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The Spatial Distribution and Income Increasing Effect of Geographical Indication Products in Guangdong Province Using GIS Technology

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Abstract: *This study is based on GIS (Geographic Information System) technology to analyze the spatial distribution and income increasing effects of geographical indication products in Guangdong Province. Through spatial analysis of the distribution characteristics, industrial features, and value-added benefits of geographical indication products in Guangdong Province, the agglomeration patterns and economic effects of geographical indication products in different regions were revealed. The research results indicate that geographical indication products in Guangdong Province are mainly concentrated in the Pearl River Delta Economic Zone and some mountainous areas, reflecting obvious regional distribution characteristics. Geographical indication products play a significant role in increasing farmers' income, promoting local economic growth, and advancing agricultural industrialization, especially in brand building and market expansion. However, the development of geographical indication products still faces problems such as uneven spatial layout and incomplete industrial chain. The study suggests that the government should strengthen measures such as optimizing regional layout, improving industrial chains, and increasing policy support to enhance the overall value-added benefits of geographical indication products and promote high-quality economic development in Guangdong Province.*

Keywords: *GIS technology, Geographical indication products, Spatial distribution, Income increasing effect, Guangdong Province*

1. Introduction

Geographical Indications (GI) refer to agricultural products or handicrafts that have specific geographical origins and are endowed with unique qualities due to their unique geographical environment, climate, soil, and other factors [1]. These products not only represent the culture and traditions of the region, but also play an important role in promoting local economy and enhancing brand value. In recent years, geographical indication products, as a special form of industry, have gradually become an important force in promoting local economic growth and increasing farmers' income. As one of the economically developed provinces in China, Guangdong Province has a wide variety of geographical indication products, covering multiple fields such as agriculture and handicrafts, with significant regional characteristics and strong market competitiveness.

With the development of information technology, especially the continuous maturity of geographic information system (GIS) technology, GIS has become an important tool for analyzing and studying the spatial distribution and economic benefits of geographical indication products. GIS technology, through the collection, processing, and analysis of spatial data, can intuitively display the distribution pattern of geographical indication products in a region, reveal their spatial agglomeration effects, and provide powerful data support and decision-making basis for policy makers, enterprises, and academia..

This study aims to explore the spatial distribution characteristics and income increasing effects of geographical indication products in Guangdong Province based on GIS technology. Through spatial analysis, this article not only aims to reveal the spatial distribution patterns of various geographical indication products in Guangdong Province, but also to analyze the actual effects of these products in promoting local economic growth and increasing farmers' income. Ultimately, this study aims to

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provide theoretical support and practical guidance for the industrialization of geographical indication products in Guangdong Province and other regions, in order to achieve optimal resource allocation and sustainable regional economic development.

2. Literature review

2.1 Definition and characteristics of GI products

Geographical Indications (GI) refer to products that rely on specific geographical environments, climate conditions, production technologies, and cultural traditions, and have unique quality or reputation. These types of products are usually closely related to specific geographic regions and are a comprehensive reflection of the natural conditions and cultural factors of that area. According to the definition of geographical indication by the World Trade Organization (WTO), a geographical indication is an identifier that indicates the origin of a commodity, and the quality or reputation of the commodity must benefit from the specificity of its geographical origin [2]. Geographical indication products not only help protect traditional production methods and handicrafts, but also enhance the value of local brands and increase market awareness of products. Geographical indication products have irreplaceable uniqueness, and their production process relies heavily on traditional techniques or specific processing methods. They also have high market added value and competitiveness, and can achieve high premiums through uniqueness. Therefore, geographical indications have become an important tool for enhancing the competitiveness of agricultural products in the market.

2.2 Application of GIS technology in agricultural and economic research

Geographic Information System (GIS), as a spatial data processing and analysis technology, has been widely applied in agricultural and economic research [3]. GIS can intuitively display the distribution characteristics and spatial correlations of geographical phenomena through the collection, processing, analysis, and visualization of spatial data, thereby providing scientific basis for regional development, land management, agricultural planning, and other fields. Especially in the research of geographical indication products, GIS can help analyze the spatial distribution, agglomeration effects, and influencing factors of different products. In the field of agriculture, GIS technology can help identify the optimal geographical area for the growth of a specific agricultural product [4]. For example, by analyzing factors such as soil type, climate conditions, precipitation, etc., GIS can provide scientific production guidance for farmers. For geographical indication products, GIS can also help determine the boundaries of their production areas, monitor the sources and circulation paths of geographical indication products, and avoid the occurrence of counterfeit and inferior products. In economic research, GIS can use spatial economic models to analyze the spatial distribution of economic activities in different regions and reveal the formation and development laws of industrial clusters [5]. Through spatial analysis of the geographical indication product industry, GIS can not only reveal the regional distribution pattern of the product, but also evaluate the impact of the product on local economic value-added, further providing data support for policy-making.

2.3 Relationship between GI products and economic benefits

Geographical indication products play a significant role in promoting local economic growth, job creation, increasing farmers' income, and industrial upgrading [6]. Firstly, geographical indication products drive industrial agglomeration effects, form local characteristic industrial chains, enhance economic output, and create a large number of employment opportunities. Secondly, by enhancing brand value and market recognition, these products can increase added value, thereby promoting local revenue growth. For example, well-known geographical indication products such as French champagne and Italian Parmesan cheese are competitive in the global market and drive local economic development through their unique quality and brand effect. Geographical indication products have also promoted agricultural structural adjustment and increased farmers' income. The market premium provides farmers with higher income, encourages scientific production methods, and improves agricultural production efficiency and product quality. This effect not only promotes agricultural modernization, but also provides opportunities for poverty-stricken areas to lift themselves out of poverty and become prosperous. Therefore, how to use GIS technology to analyze the spatial distribution and economic benefits of geographical indication products has become an important research topic.

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3. GIS spatial analysis methods and data processing

3.1 GIS technology fundamentals and spatial analysis methods

Geographic Information System (GIS) is a technology platform that can collect, store, manage, analyze, and display spatial data. It integrates knowledge from multiple disciplines such as computer science, geography, remote sensing technology, cartography, and spatial statistics, and is an important tool for spatial analysis and decision support. The application of GIS technology has greatly improved the scientificity and accuracy of decision-making in fields such as agriculture, environmental management, urban planning, and transportation. The spatial analysis method is the core part of GIS technology, which provides researchers with a visual representation of spatial phenomena and their interrelationships through the processing and analysis of spatial data.

The foundation of GIS technology includes data collection and input, storage and management, spatial analysis and modeling, as well as result display and visualization. In terms of spatial analysis, GIS technology can apply various methods, including buffer analysis, overlay analysis, spatial interpolation, hotspot analysis, and spatial autocorrelation analysis. Buffer zone analysis is widely used in the field of agriculture, especially in the analysis of the relationship between the production area of geographical indication products and the surrounding environment, by setting a certain distance range around spatial objects. It helps to determine the impact of protection zones or ecological zones on the quality of agricultural products and the ecological environment. Overlay analysis is the process of overlaying spatial data from multiple layers to analyze their spatial relationships and interactions. This helps identify optimal production conditions and regional patterns when studying geographical indication products. Spatial interpolation calculates the values of unknown areas based on known data points, and is commonly used for spatial distribution analysis of environmental factors such as soil quality, precipitation, and temperature. It can provide data support for optimizing the selection of geographical indication product production areas. Hotspot analysis helps researchers discover production concentration areas and analyze their economic and social reasons by identifying the spatial distribution pattern of a phenomenon. Spatial autocorrelation analysis studies the correlation of spatial data, revealing the mutual influence between different regions in terms of production methods, market demand, etc., thus providing scientific basis for the formulation of industrial policies and regional development strategies.

3.2 Data collection and processing

The core of GIS spatial analysis is high-quality spatial data, and data collection and processing are key in technical applications, directly affecting the accuracy and reliability of analysis results. The spatial analysis of geographical indication products involves a wide range of data sources, including geography, climate, soil, population, land use, transportation, and other fields. Data is usually obtained through remote sensing satellites, drones, GPS, and ground measurements. Remote sensing technology helps to obtain environmental and land use data, while GPS can accurately locate production locations. The rise of big data and open platforms has provided support for meteorology, soil quality, and market demand, further enriching GIS analysis. In addition, socio-economic data such as agricultural production, farmer income, industrial chain structure, and market circulation are crucial for understanding the production environment and market potential of geographical indication products. After data collection, data processing and cleaning must be carried out to ensure accuracy and consistency of the data. The processing steps include format conversion, missing value filling, outlier detection and correction, etc. Due to the complexity and multidimensionality of geographic information data, there are issues such as scale differences and spatial inconsistencies, which require operations such as coordinate system conversion, accuracy correction, and spatial resolution unification. Data cleaning also includes removing redundant data and correcting inaccurate data. For example, in remote sensing image processing, it is necessary to correct the impact of factors such as cloud cover and haze on the image; for farmland data, it is necessary to calibrate land use images from different years to ensure data timeliness. Integration and standardization are key to ensuring data consistency. Data from different sources (such as raster data and vector data) need to be formatted uniformly and aligned according to geographic location; Standardization ensures that the scale, accuracy, and timeliness of different data layers are consistent, avoiding analysis results bias caused by inconsistent data.

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3.3 Analysis of spatial distribution patterns

Spatial distribution pattern analysis is a core content in GIS applications, aiming to reveal the distribution patterns and influencing factors of research objects in geographic space. In the research of geographical indication products, spatial distribution pattern analysis can help researchers understand how geographical indication products in different regions present different distribution characteristics based on environmental, socio-economic, and cultural factors, thereby providing scientific basis for local economic policies, industrial development strategies, and market promotion.

The spatial distribution of geographical indication products shows a clear geographical concentration phenomenon, which is usually influenced by various factors such as geographical conditions, climate characteristics, soil types, and production technology. Through GIS spatial analysis, researchers can identify the distribution hotspots of geographical indication products, reveal which regions have the conditions to produce a specific product, and which regions have formed traditional production advantages due to natural conditions or historical and cultural reasons. Meanwhile, spatial clustering analysis can reveal the concentration of different geographical indication products in specific regions, analyze whether there is a clustering effect in product production, and help discover the formation mechanism of industrial clusters and their relationship with economic development. Some regions may have formed unique industrial clusters due to their historical and cultural background and the inheritance of production technology, thereby enhancing local brands and market competitiveness. In addition, spatial heterogeneity analysis reveals differences in environmental, socio-economic, and cultural aspects among different regions, which may lead to spatial imbalances in the production and sales of geographical indication products, affecting local economic and social development. Environmental factors, such as climate, soil, and terrain, are key factors affecting the spatial distribution of geographical indication products. Through spatial interpolation and multi factor analysis, GIS technology can evaluate the impact of these factors on product quality and distribution, helping to determine the optimal production area. By integrating these spatial analysis methods, GIS provides accurate data support for the research of geographical indication products, revealing their distribution patterns, optimizing production area selection, and promoting regional economic and industrial upgrading.

4. Spatial distribution characteristics of geographical indication products in Guangdong Province

4.1 Spatial distribution characteristics of geographical indication products

The spatial distribution of geographical indication products in Guangdong Province presents significant regional and diverse characteristics, mainly manifested as regional concentration, differences in resource endowment, historical and cultural factors, and the influence of economic and transportation conditions. The Pearl River Delta, with its superior natural conditions and profound historical and cultural resources, has become the main production base of geographical indication products, such as Zhuhai, Shantou, Guangzhou, Foshan and other places where the types and quantities of geographical indication products are prominent. The suitable climate in Huizhou, Shantou and other places in eastern Guangdong has made them the main production areas for fruits such as lychee and longan, while Qingyuan and Shaoguan in the north are gathering places for tea and medicinal herbs. In addition, historic handicrafts such as Dongguan woodcarving and Jieyang Chaozhou embroidery fully reflect the local cultural characteristics. The economically developed Pearl River Delta Economic Zone, due to its convenient transportation and high market demand, has made its geographical indication products more influential in the market. However, remote areas face certain limitations in the development of their geographical indication products due to inconvenient transportation and limited market radiation.

4.2 Agglomeration effect and spatial correlation analysis of geographical indication products

The spatial distribution of geographical indication products in Guangdong Province is influenced by multiple factors such as natural resources, cultural background, market demand, and industrial chain layout, exhibiting significant agglomeration effects and spatial correlations. Agglomeration effect refers to the advantages of resource sharing, information flow, and labor agglomeration brought about by the concentrated distribution of similar industries. As an economic center, the Pearl River Delta region has formed multiple industrial clusters of geographical indication products, such as Foshan ceramics and Zhaoqing Xijiang grapes. These clusters rely on a sound industrial chain and

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technological innovation to promote the improvement of production and processing efficiency, and promote the formation of brand effects. For example, Jieyang's longan has become a globally renowned brand through cluster planting. The agglomeration effect also promotes technology sharing and production process upgrading, enhancing industrial competitiveness. The spatial correlation analysis of geographical indication products reveals their interrelationships in natural, social, and economic networks. Many products are concentrated in production due to similar climate and soil conditions, such as tea in northern Guangdong, forming a market competitive advantage. The consumer demand in big cities such as Guangzhou and Shenzhen has driven production in surrounding areas and provided sales platforms. In addition, the handicrafts and cuisine in the Chaoshan region have gradually formed unique market characteristics with the help of regional culture. Policy support, especially within the cooperation framework of the Guangdong Hong Kong Macao Greater Bay Area, has further promoted the circulation and industrial linkage of geographical indication products. Overall, geographical indication products in Guangdong Province exhibit regional concentration and diversity in space, and agglomeration effects and spatial correlations play an important role in promoting industrial development, technological innovation, and market expansion, becoming the key to understanding their economic and cultural significance and regional coordinated development.

5. Analysis of the income increasing effect of GI products in Guangdong Province

5.1 Impact of GI products on local economy

Geographical indication products are not only representative of local characteristics, but also an important driving force for promoting local economic growth. They generate positive economic benefits by creating unique product value, promoting the formation and upgrading of the industrial chain, and increasing employment opportunities. Geographical indication products in Guangdong Province have played an important role in enhancing local economic vitality and promoting industrial transformation, manifested in several aspects. Firstly, these products have promoted the upgrading of local industrial structure by relying on unique geographical environment, climate conditions, and historical culture. For example, the "Shantou Chaoshan Crafts" in eastern Guangdong and the "Qingyuan Huangpi" in northern Guangdong have helped promote the development of local agriculture and handicrafts, and promoted the modernization of the agricultural industry and the transformation of production methods. Secondly, geographical indication products are often the core of the agricultural industry chain, giving rise to the development of related industries such as processing, logistics, packaging, and tourism. For example, "Yangjiang Cutting Tools" has formed a complete industrial chain through research and innovation, driving the all-round development of the local economy. In addition, the certification and protection of geographical indication products help enhance local brand image. Guangdong Province's "Nanhai Eel" has successfully shaped a high-quality market image through geographical indication protection, improved market competitiveness, and enhanced the discourse power of local economy. Finally, these products usually require high labor input, which drives employment and increases farmers' income, especially industries such as "Foshan Ceramics" and "Chaoshan Crafts" that absorb a large amount of local labor, improve the economic situation of farmers in remote areas, and raise their income levels.

5.2 Quantitative analysis of income increasing effect

In order to comprehensively evaluate the income increasing effect of geographical indication products in Guangdong Province, in addition to analyzing the overall economic impact, quantitative methods should also be used to measure their direct and indirect income increasing effects, mainly involving indicators such as output value, employment, and farmers' income growth. Firstly, the income increasing effect of geographical indication products is significant in terms of output value growth. For example, the "Shantou Litchi" in eastern Guangdong has achieved an average annual output value growth of over 10% under brand protection and market promotion. By comparing the data before and after certification, it can be seen that geographical indication certification has increased market prices, production volume, and sales revenue. Secondly, the industrial chain of geographical indication products is relatively long, covering agricultural planting, initial processing, deep processing, packaging, marketing and other links, which promotes the increase of employment opportunities. Under the promotion of geographical indication products, the ceramic industry in Foshan has absorbed a large number of workers and technicians, creating over 100000 job opportunities. In addition, geographical indication products have a particularly significant effect on increasing farmers' income.

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For example, after the certification of "Qingyuan Huangpi" in Qingyuan, the average annual price is more than 30% higher than non-standard Huangpi, which has driven a significant increase in farmers' income. Farmers who participate in production have an average annual income 20% -30% higher than those who do not participate. Finally, the promotion of geographical indication products not only promotes agricultural economy, but also drives local economic growth, especially under the brand building and market expansion of products such as "Yangjiang Cutting Tools", the region's foreign trade exports have grown, contributing nearly 100 million yuan in foreign exchange income to the local economy on an average year.

5.3 Case study: The income increasing effect of specific GI products

Yangjiang knives and Chaoshan handicrafts are representative geographical indication products in Guangdong Province, both of which have important market value and cultural significance. Yangjiang Cutting Tools has been developing since the 1970s. After obtaining geographical indication certification in 2006, brand building and market expansion have driven its annual growth rate to over 15%, with market prices 20% -30% higher. The industrialization process not only creates a large number of employment opportunities, but also drives the increase of income for surrounding farmers. Many people obtain stable income by participating in the production and sales of cutting tools. Chaoshan handicrafts, such as ceramics and carvings, have entered the domestic and international markets through geographical indication certification, with an output value growth of about 12% in the past five years. Especially with the increasing demand in the art market, prices have significantly increased. The handicraft industry chain is relatively long, involving design, production, and sales, providing a large number of employment opportunities for craftsmen and increasing the income level of practitioners. Overall, geographical indication products in Guangdong Province have significantly promoted local economic development and increased farmers' income by enhancing added value, extending the industrial chain, and creating employment opportunities. In the future, with further policy support and market demand growth, these products will provide stronger impetus for coordinated regional economic development and rural revitalization.

6. Policy recommendations for promoting the development of GI products in Guangdong

6.1 Strengthen the optimization of regional layout of GI products

In response to the uneven distribution of geographical indication products in Guangdong Province, the government should further optimize the layout of geographical indication products in the region and promote the rational allocation of resources. As the core area of economic development in Guangdong Province, the Pearl River Delta region can continue to strengthen the brand building and market promotion of geographical indication products; For some geographical indication products in mountainous and remote areas, special support policies should be formulated to encourage the production and marketing of local characteristic agricultural products, and to make up for the existing spatial imbalance.

6.2 Improve the industrial chain and promote upstream and downstream integration

The government should strengthen the integration of the industrial chain of geographical indication products, especially in agricultural product processing and brand promotion. By guiding enterprises to participate in the deep processing, packaging design, and logistics system construction of geographical indication products, we can promote the value-added effect of geographical indication products. Especially in terms of agricultural industrialization, the government can encourage agricultural enterprises to cooperate with local farmers, establish alliances or cooperatives, and jointly develop and promote industries related to geographical indication products. By extending and improving the industrial chain, not only has the added value of geographical indication products been increased, but more employment opportunities have also been provided for farmers.

6.3 Strengthen brand building and enhance market competitiveness

Brand building is an important way to enhance the market value of geographical indication products. Guangdong Province should increase its brand promotion efforts for geographical indication products, especially in domestic and international markets. The government can enhance the visibility and market

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influence of geographical indication products by organizing exhibitions, collaborating with e-commerce platforms, and other means. At the same time, a sound brand protection mechanism should be established to prevent the occurrence of counterfeit and inferior products and protect the interests of local farmers.

6.4 Increase policy support, provide funding and technical assistance

In order to promote the sustainable development of geographical indication products, the government needs to increase policy support for geographical indication products. Especially for some remote areas, the government can encourage farmers and enterprises to participate in the certification and promotion of geographical indication products through policies such as financial subsidies and tax reductions. In addition, the government should organize technical training and assistance to help farmers improve their production technology, further enhance product quality, and ensure that geographical indication products can continue to attract market demand.

6.5 Promoting agricultural tourism and diversified development

Geographical indication products are not limited to agricultural production, but can also expand their added value through agricultural tourism and other means. Guangdong Province can combine local characteristic geographical indication products to develop rural tourism, agricultural experience activities, etc., attract tourists to visit and consume, and promote the sales of geographical indication products and the development of the local economy. For example, certain geographical indication products with traditional characteristics, such as tea, fruits and vegetables, combined with local customs and natural landscapes, can form a complete tourism industry chain and further increase farmers' income.

6.6 Strengthen cross regional cooperation and experience sharing

Given the uneven development of different regions within Guangdong Province, the government should promote cross regional cooperation and experience sharing. For example, the Pearl River Delta region can share its experience in the marketization and brand building of geographical indication products with mountainous areas and other underdeveloped regions. By organizing regional forums, training courses, and other means, we aim to enhance the capabilities and awareness of local governments and farmers in the field of geographical indication products, and promote coordinated development between regions.

7. Conclusion

This study utilized Geographic Information System (GIS) technology to analyze the spatial distribution characteristics of Geographical Indication Products (GIs) in Guangdong Province and their impact on increasing farmers' income. Research has found that the distribution of geographical indication products in Guangdong Province exhibits significant regional characteristics, mainly concentrated in the Pearl River Delta region and some mountainous areas, influenced by natural resources, agricultural production history, and socio-economic conditions. The Pearl River Delta has become a production hub for multiple geographical indication products due to its developed agricultural economy and superior geographical conditions, while mountainous areas have formed characteristic products due to their unique climate and soil conditions. Geographical indication certification enhances the added value and market awareness of products, enabling farmers to sell at higher prices. The income of farmers in core areas is significantly higher than that in unverified areas, indicating that certification contributes to income growth. In addition, brand building and market expansion have enhanced the competitiveness of products, promoted the development of industries such as agricultural tourism and agricultural product processing, and formed a diversified industrial chain. However, there are problems with uneven spatial layout and incomplete industrial chain in the development of geographical indication products in Guangdong Province, and some areas lack effective market promotion and brand operation, resulting in resource waste. There is still room for improvement in the overall industrial chain, especially in the areas of deep processing and brand promotion. Policy support is crucial, and the government should introduce relevant support policies to strengthen brand building, market expansion, and industrial chain integration, promote the regionalization and branding of geographical indication products, and enhance economic benefits.

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