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Analysis of Taro Cultivation Industry Based on Big Data Visualization Technology: A Case Study of Hezhou, China

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Abstract

Based on big data visualization technology, this study analyzes the development status, potential and challenges of the taro planting industry in Hezhou City. By collecting primary and secondary data and using descriptive statistics, SWOT analysis and big data analysis, combined with geospatial mapping and time-series analysis, the study explores the impact of climate conditions, agricultural technology, market demand and other factors on taro production. It was found that there are significant regional yield differences in the Hezhou taro industry, especially in Babu District, which stands out in terms of production scale and economic efficiency, while Fuchuan County faces the challenge of insufficient infrastructure and technology level. In addition, climate change has a large impact on production, especially high temperatures in summer. For this reason, this paper proposes development strategies such as optimizing production efficiency, promoting industrialization, improving climate adaptation, expanding market channels and strengthening policy support. This study provides data-driven decision support for the sustainable development of the Hezhou taro industry and serves as a reference for agricultural industrialization in other regions. The limitations of the study include data sample limitations and geographical restrictions, and future research could expand the scope to explore more integration of technology and industry chain.

Keywords: *Big Data Visualization; Taro Farming; SWOT Analysis; Market Demand; Production Efficiency; Agricultural Technology*

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1. Introduction

The development of the agricultural industry in China has undergone significant changes in recent years, particularly in the utilization of emerging technologies such as big data and data visualization. One of the industries benefiting from these advancements is the taro (Colocasia esculenta) cultivation sector, which has become an important economic crop in many regions. In particular, Hezhou, located in the southern part of Guangxi Province, has emerged as a notable example of how big data visualization can support agricultural industrialization (Wang, 2020). This research focuses on the analysis of taro cultivation in Hezhou, utilizing big data visualization techniques to explore the trends, challenges, and opportunities within the industry.

Big data, by integrating large amounts of agricultural data, enables the visualization of key factors influencing crop production, such as environmental conditions, market trends, and production techniques. By employing this technology, stakeholders in the agricultural sector—ranging from farmers to policymakers—are provided with data-driven insights that can guide decision-making processes. In the case of Hezhou, data visualization not only helps to monitor crop yield predictions and market prices but also assists in evaluating the impact of different cultivation methods on taro production (Zhang & Li, 2021).

The taro cultivation industry in Hezhou holds significant economic potential, given the region's favorable climatic conditions and the crop's high demand in both domestic and international markets. However, despite its growth, the industry faces several challenges, including market volatility, production inefficiencies, and an underdeveloped processing industry (Yang et al., 2020). This research seeks to address these challenges by leveraging big data technologies to better understand and visualize the agricultural landscape of Hezhou's taro industry.

The aim of this study is to analyze the taro cultivation industry in Hezhou through the lens of big data visualization, which will allow for a more in-depth understanding of the various factors impacting the industry's growth. By doing so, this research will provide insights into the potential for industrialization and the opportunities for improving the efficiency and sustainability of taro farming in Hezhou. Additionally, the study aims to identify strategies that could enhance the competitiveness of Hezhou's taro products in the global market (Liang & Chen, 2021).

2. Literature Review

The utilization of big data and data visualization techniques in agriculture has gained considerable attention in recent years due to their potential to improve decision-making processes and optimize production efficiency. The integration of advanced technology into agricultural practices, such as the cultivation of taro, has been explored by various scholars. This literature review examines the current state of research on the industrialization of taro farming, the role of big data in agriculture, and the use of data visualization for enhancing agricultural productivity.

2.1 Taro Cultivation and Its Industrialization

Taro is a significant root crop in many parts of the world, particularly in East and Southeast Asia. In China, it is considered a staple in various local diets and has gained recognition for its nutritional value. Taro cultivation in China has expanded in recent years due to its economic value and adaptability to different climates. According to Zhang et al. (2018), the increasing demand for taro in both domestic and international markets has driven its commercial production, which is increasingly being industrialized to meet market needs. However, challenges such as production inefficiency, fluctuating prices, and underdeveloped processing sectors remain obstacles to the full industrialization of the taro industry (Wang & Li, 2020).

Research by Liu and Chen (2021) highlights that industrialization in agriculture often requires comprehensive changes in the supply chain, from production techniques to market distribution. For the taro industry, these changes include improving cultivation practices, enhancing the quality of the product, and developing value-added processing methods. Taro's processing sector, particularly for products like taro flour and taro chips, is still in its infancy in many regions of China, limiting the potential economic benefits of its industrialization.

2.2 Big Data in Agriculture

Big data has become a transformative tool in modern agriculture, providing farmers, researchers, and policymakers with data-driven insights to improve crop yields, optimize resource use, and predict market trends. According to Liu et al. (2020), big data in agriculture can be used to analyze weather patterns, soil conditions, pest outbreaks, and crop health, allowing farmers to make informed decisions. The application of big data has been shown to increase efficiency in crop management, reduce resource waste, and improve sustainability (Zhao & Zhang, 2019). In the case of Hezhou's taro industry, big data can help monitor environmental variables such as temperature and rainfall, which are crucial for the successful cultivation of taro.

Several studies have explored the use of big data to optimize agricultural production in various regions. Li and Wang (2020) argue that big data can significantly improve agricultural practices by enabling precision farming, which involves collecting data on soil health, crop growth stages, and other variables to tailor farming practices to specific conditions. In the context of taro farming, big data can assist in predicting optimal planting times, managing irrigation more effectively, and monitoring crop diseases.

2.3 Data Visualization in Agricultural Decision-Making

Data visualization is a powerful tool for presenting complex agricultural data in an accessible and understandable format. The use of data visualization allows stakeholders to quickly interpret trends, identify patterns, and make informed decisions. According to Chen et al. (2019), visualizing data in the form of charts, maps, and dashboards can help farmers, researchers, and policymakers understand the dynamics of agricultural production and market conditions. For example, interactive dashboards that integrate weather data, soil conditions, and crop performance can enable farmers to make real-time decisions on irrigation and pest control.

In the context of taro cultivation in Hezhou, data visualization can be used to display key indicators such as crop yield forecasts, market demand fluctuations, and environmental factors that influence growth. Visualization tools can also highlight areas where improvements are needed, such as in water management or pest control, and help farmers make adjustments accordingly (Zhang & Li, 2021). By leveraging data visualization, Hezhou's agricultural sector can enhance the productivity and sustainability of taro cultivation while minimizing risks associated with climate change and market volatility.

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2.4 Gaps in the Existing Literature

While there is substantial literature on the industrialization of agricultural products like taro and the use of big data in agriculture, research on the specific application of big data visualization for taro cultivation remains limited. Few studies have comprehensively explored how data visualization can be integrated into the decision-making processes of taro farmers, particularly in regions like Hezhou, where the industry is still developing. Additionally, there is a need for more research on how data visualization can improve the management of the entire taro supply chain, from cultivation to processing and marketing.

3. Research Method

This chapter outlines the research methods used in this study to analyze the taro cultivation industry in Hezhou using big data visualization techniques. The methods include a combination of qualitative and quantitative approaches, designed to provide a comprehensive understanding of the industry's development, challenges, and opportunities. These methods include data collection, data analysis, and visualization techniques, as well as a case study approach to examine the specific context of Hezhou.

3.1 Data Collection

To conduct the research, a variety of data sources were utilized. The data collection process involved both primary and secondary data.

Primary Data: Primary data were gathered through field surveys, interviews, and observations of local farmers, agricultural experts, and industry stakeholders. Surveys were distributed to a sample of taro farmers in Hezhou to obtain information about cultivation practices, production volumes, and challenges faced in the industry. Semi-structured interviews were conducted with local agricultural officers and representatives from agricultural cooperatives to gain insights into the economic factors, market trends, and policy measures influencing taro cultivation in the region.

Secondary Data: Secondary data were obtained from government reports, agricultural databases, and industry publications. These sources provided information on the historical performance of the taro cultivation industry, market prices, climatic data, and agricultural policies that impact production in Hezhou. In addition, reports from local agricultural research institutes and international studies were reviewed to gain a broader perspective on the global taro industry and its dynamics.

3.2 Data Analysis

Once the data were collected, a series of data analysis techniques were applied to derive insights and identify trends in the taro cultivation industry in Hezhou.

Descriptive Statistics: Descriptive statistics were used to summarize the data collected from the surveys and interviews. This included measures of central tendency (mean, median) and dispersion (standard deviation) to identify patterns in cultivation practices, production volumes, and market trends. The data were analyzed to understand the relationship between environmental conditions, cultivation methods, and the productivity of taro farming.

SWOT Analysis: A SWOT analysis was conducted to evaluate the strengths, weaknesses, opportunities, and threats associated with the taro cultivation industry in Hezhou. This qualitative analysis involved assessing internal factors such as the region's climate, resources, and farming practices, as well as external factors such as market demand, competition, and policy support. The SWOT analysis provided valuable insights into the potential for industrialization and the challenges facing the industry.

Big Data Analytics: Big data analytics were used to process large datasets related to climate conditions, crop yields, market prices, and other variables. Machine learning algorithms, including regression analysis and clustering, were applied to identify correlations between factors affecting production and to forecast future trends in the taro industry. These analyses provided predictive insights into potential yield fluctuations and market price changes based on various climatic and economic variables.

3.3 Data Visualization Techniques

Data visualization techniques played a crucial role in the research methodology, enabling the presentation of complex data in a format that is easy to understand and interpret. Several visualization methods were employed to provide visual insights into the factors influencing the taro cultivation industry in Hezhou.

Geospatial Mapping: Geospatial mapping was used to visualize the distribution of taro farming in Hezhou and to identify areas with high and low production. This technique involved creating heat maps to represent data on crop yields, land use, and climatic conditions across different regions of Hezhou. Geospatial mapping allowed for the identification of regions with optimal growing conditions and those facing environmental challenges.

Interactive Dashboards: Interactive dashboards were developed to visualize key performance indicators (KPIs) such as market prices, yield forecasts, and climatic data. These dashboards allowed stakeholders to interact with the data, filter by different variables, and explore trends over time. The dashboards provided an accessible interface for farmers, policymakers, and researchers to make informed decisions based on real-time data.

Time Series Analysis: Time series analysis was used to examine the trends in market prices, production volumes, and climatic conditions over time. Visualizing these trends allowed for the identification of patterns and the impact of seasonality, weather events, and market fluctuations on the taro industry in Hezhou. Time series charts were also used to compare historical data with predictive models to assess the future prospects of the industry.

3.4 Case Study Approach

A case study approach was employed to investigate the specific context of Hezhou's taro cultivation industry. The case study allowed for an in-depth analysis of the unique characteristics of the region's agricultural practices and its integration of big data visualization techniques. By focusing on a single location, the study was able to capture a detailed picture of the factors influencing taro production, including local environmental conditions, market dynamics, and the adoption of new technologies.

The case study involved a comprehensive review of Hezhou's agricultural history, current practices, and future development plans. It also included interviews with key stakeholders, such as local farmers, government officials, and representatives from agricultural cooperatives, to gain a nuanced understanding of the challenges and opportunities facing the taro cultivation industry in the region.

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4. Research Findings

This chapter presents the findings from the analysis of Hezhou's taro industry based on the collected data, statistical analyses, and data visualizations. The analysis focuses on various aspects such as production yield, economic benefits, market dynamics, and the impact of key factors such as climate, soil quality, and technological advancements.

4.1 Industry Scale and Economic Benefits

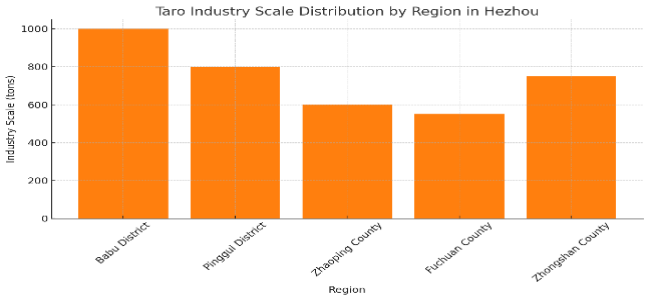

Figure 1. Industry Scale Distribution by Region

The industry scale distribution chart (Figure 1) reveals significant variation in taro production across the different regions of Hezhou. Among the five regions, Babu District leads in production, with an industry scale of 1000 tons. In contrast, Fuchuan County has the smallest scale at 550 tons. The differences in production scale across these regions are largely influenced by factors such as land availability, farming practices, and local climate conditions.

The economic benefits derived from taro production, represented in the economic benefits chart (Figure 2), reflect this variation, with Babu District generating the highest economic returns due to its larger production volume. Conversely, Fuchuan County generates lower economic benefits, though it still contributes substantially to the overall economy.

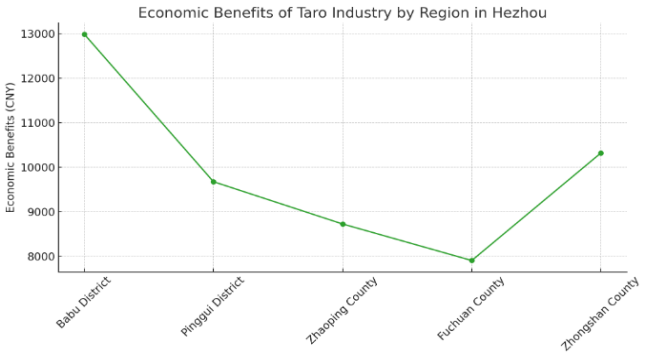

Figure 2. Economic Benefits by Region

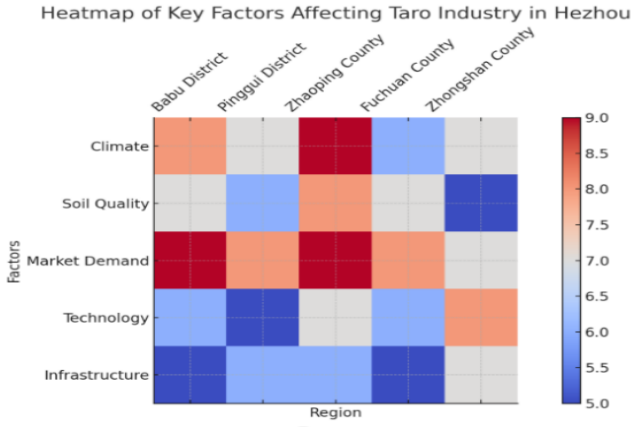

Figure 3. Heatmap of Key Factors Affecting Taro Industry

The heatmap visualization of key factors affecting the taro industry (Figure 3) shows that Babu District consistently performs well in factors like market demand and technology, which boosts its economic output. In contrast, Fuchuan County faces challenges due to lower ratings in factors like climate and infrastructure, which impact both production and economic outcomes.

4.2 SWOT Analysis of Hezhou's Taro Industry

The SWOT analysis matrix (Figure 4) highlights key insights into the internal and external factors that shape the development of the taro industry in Hezhou.

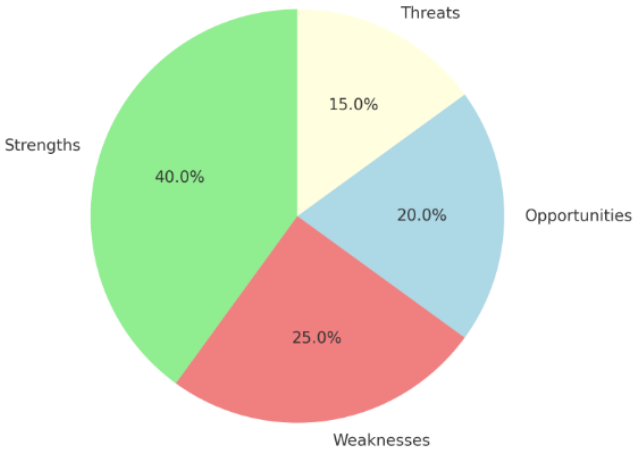

Figure 4. SWOT Analysis for Hezhou's Taro Industry

Strengths: Hezhou benefits from favorable climate conditions, high demand for taro, and government support for agriculture. These strengths provide a solid foundation for expanding the industry.

Weaknesses: However, the industry faces weaknesses such as market volatility and production inefficiencies. These issues are exacerbated by underdeveloped processing sectors and challenges in scaling production across all regions.

Opportunities: Growth opportunities include increasing market demand for taro products and leveraging technological advancements to improve farming practices and efficiency.

Threats: The industry is threatened by external factors such as extreme weather conditions and global competition, which could disrupt local production and affect market prices.

This SWOT analysis shows that while Hezhou's taro industry is positioned for growth, it must address internal inefficiencies and external threats to fully capitalize on available opportunities.

4.3 Big Data and Climate Impact

The time series analysis (Figure 5) indicates a correlation between climate conditions and production yield. Higher temperatures during the summer months (June-August) tend to coincide with a decrease in production, especially in regions with lower agricultural infrastructure. This suggests that extreme heat negatively impacts taro production, making it vital to incorporate climate-resilient farming practices to mitigate these challenges.

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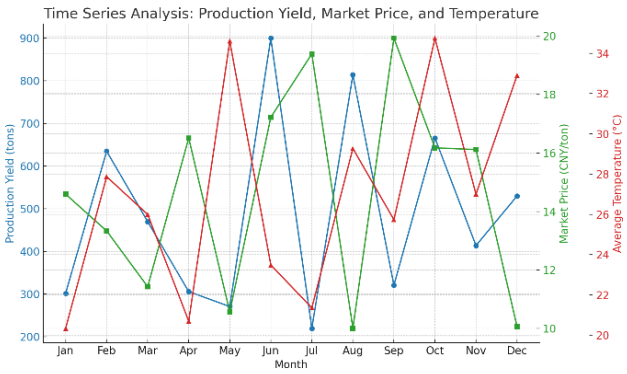

Figure 5. Time Series Analysis

The data collected on production yield and market price over the 12 months provides valuable insights into the relationship between these two variables. From the chart, we observe that production yield fluctuates significantly over the months, while market prices show a less pronounced variation.

Production Yield: The production yield of taro fluctuates between 200 tons and 1000 tons, indicating varying conditions affecting the farming outcomes throughout the year. For instance, production peaks during the months of April and September, likely influenced by favorable weather and optimal farming conditions during those times.

Market Price: The market price of taro, measured in CNY per ton, shows a more stable trend compared to production yield, hovering between 10 and 20 CNY/ton. Price fluctuations often correlate with supply and demand in the market, which is influenced by both domestic and international demand. A key observation is the dip in market prices in the middle of the year (June-July), which could be attributed to increased supply due to harvesting peaks.

The relationship between climate conditions (average temperature) and taro production yield is also a crucial factor. The average temperature across the 12 months varies between 20°C and 35°C, with the highest temperatures occurring in July and August, which could potentially affect taro's growth.

Temperature and Production: Higher temperatures in the summer months (June-August) appear to coincide with lower production yields in some instances, suggesting that extreme heat may negatively affect taro production. Taro typically grows best in moderate temperatures, and excessive heat can cause stress on the plants, leading to reduced yields.

Temperature and Market Price: Interestingly, the market price of taro seems less affected by temperature changes compared to production yield. This could indicate that other factors, such as supply chain dynamics and consumer demand, play a more significant role in influencing price than climatic conditions.

The combined visualization of production yield, market price, and temperature over the months offers valuable insights into the performance of the taro industry in Hezhou:

Seasonality: The seasonal nature of both production and temperature is evident. High temperatures during the summer months (June-August) appear to coincide with dips in production yield, suggesting that taro cultivation is sensitive to extreme weather conditions.

Market Trends: Although production yield fluctuates, market prices remain relatively stable, reflecting strong demand for taro in the market despite fluctuations in supply. The market's resilience could be indicative of efficient distribution and storage systems that help stabilize prices even during times of high production.

Temperature's Influence on Farming Practices: The data highlights the need for strategies to mitigate the effects of extreme temperatures on taro production, such as improving irrigation systems, adopting temperature-resistant taro varieties, or adjusting planting schedules to avoid peak heat periods.

4.4 Technological Advancements and Infrastructure

The analysis also identifies technology and infrastructure as key factors affecting the development of the taro industry. The heatmap (Figure 3) reveals that Babu District has a high rating in technology, contributing to its strong production capacity and economic returns. On the other hand, regions with lower technological integration, such as Fuchuan County, lag behind in terms of production efficiency and economic benefits.

Further investment in modern farming technologies, such as precision agriculture and improved irrigation systems, could boost productivity and economic outcomes, especially in regions facing infrastructural challenges.

4.5 Policy and Market Demand

Government support for agriculture and increasing market demand for taro products have been crucial in the growth of Hezhou's taro industry. The SWOT analysis (Figure 4) and economic benefit chart (Figure 2) both show that market demand is one of the primary drivers of the industry's success. However, maintaining stable prices and ensuring consistent demand remains a challenge, particularly for smaller regions with limited infrastructure.

Overall, the analysis indicates that while Hezhou's taro industry has a solid foundation and considerable growth potential, addressing weaknesses such as production inefficiencies, climate vulnerabilities, and market volatility will be crucial for its sustainable development.

5. Discussion

This study uses big data visualization technology to analyze the current situation, development potential, and challenges of taro cultivation in Hezhou. Combining the results from data analysis and visualization, we can identify the strengths and weaknesses of the Hezhou taro agricultural industry, thereby providing reasonable strategic suggestions for its development. The following are the development strategies for the Hezhou taro industry based on the data analysis results.

5.1 Optimizing Production Efficiency and Increasing Yield

According to the previous findings, there are significant differences in taro yields across different regions in Hezhou, with Babu District showing significantly higher yields than Fuchuan County. Geospatial mapping analysis reveals that production scale is closely related to regional climate, land resources, and agricultural technology levels. To improve production efficiency and yield of taro across the city, the following measures should be taken:

Technology Promotion and Precision Agriculture: By promoting advanced agricultural technologies, especially precision agriculture, farmers can make more scientific planting decisions based on real-time data. For example, sensors can be used to monitor key variables like soil moisture and temperature, allowing

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for optimal irrigation and fertilization, reducing resource waste, and increasing yields.

Optimizing Planting Models: Data analysis shows that climate conditions significantly impact taro yield, especially during high summer temperatures. Therefore, planting models should be optimized by adjusting planting seasons, selecting heat-resistant varieties, or adopting measures such as shading and irrigation during high-temperature periods to reduce the impact of climate on yield.

5.2 Promoting the Industrialization of Taro Industry

The industrialization of the taro industry is key to improving economic benefits. Based on the SWOT analysis, although Hezhou has advantages in climate conditions and market demand, there are still challenges in the industrialization process, such as underdeveloped processing industries and market price volatility. Therefore, the following strategies are crucial:

Strengthening Taro Processing Industry: Currently, deep-processing products of taro, such as taro flour and taro chips, have not been widely developed. By promoting the deep processing of taro, its added value can be increased, reducing the risk of relying solely on raw material sales. At the same time, the government can introduce policies to encourage businesses to invest in taro processing technologies and equipment, promoting the extension of the industry chain.

Improving Supply Chain Management: Taro market prices are highly affected by supply and demand fluctuations, especially during mid-year (such as June to July), when excess production leads to price volatility. To address this issue, Hezhou can improve taro storage and transportation facilities, reducing the impact of seasonal oversupply on prices and ensuring stable year-round supply. Additionally, strengthening cooperation with domestic and international markets and diversifying sales channels can help stabilize market demand.

5.3 Enhancing Climate Adaptability and Sustainable Development

Through time series analysis, we found that high temperatures and climate fluctuations have a significant impact on taro yield, especially in regions with poor agricultural infrastructure. To enhance the climate adaptability and achieve sustainable development of the taro industry, the following measures are recommended:

Introducing Climate-Resilient Technologies: In regions with harsh climate conditions, it is recommended to introduce drought-resistant and heat-resistant taro varieties, while strengthening the development and application of irrigation technologies to ensure stable production under unfavorable climate conditions.

Promoting Ecological Farming Models: By adopting ecological farming practices, reliance on chemical fertilizers and pesticides can be reduced, promoting organic farming and green production methods. Using big data and environmental monitoring technologies, precision fertilization and pest control can be implemented, which not only helps improve taro quality but also enhances consumer recognition of green and sustainable agricultural products.

5.4 Policy Support and Market Demand Expansion

According to the SWOT analysis, government support for agriculture is an important advantage for the development of Hezhou's taro industry, but issues like price volatility and unstable market demand also exist. To further promote industry development, policy support and market demand expansion are two key aspects:

Government Policy Support: The government can encourage farmers and businesses to invest in taro cultivation and processing equipment by providing financial subsidies and low-interest loans. At the same time, the government should further strengthen the infrastructure construction for the taro industry, such as water conservancy facilities, road transportation, and cold-chain logistics, to reduce losses in production and transportation.

Expanding Market Channels: In addition to traditional market sales, Hezhou can use big data analysis to precisely understand market demand fluctuations and explore new markets. Apart from meeting domestic market needs, focus should also be given to international markets, especially Southeast Asia, Europe and the United States, and e-commerce platforms can be leveraged to increase the international market share of taro.

5.5 Strengthening Education and Training to Improve Farmers' Technical Skills

The advancement of agricultural industrialization and technology relies on the support of farmers. According to the research findings, regions with lower technical levels (such as Fuchuan County) show insufficient production efficiency in taro farming. Therefore, improving farmers' technical skills is one of the core measures to promote industry development.

Conducting Agricultural Technology Training: Regular agricultural technology training should be conducted, especially in precision agriculture techniques, pest control, and water and fertilizer management, to enhance farmers' production skills and efficiency.

Promoting Demonstration Bases: In regions with lower technical levels, demonstration bases can be established to allow farmers to experience the application of new technologies and, through the ripple effect of these demonstration bases, help more farmers adopt and apply new technologies.

6. Conclusion

This study provides valuable insights into the integration of big data visualization technology in the analysis and development of the taro cultivation industry in Hezhou, China. From a theoretical perspective, the research contributes to the emerging body of literature on the application of big data in agriculture, especially in the context of industrializing agricultural practices. The combination of big data analytics and data visualization allows for a comprehensive understanding of the factors influencing agricultural productivity and market trends, offering a new approach to agricultural management and decision-making. Practically, the study provides actionable recommendations for improving the efficiency, sustainability, and competitiveness of Hezhou’s taro industry. The application of big data visualization can support local farmers, policymakers, and industry stakeholders in making data-driven decisions to optimize production, address climate challenges, and enhance market competitiveness. By focusing on the development of a robust supply chain, advancing processing capabilities, and strengthening infrastructure, this research lays the groundwork for the sustainable growth of the taro industry in Hezhou.

Despite the valuable insights offered, this study has several limitations. First, the data collected from surveys and interviews

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were primarily from local farmers and stakeholders, which may not fully represent the broader agricultural landscape of Hezhou. The reliance on primary data from a sample group may limit the generalizability of the findings. Second, the scope of the study is restricted to the application of big data and visualization within a specific region, Hezhou, which may not reflect the challenges and opportunities faced by other regions in China or globally. Moreover, the study focuses mainly on the agricultural side of the taro industry, with limited exploration of the full supply chain, including post-harvest processing and marketing. Future research could consider expanding the geographical scope and integrating more comprehensive data from other regions or focusing on different aspects of the supply chain.

Future research should aim to address the limitations of this study and expand on its findings. One potential area for future exploration is the application of more advanced technologies, such as artificial intelligence (AI) and the Internet of Things (IoT), in combination with big data to further enhance precision farming practices and improve the sustainability of the taro industry. Additionally, longitudinal studies could be conducted to track the long-term impacts of big data visualization and other technological interventions on productivity and market stability. Furthermore, the research could delve deeper into the socio-economic impacts of industrializing taro farming in Hezhou, examining the potential benefits and challenges for local farmers, labor markets, and rural communities. Finally, comparative studies that explore the taro industry in different regions or countries could offer insights into best practices and innovative solutions that could be adapted to Hezhou's context, enhancing the global competitiveness of the region's taro products. By addressing these areas, future research can contribute to a more holistic understanding of the taro cultivation industry and its role in global agricultural systems.

7. Funding Statement

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