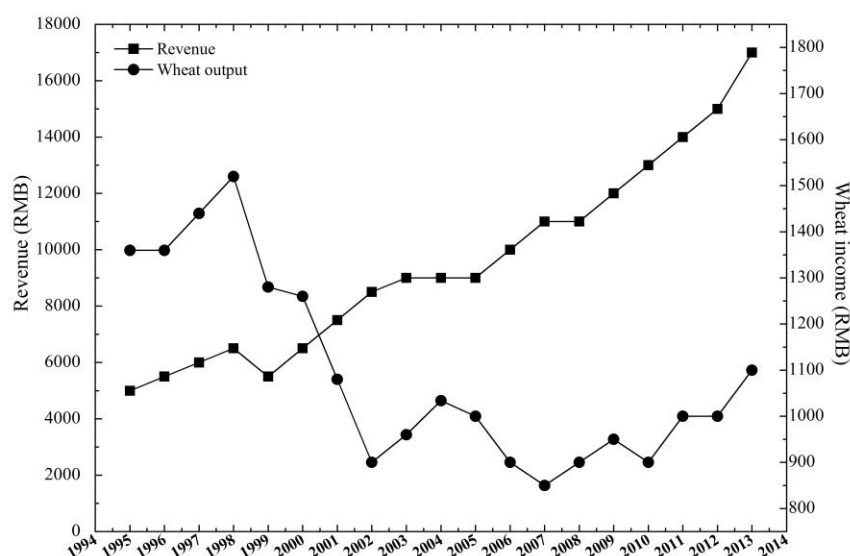


Figure 6. Revenue and wheat income per household change in Longzhong district during 1995-2013.

Based on these reasons, Longzhong should keep the basic crop area and exert to develop food production base. Longzhong should further adjust the proportion of summer and autumn crops and soybean in crop production, reduce appropriately the sown area of summer crops, increase moderately the sown area of autumn crops, particularly, and increase the sown area of high-yield corns, potatoes, soybeans, coarse cereals, ect. In the Yellow River coast used the electricity to irrigate, the most land is plain and the irrigable land also is relative concentrated, in view of this, the region should improve the food yield per unit by intensive cultivation, and built the commodity grain base in order to stabilize the supply and demand balance in inner region, Gansu.

4.3. An empirical study of Longdong district

Longdong district, locates in a typical region in Loess Plateau, including Pingliang and Qingyang city (figure 1), is one of the major food production bases in Gansu. Due to the geographical location and special nature conditions, Longdong takes on some obvious differences in crop production structure and farmers' behavior, compared with Hexi and Longdong districts. In Longdong, the research team surveyed 160 rural families in three villages, including Yuanquancheng village, Gaoping town and Gaohu village, Baima town in Qingcheng county, Pingliang city, and Ren village, Jiaocun town in Ning County, Qingyang city. The survey results showed that the cultivated area per household surveyed decreased by 20.74% in 2014, compared with 1995. Wheat area per household surveyed showed a first decrease and then increase trend in the past 20 years, while cash crop area per household showed a trend of first increase and then decrease (figure 7).

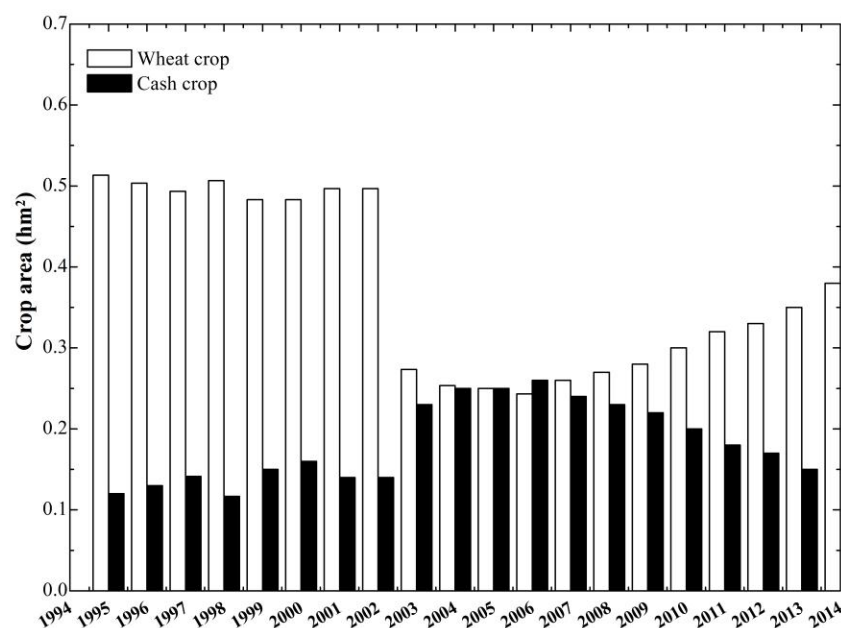


Figure 7. Crop production structure change of the households surveyed in Longdong district during 1995-2014.

The main reason was that the rehabilitating plough to forest (grassland) and pastureland rehabilitation project implemented on the large range in Gansu, the urbanization process accelerated further, the original sloped farmland turned into woodland and grassland, and some arable lands turned into urban areas, all which resulted in the cultivated land area decreasing. During 20 years from 1995 to 2014, the farmers' income came mainly from food crop. Although the sown area of food crop decreased to some extent, farmers' revenue and wheat income increased synchronously in the past 20 years. In the same period, the farmers' revenue and wheat income increased significantly with a rate of 589.47 RMB/a ($P < 0.001$, $R^2 = 0.98$) and 156.71 RMB/a ($P < 0.001$, $R^2 = 0.97$). Especially, in 2014, per household revenue and wheat income reached to respectively 16,000 RMB and 3,900 RMB, rose by 214% and 195%, compared with 1995 (figure 8). However, food self-balance in Longdong now begins to appear inadequate.

However, food output and farmers' income in Longdong appeared the same change trend, in contrast to Hexi and Longzhong districts. The main reason was that Longdong was suitable for planting autumn crops and pollution-free vegetables because of special soil and weather conditions. In recent years, food output and market of miscellaneous grains, such as sorghum, bean, and buckwheat thrived especially. The farmers not only increased wheat output, but also effectively increased economic income and formed a benign interactive development pattern. In view of this, Longdong

should prioritize to stabilize the basic farmland area, develop food production base, and mainly improved food yield per unit in order to increase food overall yield. Meanwhile, Longdong should also reduce moderately the summer crop area, enlarge the autumn crop area, increase properly cereal crop area, and extend the high yield corn crop area in the places with better water and heat conditions. In addition, Longdong should also spread cash crop and forage crop area, and develop vegetable and fruit industry in order to increase farmers' economic income.

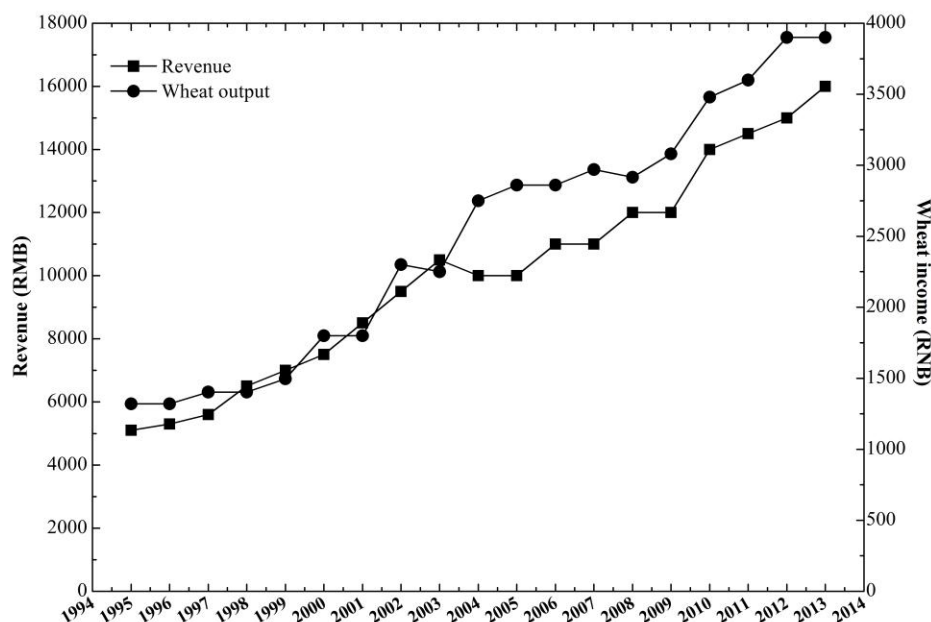


Figure 8. Revenue and wheat income per household change in Longdong district during 1995-2013.

4.4. Overall survey result

In the past 20 years, the cultivated land area of the surveyed farmers decreased by 2.40%, in which food crop area decreased by 3.16%, whereas yet cash crop area increased by 129%. At the same time, the surveyed farmer income per household increased 162.99%, while the income from food crop only increased by 17.42% during 1995-2013. The investigation data showed that Hexi and Longzhong districts appeared a trend that food output increased without income (from wheat) increasing after 2001. The main reasons are as follow: (1) The inputs cost of agriculture crop production increased continuously; (2) The income from wheat crop remained lower; (3) Gansu lacked for better quality agricultural products with higher prices. In order to pursue higher economic efficiency of cultivated land, the farmers were forced to adjust the agriculture structure and develop characteristics industries, profitable agriculture and cash crop growing with comparative advantage. In addition, with labor force moving and wheat output falling, most of farmers' food stock is very few and food stock is used only by them next year, all which impacted seriously on food security. With the policies on rehabilitating plough to forest (grassland) and pastureland rehabilitation project implementing on the large range and water-saving agriculture industry establishment, it is difficult to change entirely food output downtrend.

5. Conclusion

With the policies on rehabilitating plough to forest (grassland) and pastureland rehabilitation project implementing on the large range and water-saving agriculture industry establishment, it is difficult to change entirely food output downtrend. At the same time, the inputs cost of agriculture crop production increased continuously and the income from wheat crop remained lower in recent decades. State lacked for several better agricultural products with higher quality and prices. The farmers were

forced to adjust the agriculture structure and develop characteristics industries, profitable agriculture and cash crop growing with comparative advantage in order to pursue higher economic efficiency of cultivated land, all which impacted seriously on state food security.

Therefore, state food security must rely solely on the major food production areas. The major food production areas must strictly protect cultivated land area, increase science and technology investment, improve the legal system of food security, and implement agriculture zoning program. Especially, considering global economic change, international security, domestic agricultural development, natural disasters, emergencies and inhabitants' consumer habits and other relevant factors, it is not realistic to depend highly on foreign food import. The major food production areas must pay attention to adjust and optimize crop production structure and increase food output, focus on food quality, and take it as an opportunity to improve farmers enthusiasm to grow food crop and increase farmers' income in order to achieve food supply and demand balance and food security in the main food production and sale areas.

Acknowledgments

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