DOI 10.15302/J-SSCAE-2019.05.025

Food Security and Sustainable Development in the Southeast Coastal Region of China

Zeng Yurong[1], Du Qiong[2], Chen Jianping[3]

1. Fujian Academy of Agricultural Sciences, Fuzhou 350003, China
2. Zhejiang Academy of Agricultural Sciences, Hangzhou310021, China
3. Ningbo University, Ningbo, Zhejiang 315000, China

Abstract: This paper is based on the results of two featured projects—Forest Food Security and Marine Fishery Resources Strategy—and the research of food security and sustainable development in the southeast coastal region of China that includes Shanghai, Zhejiang, Fujian, Guangdong, and Hainan. It first analyzed the agricultural natural resources endowment, changes in food supply and demand, food security assurance ability, and the main challenges that affect food security in this region, using field investigation, statistical analysis, econometric model prediction, and other methods, and then explored strategies for assuring food security against the backdrop of resource scarcity, internationalization, and greenization. The paper proposes that an overall food view should be developed, integration of the three industries promoted, and strategies that benefit ecology and encourage globalization be implemented. Based on the technological needs and policy objectives of the southeast coastal region, ten engineering measures are proposed, including germplasm resources and modern breeding engineering, high quality agricultural products and ecological agriculture engineering, and big data refined management engineering for farm equipment.
Keywords: southeast coastal region; food security; sustainable development

1 Introduction

The “southeast coastal region of China” (which specifically refers to Shanghai, Zhejiang, Fujian, Guangdong, and Hainan in this paper), has a high degree of uniformity in climate, and rich natural resources [1]. It therefore has obvious advantages in agricultural productivity compared with other regions in the country that face seriously constrained environmental resources. However, the region is facing similar food security issues due to radical changes in consumption, the environment, and land degradation, and fluctuations in the international grain market, among other factors. Moreover, with rapid urbanization and modern agricultural development, a gap has been developing between a growing population and soaring food consumption in every province of the country, which poses a tough task for the safeguarding of food supply and safety. This study which examined food security and sustainable development in the southeast coastal region in China, as well as the changing trends in grain and food safety during the 13th Five-Year Plan period (2016–2020) and until 2030, not only plays an important role in ensuring regional food safety, but is also of great significance in piloting and steering an innovative and coordinated development of a green, open, and inclusive modern regional agriculture.

Received date: September 10, 2019; **Revised date:** September 16, 2019
Corresponding author: Chen Jianping, Research from Ningbo University, member of the Chinese Academy of Engineering. Main research fields include plant protection and macro agriculture. E-mail: jpchen2001@126.com
Funding program: CAE Advisory Project “Research on National and Regional Food Security and Sustainable Development Against the Background of Internationalization and Greenization” (2016-ZD-09)
Chinese version: Strategic Study of CAE 2019, 21 (5): 045–053
Cited item: Zeng Yurong et al. Food Security and Sustainable Development in the Southeast Coastal Region of China. *Strategic Study of CAE*, https://doi.org/10.15302/J-SSCAE-2019.05.025

2 The analysis of food safety status and momentum in the southeast coastal region

2.1 Food production data

2.1.1 Grain acreage and production are slowly declining

The acreage and production of staple foods have steadily dropped. Total grain acreage dropped by 18.62% in the period 2007 to 2017, with a corresponding decrease in production by 14.67%. Rice remained the leading crop but accounted for a shrinking share. The average yield of rice was 6239.57 kg/km^2. It occupied 78% of the total grain acreage and 83.05% of overall grain output in 2017, little changed from 2007. Potatoes, beans, corn, and wheat have increased their share from 14.53% to 21.44%. In 2017, the southeast coastal region produced 3.8% of the total grain output of China, but accounted for 11.83% of the total food demand, with a gap of 6.834×10^7 t, and a self-sufficiency rate of only 26.89%.

2.1.2 Production of animal products, mostly pork and poultry, rose and then fell

In 2017, the total meat output in the southeast coastal region was around 8.603×10^6 t, 17.34% higher than 2007, and accounted for 10% of overall output in China. The total output of dairy products and poultry eggs was 6.581×10^5 t and 1.138×10^6 t respectively, drops of 11.51% and 1.17% compared with 2007 (Table 1).

Table 1. Production and changing trends for the main foods in the southeast coastal region, 2007–2017 ($\times10^4$t).

Year	Rice	Wheat	Corn	Soybean	Other foods	Vegetables	Fruits	Meat	Eggs	Dairy	Aquatic products
2007	2401.66	44.75	84.59	54.16	393.50	6255.67	2418.93	733.13	115.10	74.37	1794.47
2008	2397.34	41.37	76.68	40.56	368.60	6387.06	2543.60	804.91	116.08	73.87	1825.14
2009	2461.94	46.99	85.54	41.38	377.22	6547.27	2559.95	835.09	115.29	70.95	1890.40
2010	2426.69	45.48	87.24	40.58	366.09	6757.36	2644.52	864.84	114.75	75.13	1972.85
2011	2468.85	52.41	92.45	41.29	368.73	6962.87	2766.88	873.05	116.85	79.49	2070.73
2012	2453.77	50.88	111.33	53.49	358.10	7127.99	2859.56	914.09	114.79	74.84	2108.86
2013	2331.47	46.47	110.88	50.81	346.90	7226.23	2960.13	932.49	116.47	73.45	2185.10
2014	2379.76	50.57	109.55	52.88	353.60	7404.70	3021.94	916.74	113.30	71.55	2283.33
2015	2209.04	59.65	103.05	50.59	324.43	7595.69	3113.61	886.33	108.57	72.21	2378.68
2016	2196.37	42.50	104.94	48.67	311.25	7738.53	3138.24	868.80	107.30	69.88	2413.89
2017	2110.69	52.32	79.78	37.70	261.13	7964.92	3327.72	860.27	113.75	65.81	2461.27

Note: Based on publicly available information released by the National Bureau of Statistics.

2.1.3 Vegetable production has been rapidly increasing in both acreage and output

In 2017, the area of vegetable cultivation in the southeast coastal region was approximately 2.947×10^6 hm^2, with an output of 7.965×10^7 t, making up 13.77% and 10.77% of the respective national totals. Over the period 2007 to 2017, the cultivation area increased by 15.2%, and output grew by 27.32%.

2.1.4 Aquatic products account for more than a third of the national output, and the proportion of aquaculture is on the rise

The output of aquatic products in 2017 was an estimated 2.461×10^7 t, accounting for 36% of the national output, of which 51% consisted of marine products, and 20% freshwater products. Freshwater aquaculture output increased rapidly over the 10-year period while long range fishing slightly decreased.

2.1.5 There has been a massive increase in fruit and forest food production

In 2017, orchards occupied about 1.979×10^6 hm^2 in the southeast coastal region, which is 16.0% of the national total. The fruit yield was 3.328×10^7 t, accounting for 13.4% of the country's overall output. The average per-unit yield was 16 812.61 kg/km^2.

The southeast coastal region also abounds with forest foods. The overall output reached 9.182×10^5 t in 2015, which was approximately 21.68% of the national overall output [2]. This included 8.965×10^5 t of forest vegetables, and 4.081×10^5 t of forest foods. The area cultivated with *Camellia oleifera* was 17.22% of the Chinese total of

DOI 10.15302/J-SSCAE-2019.05.025

4.003×10^6 hm^2 and accounted for 16.27% of the total national output.

2.2 Food consumption trends

2.2.1 Population size and structural features

Both the general population and the urban population of the southeast coastal region of China have been on the increase. During the period 2007–2017, the general population grew by 12.3%, from 192.7586 million to 216.4751 million. Over the same period, the urban population increased by 29.47%, while the rural population declined by 11.65%.

2.2.2 The main food consumption structure

In 2015, the per capita consumption figures in the southeast coastal region were, in order, 119.65 kg of grain rations, 95.61 kg of vegetables and edible fungi, 40.06 kg of dried and fresh fruits and melons, 32.34 kg of meat, 23.82 kg of aquatic products, 14.58 kg of poultry, 10.99 kg of dairy products, and 7.59 kg of eggs.

Compared with the urban population, those in rural areas consumed 48.8% more grains, roughly the same amount of meat and poultry, and less of the other foods, including 60.3% less dairy products, 41.4% less dried and fresh fruits and melons, 17.5% less eggs, 4.2% less vegetables and edible fungi, and 3.7% less aquatic products.

2.2.3 Enormous disparity of food supply security

First to note, the region achieved at least an 80% self-sufficiency rate in grain rations, pork, and poultry. The self-sufficiency rates in 2016 were 80.7% for grain rations, and 84.21%, 93.5% and 80.3% for rice, pork, and poultry respectively. Second, the supply of staple food, beef, lamb, dairy, and eggs has not kept pace with demand and the region was therefore heavily dependent on supplies from other regions. In 2016, the self-sufficiency rate of staple food was only 32.7%, and that of beef, lamb, dairy, and eggs was 32.9%, 45.6%, 28.1%, and 57.0%, respectively. Third, there has been a surplus of vegetables, fruits, and aquatic products. In 2016, the self-sufficiency rate for vegetables was as high as 359.1%, and that of fruits and aquatic products were 391.5% and 432.6%. Large amounts of these products were exported to other provinces and countries after meeting the demand of local consumers. There were also frequent seasonal adjustments.

3 Analysis of the sustainable development of food safety in the southeast coastal region

3.1 The food supply forecast

3.1.1 Grains: a basically steady acreage and output

In the next decade, with the application of a strict farmland protection system, the agricultural acreage in the southeast coastal region is expected to fall more modestly, although grain cultivation will still be restricted by the limited arable land and low economic benefits. Rice production layout is still important, and potatoes, corn, wheat, and beans are expected to show some growth. The overall food production forecast for the southeast coastal region is shown in Table 2.

Table 2. Food production forecast of the southeast coastal region during 2020–2035 ($\times10^4$ t).

Year	Grains	Vegetables	Meat	Fruits	Aquatic products	Eggs	Dairy products
2020	2332.86	8245	877	4384.77	2752	111.67	78.2
2025	2325.06	9052	919	5238.07	3096	125.42	88.8
2030	2316.15	9789	977	5887.91	3385	141.85	104.3
2035	2324.77	10 640	1024	6570.13	3671	155.94	120.8

Note: Based on reports from the provinces/cities of the southeast coastal region.

3.1.2 Vegetables: cultivated area and yield continue to grow

The cultivated area and yield of vegetables is expected to continue to grow rapidly in the future.

3.1.3 Meat: mainly pork and poultry, with good growth potential

The environmental requirements of livestock and poultry breeding have developed with the economy. The expansion of meat production requires larger-scaled and more ecological farming and needs to adopt a green and clean production approach.

3.1.4 Fruits: growing acreage and production capacity

The southeast coastal region, located across the tropical and south subtropical zones, has always been the most important fruit production area of China owing to the favorable natural conditions of water, soil, air, and temperature, as well as its geographical advantage.

3.1.5 Aquatic products: a steady increase in yield

This region is situated next to the East China Sea and the South China Sea, abundant with seawater and freshwater resources. It is an economically developed and scientifically advanced region of the country with a large aquaculture production area [3]. It is estimated that the output of aquatic products will grow steadily, while production from fishing will be further reduced.

3.1.6 Egg and dairy products: a slow increase in output

The output in growth of egg and dairy products in the five coastal provinces/cities in Southeast China will be slow given the natural resource and environmental constraints.

3.2 Food consumption demand forecasts

The forecasts for urban and rural household consumption are shown in Table 3, based on the *Chinese Food and Nutrition Development Program (2014–2020)* [4], issued by the State Council in 2016, and the *New Dietary Guidelines* compiled by the Chinese Nutrition Society.

Table 3. The per capita food consumption structure forecast for the southeast coastal region **(**kg/person).

Food categories	Rural residents		Urban residents	
	2020	2025	2020	2025
Rice	95.50	91.33	94.88	90.13
Vegetables	99.42	95.86	100.06	97.14
Edible vegetable oils	10.23	10.30	10.23	10.30
Meat	29.07	36.36	43.35	42.92
Aquatic products	21.52	22.65	22.65	25.85
Fruits	50.64	54.47	50.97	55.20

Note: Based on reports from the provinces/cities of the southeast coastal region.

3.3 Self-sufficiency rate forecasts for the main food groups

Table 4 shows the prediction of food consumption demand and self-sufficiency rates until 2020, 2025, and 2035, based on predictions made by provinces and cities in the southeast coastal region.

Table 4. Forecasts of self-sufficiency rates in the southeast coastal region (%).

Year	Grain rations	Vegetables	Meat	Eggs	Dairy products	Aquatic products	Fruits
2020	84.55	307.7	59.12	32.55	12.68	297.2	205.8
2025	86.15	316.8	57.63	33.03	10.99	286.4	221.3
2030	87.15	320.1	56.85	34.39	11.53	281.0	225.6
2035	88.24	325.9	55.22	33.94	11.85	267.3	232.1

Note: Based on reports from the provinces/cities of the southeast coastal region.

3.4 The major problems of food security

In general, the food security problems of the southeast coastal region of China can be summarized as follows: the low benefits in grain production coexist with a shortage of quality grains, a shortage of feed coexists with insufficient livestock and poultry production, and the outward transfer of large amounts of aquatic and food products coexists with large imports of other foods.

DOI 10.15302/J-SSCAE-2019.05.025

3.4.1 The inward transfer of products faces challenges

The southeast coastal region adjoins several provinces in the country such as Jiangsu, Anhui, Jiangxi, Hunan, and Guangxi, and is contiguous with Hong Kong and Macao. This region is also a strait away from Taiwan, China, and close to Southeast Asia. It is situated at the center of the economically active Asia-Pacific economic circle. The region has a distinct advantage in access to overseas funds and technologies, and has substantial economic, technological, and logistical cooperation with foreign countries. However, the transfer of agricultural products in and out of this region faces the following main challenges:

(1) The major agricultural areas have difficulties selling their products. Transport of the winter and spring grain harvests is affected by the transport demands of Spring Festival travelers. As a result, they have to resort to more expensive transport such as the combination of rail and water, or use container shipping.

(2) It is difficult to supervise the quality and safety of imported agricultural products because of the wide diversity and multiple origins of the products.

(3) There is difficulty managing agriculture outside the region. Compared with locally grown agricultural products, those from outside are much more difficult to manage. The management of agricultural production and operation is inefficient and the product quality is not guaranteed [5]. In addition, the transport of agricultural products from outside the region can face delivery difficulties and incur high costs.

3.4.2 The pressure of ensuring an effective supply of foods

(1) It is difficult to keep grain crop acreage stable. With urbanization and industrialization, much farmland near cities and towns that was previously used for grain crops is now being used for construction or to grow cash crops instead. There are shrinking opportunities to expand agriculture or the grain industry.

(2) The supply-demand relation of meat tends to become intensive. In recent years, many provinces in China have adjusted and improved their animal husbandry structures to adopt the “grain-for-forage” policy and an approach of “reducing pork and poultry production and increasing beef and lamb production” [6]. There has been a slump in pork production, but rapid development of herbivores such as cattle and sheep has yet to be achieved.

(3) The potential for exploiting arable land has been exhausted. The southeast coastal region is generally a mountainous area with limited arable land resources, and the per capita arable land in this region is less than half of the national average. As a result, there is limited potential for developing more farmland.

(4) There is a striking imbalance between supply and demand for agricultural products. This region has a developed economy and its per capita gross domestic product (GDP) has reached the level of medium developed countries. There is a growing demand from consumers for agricultural product quality and safety. As a result, middle- and high-end agricultural products have been in short supply, whereas low-end products have become overstocked and unsalable.

3.4.3 The management system and equipment for agricultural storage and transport needs to be improved

With the rising costs of production, the large-scale bases for the “vegetable basket” program have been caught in a “scale trap,” with many now facing various difficulties and problems. Without subsidies from the government, they are struggling to make profit and grow. The local grain and oil reserves have been under the triple management of the province, city, and county, which can cause “free riding.” This further leads to economic externality and severe waste in transportation. The construction of modern storage equipment for cold storage and cold transport chain has been extremely slow. Consequently, the loss of postharvest agricultural products during transportation is as high as 20%–30% [7].

4 Strategies for food security and the sustainable development in the southeast coastal region of China

4.1 Basic orientation

4.1.1 Food security in the southeast coastal region is vulnerable

With a growing population, and accelerated social and economic development and urbanization, the overall position of grain production security and food security in the southeast coastal region appears bleak, and this will have a significant impact on the country’s overall strategy to ensure food security.

4.1.2 The southeast coastal region is an important production area for quality agricultural products in China

The favorable ecological conditions in this region are advantageous for the development of highly efficient modern eco-agriculture. Many agricultural products from this region such as vegetables, fruits, tea, nuts, and aquatic

products are of great importance to the nation.

4.1.3 The southeast coastal region has the highest food quality standards

The requirements of consumers in this region go beyond “having enough to eat.” Instead, they want to eat well. The consumption concepts of upholding food safety, nutrition, and health have a significant impact on food security and sustainable development of the country.

4.1.4 The southeast coastal region is the frontier zone of marketization and links to the international market

With more than 40 years’ development since the reform and opening up, the southeast coastal region has grown into the most market-oriented area in China, where export-oriented agriculture is fast developing. The region has become the frontier zone for marketization and links to the international market, and thus occupies an important position in the global trade pattern for agricultural products. It also serves as the benchmark and takes the leading position in the nation’s food trade and security, and agricultural “going global” practices.

4.1.5 The southeast coastal region plays an important role in promoting nationwide production and marketing cooperation

The southeast coastal region plays an important role in promoting its agricultural product production and in developing marketing cooperation with the middle and western regions of China. It provides a stable consumer market for agricultural and rural development of these regions.

4.2 Strategic thinking

4.2.1 Develop an inclusive big food view, and coordinate the reform of the agricultural supply-side structure

First, it is necessary to establish the big food principle of ensuring basic supply, transforming structure, and increasing overall output [8], and evolve a new strategic approach to food security development in the southeast coastal region and even the whole country. Second, regional trade and coordination should be strengthened to increase the capacity of inter-regional food transfer. Food security needs to be ensured through regional coordination and international trade. Third, dietary guidelines that are compatible with local production should be developed to suit the needs of local residents. A balance needs to be found between production and consumption to reduce dependence on purchased foods. Fourth, in compliance with the big food view, we should adjust and improve the industrial structure and accelerate the development of industries with local characteristics.

4.2.2 Implement a strategy of integrated development of the primary, secondary and tertiary industries, and continue to develop the value-added whole agricultural chain

Currently, in the southeast coastal region, the value formation and added value tend to move from productive areas toward the secondary and tertiary industries such as logistic processing and agricultural tourism. To this end, first build innovation capacity and elevate technology content to make agricultural products more competitive. Second, steer related industries toward the direction of scaled-up and standardized base production so as to enable the industries to develop steadily. Third, promote the integrated development of the primary, secondary, and tertiary industries, and increase the added value of agricultural products. Profits from the extended agricultural industry should remain in agriculture and the rural areas [9], so as to increase rural incomes, agriculture development, and the revitalization of rural areas.

4.2.3 Develop agriculture with two distinct features, and implement “greening” and ecologically sound strategies

First, adhere to the requirements of “two types of agriculture,” that is, agricultural models featuring “resource saving and environmental friendliness.” Agricultural practices such as recycling, stereoscopic recycling, and clean resource saving production will be promoted. Second, develop green agriculture. Establish the high-price-for-quality-product mechanism that will, in turn, improve product quality. Improve quality and safety levels and minimize the adverse effects on the environment. Third, reinforce the creative mindset, and develop the science and technology support system. Promote international cooperation and exchange in agricultural sciences, interact with the national innovation system and establish scientific innovation alliances so as to drive forward the development of agriculture featuring resource saving and environmental friendliness.

4.2.4 Implement a globalization strategy with new reforms and greater opening up

Make proper use of the markets and resources both within and outside China and have more say in international grain pricing through opening up and cooperation. Realize the sustainable development of food security. The first

DOI 10.15302/J-SSCAE-2019.05.025

goal is to go global and make use of the comparative advantages of the region to take part in international economic division of labor. Implement the “going global” strategy in agricultural development. The second is to extend the space for agriculture development by adopting the “enclave” strategy. The constraints of limited land resources will be removed, and the resources of enclave production base will be expanded through capital factor flows, development of industry clusters, and brand management and influence. The third is to establish an agricultural resources innovation planform open to the country and the world, an incubation platform for independent innovations, and a service platform to make use of the spillover from international research institutions, international scientific resources, and critical technologies [10].

4.3 Strategic targets

4.3.1 Targets for food production and self-sufficiency rates

In 2020, the average annual growth rate target for grain output was 1.51% over a five-year period; by 2035, the annual grain output growth rate is set to be 0.1%, striving to guarantee a stable self-sufficiency rate of 29%.

By 2035, there will be an over-supply of vegetables, fruits, and aquatic products. The self-sufficiency rate of meat should be above 68%. The rate for eggs is over 37%, and that for milk and its products exceeds 12%.

4.3.2 The targets for agricultural product quality and safety

By 2020, in general over 96% of tested agricultural products will meet the standards in routine monitoring tests. The qualification rates in sampling tests will be over 95% for each of the five types of daily necessities, namely, grains, oil, meat, eggs, and dairy.

5 The strategic path and scientific projects for food security and sustainable development in the southeast coastal region in China

5.1 Strategic path

5.1.1 Preserve and enhance the potential for grain production, and implement the strategy of “storing grain in arable land and technology”

(1) Preserve soil fertility and productivity. Execute ways to increase soil fertility, soil improvement, balanced nutrients, and soil restoration. Prioritize study in the rapid biodegradation of straw returned to local fields and explore opportunities to establish a system for the storage of organic topsoil from construction sites. Prepare for rapid increases of grain production capacity in special situations. Step up the pace to upgrade low- and medium-yield fields and promote green production practices such as “producing more than half-a-ton of grain and earning 10 000 yuan of income” [11]. Optimize the variety mix.

(2) Improve infrastructure and the maintenance mechanism. Step up the pace with continued construction and renovation in large- and medium-sized irrigation areas. Plan for large hydraulic projects and support facilities for the grain industry to increase the percentage of effective farmland irrigation. Construct water conservancy facilities for small-scale farmland, with a focus on irrigation and drainage channels and water source management projects for drought conditions [12].

5.1.2 Ensure grain production security. Adjust the structure of grain varieties by maintaining a steady production of rice, and growing more upland crops

(1) Uphold the “perspective of big grain security.” Include more types of upland crops in the subsidy list. Make full use of mild slopes of low mountains and hills and winter fields for the development of characteristic upland grain crops and increase production benefit of both upland and overall grain crops [10]. This paper proposes incorporating fresh corn and sweet potato into the staple food grain list for the region, in order for them to fall under the same policy that applies to rice and wheat.

(2) Accelerate the establishment of the industry system for quality rice. With the premise of “the absolute security of grain rations,” meet the growing demand for middle- and high-end rice in the southeast coastal region. Allow, or even encourage, this region to set quality rice acreage as the primary indicator used to evaluate food security.

5.1.3 Produce middle- and high-end quality products, and improve product competitiveness

In compliance with the rapidly developed social economy and internationalization in the southeast coastal region, food security should be oriented toward “quality improvement” rather than “production increase” [13].

(1) Build a production system for middle- and high-end agricultural products. Establish a cluster of competitive

high-end industries with distinctive features. Put focus on the optimization of product mix, industry structure, and regional structure [14].

(2) Develop a production environment and cropping system for middle- and high-end products. Build a protective tillage system with regional characteristics through the integration of agricultural machinery, technologies, engineering, and biological measures. Promote the "standardized plus" agriculture model and improve the benefit binding mechanism to sustain the increase in farmers' income.

(3) Establish a quality control management system for middle- and high-end products. Promote the highlighted "regional public parent brand plus enterprise private sub brand" development model. Reinforce quality certification of agricultural products and make new advances in the GMP certification of agricultural inputs, GAP certification of crop products, CCP certification in livestock and poultry farming, aquaculture and processing, and the "two foods and one indication" quality authentication (Two foods: green food and organic food. One indication: geographical indication of agricultural products). An archive registration system should be adopted by production organizations above the designated scale. Explore and establish a range of systems for quality tracing, risk early warning, and stress response in production and circulation.

5.1.4 Explore potential "blue granary" and forest food development using the abundant resources in mountains and oceans

According to public statistics, mountains and hills take up more than 70% of the area in the southeast coastal region. Its 2.82×10^6 hm^2 of ocean area accounts for about 94% of that in the country. The mountains and oceans have extremely abundant resources.

(1) Focus on the development of a marine fishery economy [15]. Research the carrying capacity of fisheries and strengthen the protection of coastal fishery resources to restore marine fishery ecology in the region. Develop ecological marine aquaculture and make better use of the "blue granary." Expand the development space of the fishery, so that it will grow into the region's most competitive agricultural industry on the market. Explore new models of fishery property rights management and localize the exploitation rights of coastal fisheries. Increase the efficiency of aquaculture on tidal flats while reducing the volume. Improve production capacity and quality [16, 17].

(2) Enhance the cultivation of forest food resources [18]. Make good use of mild slopes and forests, and exploit forest foods, wood oil plants, and meat as a potential growth point for ensuring food security. Treat forest food cultivation as the core work. Demonstrate and promote the combined ecological production mode of forest foods. Recover and increase forest productivity and extend the industrial chain.

5.1.5 Make good use of the markets and resources both inside and outside China based on complementary advantages, and stabilize market supply of agricultural products

(1) Maintain a stable supply of grains and animal products through more coordination with the upper and middle reaches of the Yangtze River Economic Zone, which will become the stable supply base of grain, livestock, and poultry. Establish a closer cooperation with Taiwan, China in quality agriculture, and accelerate the creation of a production system and an industrial system for middle- and high-end agricultural products.

(2) Strengthen cooperation with the "Belt and Road" countries. Encourage agricultural enterprises to go to these countries and areas for agricultural cooperation and development. Give major support to projects in grain and oil crop cultivation, and agricultural and livestock farming.

(3) Establish production bases for exported aquatic products, fruits, and vegetables, and develop an export-oriented agriculture. Establish export bases for competitive aquatic products, fruits, and vegetables. Push forward the strategy of "export substitution" to expand exports and absorb the surplus productivity.

5.2 Major scientific engineering projects

Exploit resource advantages in the region and build regional brands. Steer the southeast coastal region to lead the middle- and high-end agricultural product industries and high-quality agriculture development with the following practices: breeding and extension of quality varieties with multi-resistance, appropriately-scaled and diversified operations, and brand agriculture.

5.2.1 Animal and plant germplasm and modern breeding engineering

First, explore biological germplasm resources and new technologies applicable to animal and plant breeding. Second, breed breakthrough varieties and smart plants through molecular design. Reinforce the research and development of major engineering techniques in food security, which include key technologies in modern seed

DOI 10.15302/J-SSCAE-2019.05.025

industry, animal and plant genetic improvement, seed industry promotion, and a new round of variety replacement. Develop critical technologies for green and safe animal production, such as new feed resource development, prevention and control of epidemics, quality testing techniques, and technologies for healthy breeding. Develop value-added technologies for post-production agricultural products, intelligent intensive processing technology, quantity, and quality control technologies for agro-products. Conduct research and development of agricultural ecological protection technologies, and their integration and extension. Develop intelligent monitoring of the agricultural environment, smart management of digital agriculture, smart agriculture production, intelligent greenhouse agriculture; and research and development, integrated demonstration, and extension of digital and precision short- and medium/long-term early warning analysis system, among others.

5.2.2 Quality agricultural products and eco-agricultural engineering

The highlighted areas of research include ecological farmland remediation and safety production, non-point source pollution control, comprehensive treatment of rural environments, and biodiversity protection and utilization. Carry out agricultural production system development and research on the balance mechanism. Speed up the building of a technical support system for green agriculture development, including pollution treatment and circular agricultural engineering, the engineering of ecological environment quality and safety, and a system for process control of agricultural product quality and safety.

5.2.3 Equipment management engineering in fine farms with big data application

Build an intensive, efficient, safe, and sustainable support system for smart agriculture to meet the urgent demands of modern agriculture for mechanical equipment and push forward the development of high quality modern agriculture and a green and beautiful economy. This includes “digital agriculture” information engineering techniques which drive the production and circulation of agricultural products; the manufacturing of agricultural equipment capable of medium- and small-scaled, high-speed, and multi-tasked agricultural operations; and intelligent equipment applicable for use on plains, hilly and mountainous regions, and in forests.

5.2.4 Industrialization of healthy and nutritious foods

In response to the national dietary consumption structure and nutrition adjustment, devote more effort to the research and development theory of nutritious and healthy foods, and critical production technologies and equipment development, to realize the industrialization and fast-track development of healthy and nutritious foods.

(1) For the development of healthy and nutritious foods, study and explore the functional components, and develop extraction, separation, and stabilization technologies. Develop healthy functional foods with modern processing technologies. Strengthen the resources for the evaluation and utilization of new resource foods, featured agricultural products, and products used both as food and medicine.

(2) For modern manufacturing technologies of featured foods, develop critical energy-saving and efficient equipment and a complete production line for modern food processing. Improve sensory properties and physicochemical characteristic of products and realize mechanization, standardization, and industrialization.

(3) In respect of fresh-keeping and logistic techniques, the focus is on addressing such problems as quality deterioration and loss during transportation.

(4) For food processing equipment, carry out the integration and development of critical technologies and equipment for sterilization, energy-saving drying, and high-speed packaging.

5.2.5 Integration of the whole industrial chain and re-innovation engineering

Speed up the “agriculture plus” integration, and carry out the integration, fusing and grafting, and re-innovation of crossover technologies being applied to agriculture.

(1) Explore, expand, and enhance the functions of agriculture, and build brand awareness and reputation of middle- and high-end agricultural products.

(2) Provide generous support to the fishery real economy and convert from the perspective of single deep-sea fishing to that of a whole industry chain development and diversified operations.

5.2.6 Biodiversity engineering of farmland ecosystems

Adhere to the policy of prioritizing conservation and protection, and a natural-recovery based practice. Develop a spatial structure featuring resource conservation and environment protection.

(1) Carry out research into how farmland biodiversity influences efficient utilization of nutrients and pest outbreaks, including the impact of farmland quality, biodiversity, irrigation systems (drip or flood), and

mechanization on farmland pest outbreaks and disaster characteristics [19].

(2) Implement the engineering of important ecosystem protection and remediation [20, 21]. First, strengthen the remediation and conservation of the farmland biotic environment, water recovery and conservation, ecological vegetation improvement, farmland quality protection, and the improvement of ecosystem quality and stability. Second, put more effort into soil pollution control and remediation, agricultural non-point pollution treatment, and solid wastes and garbage disposal. Third, improve natural forest protection and devote more effort to wetland protection and restoration. Fourth, apply strict protection measures to land use, and commence more pilot practices into the crop rotation and fallow system. Develop a mechanism for ecological compensation.

5.2.7 High value-add-based intensive processing of agricultural products

Perform studies on the physicochemical traits, nutritional properties, storage and processing characteristics, functional features, processing standards, and comprehensive utilization of high value-added agricultural products.

(1) Basic research should be conducted on nutrition and quality changes during transport and processing, nutrient interaction mechanisms, cutting-edge technologies for bio-manufacturing of agricultural products, and others.

(2) Technology development. This includes non-thermal processing technology, energy-saving drying technology, efficient separation and extraction techniques, long-acting bacteria-reducing packaging, and the upgrading and integration of clean production technologies. Develop bioengineering technologies and equipment in enzyme, cell, fermentation, and protein engineering.

(3) Carry out research and development on nutritional and functional foods. Develop functional foods, foods for people with special dietary requirements, health foods, and foods with nutrient function claims, among others.

5.2.8 Green and environmentally-friendly factory farms for livestock and poultry

Given the limited load-bearing capacity of resources and the environment [22], develop factory farms for livestock and poultry in an environmentally-friendly and green way. Speed up the transformation and upgrading of animal husbandry and develop the industry to concentrate on high benefit and high quality. Develop and implement quality and safety standards for animal husbandry and feed production. Carry out system development in inspections and testing, safety evaluation, supervision and law enforcement, and oversight capacity building. Adopt livestock and poultry labeling systems and an animal archive system across the country and improve quality and safety regulations and traceability systems for animal products.

5.2.9 Sustainable utilization of living marine resources

Development should be in three major directions, namely focusing on deep-sea resources, expanding exploration of the open sea, and making full use of inshore resources. In light of this, integrate arrangements for the innovation chain and the main missions using living marine resources, centered around group, genetic, and product resources specific to the sea, to ensure Chinese food security [17].

First, carry out an evaluation of marine biology and resources. Draw up plans to investigate global marine fishery resources, which will be coordinated, arranged, and funded by the Ministry of Finance and the Ministry of Agriculture and Rural Affairs. Increase the ability to explore and acquire deep-sea living resources, carry out research on cutting-edge deep-sea life sciences and conduct applied research [23]. Second, develop pelagic biological resources and enhance the utilization of new resources of strategic importance such as *Euphausia superba*. Explore and evaluate new biological resources of the open sea and develop key fishing technologies and equipment. Third, research inshore marine life diversity and evaluate biological resources to establish an inshore ecological protection technology system. Fourth, carry out innovative research and development of marine medicinal and high-end biological products, and develop a processing system for new marine products, and seamless security control of the whole industry chain. Fifth, carry out fishery restoration and marine “blue granary” development to form a cluster of industries in the “blue granary” that will form a complete industrial chain [24].

5.2.10 Scientific and technological innovation engineering of forest foods

Guarantee the stable development of forest foods. Meanwhile, increase as appropriate the contribution of forest foods to food security. Carry out agricultural production under tree canopies in the forest and develop steadily toward standardized large-scale safe production. Promote forest food certification, and the technological engineering of efficient cultivation of forest resources and improvements in precision quality. Develop and improve systems for germplasm collection and preservation, and for the research and development of elite variety production and supply. Increase the per-unit yield.

DOI 10.15302/J-SSCAE-2019.05.025

References

[1] Wu S D, Wang Q. Regional economic disparities and coordination of economic development in coastal areas of Southeastern China [J]. Journal of Geography, 2008 (2): 123–134. Chinese.

[2] Zhao C J, Liu Q B, Song S. Research progress of forest food in China [J]. Forestry Economy of China, 2015 (3): 76–78. Chinese.

[3] Xu H X. Discussions on the issues of trans-century marine fishery resource exploitation & its management in the East China Sea [J]. Journal of Zhejiang Ocean University (Natural Science Edition), 2000 (3): 197–203. Chinese.

[4] Zhao L Y, Liu S, Yu D M, et al. Comparative analysis of dietary nutrition status of Chinese residents and related targets of Chinese food and nutrition development program (2014—2020) [J]. China Food and Nutrition, 2015, 21(8): 5–7. Chinese.

[5] Pan J P. Study on the development of extra-regional agricultural economy in Pudong New Area, Shanghai [J]. Shanghai Rural Economy, 2015 (1): 19–22. Chinese.

[6] Zheng R Q, Liu X C, Yang L P. “Grain for forage” policy effect analysis and key issues research review [J]. Feed Industry, 2016, 37(3): 62–64. Chinese.

[7] Li Z C, Shi Y Q. Research on location optimization of agricultural products logistics distribution center [J]. Modern Marketing (Late issue), 2018 (7): 101–102. Chinese.

[8] Cheng G Y, Wang X H, Guo Y Z, et al. National grain security assurance requirement, ways and countermeasures under concept of “Big Food” [J]. China Agricultural Science and Technology Report, 2017, 19(9): 1–7. Chinese.

[9] Tan M J. Theoretical and empirical research on convergence development of primary, secondary and tertiary-industry in rural areas [D]. Wuhan: Huazhong Agricultural University (Doctoral dissertation), 2016. Chinese.

[10] Liang W H. Research on the impact of China’s OFDI reverses technology spillover to independent innovation [D]. Beijing: Capital University of Economics and Trade (Doctoral dissertation), 2017. Chinese.

[11] Xu W H. Research on technology of the paddy field farming system producing more than half-a-ton of grain and ten-thousand yuan of income per mu yearly in Zhejiang province [D]. Hangzhou: Zhejiang University (Master’s thesis), 2016. Chinese.

[12] Xie G R. Measures to strengthen the operation, maintenance and management of small-scale farmland water conservancy projects [J]. Pearl River Water Transport, 2018 (6): 50–51. Chinese.

[13] Li S J. Thoughts on food security in China in the new era [J]. The Agricultural Development and Finance, 2019 (6): 25–27. Chinese.

[14] Shi Y, Yang X H, Xie H Y, et al. Agricultural supply-side structural reform and its realization form-pastoral complex [J]. Jiangsu Agricultural Sciences, 2017, 45(24): 320–326. Chinese.

[15] Hu Q G, Wang X J, Cao L L. Interprovincial spatial-temporal difference analysis of development potential of blue ranch in China [J]. Chinese Rural Economy, 2015 (5): 70–81. Chinese.

[16] Wang B, Ni G J, Han L M. Impact of the evolution of industry structure on the economic fluctuation of marine fishery [J]. Resource Science, 2019, 41(2): 289–300. Chinese.

[17] Li Q. Problems and countermeasures in the economic development of China’s marine industry [J]. Economist, 2019 (4): 10–11. Chinese.

[18] Hu X. The strategy of developing modern forestry economy to boost rural rejuvenation [J]. Zhejiang Forestry, 2018 (10): 4–5. Chinese.

[19] Li L K. The research on how utilization factors of agricultural production impact grain production and environment [D]. Beijing: China Agricultural University (Doctoral dissertation), 2015. Chinese.

[20] Overall planning of landscape, forestry, field, lake and grass system for ecological civilization construction has reached a new height [J]. Land Greening, 2018 (5): 1. Chinese.

[21] Zhang H Y, Hao H G, Zhai R X, et al. Issues and suggestions on constructing ecological security during the “13th Five-Year” period [J]. Environmental Protection, 2017, 45(1): 25–30. Chinese.

[22] Gao X Y, An H Z, Liu H H. Views on China’s resources and environmental loading capacity [J]. Resources and Industry, 2012, 14(6): 116–120. Chinese.

[23] Li Z D. Development research on marine-inland economic integration in Guandong-Hong Kong-Macau Greater Bay Area [D]. Shenyang: Liaoning University (Doctoral dissertation), 2019. Chinese.

[24] Yang H S, Xing L L, Zhang L B. Promoting systematic design and innovation-driven development for modern fishery [J]. Journal of the Chinese Academy of Sciences, 2016, 31(12): 1339–1346. Chinese.