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Revitalizing Bamboo Shoot Industry in Ninghai Mountainous Areas: Challenges and Strategic Practices

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Abstract This study analyzes the key challenges facing the bamboo shoot industry in Ninghai and uses the innovative practices of Ningbo Shanlixiang Agricultural Science and Technology Development Co., Ltd. as a case study to summarize its successful strategies for revitalizing the industry through resource integration, technological innovation, and industrial chain extension. The findings reveal that the company implemented various measures, such as establishing a bamboo shoot industry consortium, developing e-commerce and live-streaming sales platforms, and adopting initiatives like the ‘Bamboo Shoot Garden’ project and the ‘Bamboo-for-Bamboo’ model. These efforts effectively consolidated scattered bamboo forest resources, optimized sales channels, and significantly improved bamboo shoot yield and quality. Additionally, the company developed high-value-added bamboo shoot products and extended the industrial chain into high-end sectors such as eco-tourism. The successful practices of Fujian Province's bamboo shoot industry further underscore the critical role of policy support, technological innovation, and multi-stakeholder collaboration. This study proposes key strategies, including strengthening policy support, advancing technological innovation, diversifying product development, and fostering community collaboration, to serve as practical references for the sustainable development of the Ninghai bamboo shoot industry and other mountainous bamboo shoot industries.

Keywords Bamboo shoot industry; Resource utilization; Technological innovation; Policy support; Industrial chain extension; Eco-tourism

1 Introduction

Bamboo, often referred to as the “world’s second largest forest”, holds a unique and significant place in Chinese history and culture. From the description in the Song Dynasty’s *Ninghai County Ode*- “Bamboo thrives in music, strength, simplicity, and bitterness” -to physical bamboo relics unearthed at the Hemudu site in Yuyao dating back 7 000 years, bamboo has been deeply intertwined with China’s historical memory, embodying rich cultural significance (Pérez et al., 2014; Campbell, 2023). Beyond serving as a building material and a medium for artistic creation, bamboo is an essential component of Chinese culinary culture (Manandhar et al., 2019; Silva et al., 2020). Bamboo shoots, celebrated as a “delicacy among vegetables”, are prized for their unique aroma and nutritional value. In recent years, bamboo shoots have gained prominence as a green health food due to their benefits in weight loss, cholesterol reduction, and anti-aging (Dam et al., 2018; Nirmala et al., 2018). This combination of historical and functional significance makes bamboo an indispensable part of Chinese culture and daily life.

China boasts the world’s richest bamboo resources, with over 500 species, nearly half of the 1 200 species globally (Zhou et al., 2011). According to the national land survey, China’s bamboo forest area covers 7.0197 million hectares, ranking first in the world in bamboo forest area, stock volume, bamboo product output, and export value, earning the title of the “Bamboo Kingdom”. In the bamboo shoot industry, China has more than 200 edible bamboo species, with over 30 varieties renowned for their quality as food bamboo shoots (Sood et al., 2017).

In 2022, the country’s total bamboo shoot production reached 3.73 million tons, generating an output value of approximately 6 billion RMB. Additionally, China produces over 1.7 million tons of processed bamboo shoot

products annually, with over 1 million tons exported to Asian markets such as Japan and South Korea, and gradually penetrating European and American markets, showcasing a promising trend of globalization (Satya et al., 2010; Yuan, 2012).

The bamboo economy spans the primary, secondary, and tertiary sectors, offering broad development opportunities across multiple domains of the social economy (Mishra, 2015; Liu et al., 2018; Rathour et al., 2022). In provinces like Fujian, Sichuan, and Zhejiang, mature industrial chains for bamboo have been established. For instance, the total bamboo industry output value in Nanping City, Fujian, reached 44 billion RMB in 2022, while in Yibin City, Sichuan, it reached 35.3 billion RMB (Wang et al., 2010; Wu and Yu, 2012, Sichuan Forestry Science and Technology, 33(3): 112-114). Meanwhile, Anji County in Zhejiang, despite having less than 1% of the country's bamboo forest area, contributes over 5% of the national bamboo industry output value (Flynn et al., 2017). Through bamboo processing, innovative bamboo products, and bamboo forest ecotourism, these regions have fully exploited the potential of bamboo resources, creating significant economic and social benefits (Wang et al., 2021).

Despite the overall strong momentum of China's bamboo shoot industry, the bamboo shoot sector in the mountainous region of Ninghai has encountered difficulties. Of the county's 230 000 mu (15 333 hectares) of bamboo forests, 90% lie abandoned. Once a vibrant green industry that enriched local livelihoods, the bamboo shoot sector now struggles to survive. This study analyzes the main challenges faced by Ninghai's bamboo shoot industry and explores the 'breakthrough practices' of Ningbo Shanlixiang Agricultural Science and Technology Development Co., Ltd., summarizing its successful experiences to provide feasible strategies and recommendations for revitalizing Ninghai's bamboo shoot industry.

2 Major Challenges in the Bamboo Shoot Industry in Ninghai

2.1 Incomplete industry system

The bamboo shoot industry in Ninghai faces significant systemic deficiencies, particularly in the coordination of production, processing, and sales. Primary production remains inefficient due to traditional bamboo forest management practices, with most bamboo forests left untended, resulting in low productivity. Bamboo shoot harvesting is labor-intensive, and the shortage of labor, especially amid rural-to-urban migration, leaves elderly and female residents unable to handle the workload. Furthermore, poor mountain transportation conditions and high logistics costs further constrain industry development (Zhang et al., 2021). In the secondary sector, a lack of leading enterprises has resulted in a reliance on small-scale family workshops for bamboo shoot processing (Figure 1). These operations often produce semi-finished products with inconsistent quality, lacking standardized food testing and quality management. Such disorganized practices severely limit the market competitiveness and added value of bamboo shoot products. The tertiary sector is underdeveloped, with high-value activities such as eco-tourism and leisure tourism associated with the bamboo shoot industry yet to materialize. Bamboo cultural products also lack regional characteristics and cultural depth, failing to attract consumer interest. This lack of integration across the primary, secondary, and tertiary sectors significantly hampers the overall development of the bamboo shoot industry.

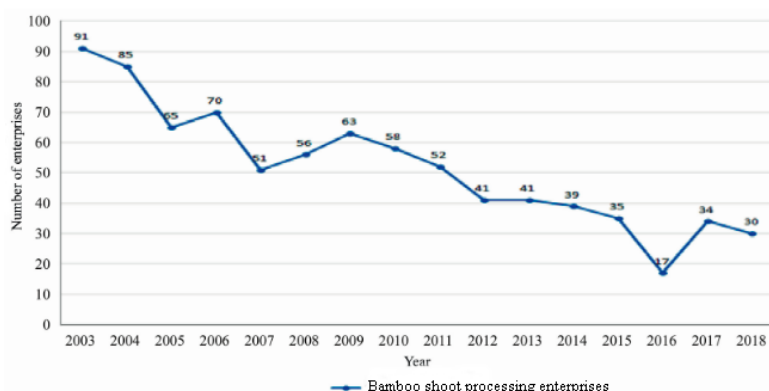


Figure 1 The number of bamboo shoot processing enterprise in Ningbo (Adopted from Zhang et al., 2021)

2.2 Low resource utilization rate

Despite Ninghai County's 230 000 mu (15 333 hectares) of bamboo forests, accounting for 14.8% of its total forested area, the utilization rate of bamboo resources is less than 30%. The use of bamboo resources remains limited to the basic sale of raw materials and fresh shoots, failing to unlock the potential of bamboo shoots in food, medicine, and construction sectors. The industry is stuck in a low-end development cycle. Bamboo forest management is fragmented, lacking unified planning and large-scale operations. Over the past two decades, declining market demand has led farmers to lose enthusiasm for managing bamboo forests, resulting in aging forests. Additionally, authorities have been unable to effectively facilitate land circulation and consolidation, with delayed adoption of advanced technologies and high-yield forest cultivation methods. Resource wastage is a significant issue. Farmers typically focus on harvesting high-quality winter shoots, spring shoots, and whip shoots for economic gain, leaving other varieties underutilized (Zhang et al., 2021). Similarly, in the bamboo processing sector, limited market demand leads to the selection of only premium bamboo, while other materials remain unused, further exacerbating resource waste (Lin et al., 2018).

2.3 Monotonous business model

The bamboo shoot industry in Ninghai lacks innovation and diversity in its business model, particularly in planting, processing, and sales. Planting practices are restricted to traditional natural growth methods, with insufficient development of the under-forest economy. Dense bamboo forests lack selective harvesting and rational management, resulting in stagnant forest productivity. Processing activities remain focused on primary products, such as dried shoots and salted shoots, which have low added value (Zhang et al., 2021). The development of higher-end products, such as canned bamboo shoots and bamboo shoot beverages, has yet to begin, with even basic industrialization conditions lacking. Sales channels are traditional and limited, with most fresh shoots sold through door-to-door purchases or wholesale markets. This “wait-and-see” sales approach fails to meet modern market demands and hampers market expansion and brand development (Lu et al., 2018).

2.4 Insufficient policy support

A lack of strong policy support is a critical factor in the challenges faced by Ninghai's bamboo shoot industry. Policy implementation has failed to fully exploit the industry's potential, with insufficient systematic research and planning by relevant authorities leading to ineffective support measures (Zhang et al., 2021). Funding shortages exacerbate the problem. While afforestation funds are relatively sufficient, subsequent maintenance and cultivation funding are severely lacking, hindering bamboo forest productivity and preventing the establishment of high-efficiency bamboo shoot bases. The social service system is underdeveloped, leaving farmers without access to scientific training in bamboo shoot cultivation and processing or standardized product processing guidelines. Limited market guidance further prevents farmers from adapting to modern consumer demands, restricting the sustainable development of the bamboo shoot industry.

3 Innovative Practices for Revitalizing the Bamboo Shoot Industry in the Mountainous Areas of Ninghai

3.1 Optimizing the industrial environment

Bamboo forests, as critical ecological barriers, symbolize “lucid waters and lush mountains” and serve as pathways to achieving “gold and silver mountains”. Against this backdrop, Shanlixiang Company has played a leading role in optimizing the bamboo shoot industry's overall environment in Ninghai. The company established a bamboo shoot industry consortium to integrate bamboo forest resources, transferring a significant amount of bamboo forest land to lay the foundation for large-scale operations. To address long-standing sales challenges, the company consolidated scattered resources and created an efficient sales platform. This platform not only helped villagers handle surplus dried bamboo shoots but also opened modern sales channels through e-commerce and live-streaming platforms, ensuring the efficient flow of bamboo shoot products. In 2023, e-commerce live streams helped the company generate over 8 million RMB from spring bamboo shoots and 5 million RMB from processed bamboo shoot products (Yu et al., 2007). Additionally, the company initiated skill training programs in partnership with Huangtan Town, offering bamboo shoot cultivation and processing courses to over 2 000 participants. These programs enhanced local villagers' technical expertise, supported over 120 entrepreneurial ventures, and created

employment opportunities for more than 1 000 residents. By establishing local standards for product processing and standardizing industry procedures, the company significantly improved product quality, laying a solid foundation for industry development.

3.2 Strengthening the industrial foundation

To awaken dormant bamboo forest resources, Shanlixiang Company implemented a series of technological innovations. The company collaborated with multiple agricultural cooperatives and family farms, collectively developing 10 635 mu of bamboo forest through land transfer. This large-scale land consolidation promoted efficient bamboo resource utilization, enabling farmers to share in the “ecological dividends”. A key initiative, the “Bamboo Shoot Garden” project, involved selecting and removing aging bamboo, adjusting bamboo forest density, and optimizing bamboo growth environments. The project also included soil tillage, the application of organic fertilizers, and the installation of drip irrigation systems, effectively improving the quality and yield of bamboo shoots (Yu et al., 2007). Additionally, the company constructed a 2 346-meter-long rail transportation system, significantly enhancing logistics in mountainous areas and reducing bamboo shoot transportation costs. The company also proposed a “bamboo-for-bamboo” circular utilization model, turning weeds and discarded bamboo materials into organic fertilizers to improve soil fertility. Moreover, the company experimented with growing mushrooms and other under-forest crops, maximizing the use of under-forest resources and achieving diversified operations.

3.3 Perfecting the industrial system

Shanlixiang Company aims to establish an integrated production-to-sales operational model to enhance the bamboo shoot industry's value chain. In collaboration with enterprises in Fujian Province, the company developed ready-to-eat bamboo shoot dishes and extended the freshness period of spring bamboo shoots to 25 days using cold chain technology. In 2023, this initiative resulted in sales exceeding 2 000 tons and a production value of 11 million RMB. The company combined traditional craftsmanship with modern technology to produce safe and authentic bamboo shoot products. It also developed bamboo charcoal and bamboo cake fuel products, converting bamboo remnants and shells into organic fertilizers, thus forming a sustainable resource recycling system (Yu et al., 2007). To further encourage farmer participation, the company provided bamboo shoot drying and refrigeration equipment and invented machines for peeling and cutting bamboo shoots, significantly improving processing efficiency. These machines have been certified with national patents. The company has actively explored the integration of the tertiary sector. Leveraging Ninghai's rich ecological bamboo forest resources, it developed demonstration bases combining bamboo shoot production with experiential tourism. Featured tourism projects, such as bamboo shoot picking and tea garden tours in Huangnikeng Mountain, were introduced, along with scenic attractions like observation decks and windmill mountains, successfully drawing numerous visitors. These efforts infused new vitality into the bamboo shoot industry. Shanlixiang Company's practices demonstrate that technological innovation, resource integration, and value chain extension are key pathways for revitalizing Ninghai's bamboo shoot industry. These innovative measures not only activated bamboo forest resources but also brought economic benefits to farmers, achieving a win-win situation for both ecological and economic outcomes.

4 Case Analysis of Bamboo Shoot Industry Development

4.1 Successful experience of the bamboo shoot industry in Fujian province

The bamboo shoot industry in Fujian Province serves as a national model, offering valuable insights for revitalizing the bamboo shoot industry in Ninghai. Fujian has established a comprehensive bamboo shoot industry system through government support, industrial chain integration, and technological innovation. The province prioritizes policy support, providing financial, technical, and market assistance to bamboo shoot production and processing enterprises, which has significantly enhanced resource utilization and industrial diversification. For example, special funds have been allocated for transforming low-yield bamboo forests and cultivating high-yield forests, greatly improving the yield and quality of bamboo shoots. Fujian leverages the leading role of key enterprises to drive vertical integration across the industry chain, covering bamboo forest cultivation, bamboo shoot harvesting, and deep-processing product development. Its product range includes high-value-added items such as canned bamboo shoots, bamboo shoot products, and bamboo juice beverages, marketed domestically and

internationally under branding strategies (Liu et al., 2018; Wang, 2018). In 2022, Fujian's bamboo industry achieved a total output value of 44 billion RMB, employing 600 000 people and showcasing the advantages of large-scale operations. Additionally, Fujian has extended the bamboo shoot industry into cultural tourism by developing activities such as bamboo shoot harvesting experiences and bamboo forest sightseeing, infusing the industry with cultural and tourism value to maximize bamboo resource benefits.

4.2 Bamboo forest ecotourism in Ninghai

The integration of the tertiary sector in Ninghai's bamboo shoot industry is also reflected in the exploration of bamboo forest ecotourism. Shanlixiang Company has established a bamboo forest ecotourism demonstration base in Zhongyangshan Village, Huangtan Town, combining bamboo forest resources with tourism to create unique bamboo shoot harvesting experiences. Known for its large, tender, and sweet bamboo shoots, Zhongyangshan Village has become a popular destination thanks to the company's efforts to transform bamboo forests into "internet-famous" tourist spots, attracting visitors to experience the joy of harvesting bamboo shoots. The company also converted nearby tea gardens into pick-your-own tourist attractions, enriching tourism offerings. Additionally, the base features scenic facilities such as viewing platforms and windmill clusters, with comprehensive upgrades to roads and waterways to enhance visitor experiences. This bamboo forest ecotourism model not only injects new momentum into the bamboo shoot industry but also drives local economic development (Weng et al., 2015; Wang, 2023). By tapping into the cultural and ecological value of bamboo forest resources, Ninghai's mountainous areas are gradually forming a new industrial pattern centered on bamboo shoots, integrating sightseeing, leisure, and agricultural production, embodying the concept that "ecology itself is value".

5 Strategies for Sustainable Development

5.1 Policy and financial support

Sustainable development of Ninghai's bamboo shoot industry requires integrated strategies encompassing policy, technology, and community collaboration. Government policy support and financial investment form the foundation for revitalizing the industry (Monaco and Shao, 2022). Enhanced policy measures should designate the bamboo shoot industry as a priority for local economic development, with specific plans outlining goals and implementation pathways. For example, policies should promote the transformation of low-yield bamboo forests and the cultivation of high-yield bamboo forests to improve production efficiency and quality. Special funds should support the entire industry chain, with fiscal resources allocated to bamboo shoot harvesting, processing technology upgrades, and market expansion. For instance, subsidies for equipment procurement in harvesting, encouragement of high-value-added product development in processing, and financial support for e-commerce platforms and logistics systems in sales can boost the industry's growth. Introducing carbon trading mechanisms to monetize the ecological benefits of bamboo forests can further enhance the competitiveness of the bamboo shoot industry. Effective monitoring and enforcement of policy implementation are crucial to ensure that funds and resources are directed to industry development. Additionally, establishing a robust social service system to provide technical guidance, market information, and legal support to farmers can help them integrate better into modern industry chains (Chan and Flynn, 2018).

5.2 Technology and innovation-driven development

Technology and innovation are core drivers for revitalizing Ninghai's bamboo shoot industry. Scientific bamboo forest management should be prioritized, with projects such as the "Bamboo Shoot Garden" initiative expanded and implemented. For example, digitalization and intelligent bamboo shoot cultivation can be achieved through smart irrigation systems, precise fertilization technologies, and bamboo forest health monitoring devices, significantly improving yield and quality (Guo, 2022). Advancing bamboo shoot processing technologies and expanding product varieties and value-added offerings are also critical. Enterprises should be encouraged to develop high-value-added products such as canned bamboo shoots, bamboo juice beverages, and bamboo fiber-based foods, along with byproducts like bamboo charcoal and bamboo cakes, to maximize resource utilization (Tariga, 2020; Borowski, 2021). Moreover, adopting food safety technologies and establishing standardized bamboo shoot product systems can ensure quality and market competitiveness. Innovations in sales models should leverage big data, artificial intelligence, and blockchain technologies to build efficient supply

chains from harvest to sale. For example, promoting live-stream sales and deepening collaboration with e-commerce platforms can expand domestic and international markets, enabling the scaled and diversified growth of Ninghai's bamboo shoot brand.

5.3 Community and stakeholder collaboration

Collaboration among communities and stakeholders is crucial for the development of the bamboo shoot industry. A cooperative mechanism among farmers, enterprises, and governments should be established to ensure fair distribution of benefits. The government can take the lead in forming bamboo shoot industry cooperatives or alliances, encouraging farmers to contribute resources such as land and labor as equity, with enterprises providing technical support and market expansion, fostering a win-win outcome. Enhancing community participation and enthusiasm is key (Flynn et al., 2017; Ekawati et al., 2023). For example, organizing technical training and demonstration activities can improve villagers' bamboo shoot cultivation skills, while offering entrepreneurial support can attract young people to return to rural areas and engage in the bamboo shoot industry. This approach addresses labor shortages in rural areas while advancing rural revitalization. Integrating the bamboo shoot industry with cultural and tourism activities can further amplify the community's role in ecological conservation and cultural heritage preservation. Projects such as bamboo shoot harvesting experiences and bamboo forest ecotours enable local residents to directly benefit from the tertiary sector, fostering a sense of ownership and active participation in bamboo forest resource protection.

6 Concluding Remarks

The bamboo shoot industry in the mountainous regions of Ninghai was once a key driver of local economic growth. However, issues such as an underdeveloped industrial system, low resource utilization, a lack of diversified business models, and insufficient policy support have led to its decline. Through in-depth analysis, this study has identified the major challenges and highlighted the innovative practices of Ningbo Shanlixiang Agricultural Science and Technology Development Co., Ltd. as a valuable reference for revitalizing the Ninghai bamboo shoot industry. On the industrial environment front, the company established a bamboo shoot industry consortium, built e-commerce sales platforms, and organized training programs, thereby improving infrastructure and expanding market channels. In terms of strengthening the industrial foundation, initiatives such as the "Bamboo Shoot Garden" project and the "Bamboo Nourishes Bamboo" model enhanced both yield and quality. Additionally, advancements in product processing technology, cold chain logistics, and extended industry chains added value and market competitiveness. The successful practices in Fujian's bamboo shoot industry and Shanlixiang's case study underscore the critical importance of policy support, technological innovation, and multi-stakeholder collaboration, providing clear direction for future development.

Looking forward to the future, the development of Ninghai bamboo shoot industry still needs to continue to make efforts in the following aspects. The implementation of policies and resource integration should be further promoted. The government needs to strengthen the top-level design, optimize capital investment and support, and promote the large-scale management of bamboo forest resources. Through new mechanisms such as carbon sink trading, the ecological benefits of bamboo forests will be organically combined with economic benefits to help the green development of bamboo shoot industry. Focus on technological innovation and diversified product development. Through the introduction of intelligent management technology, the precision and high efficiency of bamboo plantation can be realized. Increase research and development investment, develop more high value-added bamboo shoots products, and expand the application space of bamboo shoots in food, medicine and environmental protection materials.

It is necessary to strengthen the integration of bamboo shoot industry and cultural tourism, and create the brand of "bamboo culture + bamboo industry". For example, the development of bamboo shoot picking, bamboo forest hiking and other special tourism projects, enhance the comprehensive benefits of bamboo forest resources, and form a positive interaction between industrial economy and local culture. Attach importance to community collaboration and talent training. Through multi-party cooperation, a community of farmers, enterprises and governments should be built to ensure fair distribution of benefits. At the same time, it will attract young talents to

return home and start businesses, and promote the bamboo shoot industry to develop in the direction of specialization and scale. In the future, Ninghai bamboo shoot industry is expected to achieve sustainable development under the joint action of policy support, technological innovation and multi-party cooperation, which will not only promote local economic prosperity, but also provide valuable experience for the revitalization of bamboo shoot industry in similar mountainous areas across the country, writing a new chapter in green development and rural revitalization.

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Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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