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Modernization through the BCG Model: Rice Industry in Circular Economy

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Abstract

This study investigates the potential integration of the BCG Model and innovative practices into Thailand's rice supply chain. The BCG Model, renowned for its versatility across industries, offers a promising framework for enhancing efficiency and sustainability in rice production. Through the adoption of innovative strategies such as precision agriculture and value-added product development, this study aims to optimize resource utilization, reduce production costs, and enhance the value proposition of Thai rice products. By examining stakeholder engagement, technological adoption, and market dynamics, this study seeks to delineate actionable strategies for effectively implementing the BCG Model and fostering innovation within Thailand's rice supply chain. The findings contribute to the discourse on sustainable agricultural practices, offering insights for policymakers, industry stakeholders, and researchers who seek to promote economic growth and environmental stewardship in the rice industry. This study underscores the importance of combining cutting-edge methodologies with traditional practices to achieve a balanced approach to rice production that can address both economic and environmental concerns. Through collaborative efforts and strategic initiatives, Thailand can position itself as a leader in sustainable rice production, driving positive change within the global agricultural landscape.

Keywords: *BCG Model, Rice Supply Chain, Sustainable Development, Circular Economy*

1. Introduction

The connection between Thai people and rice is longstanding. Thailand's rice production plays a crucial role in its economy. Out of approximately 146 rice producing countries in the world, the top rice producers and exporters are in Asia (FAO, 2023). The People's Republic of China is the world's largest rice producer, contributing 27% of global rice production, followed by India (25.3%), Bangladesh (7%), Indonesia (6.7%), Vietnam (5.2%), and Thailand which ranks sixth at 4.4% (FAO, 2023). In China, 29% of rice production is consumed domestically, in India at 21.4%, while in Bangladesh almost all is consumed domestically. In terms of export value, India is the largest contributor to global rice exports at 38.8%, followed by Thailand at 13.5%.

During the period from 2023 to 2024, Thailand experienced a decline in rice production. This decline can be attributed to several factors. One factor was the adverse effects of El Niño on weather patterns, resulting in diminished rainfall and water levels in reservoirs. Additionally, the persistently high cost of cultivation poses a significant challenge to farmers, despite ongoing government supports. Nevertheless, there are indications of potential improvement in domestic rice consumption as the service and tourism industries, encompassing restaurants, hotels, and related sectors, gradually recover from the impacts of the COVID-19 pandemic. Furthermore, there is an optimistic sign of expanded exports post-pandemic, driven by the expected recovery of purchasing power and ongoing concerns about food security stemming from the protracted Russia-Ukraine conflict. Simultaneously, the price of Thai rice is projected to increase due to the anticipated reduction in production and the sustained rise in global demand. However, Thai farmers and exporters continue to face tough competition from key competitors such as India and Vietnam, particularly in terms of pricing, given that Thai rice generally commands higher selling prices compared to rice from other exporting countries (Wisalaporn, & Sripruetkiat, 2023).

Major concerns and issues experienced by relevant stakeholders regarding the domestic and international rice production and sales chain can be summarized as follows: 1) Farmers: Despite the government's continuous

support, farmers are still grappling with weather fluctuations and declining water levels, leading to high production costs; 2) Rice Mills: There's a decline in output, leading to limited profitability and intense competition, particularly from large and comprehensive rice mills; 3) Bagged Rice Producers: They are experiencing a trend towards increased income, yet facing stiff competition in the market; 4) Traditional Rice Retailers: They are facing fierce competition and constrained profitability; 5) Rice Exporters: Thailand's rice export volume is on the rise, indicating heightened global competition; and 6) Granary Operators: They are witnessing a decline in income amidst intense competition.

The aforesaid concerned and issues have led to a decline in the competitiveness of Thai rice production and exports. Consequently, the government has introduced the concept of circular economy (Bio Economy, Circular Economy, Green Economy: BCG Model) as a strategic driver for the overall agricultural sector in a country where rice holds significant economic importance. As part of this initiative, modern rice production concepts like the "Rice Saves the World Project" or BCG Model are being promoted to reduce costs, foster environmental sustainability, and restore balance to ecosystems. This concept was highlighted at the APEC meeting hosted by Thailand in 2022, (National News Bureau of Thailand, 2022) emphasizing holistic economic development aimed at advancing three economies simultaneously. The bioeconomy, focusing on leveraging biological resources to create added value, prioritizes the development of high-value products. Linked to this is the circular economy, which aims to maximize the reuse of materials. According to the BCG Model, both economies operate within the framework of the Green Economy, which advocates for balanced economic, social, and environmental development to ensure stability and sustainability. By harnessing Thailand's biological and cultural diversity, innovative competition is encouraged to cultivate the BCG Model for global competition. This strategy aims to distribute income within communities, reduce inequality, foster strong community bonds, and promote environmentally friendly and sustainable development (Chutipat, Sonsuphap, & Pintong, 2023; Intapan, & Chaiboonsri, 2023; Sirilertworakul, 2021).

The BCG Model involves four strategic sectors: agriculture and food, health and medicine, energy, materials and biological chemistry, as well as tourism and the creative economy which currently contribute approximately 3.4 trillion baht, or 21 percent, to the GDP. Projections indicate that within the next five years, this contribution would increase to 4.4 trillion baht, marking an annual growth of 200 billion baht. Moreover, it aims to elevate the employment rate from the current 16.5 million to 20 million, generating numerous job opportunities. This expansion will facilitate income redistribution across the public sector and middle-class segments, ultimately alleviating poverty and driving sustained economic advancement in Thailand (National Science and Technology Development Agency, 2021). The study is centered on implementing the circular economy concept, as encapsulated in the BCG Model, within Thailand's rice production chain. This initiative is geared towards enhancing the country's competitiveness in rice production.

1.1 Literature review

The central focus of this study is the BCG Model, which integrates the principles of circular economy and green economy (Bio – Circular – Green Economy: BCG Model), providing an economic framework for sustainable development. Aligned with the Sustainable Development Goals (SDGs) and reflective of the Sufficiency Economy Philosophy (SEP), a national priority in Thailand, the philosophy of Sufficiency Economy paves the way towards the "BCG Model." This model integrates three key economies: bioeconomy, circular economy, and green economy, leveraging science, technology, and innovation to drive sustainable development in Thailand (Edyvean et al., 2023). The bioeconomy encompasses a wide array of elements including biomass, biological processes, renewable biological resources, biotechnology businesses, and energy industries. It is primarily driven by advances in both social and economic realms, with a strong emphasis on fostering sustainable, long-term growth (Bröring, Laibach, & Wustmans, 2020). In the circular economy paradigm, the focus is placed on optimizing resource utilization, enhancing manufacturing efficiency, and extending the lifespan of goods, materials, and resources through effective recycling and waste reduction practices. This approach leverages scientific or semi-scientific principles to accomplish its objectives (Carus, & Dammer, 2018; Corvellec, Stowell, & Johansson, 2022; Kardung et al., 2021; Marsh, Velenturf, & Bernal, 2022; Stegmann, Londo, & Junginger, 2020). The green economy emerges as a pivotal strategy for mitigating adverse environmental impacts by promoting the prudent and responsible use of finite resources. Integral to its success is the establishment of key metrics to monitor resource consumption and waste emissions. Aligned with the Sustainable Development Goals

(SDGs), the green economy facilitates the transition towards low-carbon, resource-efficient economies, thereby fostering holistic sustainability (Khoshnava et al., 2019; Phurksaphanrat, & Panjavongroj, 2023).

The concept of bioeconomy traces back to the 1960s when the utilization of biological resources to stimulate economic growth was emphasized. Presently, there is a shift towards leveraging knowledge and innovation to extract added value from biological resources. The circular economy dimension, introduced by Blomsma, and Brennan (2017), initially focused on managing leftover materials, resources, and production waste. Currently, it extends to recycling consumer waste, fostering a continuous cycle devoid of waste and addressing environmental challenges and ecological deficits. The above concepts have catalyzed the emergence of green economy and sustainable development. Concerns about the ecological and environmental impacts of chemical usage since the mid-1960s led to the United Nations Conference on Environmental Conservation in 1972 and the establishment of the United Nations Environment Program (UNEP) in the same year. These initiatives stimulated the development of the green economy and sustainable development concepts. UNEP's publication, *Rethinking the Economic Recovery: A Global Green New Deal, in 2009* advocated for reforming investment practices towards ecosystems and the environment, using pricing mechanisms to transition towards a green economy. This transformative economic approach aims to enhance quality of life, promote social justice, and mitigate environmental risks and ecological flaws. In essence, a green economy is defined as one that elevates societal quality of life and equity while mitigating environmental risks and ecological shortcomings (Birner, 2018; Barbier, 2009; Jaroenkietkajorn et al., 2024).

The process of implementing the BCG Economy Model comprises four drivers (BCG Drivers) and four enablers (BCG Enablers). The drivers encompass: 1) the advancement of strategic sectors, 2) spatial development, 3) business and entrepreneurial growth promotion, and 4) the advancement of cutting-edge technology and knowledge. Meanwhile, the enablers include: 1) alleviating legal and regulatory constraints, 2) enhancing workforce capabilities, 3) developing essential infrastructure and facilities, and 4) bolstering international partnership networks. These initiatives are facilitated through a digital platform to integrate and enhance the value chain of the BCG Model (Mesinsee, 2020).

The BCG Economy Model underscores the importance of leveraging Thailand's inherent strengths, such as biodiversity and cultural diversity, to amplify value within the production chain of goods and services. This encompasses four pivotal industry sectors: 1) agriculture and food, 2) health and medicine, 3) energy, materials, and biochemicals, and 4) tourism and the creative economy. These industry sectors encompass ten S-Curve industries, boasting a collective value exceeding 3.4 trillion baht and employing over 16.5 million individuals within the system under suitable policies and management. Under the BCG Economy Model, this industrial cluster has the potential to generate economic value exceeding 4.4 trillion baht and provide employment opportunities for over 20 million people within the next five years (BCG, 2023; Kaewhao, 2023; Thiengkamol, 2020).

Rice is Thailand's staple crop with a history spanning over 5,500 years. The oldest evidence of rice cultivation in Thailand dates back to the Ban Chiang era. The earliest rice varieties grown in Thailand were glutinous and non-glutinous types. Subsequently, the cultivation of long-grain rice became more prevalent, believed to have been introduced by the Khmer Empire. The northeastern region accounts for 45% of the country's total rice cultivation area, with fragrant jasmine rice being the predominant variety. Thailand is the world's largest exporter of rice and serves as a hub for rice variety research. Rice is a staple food for Thai people and a significant economic crop contributing to the country's income (Thai Rice Exporters Association, n.d.)

Social innovation refers to the adaptation of activity and service delivery patterns driven by societal needs. These activities may involve development and problem-solving endeavors. Scholars emphasize understanding social innovation in three dimensions: 1) Individual-centric dimension which focuses on individuals who possess strength and resilience and initiate social change; 2) Collective dimension which focuses on groups with common goals, collaborating to enact societal change; and 3) Organizational dimension which focuses on mechanisms and structures supporting social innovation (Mulgan, Tucker, Ali, & Sanders, 2007). Examples of social innovators include: (i) Robert Owen: Developed New Lanark, a model community emphasizing education, welfare, and entertainment, (ii) David Oxtoby Hill: Transformed Paradise Place from a slum into a thriving community which focuses on quality housing, family life, and public gardens; and (iii) Michael Young: Pioneered welfare state policies and public services which emphasizes the decentralization of power to people.

The theory of social innovation sheds light on the mechanisms and processes driving societal change. In this context, according to this theory, these groups can be divided into seven distinct categories as follows: 1) Social Organizations and Enterprises: These entities are committed to addressing social issues, often driven by community involvement and necessitating sustained developmental endeavors. Examples include foundations, community groups, and non-profit organizations (NGOs). 2) Social Movements: Stemming from potent emotions such as fear, anger, or hope, social movements strive to advocate for change. Critical success factors encompass the perceived value, utility, participation levels, and dedication of their members. Examples range from environmental campaigns to movements advocating for equal rights. 3) Political and Governmental Sectors: The political domain formulates policies for public benefit, with a focus on securing votes, while the governmental sector implements strategies to optimize costs or streamline procedures. 4) Market Sector: Markets serve as robust platforms for fostering social innovation. Prominent examples include companies like The Body Shop, renowned for their environmentally friendly products. 5) Educational Institutions: These institutions serve as breeding grounds for new ideas through research, experimentation, and widespread dissemination. 6) Foundations: Foundations assume a critical role by providing financial supports, disseminating information, and spearheading social change initiatives. 7) Social Software and Open Source: Online networks serve as invaluable tools for initiating, learning, and disseminating innovative concepts. The Wikipedia website stands as a quintessential example of the potential of social software and open-source platforms in fostering collaborative innovation.

In summary, these groups or organizations fulfill various roles in fostering social innovation. Each group possesses distinct strengths, weaknesses, and mechanisms of action. Collaboration and coordination among different groups can effectively drive social change.

The BCG Economy Model strives for the 2030 Agenda for Sustainable Development Goals by contributing to the following goals: no poverty (SDG 1); responsible consumption and production (SDG 12); sustainable cities and promotion of inclusive and sustainable industrialization and innovation (SDG 9); affordable and clean energy (SDG 7); and clean water and sanitation (SDG 6). Education and raising awareness to safeguard the environment and conserve resources are also part of the BCG Model and is an important aspect for realizing the SDGs (Pasca, Padovani, Arcese, & Mugion, 2023). Apart from the above SDG goals, the BCG Economy Model aims to enhance the role of quality education and gender equality aspects.

The application of the BCG Economy Model for development in various countries has shown remarkable success, particularly in the Netherlands, where the implementation of the circular economy policy since 2013 has resulted in significant job creation and income generation, as well as efficient reduction and reuse of materials. From 2016 to 2020, policy-driven mechanisms have been instrumental in achieving economic success and fostering international cooperation to promote sustainable economic transformation. Similarly, in China, the implementation of the BCG Economy Model through the "Park City" strategy has yielded impressive results, focusing on urban development, housing, environmental protection, and the development of green industries using new technologies and processes to address environmental issues and promote sustainable economic development. In summary, the application of the BCG Model in each country highlights the crucial role of leadership and government in strategizing and policymaking to create environments conducive to development. Legal and regulatory reforms are essential for effective change, along with the presentation of action plans and collaboration among all stakeholders to support successful development at both the urban development and industrial sector levels.

In light of the move to sustainability, studies on sustainability of rice production have seen the use of life cycle assessments, and other tools have been used to evaluate environmental performance of rice supply chains. Many studies reported varying magnitudes of environmental impacts such as emissions, freshwater usage, fossil depletion, toxicity from use of fertilizer and pesticides. However, few studies dealt with the application of BCG Model on the agricultural sector, particularly that of rice production.

Jaroenkietkajorn et al. (2024) explored the challenges and opportunities in applying the bio-circular and green economy model to the agricultural value chains through a sustainability assessment framework in which the life cycle assessment, social life cycle assessment and cost-benefit analysis are used. The study considered value-added products generated from all biomasses aligned with the goal to promote carbon neutrality under the BCG Model. The findings indicated that opportunities to enhance agricultural value chain can be done through the use of bio-refinery concept; however, the employment of technology for biorefining to produce value-added products and investment costs posed some challenges [to the BCG Model application].

Vinci et al. (2023) systematically reviewed recent literature related to life cycle assessment of rice production to discover the extent to which life cycle concept and an application of the three pillars of sustainability were implemented, including to highlight possible research gaps. Through an analysis of 40 articles published between 2012-2022, it was found that research gaps on rice production were on depletion aspects and organic farming, while results of studies were difficult to make meaningful comparisons due to varying soil and climate conditions. Based on their sustainability analysis, it was found that less focus was given to socio-economic dimensions. After a social life cycle assessment was integrated into the studies, findings show that medium to high social impacts were seen in India, Sri Lanka, Thailand and Bangladesh.

Chen et al. (2019) studied the socio-economic impacts after circular economy was introduced to the Mediterranean rice production through a hybrid life cycle assessment model on the use of bio-fertilizer through recirculating rice bran and husk compared to conventional approaches. The findings indicated that the circular system can potentially increase the gross value added and employment, compared to conventional rice system, and reduce the risk of supply chain failure. However, the findings also showed that the circular system did not necessarily achieve more positive social-economic impacts than the convention system. Further developments are still required. For instance, technology development is needed to reduce unit production cost, and infrastructure development is required to support bio-fertilizer production.

Studies concerning the socio-economic impacts on the use of sustainability practices or an application of the BCG Model are often explored from a single angle such as the use of bio-fertilizers, or recycling waste. Thus, research gaps exist in exploring the application of the entire BCG Model’s components to the rice production chain.

2. Objectives

1. To explore BCG economic concept and its applicability to promote Thai rice industry.
2. To study agricultural infrastructure and supply chain of rice industry in Thailand.

3. Materials and Methods

This study employed a qualitative research approach, utilizing in-depth interviews as the primary data collection method to explore an implementation of the BCG Model and innovation in Thailand's rice supply chain. The research design incorporated both primary and secondary data sources. Initially, a thorough examination of relevant documents and data related to the circular economy concept (BCG Model) and its application in Thailand's rice production chain system was conducted. This was followed by fieldwork which involved in-depth interviews with key informants selected through a purposive sampling method. This sampling method leveraged the researcher's expertise to identify participants most relevant to the study, ensuring a comprehensive understanding of the phenomenon. The interviews, which were structured to align with individual experiences, targeted diverse groups associated with Thailand's rice production chain system. The interviews also allowed for the collection of rich, detailed data through interactive, two-way communication, providing comprehensive insights into the targeted topics. The combination of document analysis and in-depth interviews enabled a thorough exploration of the underlying factors influencing decision-making and behaviors within the context of the Thailand’s rice supply chain, generating precise information aligned with the study's objectives. The number of interview participants was presented in Table 1 Key informants, representing diverse groups associated with Thailand's rice production chain system, were identified and interviewed to gather comprehensive insights, ensuring a holistic understanding of the entire production chain ecosystem. Interviews were conducted either in person or through video conferencing platforms, based on the informant’s preference. With the informants’ consent, all interviews were audio-recorded. Additionally, field notes were taken during the interview sessions to document non-verbal cues and immediate reflections, ensuring a more comprehensive understanding of the responses.

Table 1 Numbers of Informants

(Types of) Informants	Number
Rice farmers	15
Rice mills	3
Rice bag manufacturers	2
Traditional rice retail shops	3
Rice exporters	2
Rice warehousing business operators	3
Thai Rice Exporters Association	2
Total	30

4. Results and Discussion

4.1 Implementing Circular Economy Principles in Thailand's Rice Production

From the past to the present, it is undeniable that farmers constantly face the problem of declining agricultural product prices or rice cultivation is not worth the cost, and they still face heavy debts. Many farmers are unable to preserve their paddy fields. Most of them end up selling them to repay their debts which are caused by low rice yields or their spending behaviors. Policy is one of the important tools to solve these problems as it can help promote the country's development in various aspects and levels, especially the implementation of policies that can meet the needs of people in each region. In this regard, rice policy implementation must be contextually sensitive and responsive to farmers' actual needs. Guidelines adaptable to local conditions are essential for success. Balancing top-down and bottom-up power dynamics is crucial, alongside efficient risk management and network collaboration. Minimizing political influence and bureaucracy while empowering farmers to become entrepreneurial is vital for sustainable development. In conclusion, successful policy implementation in Thailand necessitates an understanding of regional nuances and a focus on farmers' genuine needs. Flexible, localized guidelines and a balance of power dynamics are essential for sustainable agricultural development.

Utilizing the Circular Economy framework in Thai rice production is pivotal for fostering a sustainable economy amidst global environmental crises and resource scarcity driven by population growth. The circular economy emphasizes resource circulation to optimize resource utilization and minimize waste. However, the expansion of resource-dependent economic activities exacerbates resource depletion and environmental degradation. Thus, the circular economy emerges as a solution, aiming not only to preserve the environment and society, but also to generate economic benefits. In 2019, the Thai government outlined national development objectives within the circular economy paradigm, aligning with the BCG Model's emphasis on integration and the development of bioeconomy, circular economy, and green economy. Leveraging science, technology, and innovation, the goal is to enhance sustainable competitiveness across four target industries: agriculture and food, energy and materials, health and medicine, and tourism and services. These industries are poised to become the country's primary economic drivers, contributing over 4.4 trillion baht (24 percent of the GDP) in the next five years through resource-efficient practices, reduced energy consumption, and systematic waste management.

The BCG Model aligns with the United Nations' Sustainable Development Goals, emphasizing sustainable production and consumption, climate change mitigation, biodiversity conservation, and fostering cooperation for sustainable development. It also resonates with Thailand's Sufficiency Economy philosophy, a key principle in its economic and social development. Implementing the circular economy in Thailand entails collaboration among various stakeholders, including the public and private sectors, communities, academia, research institutes, and international agencies. This collaboration leverages collective knowledge, skills, and scientific expertise to adapt effectively, focusing on the complete product lifecycle, from reuse and refurbishment to sharing, recycling, and upcycling. Emphasis is placed on minimizing waste in product design and production processes, aiming for a zero-waste production. Key initiatives include leveraging waste management technologies, maximizing waste utilization, promoting the transition to a zero-waste society, establishing a platform for green innovation incubation, and employing scientific tools to assess production systems and products. These efforts aim to foster the development of environmentally friendly products and production methods in line with circular economy principles.

The Thai rice supply chain involves a diverse range of stakeholders, encompassing everyone from rice producers to consumers. It undergoes a complex process of processing and marketing. The Thai rice supply chain is segmented into three main components:

1) Upstream Industry (Input Provider) Farmers are pivotal in rice production, utilizing raw materials and production factors sourced from various outlets such as rice varieties, fertilizers, pesticides, labor, and machinery. The Bank for Agriculture and Agricultural Cooperatives (BAAC) also plays a significant role in supporting farmers across different areas.

2) Midstream Industry (Processing) This sector serves to bridge farmers with rice traders or millers. Rice mills are key players in processing paddy rice into milled rice. This industry is actively developing technology and management systems to enhance efficiency and mitigate risks.

3) Downstream Industry (Export). The focus here is on marketing rice both domestically and internationally. Entrepreneurs in this sector are involved in product distribution, brand building, and adapting to evolving consumer demands.

In essence, the Thai rice supply chain is intricate, involving numerous stakeholders. Challenges persist in certain segments of the supply chain, underscoring the need for continual and mutual development and enhancement of the Thai rice supply chain.

The study and analysis of the rice value chain of rice reveal its significant and diverse impacts across various industries. These impacts can be categorized into three different groups:

1) Food and Health Industry: Rice is utilized in the production of consumer food products and exports, such as noodles, pasta, crispy snacks, and ready-to-drink rice milk.

2) Processing Industry: Rice is processed into semi-finished and finished products through milling processes in rice mills, especially for export-oriented products.

3) Research and Development: After harvesting, rice is collected for research and development purposes, particularly in the improvement of rice varieties. Furthermore, rice finds applications in other industries such as alcoholic beverage industry, animal feed industry, vegetable oil industry, bioplastic industry, bioenergy, and fertilizer industry.

In conclusion, the value chain of rice extends beyond food production, impacting various sectors and highlighting its versatility and significance in numerous industries.

Thai rice exports rival domestic consumption in volume, maintaining its reputation for quality and high demand in the global market. However, white rice exports face stiff competition from countries like India, Vietnam, Cambodia, and Myanmar where production costs are lower, making them more competitive. Thailand's higher production costs, attributed mainly to lower rice yields and occasional crop damage from droughts or floods, contribute to this challenge. The export price of Thai rice also fluctuates significantly. Addressing these challenges requires urgent attention to water management for rice cultivation, alongside efforts to increase yields and reduce production costs. This can be achieved through promoting the consolidation of small farmers' fields to benefit from economies of scale and leveraging agritech to enhance cultivation efficiency. Such measures not only stabilize production volumes, but also ensure food security and bolster Thailand's competitiveness in the global rice market. Furthermore, establishing shorter supply chains for food production domestically can mitigate risks of disruptions and diversify food imports from various sources. Exporting countries should prioritize improving food quality to meet importers' needs and focus on producing health-beneficial food items to expand or maintain market share in the global food market. These initiatives will not only support the sustainable growth of the Thai rice industry, but also ensure Thailand's resilience in times of increasing global demand, ultimately enhancing its competitiveness in rice exports.

4.2 Guidelines for the Implementation of the BCG Model in the Thai Rice Production Supply Chain

The present study indicates that integrating the circular economy approach (BCG Model) into the Thai rice production chain is highly feasible and offers significant potential as set out below:

1) Enhancing efficiency and cost reduction: The BCG Model enables farmers to cut down on rice production expenses through several methods, e.g., substituting chemical fertilizers and pesticides with organic alternatives and adopting precision agriculture technology to minimize post-harvest losses.

2) Adding value to products: With the BCG Model, farmers can transform rice into high-value goods such as organic rice, brown rice, rice flour, and rice bran oil; all of which command higher prices than conventional paddy rice.

3) Generating extra income: The BCG Model empowers farmers to diversify their income streams by tapping into other products such as vegetables, fruits and organic fertilizers.

4) Environmental protection and sustainability: By mitigating pollution from agriculture, the BCG Model contributes to environmental conservation and fosters a balanced ecosystem.

However, certain challenges remain:

1) Knowledge and technological deficiency: Some farmers lack the necessary expertise and technology to implement the BCG Model effectively within their rice production chain.

2) Financial constraints: Limited funds pose a barrier for some farmers intending to invest in BCG Model projects.

3) Market limitations: Certain products derived from the BCG Model concept face insufficient market demand.

Based on the above-mentioned challenges, key strategies to promote the BCG Model include disseminating knowledge and technology to farmers, providing additional financial assistance, and expanding markets for BCG Model-based products. Collaboration between the public and private sectors is crucial for earnestly promoting the adoption of the BCG Model within the rice production chain system.

5. Conclusion

The research on the Circular Economy introduces innovative strategies for managing resources within the economy, with a primary focus on resource utilization and waste minimization in production and consumption. Departing from the Linear Economy model, which prioritizes resource use and disposal, the Circular Economy emphasizes resource efficiency and waste reuse. Informed by biomimicry and environmental design, its first principle aims to conserve and enhance natural resource efficiency. This entails optimizing resource utilization and ensuring system efficiency through effective resource flow management. Ultimately, the Circular Economy drives long-term sustainable development across economic, social, and environmental spheres, highlighting the significance of resource efficiency and waste reduction for businesses' sustainable growth, quality of life, and the planet's future.

The second principle of establishing the Circular Economy emphasizes optimizing resource utilization by facilitating the continuous circulation of raw materials, products, components, and materials. This is accomplished through the adoption of long-lasting design strategies, ensuring products are durable, non-toxic, and biodegradable to minimize waste and harmonize with natural cycles. Products crafted from plastic, polymers, alloys, or synthetic materials should be designed for reusability with minimal energy consumption, striving to preserve their original quality whenever feasible. Moreover, techniques like remanufacturing involve refurbishing used products to meet new product standards, while refurbishing focuses on repairing damaged or defective items for resale. Maintenance ensures the functionality of materials and equipment, while repairing aims to restore broken items to their former state. Reuse promotes the utilization of still-functional items to their maximum capacity, whereas recycling entails processing used materials into raw materials for crafting new products. Finally, upcycling transforms waste materials into aesthetically appealing products with added value, nurturing innovation and sustainability in resource management.

The third principle of the Circular Economy underscores the critical importance of maintaining system efficiency through proactive design to mitigate the negative externalities associated with products. This entails efforts aimed at minimizing adverse impacts on the environment, economy, society, quality of life, and overall well-being. Addressing the negative consequences arising from resource utilization, including land use, air and water pollution, noise pollution, and climate change, is imperative. Innovation and collaboration across various sectors serve as essential drivers for transitioning to a sustainable circular economy. This transition necessitates robust policy support from the government and a shift in behavior among both producers and consumers. Such coordinated actions are indispensable for facilitating a seamless and effective transition toward a circular economy society.

6. Limitations and recommendations

1) Guidelines for developing the application of the Circular Economy system should be studied uniformly to enable data comparison.

2) Data analysis should include data from quantitative research methods to gather diverse information.

3) Interviews should be conducted comprehensively to gather information from all aspects. This will guide the development of the Circular Economy system and establish strategies, plans, and goals to enhance business operations in alignment with sustainable development.

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