Optimization Research of Regional Distribution of Hainan Agricultural Industry Based on Comprehensive Comparative Advantages

Huijian Zhang¹, Jun Jiang² and Junfeng Wang¹

¹Institute of Scientific and Technical Information, Chinese Academy of Tropical Agricultural Sciences (CATAS), Haikou 571101, Hainan, P. R. China
²School of Tourism, Hainan Tropical Ocean University (HNTOU), Sanya 572022, Hainan, P. R. China

*Corresponding author. Email: sjrdxx@126.com

Abstract. Based on the statistical data of 18 cities or counties in Hainan from 2011 to 2018, this research comprehensively utilizes agricultural production comparative advantage and environmental comparative advantage to build a comprehensive comparative advantage system, guide the optimization of Hainan's agricultural industry layout. The result shows that the comprehensive comparative advantages and environmental bearing capacity of Sanya, Qionghai, Wanning, Baoting and Qiong Zhong are greater than 1, have significant advantages in agricultural production; And the comprehensive comparative advantage of Ding'an, Tunchang and Ledong is greater than 1, but the environmental carrying capacity is between 0-1, so they are medium advantage zone of agricultural production; The comprehensive comparative advantages and environmental carrying capacity of Haikou, Wenchang, Lin'gao, Danzhou, Dongfang, Lingshui and Changjiang are all between 0-1, are disadvantaged area of agricultural production. According to the evaluation results of comprehensive comparative advantages, the following optimization paths are proposed, firstly, it is proposed to improve the significant advantages zone, and limit the scale of low efficiency and high consumption of agricultural products in medium advantages zone, and adjust the industrial structure and layout of the disadvantaged zone. Secondly it is proposed to promote the production mode of comprehensive development of agriculture, forestry, animal husbandry and fishery. Thirdly, it is considered of multi compliance of the impact of planting, animal husbandry and fishery layout on the environment. Then the pollutant discharge in agri-production should be strengthening controlled. Finally, this research puts forward some policy suggestions to support the optimization of regional layout of agricultural industry.

Keywords: Hainan agricultural industry, comprehensive comparative advantage, optimization of regional layout.

1. Introduction
With the rapid developing of construction of China (Hainan) free trade port, new varieties, products and brands of agricultural products in Hainan are constantly launched, the level of production
ecologicalization, standardization, specialization, scale and marketization is getting higher and higher, and great changes have taken place in the quality, technical conditions, spatial distribution and market competitiveness of agri-products. Under this situation, it is urgent to optimize the regional distribution of agri-products in Hainan, further enrich and adjust the layout of advantageous areas, and improve supporting policies, promoting farmers' income, agricultural efficiency and rural beauty.

Comparative advantage is the basis of regional division of labor and inter-regional trade, its theory is the basic theory to guide the layout of agricultural industry. Many scholars have shown that, it is scientific and universal using this theory to guide the layout of agricultural industry. The existing layout of agricultural industry in Hainan is mainly formed by national demand, natural conditions and market demand. There are still problems in Hainan such as the mismatch between the layout of agricultural industry and the positioning of the main functional areas of cities and counties, the local resource endowment, the "small but comprehensive" regional layout, the agricultural industry layout fails to realize the seamless connection with the secondary and tertiary industries, agricultural regional overall planning are still obstacles, the level of regional scientific and technological innovation is in a backward position in China, and the ability to coordinate two markets and two resources is not strong. Therefore, it is necessary to take comparative advantage theory and location theory as guidance, the comparative advantage of environment in 18 cities or counties of Hainan is first calculated, and then it is introduced into the comparative advantage of agricultural production to building a comprehensive comparative advantage system. The result can provide data supporting the optimization of Hainan's agricultural industry layout, put forward the direction and key points of the optimization of Hainan's agricultural industry layout.

2. Research methods and data source
The distribution law of agricultural industry follows the principle of comparative advantage. In the past, the judgment of comparative advantage was based on input factors, market conditions, etc. With increasing threat of the current agricultural production mode to the environment, the restrictive effect of environment on agricultural development is more and more obviously. Under market and policy guiding, dominant varieties tend to be concentrated in dominant production areas. In the same region, it is more and more intensive competition between the superior products in water and soil resources and environment, including within and between agricultural products. In this situation, integrating the comparative advantage of environmental factors into the planning of agricultural production layout, it would be optimizing the relationship between industrial development and ecological environment protection, and promote the optimization of agricultural production structure and regional layout in the future. Therefore, the rational planning of agricultural production layout must be based on the estimation and judgment of the quality of environmental factors in the main production areas. Based on the above judgment, it is assumed that environmental factors and production factors are equally important in the formation of comprehensive comparative advantage during the agricultural industry developing, and the relationship between them is significant. We refers to the construction method of comprehensive comparative advantage index by Zheng Weiwei, Xu Zhigang and Zhang Hui, Using the arithmetic average of the environmental comparative advantage index and the production comparative advantage index to construct the comprehensive comparative advantage index. Among them, the ratio of the relative scale of regional water surplus and total water resources to the provincial average level reflects the comparative advantage index of environment, the water surplus is equal to the difference between the total amount of water resources and the amount of ash water needed to dilute the excess nitrogen; the comparative advantage index of production is reflected by the ratio of the relative level of the gross production of agriculture, animal husbandry and fishery to the average level of the whole province; The comparative advantage index of production is reflected by the ratio of the relative level of the gross production of agriculture, animal husbandry and fishery to the average level of the whole province.
2.1. Calculation of environmental comparative advantages

Environment is an important natural endowment in agricultural production. Different environmental resources determine the land fertility, water resource richness and other important factors, and then affect the suitable varieties and the mode of agricultural production in the area. With the technology developing, the production mode of modern agriculture has more and more influence on the surrounding environment, the environment also more and more restricts agriculture developing. Integrating the environment factor into the calculation of comparative advantage has a positive guiding significance for the future development of agriculture in this region. Taking water resources as the research object, we calculate the relative comparative advantages of 18 cities of counties in Hainan Province, so as to assess whether the region has environmental comparative advantage. The calculation formula is as following.

\[
WAI_i = \frac{WS_i / WAS_i}{AWS_i / AWAS_i}
\]  

(1)

\(WAI_i\): The index of regional environmental comparative advantage in region I  
\(WS_i\): Water Surplus margin in region I, i.e. total water resources of the area minus ash water consumption of diluted nitrogen element  
\(WAS_i\): Total regional Water resources in region I  
\(AWS_i\): Average Water Surplus in Hainan in region I  
\(AWAS_i\): Average Water resources in Hainan in region I

2.2. Calculation of production comparative advantage

Production comparative advantage refers to the natural advantages of this region compared with other regions in terms of production factors, is an important embodiment of regional invisible comprehensive advantage. By calculating the production advantages of 18 cities and counties, the paper takes GDP as the research focus, and evaluates the cities or counties that are suitable for the development of agriculture and animal husbandry, we can make preparations for the study of the comprehensive comparative advantage of the region. The calculation formula is as following.

\[
VAI_i = \frac{VP_i / VNP_i}{AVP_i / AVNP_i}
\]  

(2)

\(VAI_i\): Production comparative advantage index in area I  
\(VP_i\): Gross production of agriculture and animal husbandry in area I  
\(VNP_i\): Gross production of agriculture, forestry, animal husbandry and fishery in area I  
\(AVP_i\): Average Value of total output value of agriculture and animal husbandry in Hainan  
\(AVNP_i\): Average Value of gross production of agriculture, forestry, animal husbandry and fishery in Hainan

2.3. Calculation of comprehensive comparative advantage index

Comprehensive comparative advantage index is the comprehensive index of environmental advantage and comparative index of production advantage, and then calculates the region whether still has comparative advantage under the influence of environmental and production factors. The paper take the arithmetic average of environmental comparative advantage index and production comparative advantage index to constructing the comprehensive comparative advantage index. The calculation formula is as following:

\[
CAI_i = \sqrt{VAI_i \cdot WAI_i}
\]  

(3)
VAI: Index of comparative advantage of production in region I

WAI: Index of environmental comparative advantage in region I

2.4. Data sources
The research data mainly comes from Hainan Statistical Yearbook (2007-2018), questionnaire data, and published data by relevant departments and published journal papers. Among them, the macroeconomic data are mainly from the Statistics Bureau of Hainan Province, and all kinds of water resources data refer to the data published by relevant departments and published journal papers.

3. Comprehensive evaluation of comparative advantage of agriculture

3.1. Environmental comparative advantage
According to Formula 1, the following conclusions are shown in Table 1.

In Table 1, during 2011 to 2018, Sanya, Wuzhishan, Wanning, Qiongzhou, Baoting and Baisha have maintained comparative advantages in production environment; Qionghai City has changed from disadvantage to advantage; Tunchang County and Ledong County have changed from advantage to disadvantage; The production environment of the rest cities of counties has always been at a relative disadvantage.

3.2. Production comparative advantage
According to Formula 2, the following conclusions are shown in Table 2.

In Table 2, during 2011 to 2018, Haikou, Sanya, Wenchang, Qionghai, Wanning, Digan, Tunchang, Chengmai, Dongfang, Ledong and Changjiang have always maintained their comparative advantages in production; Wuzhishan, Qiongzhou and Baoting have changed from disadvantages to advantages; Lingshui County is from advantages to disadvantages; The production comparative advantages of the rest cities or counties has always been at a relative disadvantage.

Table 1. Environmental comparative advantage index of 18 cities or counties in Hainan.

| Cities or Counties | Environmental comparative advantage index (WAI) |
|-------------------|-----------------------------------------------|
|                   | 2011  | 2014  | 2018  |
| Haikou            | 0.85  | 0.82  | 0.83  |
| Sanya             | 1.17  | 1.12  | 1.26  |
| Wuzhishan         | 1.21  | 1.27  | 1.28  |
| Wenchang          | 0.72  | 0.86  | 0.82  |
| Qionghai          | 0.95  | 1.10  | 1.06  |
| Wanning           | 1.03  | 1.10  | 1.16  |
| Digan             | 0.96  | 0.93  | 0.77  |
| Tunchang          | 1.10  | 1.08  | 0.97  |
| Chengmai          | 0.47  | 0.97  | 0.75  |
| Lingao            | 0.96  | 0.51  | 0.50  |
| Danzhou           | 0.91  | 0.79  | 0.68  |
| Dongfang          | 0.68  | 0.47  | 0.57  |
| Ledong            | 1.02  | 0.91  | 0.85  |
| Qiongzhou         | 1.23  | 1.31  | 1.29  |
| Baoting           | 1.19  | 1.19  | 1.23  |
| Lingshui          | 0.92  | 0.68  | 0.86  |
| Baisha            | 1.06  | 1.20  | 1.15  |
| Changjiang        | 0.95  | 0.92  | 0.70  |

Note: If WAI > 1, it indicates that the region has environmental comparative advantage; If WAI < 1, it indicates that the region has a comparative environmental disadvantage.
Table 2. Production comparative advantage index of cities or counties in Hainan.

| Cities or Counties | Production comparative advantage index (\( VAi_i \)) |
|-------------------|---------------------------------------------|
|                   | 2011 | 2014 | 2018 |
| Haikou            | 1.26 | 1.23 | 1.19 |
| Sanya             | 1.09 | 1.15 | 1.13 |
| Wuzhishan         | 0.97 | 1.15 | 1.18 |
| Wenchang          | 1.08 | 1.06 | 1.04 |
| Qionghai          | 1.15 | 1.17 | 1.16 |
| Wanning           | 1.03 | 1.17 | 1.09 |
| Dingan            | 1.31 | 1.34 | 1.35 |
| Tunchang          | 1.02 | 1.10 | 1.13 |
| Chengmai          | 1.01 | 1.06 | 1.06 |
| Lingao            | 0.55 | 0.34 | 0.32 |
| Danzhou           | 0.65 | 0.70 | 0.69 |
| Dongfang          | 1.34 | 1.30 | 1.33 |
| Ledong            | 1.30 | 1.31 | 1.39 |
| Qiongzhong        | 0.78 | 1.05 | 1.08 |
| Baoting           | 0.92 | 1.18 | 1.25 |
| Lingshui          | 1.01 | 0.82 | 0.89 |
| Baisha            | 0.71 | 0.85 | 0.88 |
| Changjiang        | 1.01 | 0.99 | 1.00 |

Note: If the production comparative advantage index (\( VAi_i \)) > 1, it indicates that the region has a production comparative advantage; If \( VAi_i < 1 \), it indicates that the region has a comparative disadvantage in production.

3.3. Comprehensive comparative advantage index
According to Formula 3, the following conclusions are shown in Table 3.

Table 3. Comprehensive Comparative Advantage Index of Cities or Counties in Hainan.

| Cities or Counties | Comprehensive comparative advantage index (\( CAi_i \)) |
|-------------------|-----------------------------------------------------|
|                   | 2011 | 2014 | 2018 |
| Haikou            | 1.04 | 1.01 | 0.99 |
| Sanya             | 1.13 | 1.13 | 1.19 |
| Wuzhishan         | 1.08 | 1.21 | 1.23 |
| Wenchang          | 0.88 | 0.96 | 0.92 |
| Qionghai          | 1.05 | 1.13 | 1.11 |
| Wanning           | 1.03 | 1.13 | 1.12 |
| Dingan            | 1.12 | 1.12 | 1.02 |
| Tunchang          | 1.06 | 1.09 | 1.05 |
| Chengmai          | 0.69 | 1.01 | 0.90 |
| Lingao            | 0.73 | 0.42 | 0.40 |
| Danzhou           | 0.77 | 0.75 | 0.68 |
| Dongfang          | 0.95 | 0.78 | 0.87 |
| Ledong            | 1.15 | 1.09 | 1.08 |
| Qiongzhong        | 0.98 | 1.17 | 1.18 |
| Baoting           | 1.05 | 1.18 | 1.24 |
| Lingshui          | 0.97 | 0.75 | 0.87 |
| Baisha            | 0.86 | 1.01 | 1.00 |
| Changjiang        | 0.98 | 0.95 | 0.83 |

Note: If \( CAi_i > 1 \), indicating that area i has comparative advantage of environmentally friendly production; If \( CAi_i < 1 \), indicating that the production or environment in area I is in a comparative disadvantage.
In Table 3, during 2011 to 2018, Sanya, Wuzhishan, Qionghai, Wanning, Dingan, Tunchang, Ledong, Qiongzhong, Baoting and Baisha have always maintained comprehensive comparative advantages; Haikou has changed from advantage to disadvantage due to the change of environmental carrying capacity; Wenchang, Chengmai, linggao, Dazhou, Dongfang, Lingshui and Changjiang have always maintained disadvantages.

4. The optimization path of Hainan agricultural regional layout

Through analysing agricultural production comparative advantage, environmental comparative advantage and comprehensive comparative advantage, we divided tropical agricultural industry layout in Hainan into three regions, namely, the advantage area, medium advantage area and the relative disadvantage region. Among them, the advantage area (comprehensive comparative advantage and environmental carrying capacity > 1) including Sanya, Qionghai, Wanning, Baoting, Qiongzhong, Wuzhishan and Baisha; The medium advantage area (the comprehensive comparative advantage > 1, and the environmental carrying capacity is between 0-1), including Ding'an, Tunchang and Ledong; The disadvantage area (comprehensive comparative advantage and environmental carrying capacity are between 0-1) include Haikou, Wenchang, Lingao, Dazhou, Dongfang, Lingshui and Changjiang; The disadvantage area (comprehensive comparative advantage and environmental carrying capacity are between 0-1) include Haikou, Wenchang, Lingao, Dazhou, Dongfang, Lingshui and Changjiang.

4.1. Focus on developing the advantage area, limiting the scale of low efficiency and high consumption agricultural products in the middle advantage area, adjusting the industrial structure and layout of the disadvantage area

It would give priority developing the advantage area (comprehensive comparative advantage and environmental carrying capacity > 1). The prospect of agricultural production in this area is promising. As part of the region is located in the first class forest land protection zone in Hainan, in order to protecting its land and water resources, the region should give full play to the comprehensive comparative advantages, keep the original advantageous industries, develop characteristic and efficient industries.

It would be appropriately restricted the development of low efficiency and energy consuming industries in the medium advantage areas. The comprehensive comparative advantage of the area is greater than 1, while the environmental comparative advantage is less than 1. There is higher competitive in water, soil resources and environment between the existing production of planting and breeding industry in this region, and the environmental carrying capacity is weakened. Therefore, it is necessary to reduce the area of inefficient industries such as sugarcane, eucalyptus and aged rubber trees, develop efficient green industries, such as tropical fruits, facility flowers, featured green livestock and poultry products, aquatic products and etc aiming at market demand. At the same time, we should always pay attention to the carrying capacity of resources and environment.

It would be adjusted and optimized the industrial layout and industrial structure of the disadvantaged areas. The comprehensive comparative advantage of the region is less than 1, and the ecological environment is threatened by the expansion of agricultural production. Therefore, it is necessary to adjust the layout and industrial structure of the original agriculture, animal husbandry and fishery industry according to the environmental carrying capacity, while strengthening the remediation of environmental pollutants, and make overall arrangements for agricultural production. The region should develop water-saving, fertilizer saving and efficient emission reduction agriculture, such as high-quality sightseeing agriculture, facility flower industry (such as Banlan industry) and etc.

4.2. Promoting the production mode of comprehensive development of agriculture, forestry, animal husbandry and fishery

It is necessary to constructing nutrient cycling system of planting, animal husbandry and fishery in 18 counties or among counties. Using policy guidance and financial support effectively reduce the use of
chemical fertilizer and the price of organic fertilizer, increase the use of organic fertilizer, so as to reduce the occurrence of grey water and improve water quality.

4.3. Multiple planning integration considering the impact of planting, animal husbandry and fishery layout on the environment
Comprehensively considering the regional resource carrying capacity, ecological red line, regional main function orientation and agricultural development demand, it would be reasonably arranged the scale and structure of animal husbandry, fishery and planting.

4.4. Strengthen the monitoring of pollutant discharge in agri-production
It is necessary to strengthen the monitoring of agricultural non-point source pollutant discharge, research and develop clean technologies for pollutant treatment and achieve major breakthroughs, and effective control pollution source. Based on above measures, it would be improved the efficiency of pollution prevention and control, improved the environmental carrying capacity, and realized the sustainable development of agriculture.

5. Policy suggestion for the optimization of hainan's agricultural regional layout

5.1. Constructing the distinctive agricultural industrial development zone
Based on the resource endowment and its main function orientation, 18 cities or counties in Hainan are divided into the first demonstration area of Central-South high-efficiency green agriculture (industrial development advantage area, including Sanya, Qionghai, Wanning, Baoting, Qiongzhong, Wuzhishan, Baisha), Two-wings characteristic agricultural experimental demonstration area (industrial development comparative advantage area, including Ding'an, Tunchang and Ledong), and North-South high-quality agriculture and industrial integrating development zone (industrial development disadvantage zone, including Haikou, Wenchang, Chengmai, linggao, Danzhou, Dongfang, Lingshui and Changjiang). Based on stabilizing the original industries in the first demonstration area of Central-South high-efficiency green agriculture, we will develop high-efficiency characteristic industrial parks, leisure agricultural parks, bases of south propagation and industrial clusters of coconut, betel and rubber and etc. The whole industrial chain of comprehensive production area would be formed. By increased the popularization and application of new excellent agricultural varieties and advanced technologies, the agricultural quality and efficiency would be promoted; The original industries would be restricted to develop in the two-wing characteristic agricultural experimental demonstration area. Using rich light, heat, water, land resources, and marine resources, concentrated fields and oceans, and constantly emerging new agricultural forms, varieties, technologies, markets and new leaders, the two-wing characteristic agricultural experimental demonstration area would be developed featured fruits and vegetables, featured aquatic products, potato and taro, green livestock and poultry, agricultural products processing and logistics, leisure and health agriculture and other industries. In the South-North high-quality agricultural and industrial integration development zone, it is the political, economic, cultural, scientific and technological, talent and financial center in Hainan, and highly integrated with the construction of Hai-Cheng-Wen integration economic circle. It is strengthened to the ecological protection of chemical fertilizer and pesticide reduction and agricultural waste recycling, Builded green brand agricultural products production base, agricultural products processing logistics base, international agricultural products export trade base and agricultural products origin market, and developed a three industry integration industry integrating leisure and sightseeing, picking and popular science education in the region. The region would provide high-quality agricultural products and leisure places for "vegetable basket", "fruit plate" and "back garden" in Hainan, and construct green agricultural innovation economic circle by integrating talents, technology and finance.
5.2. Improving the policy guarantee system effective to the optimization of agricultural regional layout in Hainan

It would be done a good job in top-level design, established and improved the policy system, and adhered to a game of chess in the whole province.

On the basis of multiple planning into one, the land for regional advantage and characteristic industries would be given priority to the use, and the land utilization rate would be improved.

The industrial developing investment mechanism would be actively explored to promote the layout of advantageous industries in advantageous regions. Modern characteristic agriculture would be invested by raising funds through multiple channels and widely attracting social capital. Superiority characteristic agriculture in cities or counties would be increased financial investment, and reasonably and effectively integrated all kinds of agricultural funds at all levels to support.

The supporting policies would be made for the new agriculture managing body with regional characteristics.

It necessary to be formulated the policy that is "the implementation plan of the national preferential policies to support developing modern characteristic agriculture in different regions". The policy would be maked clear that developing planning projects of characteristic agricultural industry in each city or county, where is enjoying various policies stipulated by the state, such as agricultural support and protection subsidy policy, agricultural machinery purchase subsidy policy, soil testing formula fertilizer subsidy policy, characteristic agricultural garden vegetable and fruit tea standardization creation support policy, fertilizer, pesticide zero growth support policy, etc. The national policy of favorable agriculture would be fell into place.

It is necessary to improved the policy of talent flow, promoted talents flowing among regions, formed a joint force of talents, and promoted the efficiency of talent use.

At the same time, the important agenda of agricultural departments at all levels would be added content about optimizing the layout and structure of agricultural industry, so as to strengthen the interaction and contact among provinces, counties and agricultural departments within counties, ensure the scientfficity and operability of relevant policy planning and specific implementation plans, strengthen the connection and coordination of agricultural policies and plans at all levels in regional layout, clarify top-level design policy, guidance level policy and operation level policy, and optimize the regional layout of agriculture through multiple plans into one.

5.3. Implementing the preferential policies of Hainan free trade zone (port) and strengthening the capacity of two markets and two resources coordination

The policy would be implemented about “the implementation plan of financial and tax policies related to supporting the comprehensive deepening of reform and opening-up in Hainan Province”. Special support funds from the provincial finance would be allocated. The regional brand agricultural projects invested by industrial and commercial capital in line with the policy would be given priority to the loan of agricultural financing risk compensation fund, and enjoyed preferential tax and other aspects at the same time.

We would set up a fund to support the optimization of industrial regional distribution, and effectively solve the problems of difficult and expensive financing for the operators of modern characteristic agricultural projects when adjusting the distribution of agricultural industries. We would encourage and guide industrial and commercial capital investment, drive by large projects, invest in the construction of modern characteristic agricultural standard demonstration park, sharing farm, rural complex, etc.

We would gradually cancel or relax the restrictions on service trade of agricultural investment cross-border payment, natural person movement and other modes in appropriate agricultural fields, so as to improve the protection mechanism of agricultural investors' rights and interests. It is would be gradually canceled or relaxed the restrictions on service trade of agricultural investment cross-border payment, natural person movement and other modes in appropriate agricultural fields, and improved the
protection mechanism of agricultural investors' rights and interests. We would allow qualified overseas agricultural investors to freely transfer their legitimate investment income, and promote agriculture in Hainan to "go out" and "bring in". The modern characteristic agriculture in Hainan would be took financial support as an important measure and new growth point to promote cross regional and cross-border cooperation.

According to the characteristics and advantages of different counties or cities, the corresponding policy agricultural insurance should be adopted. Different financial subsidy policies should be implemented according to the relevant subsidy policies of the state for agricultural insurance premiums.

Diversified investment and financing would be promoted. The government plays a guiding role by investing a small part of funds in characteristic agriculture with development prospects, and provides supporting policy guarantees such as systems and laws to guide and drive more social capital to invest in regional characteristic agriculture, so as to enhance the enthusiasm and initiative of social capital to invest in regional characteristic agricultural projects.

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