

Challenges and Suggestions for Sustainable Development of Food Security in Southwest China

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Abstract: Sustainable development of food security in Southwest China is critical in ensuring national food security, and it concerns ecological civilization construction, ethnic unity, and poverty alleviation in China. A green and ecology-oriented development approach is an important prerequisite for ensuring the sustainable development of food security in this region. In this study, we first investigated the situation of food production in this region and then analyzed the challenges from the aspects of ecological environment as well as agricultural inputs and structure. Furthermore, according to the agricultural output and resource endowment of Southwest China, we proposed a strategic vision encompassing overall thinking, strategic positioning, general goal, and development path, as well as suggestions on policy modification and project implementation, to serve as references for the formulation of regional food security strategies.

Keywords: Southwest China; food security; green ecology

1 Introduction

Southwest China, which is composed of six provinces (autonomous regions and municipalities directly under the central government) of Sichuan, Chongqing, Yunnan, Guizhou, Guangxi, and Tibet, is an important region for food production and consumption in China. The region spans an area of 2.587×10^6 km², accounting for 26.9% of the total national land area. In 2018, population in the region was 251 million, accounting for 18.02% of the total national population. The ecological barrier function of Southwest China is outstanding. It is located in the First and Second Steps (altitudes above 4000 m and ranging 1000–2000 m, respectively) of China's topography, with the highest overall altitude and richness in biodiversity and ecological types. It is the birthplace and upstream source of important water systems such as the Yangtze and Yellow Rivers, as well as an important border area where most ethnic minorities gather. Therefore, the sustainable development of food security in this region is not only crucial for national food security, but also related to national strategies such as ecological civilization, border stability, national unity, and building a moderately prosperous and wholesome society. In recent years, especially since the 18th National Congress of the Communist Party of China, owing to the new policy incentives and scientific and technological progress, the food security in Southwest China has attained remarkable achievements in the overall food production, balancing demand and supply as well as outbound transfer of some important products. However, the sustainable development of regional food security is also characterized by over exploitation of resources, excessive agricultural inputs, and unbalanced structure, which collectively brought severe challenges to the development of green agricultural initiatives and ecological civilization development in Southwest China

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and even the whole country [1]. Therefore, the research group commissioned a study on investigation, consultation, and systematic analysis on food safety in Southwest China, and proposed countermeasures and suggestions for sustainable development of food security in Southwest China under the background of green ecology.

2 Current situation of food production in Southwest China

In the past 10 years, food production structure in Southwest China has changed significantly. The production efficiency has continue to improve, but the production scale has reached its limit with a stable total production. The planting area of main grain crops has reduced, but the yield per unit area has improved. The total production level has been relatively stable, however, the proportion of the total output in the country has decreased; the planting area and yield per unit area of crops such as potato, sugarcane, vegetable, and fruit have been increasing, and the overall total production level has improved; for animal-derived food, the number of livestock and poultry by end of the year is relatively stable, with an increased output capacity. In 2018, grain output in Southwest China was 8.97×10^7 t, accounting for 13.6% of the total national grain output; while the output of meat, vegetable, and fruit was relatively abundant, accounting for 22.5%, 20.9%, and 18.7% of the national output, respectively. However, the output of egg, milk, and aquatic products was relatively insufficient, accounting for less than 10% (Table 1). There are great differences in the quantity and structure of food production among provinces in the region. In terms of total production, Sichuan, Guangxi, and Yunnan are the major food production provinces in Southwest China; Sichuan is still the traditional major province of grain and pork production; Guangxi and Yunnan are the major provinces producing tropical crops, fruits, and specialized food, and the output sugarcane accounts for 80% of the total output of the country.

Table 1. Production proportion of main food types in six provinces in Southwest China (Unit: $\times 10^4$ t).

Food	Year	Guangxi	Chongqing	Sichuan	Guizhou	Yunnan	Tibet	Southwest	China	Proportion (%)
Grain	2018	1372.8	1079.3	3493.7	1059.7	1860.5	104.4	8970.5	65789.2	13.6
Rice	2017	1019.8	487.0	1473.7	448.8	529.2	0.5	3959.0	21267.6	18.6
Wheat	2017	0.5	9.8	251.6	41.2	73.7	21.9	398.7	13433.4	3.0
Corn	2017	271.6	252.6	1068.0	441.2	912.9	3.0	2949.4	25907.1	11.4
Vegetable	2018	3432.2	1932.7	4438.0	2613.4	2205.7	72.6	14694.6	70346.7	20.9
Fruit	2018	2116.6	431.3	1080.7	369.5	813.4	0.3	4811.7	25688.4	18.7
Meat	2018	426.8	182.3	664.7	213.7	427.2	28.4	1943.1	8624.6	22.5
Egg	2017	24.2	40.3	144.5	18.7	30.3	0.5	258.5	3096.3	8.3
Dairy	2017	8.1	5.1	63.7	4.4	56.8	37.1	175.2	3038.6	5.8
Fisheries	2017	320.8	51.5	150.7	25.5	63.1	0.1	611.7	6445.3	9.5

The change in food production capacity and structure is accompanied by the change of food circulation and consumption in the region. For circulation, when the demand and supply of grain is balanced, there is a small amount of net transfer in as seen in the small increase in recent years; the overall shortage of grain, of which the net import of corn is getting larger and growing; the output of vegetables, fruits, and sugar crops has increased; the output of animal-derived food is small, and pork and milk are mainly imported. With the continuous development of herbivorous animal husbandry, beef and mutton outputs gradually increase, however, the net transfer of animal-derived food was the same. In terms of consumption, the change in food consumption per capita in Southwest China was relatively small, but the proportion of animal-derived food increased in the diet structure, indicating a significant improvement in nutritional food consumption. The proportion of animal-derived food consumption in the rural areas increased from 8.8% in 2000 to 22.9% in 2015.

3 Key challenges under the background of green ecology

3.1 Fragility of ecological environment and limited development potential of food resources

The mountain ranges in the region such as Hengduan, Himalayas, Daba, Wuling and others, nourish the Qinghai Tibet

Plateau, Yunnan Guizhou Plateau, basin hills, and other landforms. They are the source and upstream of the Yangtze, Yellow, and southwest rivers, occupying more than 60% of the country's biological resources. According to the *National Plan for the Protection of Ecologically Vulnerable Areas (2008)* [2], there are three types of fragile ecological environments in this area. First, the southwest karst mountain rocky desertification ecological fragile area, in the administrative region involving Sichuan, Guizhou, Yunnan, Chongqing, Guangxi, and other provinces and cities, is one of the world's three major karst concentrated distribution areas, characterized by large annual precipitation, severe melt water erosion, thin karst mountain soil layer, and low soil formation. The process is slow, easy to cause severe soil erosion, landslides, causing frequent disasters due to debris flow. In the rocky desertification area of Yunnan, Guizhou, and Sichuan, about 1 cm of topsoil is lost every year, and the total sediment input into rivers is about 4×10^9 – 6×10^9 t. Second, it is the agro-pastoral transitional zone in which the administrative areas involved three municipalities including Aba, Ganzi, and Liangshan of Sichuan Province, and 40 more counties such as Diqing, Lijiang, Nujiang in Yunnan Province, and Liupanshui in Northwest Guizhou Province. Due to the undulating terrain and complex geological structure, the vertical change of water and heat conditions is aberrant, the soil layer is not fully developed, characterized as barren or with sparse vegetation. Under the strong influence of human activities, regional ecological degradation is obvious. The cultivated land in this area is characterized by broken terrain, steep slope, shallow soil layer, loose soil, poor water conservation, and low fertility. Generally, there is less irrigation and most of them are medium and low yield soil. After prolonged ploughing, soil erosion is another severe problem. Third, the ecologically fragile area of complex erosion in Qinghai Tibet Plateau. Due to the high latitude and cold terrain, severe climate, harsh natural conditions, and sparse vegetation, there are compounding erosion factors such as wind, water, freezing, and other soil erosion phenomena. Therefore, since the ecological barrier function and fragile ecological environment in Southwest China determine the total amount of development and utilization of food production, critical core resources such as land must be managed in a reasonable carrying capacity to enhance the development potential of food production and supply in the region to a certain extent.

3.2 Large use of agricultural inputs with excessive pressure on the agricultural ecological environment

The use of chemical and compound fertilizers in Southwest China has been on the rise in the past decade (Table 2). In 2005, the amount of chemical fertilizer used was 7.255×10^6 t, and increased to 9.524×10^6 t in 2015. Among them, Yunnan, Guangxi, and Chongqing increased by 81, 65.04, and 57.8 kg/ha, respectively. Total pesticide use in 2005 was 1.7×10^5 t, accounting for 11.7% of the national use, and increased to 2.25×10^5 t by 2015, accounting for 12.6% of the national use. Among them, Sichuan and Guangxi are the provinces with the highest pesticide use in Southwest China. Utilization of plastic film was 2.5×10^4 t in 2005 and 3.9×10^4 t in 2015, among which Yunnan, Sichuan, and Guizhou increased most significantly.

Table 2. Main chemical inputs of agricultural industry in Southwest China (Unit: $\times 10^4$ t).

Input	Fertilizer			Pesticide			Plastic film		
	2005	2010	2015	2005	2010	2015	2005	2010	2015
Southwest	725.5	852.8	952.4	17.0	20.8	22.5	2.4	3.1	3.9
National	4766.0	5561.7	5984.0	146.0	175.8	178.3	17.6	21.7	26.0
Proportion (%)	15.2	15.3	15.9	11.7	11.8	12.6	13.6	14.2	14.9

In addition, Southwest China has always been the prominent area for traditional culture as well feed production in China. Sichuan, Yunnan, and Guangxi are all major pig farming provinces in China. A large number of antibiotics and growth promoting drug additives are needed for epidemic disease prevention and feed processing, which increases risks to environmental management and food safety. In order to maintain the safety of animal-derived food and public health, China has successively issued the *National Action Plan to Curb Bacterial Drug Resistance (2016–2020)* and the *National Action Plan to Curb Drug Resistance of Animal Derived Bacteria (2017–2020)*. This systematic change in regional animal food production is not only a concerted effort to respond to the increased awareness on green agricultural development, but also to embrace new large-scale development and technical challenges.

3.3 Unreasonable food production structure, and disconnection with the natural resource endowment

In 2018, the gross output value of agriculture, forestry, animal husbandry, and fishery in Southwest China was 2208.12 billion yuan, accounting for 19.1% of GDP. Among them, total agricultural output value was 1277.54 billion yuan, accounting for 57.9%; total output value of animal husbandry was 602.02 billion yuan, accounting for 27.3%. In the recent

15 years, proportion of animal husbandry in agricultural production in Southwest China has been maintained at about 30%, but was slightly decreased in recent years. In terms of the internal structure of animal husbandry, Southwest China is the traditional main production area of grain consuming pigs, accounting for about 25% of the whole country; the proportion of meat produced from forage animals of grain saving type is relatively low, but the increase is obvious (Table 3). Compared to foreign countries, the output value of animal husbandry in China is relatively low, and the output value of European animal husbandry has been maintained at more than 50% of the total agricultural output value. In terms of consumption, animal-derived food consumption has increased. From 2005 to 2015, the proportion of animal-derived food consumption in rural areas increased from 8.8% to 22.9%, and the proportion of urban animal-derived food consumption increased from 29.6% to 36.9%.

Table 3. Changes in the output of major meat foods in Southwest China (Unit: $\times 10^4$ t).

Meat	Pork			Beef			Lamb		
	2005	2010	2015	2005	2010	2015	2005	2010	2015
Southwest	1225.6	1273.2	1378.2	98.2	106.0	126.1	50.4	55.6	60.8
National	4555.3	5138.4	5645.4	568.1	629.1	616.9	350.1	406.0	439.9
Proportion (%)	26.9	24.8	24.4	17.3	16.9	20.4	14.4	13.7	13.8

Although the production and consumption structure of aquaculture industry has changed, the corresponding planting structure has not been properly adjusted. Since 2000, the planting area for grain crops has remained at about 68.0% annually, while the planting area for forage crops has not increased synchronously with the development of animal husbandry. The proportion of green fodder in the planting structure has been as low as 1.4% for many years. The unreasonable planting structure not only restricts the development of animal husbandry, but also cannot make the best use of regional natural resources. Particularly, there are many areas with long frost free period, abundant heat, sufficient rainfall, synchronous rain, abundant clouds, and less sunshine in Southwest China, which are suitable for cultivating forage crops for nutrients harvesting; compared to the north, these areas do not have comparative advantages in planting grain crops, but if we could develop forage crops using these resources, we can promote the development of herbivorous animal husbandry. From the perspective of food production, we should reduce the animal husbandry of grain consuming livestock such as pigs, and increase animal husbandry of herbivorous livestock such as cattle and sheep, as well as promote the development of integrated planting and animal husbandry, which is more conducive to regional food security [3].

4 Strategic concept of sustainable development

4.1 General idea of food safety in Southwest China

In accordance with the strategic deployment of the *Opinions of the CPC Central Committee and the State Council on the Implementation of Rural Revitalization Strategy*, and in combination with its inherent production conditions and resource endowment in Southwest China, the principle of “benefit as priority, green development, adaptation to local conditions, and market-oriented” has been widely promoted; it emphasizes the implementation of the strategy for maintain the stability of grain production capacity by reserving enough farmland and improving agricultural technologies; and focuses on promoting the agricultural supply chain structure reform to focus on the integrated agriculture and animal husbandry using agricultural lands, and to coordinate the development of moderate scale operation and decentralized management. Additionally, by developing the integrated agriculture and animal husbandry including breeding and processing, the sustainable development of food safety with high quality and core ecological benefits could be realized.

4.2 Strategic orientation of food security in Southwest China

A complete understanding on the strategic positioning of food security in Southwest China is crucial. Food security should not be only locally contextualized within a province, rather an integral part of the national food security, social and economic development strategic master plan. The overall positioning as an ecological barrier is to maintain a sustainable development; the social orientation aims at maintaining border stability and ethnic harmony; the economic orientation aims at improving quality and efficiency, and to eliminate poverty and raise standards of living; the quantitative orientation aims at achieving total self-sufficiency and dynamic balance; the quality orientation aims at attaining green development and ecological diversity; and the trade orientation aims at achieving balanced cross-border cooperation.

4.3 The development path of food security strategy in Southwest China

The development path of food security strategy in Southwest China includes: (1) Optimized industrial design and layout, that is, according to the main types of food industry, implementing measures based on local contexts to improve the regional design and layout of various industries such as grain, animal husbandry, aquatic products, fruits, and vegetables. (2) Highlights of the regional characteristics, that is, development according to the ecological characteristics and geographical location namely the Sichuan Basin and Southwest Hilly multi cropping agricultural area; Yunnan Guizhou plateau mountain area; Tibet and Sichuan Plateau Tibetan area; Guangxi, Yunnan and Sichuan tropical region; and border area. (3) Change the mode of development. First, we should promote the green development mode of herbivores animal husbandry in the agricultural areas, as well as the combination of planting and animal husbandry. Second, we should make full use of international resources and markets, including expanding agricultural trade with ASEAN (Association of Southeast Asian Nations) and countries along the Belt and Road, and enhancing support for the food safety in Southwest China by importing grain to complement with local grain. Third, it is necessary to further promote a deep integration of primary, secondary, and tertiary industries, to improve the agricultural efficiency and competitiveness of the hilly and mountainous areas in Southwest China. (4) Strengthen and protect rural infrastructure construction. One is to improve the infrastructure construction for agricultural terminals in the mountainous areas. The second is to protect the rural folk culture, as well as improve standards of living. (5) We should improve the policy and incentive mechanism to strengthen the research and development (R&D) using science and technology applications, vigorously cultivating various kinds of new business entities, and actively facilitating the transfer of land management rights and the construction of new and improved social service system.

4.4 Strategic objectives of sustainable development of food security in Southwest China

By 2025, the overall supply and demand of regional food supply shall achieve a balanced state. The grain supply rate will be maintained above 85%, and the continuous production capacity of grain ration be absolutely safe; green and high-quality livestock, and poultry products will be self-sufficient and partially transferred out; the proportion of green, organic, and agricultural products with geographical indications will be no less than 55%; the comprehensive green measures will be widely used in animal and plant disease and pest control as well as soil fertility cultivation, the utilization efficiency of chemical fertilizer and pesticide will be higher than 40%, and the comprehensive utilization efficiency of livestock and poultry breeding waste will also reach 80%. By 2035, the sustainable development of food security in Southwest China will yield remarkable results; the grain production capacity will be effectively consolidated and maintained in the two key aspects of agricultural infrastructure and scientific and technological support; the grain self-sufficiency rate will be at a stable level of more than 88%; the proportion of green, organic, and agricultural products with geographical indications will not be less than 65%; the transformation of green, high-quality, and efficient production mode will be continuously promoted, and the agricultural environment will be a prominent role model for the country; the utilization efficiency of chemical fertilizer and pesticide will be higher than 45%, and the comprehensive utilization efficiency of livestock and poultry waste will be higher than 95% [4].

5 Countermeasures and suggestions

5.1 Improving subsidies for ecological barrier protection and coordinated agricultural development in Southwest China

Based on the detailed analysis above, we would like to propose eight countermeasures. (1) To strengthen the ecological barrier protection area by clearly restricting and controlling development zones, and establish a special fund for ecological barrier restoration and security compensation in the southwest region funded by the central finance, and incorporate the ecological compensation content into the vertical financial transfer payment system from the central government to the local governments. (2) Education and human resources development should be strengthened to support population migration, entrepreneurship, and employment in the ecological reserves. (3) Establish and improve the construction of regional eco-environmental protection supervision system which could compensate the government for the increased financial expenditure to ensure the implementation of eco-environmental protection and construction project planning, scientific research, monitoring and supervision, and bring the required funds into the scope of special transfer payment of central finance. (4) Actively promote the establishment of river basin ecological service compensation system. According to the principle of river basin ecological compensation, the central government shall speed up the reform of water resources tax and fee system. On the basis of implementing water allocation and consumer's right system, the basin ecological compensation fund is levied on water consumption areas and units according to water consumption. (5) Coordinate the

development of grain for green and agricultural development, strictly abide by the “red line” of cultivated land, and further improve the compensation policies for returning farmland to forest and grazing land to grassland. (6) Improve the defined scope of ecological forest and grassland, and implement targeted compensation measures. (7) Explore the market-oriented mode of ecological restoration and security in Southwest China, and guide all related parties to participate in environmental protection and ecological restoration. (8) Explore the establishment of a paid distribution mechanism for regional pollutant emission indicators, gradually implement emissions trading under government control, leverage on market mechanisms to reduce pollution control costs and improve pollution control efficiency; guide and encourage ecological environment protectors and beneficiaries to seek reasonable ecological compensation through voluntary consultation.

5.2 Implementing food safety and green construction project in Southwest China

It is an urgent task to carry out the food safety and green construction project in Southwest China, and integrate technologies regarding disease resistant varieties of crops and animals, biological diversity, new green pesticides and feed additives, as enablers to build a comprehensive ecosystem of agricultural production. Such robust agricultural system is characterized by disease resistant varieties, ecological diversity control, pest forecasting technology, and new pesticides of green, low toxicity, and high efficiency. Moreover, a comprehensive system for the production of livestock and aquatic products could be achieved by using means of disease resistant feed and healthy breeding as the basis of green farming. As for the production of crop products, we should actively promote rational pesticide and drug use, emphasize the coordinated use of “effective ingredients, pesticide dosage forms, pesticide application equipment, application technology, and target effect”; vigorously build the grain field ecosystem, implement ecological regulation, and gradually promote the construction of green projects using technologies for biological, physical, and chemical pest control; and based on the unique features of topography, airflow, mechanisms of action of pesticides, and local agricultural practices, we carried out research on the use of pesticide spraying equipment and matching technology to actively promote a variety of pesticide-saving spraying technology that could effectively control volume of spray; and strengthen the implementation of new green chemical pesticides. As for the production of livestock, poultry, and aquatic products, we should actively promote a moderate scale of standardized breeding of livestock and poultry integrated with clean and fresh water aquaculture, as well as biotechnology to transform unconventional raw materials to improve feed quality; enhance disease resistance ability and immunity by means of veterinary biological prevention and control, to reduce drug use; strengthen research on alternative feed antibiotics and green and safe feed additives. All these should be achieved by using an integrated and simplified tracer system for livestock and poultry aquatic products.

5.3 Improving subsidies for the adjustment of agricultural industrial structure

The strategic direction of agriculture industrial structure in Southwest China is: stabilizing grain production to expand economy, increasing feed to promote animal husbandry, implementing inter and multiple cropping, as well as increasing production and income. To achieve a smooth and reasonable transition to the new industrial structure, first, there is a need to improve the pricing policy for agricultural products, considering the comparative benefits of rice, wheat, corn, soybean, oil, and other crops, improving the pricing formation mechanism of primary agricultural products such as updating price information and guiding farmers to adjust their planting structures according to market demand. Second, a reasonable subsidy system for farmland rotation and groundwater pollution in different regions, should be implemented. Third, to strengthen the investment in modern farmland projects, and establish joint agricultural development fund involving the government, enterprises, and business entities to broaden the financing channels and share the risks. Fourth, the financial and insurance policies should be improved by increasing the financial and insurance support for the structural adjustment in the planting industry, focusing on giving full autonomy to leverage on financial investment, as well as access to social capital through subsidies and discounted interest. This could be achieved through a multi-input mechanism to accelerate the establishment of agricultural credit guarantee system to solve the financing difficulties faced by new business entities; as well as to expand the coverage of agricultural policy insurance. We should incrementally raise the level of support and explore the pilot scheme for price insurance of agricultural products, and encourage the use of electronic financial platforms to diversify the current financial services system. Finally, the land ownership policy should be reformed to solve the vast problem of farmers paying their mortgages; to implement differentially preferred policies for agricultural investment to access to social, industrial, and commercial capital sources; to establish and improve the agricultural information network platforms, including policy information service network, market information database, e-commerce sales platform, and agricultural product information traceability platform.

5.4 Enhancing agricultural trade with ASEAN and countries along the Belt and Road

The southwestern region of China is directly bordered with neighboring Southeast Asian countries such as Myanmar, Laos, Vietnam, etc. Due to certain extent of similar cultures and customs, China and neighboring countries in the Southeast Asia have established a long-term and friendly bilateral trade tradition with the government and private sector. Agricultural trade plays a key role in China-ASEAN bilateral political and trade cooperation. Under the background of the Belt and Road initiative, on the premise of continuing to expand the total volume of bilateral agricultural trade, it is of great strategic significance to increase the export of China's agricultural products, especially the export of agricultural science and technology, and to ensure the sustainable development of cross-border agricultural trade between China and ASEAN. To this end, China needs to strengthen agricultural technological cooperation, leveraging on China's competitive advantages in agricultural science and technology R&D, and continue to maintain its advantages in agricultural related R&D by increasing capital investment to promote and apply modern agricultural technology in ASEAN countries. The production system of agricultural products should be connected with other countries to ensure bilateral mutual benefit. For example, the advantages of China's export of hybrid rice seeds to ASEAN can be closely linked to the trade of imported rice. Additionally, there is a need to vigorously develop the southwest agricultural products value adding processing industry, to use China's advantages in capital and technology investment to cultivate leading enterprises with the ability to produce value-added agricultural products, thereby increasing the value of exported agricultural products, and further enhance China's ability to export processed agricultural products to ASEAN. Furthermore, it is an imperative step to make full use of the differences in bilateral resource endowments and production factors to adjust the production structure of southwest cross-border agricultural products. In summary, ASEAN countries have the advantages of tropical climate and land resources, while China has the capital investment and production competitive advantages in agricultural processing facility. Taking Yunnan and Guangxi as the key areas, we should vigorously develop agricultural products with export potential, improve product quality and safety, create bilateral trade as win-win cooperation, and provide services for the sustainable development of food security in the southwest region as well as the whole country.

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