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CIRCULAR ECONOMIC BUSINESS MODEL FOR SUSTAINABLE SMES FOOD SECURITY

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ABSTRACT

This study develops a circular economy-based business model aimed at enhancing food security and sustainability for Small and Medium Enterprises (SMEs) in the food sector. The research explores how digital navigation, green funding, and business collaboration can optimize resource use, minimize waste, and improve supply chain efficiency in the food industry. Results show that SMEs in Batu and Bali have started adopting digital technologies and circular economy principles, contributing to local food security and sustainability. Over 70% of factors influencing circular economy practices and food security are attributed to external influences such as green funding and business collaboration. The study highlights the positive impact of adopting digital tools, such as e-commerce and production optimization technologies, on operational efficiency. Furthermore, collaboration across sectors has been identified as a key enabler of sustainable business models, improving both food security and environmental outcomes. The study emphasizes the critical role of green financing in providing the necessary capital for SMEs to implement circular economy practices, especially for waste reduction and energy efficiency. Despite progress, challenges remain in terms of access to green funding, training, and inclusive financing mechanisms. Moreover, while circular economy practices are emerging, they require stronger institutional support for broader adoption, including technical assistance and improved access to digital tools. In conclusion, the research suggests that SMEs in the food sector must integrate digital navigation, green funding, and business collaboration to strengthen food security and sustainability. Circular economy-based business models have proven effective in waste reduction and resource optimization, but further support is needed to foster a comprehensive and inclusive transition. The findings point to the importance of policy interventions, cross-sector partnerships, and targeted financing solutions in scaling up these practices across the food sector.

Keywords: digital navigation, green funding, business collaboration, circular economy, food security, waste reduction, resource optimization, supply chain efficiency, sustainable SMEs

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INTRODUCTION

The circular economy business model plays an important role in building sustainable food security, especially for micro, small, and medium enterprises (MSMEs) in the food sector. With a primary focus on waste reduction, resource optimization, and the creation of added value from by-products, the circular economy model can improve operational efficiency while reducing costs. In Indonesia, more and more MSMEs are implementing this concept by utilizing organic waste to produce compost or fermented foods, which not only reduces raw material waste but also creates new economic opportunities. This approach provides MSMEs with a competitive advantage by increasing production efficiency and reducing dependence on external resources.

In Indonesia's food sector, major challenges include high food waste and supply chain inefficiencies, with around 30% of food being wasted during distribution (Fazle & Bin, 2024). The circular economy model can address these issues by reusing underutilized food to reduce environmental impact and create a more efficient and environmentally

friendly supply chain. In addition, the integration of digital technology and green financing greatly supports the adoption of this model, where digital technology enables MSMEs to monitor and optimize production processes, while green financing provides financial support for environmentally friendly technologies.

The circular economy model not only affects business processes and market relationships but also has a major impact on long-term food security (Chauhan et al., 2022). By increasing the efficient use of resources and reducing waste, MSMEs in the food sector can extend the shelf life of their products and improve the sustainability of their businesses. In addition, this model also reduces dependence on imported raw materials by utilizing local resources such as surplus food. The use of digital tools, such as e-commerce and marketing platforms, allows MSMEs to reach a wider market and make data-driven decisions. Collaboration between MSMEs, the private sector, and the government is needed to accelerate the transition to a more integrated and sustainable circular economy.

Several studies highlight the role of digital navigation, green financing, and business collaboration in implementing circular economy practices. However, there is a gap in understanding how these elements interact for long-term sustainability. While the adoption of these practices enhances efficiency, challenges such as limited access to resources remain.

Further research is needed to understand how the implementation of circular economy models can improve long-term food security and reduce environmental impacts, as well as to identify the obstacles faced by MSMEs, such as costs, infrastructure, and policies that support or hinder their adoption. Without an in-depth analysis of these difficulties, it is difficult to evaluate the success and effectiveness of this model in promoting policies that support its implementation in Indonesia's food sector.

LITERATURE REVIEW

The small and medium-sized enterprise (SME) and tourism sectors play an important role in the local economies of Batu and Bali, two major tourist destinations in Indonesia. With more than 97% of the national workforce employed in the SME sector, which contributes 60% to the national GDP, these sectors are crucial to the country's economic structure (Matarneh et al., 2024). However, these sectors face challenges in food security due to climate change, supply chain instability, and limited sustainable resources (Halpern et al., 2024). The growth of MSMEs has also led to increased waste and resource exploitation, with Bali producing around 3,800 tons of waste per day, mostly from food-related sectors. Food waste accounts for 30% of the supply chain (Govindan, 2023), highlighting the need for efficient business models to optimize resources and food security.

The circular economy approach offers promising solutions by reducing waste, extending product life, and improving resource efficiency (Kumar et al., 2025). Circular economy practices in the food sector can reduce waste, increase competitiveness, and promote long-term sustainability (Oncioiu et al., 2018). However, adoption of this model is hampered by limited access to information and technology, as 75% of small and medium-sized food enterprises (SMEs) face challenges, as well as dependence on inefficient conventional methods (Chauhan et al., 2022). Digital transformation is key to optimizing supply chains and increasing production (Yosep et al., 2024).

Despite its potential, digitalization has not been fully adopted by 58% of MSMEs in Batu and Bali. In addition, access to environmental financing is still limited, with many MSMEs highlighting the lack of financial support. Collaboration between the government, the private sector, and MSMEs is essential to create an ecosystem that supports sustainability and accelerates the adoption of green technology, as well as to improve food security (Khan & Mihaisi, 2023). However, such collaboration is still limited, as seen in the low participation of MSMEs in sustainability programs (Adelodun et al., 2024). An integrated business model based on the principles of circular economy, digital navigation, green financing, and business collaboration is essential to strengthen food security and environmental sustainability (Taner, 2024).

Conceptual foundations of the circular economy

The circular economy is an economic system designed to maximize resource utilization and minimize waste through strategies such as reduce, reuse, recycle, and resource recovery throughout the entire product life cycle. This model systematically replaces the linear economic approach oriented towards a "take-make-dispose" pattern with principles that emphasize the regeneration of natural systems and the extension of the value of products and materials. This framework emphasizes closed-loop material management so that resources remain in circulation within the economic system while reducing negative impacts on the environment and lowering consumption of new raw materials. This view is also recog-

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nized in a systematic review that states that the circular economy operates at various levels—micro (products/components), meso (eco-industrial parks), and macro (city/national)—to achieve sustainable development goals (Rodríguez-espíndola et al., 2022).

The circular economy grew out of several disciplines, including ecological economics, resource management, and industrial ecology, and was influenced by early thinking on waste prevention and resource efficiency. The circular economy is not only seen as a resource management strategy, but also as a response to the challenges of sustainable development that encompass environmental, economic, and social aspects. A number of studies show that integrating circular economy principles with sustainability strategies can strengthen resource efficiency and corporate competitiveness by reducing energy and material use while extending product life cycles. This approach also emphasizes the importance of technological innovation, multi-stakeholder collaboration, and the development of new business models that can capture value from previously neglected resource flows. This conceptual framework shows how the circular economy can expand the scope of value through synergies between resource efficiency and economic value creation (Pascale et al., 2023).

Circular economy in the context of MSMEs in the food sector

The circular economy is an important alternative approach to overcoming resource constraints and increasingly acute environmental problems in the food sector, especially for micro, small, and medium enterprises (MSMEs). This approach emphasizes the 4R principle (reduce, reuse, recycle, recover) to extend product life and optimize resource use, thereby reducing waste and increasing production efficiency throughout the food product life cycle. This is important because the food sector contributes to a large volume of waste due to the dominance of unsustainable linear (take-make-dispose) production and consumption patterns (Oncioiu et al., 2018).

The implementation of a circular economy in food MSMEs faces structural constraints such as limited technical knowledge, limited capital, and barriers to accessing innovative technologies. This shows that the level of circular adoption and capabilities in MSMEs is still low compared to large companies, requiring focused policy strategies and institutional support (Howard & Steffen, 2022).

The management of raw material residues into value-added products, the reuse of packaging, and the implementation of cleaner production systems have been proven to help MSMEs reduce operational costs and negative environmental impacts. Green innovations and green entrepreneurship strategies directly improve the sustainability performance of food MSMEs, although the level of impact is influenced by local environmental regulations and business awareness (Rodríguez-espíndola et al., 2022).

The circular business model in food MSMEs involves a paradigm shift from linear production to a production system that maximizes resource utilization, creates added value from waste, and promotes network collaboration. This development includes ecodesign, a more efficient supply chain, and the establishment of cooperative relationships between business actors, suppliers, and consumers. Circular business models can include innovations such as the collection of organic waste for composting, the production of animal feed from agricultural waste, and community-based production collaborations that support each other in product distribution (Hasan et al., 2025).

Digitalization and technological innovation play a crucial role in strengthening the capacity of food MSMEs to apply circular economy principles. Digital technology helps MSMEs monitor supply chains in real time, optimize logistics, and improve resource efficiency. The use of digital platforms for marketing and distribution also opens up wider market opportunities, while enabling SMEs to respond to consumer demand that is increasingly aware of sustainability (Torshizi et al., 2026).

The evaluation of the impact of circular economy implementation on food SMEs covers economic, environmental, and social aspects. Research shows that MSMEs that apply circular principles often demonstrate increased resource efficiency, reduced operating costs, and improved brand image in the eyes of consumers who care about sustainability issues. This provides opportunities for MSMEs to not only survive in the market competition but also contribute to larger sustainable development goals (Mohanty & Mohanty, 2025).

The role of digitalization in food system transformation

Digitalization has emerged as a key driver in the transformation of global food systems, where digital technologies—including blockchain, the Internet of Things (IoT), artificial intelligence (AI), and big data—are key to improving transparency, efficiency, and sustainability throughout the food value chain. Recent literature studies show that the integration of digital technology in the agri-food sector enables improved traceability down to the consumer level, strengthens trust between supply chain actors, and reduces administrative risks and errors. This approach supports real-time data management, which is critical for evidence-based decision-making in food production and distribution (Kevin et al., 2021).

The digitization of food systems also has a strong empirical link to increased food security. Research evidence shows that the adoption of digital solutions can increase food availability and reduce food insecurity, especially in developing countries, by improving production and distribution efficiency. Digital technology supports faster and more accurate access to agricultural information, optimizes production inputs, and reduces uncertainty in planning and decision-making at the farmer and food business operator levels (Khan & Mihaisi, 2023).

Although the benefits of digitization are clear in the literature, the digital transformation of food systems still faces significant challenges. Various studies point to obstacles such as the readiness of digital infrastructure, disparities in technology adoption between urban and rural areas, the need to improve digital literacy among smallholder farmers, and the need for policy frameworks that support fair and inclusive technology adoption. Recent research also emphasizes that digitization must be guided by systemic policies to avoid exacerbating inequality or deepening disparities in technology access among supply chain actors (Cardoso et al., 2024).

Green financing mechanisms

Green financing is a set of financial instruments and mechanisms aimed at supporting investment in environmentally friendly and sustainable projects and activities, such as renewable energy, energy efficiency, and responsible natural resource management. Green finance is engineered to bridge the financing gap between environmental investment needs and capital availability by attracting investment funds to sectors that support climate change mitigation and the reduction of negative environmental impacts. This mechanism also indirectly contributes to a green economy that balances economic growth with environmental conservation and social welfare. The main objective of green finance is to mobilize the large amounts of capital needed to achieve sustainable development targets, including net zero emissions and environmental regulations (Bel et al., 2025).

Green financing instruments include various products and funding schemes designed to facilitate the flow of capital to sustainable projects (Agrawal et al., 2024):

- Green Bonds: bonds whose proceeds are used specifically to finance environmentally friendly projects, such as renewable energy, clean infrastructure, and green transportation.
- Green Loans: loans provided to support activities or projects that have a positive environmental impact.
- Sustainability Linked Loans (SLLs): financing facilities that link credit requirements to the achievement of environmental, social, or governance (ESG) targets.
- Green Sukuk: Islamic financial instruments designed for green financing purposes in accordance with Sharia principles.
- Public Private Partnerships (PPP) and venture capital for clean energy and green innovation projects. This mechanism allows for diversification of capital sources to support various sustainability sectors.

Digital innovation also plays a central role in green financing mechanisms by increasing access to capital and improving investment process efficiency. Technologies such as sustainable financing digital platforms accelerate the matching of green project borrowers with investors who are oriented towards environmental impact. In addition, green financial technology (green fintech) increases the transparency of data related to project implementation, facilitates ESG reporting, and reduces transaction costs. Digital integration also enables the creation of new financial products that are more responsive to market dynamics and the needs of modern investors (Dominguez-Villanueva et al., 2025).

Green financing not only serves as a capital creation tool but also has a significant economic impact through job creation in the green sector, increased clean technology capacity, and inclusive economic growth. In the context of climate change mitigation, green finance can empirically reduce carbon emission intensity and accelerate the transition to clean energy, especially in developing countries that require large financing for new infrastructure. In addition, green finance mechanisms can improve capital allocation efficiency by channeling resources to sectors that provide long-term environmental benefits as well as economic returns (Eelager et al., 2025).

Inter-organizational cooperation as a factor in the circular economy

Inter-organizational cooperation is central to the implementation of the circular economy because the principles of the circular economy require cross-actor integration to maximize the value of resources and minimize waste. In many industrial sector contexts, collaboration between suppliers, customers, and other parties in the value chain is a key driver of the success of circular economy practices such as reuse, recycle, and remanufacture. Several recent studies have attempted to map patterns of inter-organizational collaboration within the framework of circular economy innovation ecosystems.

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Collaboration is not limited to traditional business relationships, but also involves supporting actors such as governments, research institutions, and communities. Research on stakeholder collaboration shows that the integration of various stakeholders facilitates the implementation of circular economy principles through the formulation of supportive policies, technological innovation, and the strengthening of a shared understanding of economic and environmental goals. Such collaboration is an important foundation for encouraging collective action to overcome the operational obstacles often faced by individual organizations (Gallina et al., 2024).

AIMS AND OBJECTIVES

This study aims to develop a circular economy-based business model for food SMEs, focusing on enhancing food security and sustainability. It explores how digital navigation, green funding, and business collaboration can optimize resource use, reduce waste, and improve supply chain efficiency. The research investigates key factors influencing the adoption of circular economy practices and the role of digital tools and green financing in supporting sustainable practices within the food sector.

METHODS

This study uses a mixed-method approach, combining qualitative and quantitative data analysis and conceptual modeling to develop a circular economy-based business model for MSMEs in the food sector. This study utilizes in-depth interviews, surveys, and statistical techniques such as Structural Equation Modeling (SEM) and descriptive analysis to explore key factors that influence the adoption of digital navigation, green financing, and business collaboration. Field data from 266 food sector MSME respondents in Batu and Bali was collected through a structured questionnaire, which focused on aspects such as digital navigation, environmental financing, business collaboration, circular economy practices, and their impact on food security and sustainability.

Respondents in this study consisted of entrepreneurs and managers of food sector MSMEs operating in two regions: Batu City and Bali Province. Data collection was conducted using questionnaires, which successfully gathered 266 respondents with complete and valid responses for analysis. This data provides a representative picture of the characteristics of food sector MSMEs in the region, which will be used to analyze the factors that influence the financial performance and sustainability of these businesses. The characteristics of the respondents are shown in Table 1.

Table 1. Respondent characteristics.

Description	Total	Percentage (%)
Location		
Batu City	149	56.0
Bali	117	44.0
Years of Operation		
< 2 Years	48	18.0
2–5 Years	139	52.3
> 5 Years	79	29.7
Number of Employees		
1–5 Employees	173	65.0
6–10 Employees	61	22.9
> 10 Employees	32	12.1
Business Scale		
Small	218	81.9
Medium	48	18.1

Table 1 shows that 56% of respondents are from Batu City, while 44% are from Bali, with Batu City slightly dominating due to its strong focus on the agriculture and tourism sectors. Most businesses (52.3%) have been operating for 2–5 years, indicating that many MSMEs are still in the development phase. Regarding workforce size, 65% employ 1–5 people, and most businesses (81.9%) are small, highlighting the growth from micro to small businesses. This growth opens up opportunities for increased efficiency through circular economy practices, particularly in waste management and resource

optimization. Despite the potential for green innovation, MSMEs require ongoing support in training, financing, and technical assistance to remain competitive. Many entrepreneurs start their businesses based on family heritage or post-crisis needs. In Bali, traditional food businesses preserve culture and support the economy, while in Batu, fruit chip businesses aim for economic independence. However, they face challenges such as fluctuations in raw materials, market access, capital issues, and distribution inefficiencies.

Digital Navigation

The application of digital technology in food companies is still limited, with most relying on social media, online marketplaces, and WhatsApp Business for promotion, while a few use market data dashboards or analytics. Although QR codes are used, digital data is not yet fully utilized. Nevertheless, progress is being made in digital logistics for functional foods. Green financing is still rare, with most companies lacking access to Green KUR or ESG-related funds, reflecting limited support for circular economy initiatives from green financial institutions. Business collaboration is crucial for the sustainability of food MSMEs. In Batu, entrepreneurs share resources and join MSME clusters, while in Bali, businesses collaborate in artisan communities to expand networks, improve efficiency, and promote together.

Circular economy principles are emerging but remain structurally weak. In Bali, entrepreneurs process fruit waste into fermentation enzymes and recycle seashells into crafts, while in Batu, cassava leaves are used as animal feed. However, standardized environmental management systems are lacking, and training in waste processing and ecological certification is needed.

Food businesses contribute to local food security by providing affordable, stable, and year-round products, as well as diversifying supply sources. This community-based approach strengthens local supply chains, even without formal certification. Five key themes were identified.

Food companies contribute to local food security by providing affordable, stable, and year-round products, as well as diversifying their supply sources. This community-based approach strengthens local supply chains, even without formal certification. Five main themes were identified using coding techniques, as shown in Table 2.

Table 2. Open, axial, and selective coding.

Theme	Sub-theme / Indicator
1. Digital Navigation	Use of social media, marketplaces, QR codes, and limitations on digital dashboards
2. Environmentally Friendly Financing	Low access to Green KUR (Green Financing), CSR, and personal initiatives related to environmental friendliness
3. Business Collaboration	Clustering, cooperatives, distribution, and production cooperation
4. Inclusive Circular Economy	Waste utilisation, water and energy efficiency, and local innovations based on recycling
5. Food Security	Local availability, affordability, quality, and supply stability

Food Security

Meanwhile, the frequency distribution for the food security variable provides more detailed information, as shown in Table 3.

Table 3. Description of the food security variable.

Item Statement	Respondent's Answer										Mean
	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		
	F	%	F	%	F	%	F	%	F	%	
My business contributes to the sustainable supply of local food	0	0.0	0	0.0	19	7.1	135	50.8	112	42.1	4.35
My products are easily accessible to the community in terms of price and distribution	0	0.0	0	0.0	28	10.5	152	57.1	86	32.3	4.22
I am able to maintain a stable supply of products throughout the year.	0	0.0	0	0.0	11	4.1	142	53.4	113	42.5	4.38
My food products meet safety and quality standards.	0	0.0	0	0.0	38	14.3	149	56.0	79	29.7	4.15
I help maintain the sustainability of the local food supply chain	0	0.0	0	0.0	16	6.0	156	58.6	94	35.3	4.29
Average Food Security											4.28

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Table 3 shows that the majority of respondents agree that their businesses support food security, such as the provision of sustainable local food (50.8%), accessibility (57.1%), supply stability (53.4%), food safety and quality (56.0%), and the sustainability of the local supply chain (58.6%). The average Food Security score is 4.28, indicating a positive contribution of businesses to food security.

Digital Navigation

Meanwhile, the frequency distribution of Digital Navigation among MSMEs in Batu and Bali is presented in Table 4.

Table 4. Description of the digital navigation variable.

Item Statement	Respondent's Answer										Mean
	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		
	F	%	F	%	F	%	F	%	F	%	
I use e-commerce or digital platforms in product marketing.	0	0.0	0	0.0	25	9.4	160	60.2	81	30.5	4.21
I manage business data with digital systems or management applications	0	0.0	0	0.0	27	10.2	156	58.6	83	31.2	4.21
I use data-based market information (e.g., digital dashboards)	0	0.0	0	0.0	20	7.5	125	47.0	121	45.5	4.38
I use digital technology in production/logistics (e.g., QR codes, IoT).	0	0.0	0	0.0	41	15.4	148	55.6	77	28.9	4.14
Average Digital Navigation											4.23

Table 4 shows the adoption of digital technology in business: 60.2% agree to use e-commerce for marketing (average 4.21), 58.6% agree to manage data with digital applications (average 4.21), 92.5% agree to use data-based market information (average 4.38), and 55.6% agree to use technology in production/logistics (average 4.14). The overall Digital Navigation average is 4.23.

Environmentally Friendly Financing

Table 5 shows environmentally friendly (green) financing among MSMEs in Batu and Bali.

Table 5. Description of the environmentally friendly financing variable.

Item Statement	Respondent's Answer										Mean
	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		
	F	%	F	%	F	%	F	%	F	%	
I have access to green financing, such as green KUR or CSR.	0	0.0	0	0.0	21	7.9	152	57.1	93	35.0	4.27
I use the funds for waste management or renewable energy use.	0	0.0	0	0.0	36	13.5	134	50.4	96	36.1	4.23
I have worked with ESG-based financial institutions.	0	0.0	0	0.0	10	3.8	118	44.4	138	51.9	4.48
The funds I obtained were used efficiently for circular economy practices.	0	0.0	0	0.0	43	16.2	141	53.0	82	30.8	4.15
Average Environmentally Friendly Funding											4.28

Based on Table 5, respondents agree with access to and use of green financing. Access to green financing (Green KUR/CSR) received an average score of 4.27, use of funds for waste/renewable energy 4.23, cooperation with ESG financial institutions 4.48, and efficiency of funds for the circular economy 4.15. Overall, the average score for Environmentally Friendly Financing was 4.28.

Business Collaboration

Table 6 presents the status of business collaboration in Batu and Bali.

Table 6. Description of the business collaboration variable.

Item Statement	Respondent's Answer										Mean
	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		
	F	%	F	%	F	%	F	%	F	%	
I collaborate with cooperatives/BUMDes/private companies in business development.	0	0,0	0	0,0	14	5,3	113	42,5	139	52,3	4,47
I engage in partnerships in food distribution or logistics.	0	0,0	0	0,0	23	8,6	102	38,3	141	53,0	4,44
I share raw materials, technology, or markets with other businesses.	0	0,0	0	0,0	27	10,2	132	49,6	107	40,2	4,30
I am part of a sustainable food community or cluster.	0	0,0	0	0,0	41	15,4	132	49,6	93	35,0	4,20
Average Business Collaboration											4,35

Based on Table 6, the majority of respondents agreed with business collaboration. Institutional partnerships received an average of 4.47, distribution/logistics partnerships 4.44, sharing of inputs/technology/markets 4.30, and participation in sustainable food communities 4.20. There were no rejections. Overall, the average score for Business Collaboration was 4.35, indicating strong support for collaborative practices.

Circular Economy

The circular-economy findings for Batu and Bali are presented in Table 7.

Table 7. Description of the circular economy variable.

Item Statement	Respondent's Answer										Mean
	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		
	F	%	F	%	F	%	F	%	F	%	
My products use environmentally friendly designs/packaging.	0	0.0	0	0.0	32	12.0	109	41.0	125	47.0	4.35
I create products from production waste (e.g., pulp, fruit peel).	0	0.0	0	0.0	19	7.1	135	50.8	112	42.1	4.35
Sustainable Product Design											4.35
I process waste into new materials such as compost or new products.	0	0.0	0	0.0	27	10.2	150	56.4	89	33.5	4.23
My business has reduced its excessive use of water and energy.	0	0.0	0	0.0	14	5.3	139	52.3	113	42.5	4.37
Waste and Production Residue Management											4.30
I implement a refill or take-back packaging system.	0	0.0	0	0.0	37	13.9	151	56.8	78	29.3	4.15
Reuse/refill											4.15
I work with third parties in recycling or waste utilisation.	0	0.0	0	0.0	10	3.8	140	52.6	116	43.6	4.40
Recycling partnerships											4.40
I have attended training or workshops on the circular economy.	0	0.0	0	0.0	30	11.3	135	50.8	101	38.0	4.27
I began to apply circular principles rather than linear practices.	0	0.0	2	0.8	21	7.9	141	53.0	102	38.3	4.29
Circular Economy Awareness and Education among SMEs											***4.28***
Circular Economy Average											***4.30***

Based on Table 7, the majority of respondents agreed with the application of environmentally friendly designs in their products (average 4.35). This was also reflected in products made from production waste (50.8% agreed) and the processing of waste into new materials (56.4% agreed), demonstrating a strong commitment to sustainability.

Statements about water and energy reduction scored 4.37, waste management 4.30, refillable packaging 4.15, and recycling collaboration 4.40. Participation in circular economy training and the application of circular principles scored 4.27 and 4.29, respectively. Overall, the average Circular Economy score was 4.30.

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Critical analysis of the methodological approach of previous studies

Research on the circular economy in MSMEs and the food sector shows a predominance of descriptive and exploratory approaches, with most studies using quantitative surveys or qualitative interviews to identify circular practices and barriers to their adoption. Al-Swidi et al. (2025) used a descriptive quantitative approach through questionnaires to measure the level of adoption of circular practices in MSMEs, which was effective in describing surface phenomena but limited in explaining the underlying cause-and-effect dynamics, such as the relationship between organizational capabilities and implementation success. To gain a more comprehensive understanding, future studies need to combine mixed methods that bridge numerical data with contextual insights, including longitudinal analysis capable of capturing the evolution of circular economy practices over time.

Studies that rely on traditional indicators often fail to reflect the complexity of interactions between resource flows and environmental impacts holistically. Traditional indicators are inadequate and propose the use of Circular Economy Metrics, such as the Circularity Index and lifecycle-based quantitative assessment tools Widaningsih, W. (2025). The main methodological challenge here lies in the availability of complex data and the consistency of indicator interpretation across studies, which makes cross-context comparisons across geographies and sectors difficult.

In the circular economy, there are two main methodological approaches: in-depth case studies and systematic literature reviews. Qualitative case studies, such as those conducted by several researchers in the food industry sector, produce contextual insights but are often less representative due to the limited number of subjects (L´opez et al., 2026). The systematic approach provides a macro-overview of the methodologies that have been used, but publication bias and data heterogeneity are often obstacles in cross-study synthesis. Many studies merely describe circular practices without applying strong explicit theories, such as the resource-based view, dynamic capabilities, or systems theory, to explain the phenomenon of circular transition in MSMEs (Hampton et al., 2025). Without an explicit theoretical foundation and strong empirical model validation, methodological findings tend to be descriptive and less reliable for developing appropriate policy recommendations. Model validation through advanced statistical techniques such as SEM or other structural models is important for testing causal relationships between theoretical variables. This need indicates that strengthening the theoretical framework and empirical model validation is an important entry point for strengthening the scientific basis of the circular economy as a scientific discipline.

Circular economy methodologies remain highly fragmented, with considerable variation in research design, sample size, data collection instruments, and analysis techniques (Mohanty & Mohanty, 2025). Replication is an important aspect of scientific research to verify findings and increase confidence in the generalization of findings. However, the lack of consensus on standard methodologies and the lack of data openness/instrument rules make replication difficult to avoid. To improve this, researchers need to use transparent research protocols and open data documentation more often, so that circular economy studies can be retested with stronger methodological standards.

Given these methodological limitations, it is advisable to adopt new approaches such as a literature framework that integrates circular economy metrics, advanced quantitative tools, and complex modeling techniques. For example, a circular economy maturity framework that combines qualitative and quantitative methods provides a pathway to assess the level of circularity in MSMEs more systematically through a combination of maturity scales and multi-dimensional evaluations (Bandeira et al., 2025). In addition, studies using benchmark or readiness index approaches provide opportunities to measure circularity readiness on a broader scale and compare regional contexts. Research utilizing longitudinal data and dynamic modeling to test the long-term effects of circular economy policies or interventions is urgently needed to understand the temporal impact of circular practices. The integration of these innovative methods will not only enrich the empirical database but also strengthen the methodological legitimacy of the circular economy as a mature field of scientific study.

The relationship between digital navigation, green financing, and business cooperation

The selection of digital navigation as a predictor in this study is based on the crucial role of digital technology in supporting the adoption of circular economy practices by MSMEs, particularly for operational efficiency and product innovation. Digitalization opens up opportunities for the integration of technologies such as big data, blockchain, and the Internet of Things, which can improve transparency, coordination, and resource tracking in sustainable value chains, thereby helping MSMEs support circular economy goals. Digital integration also accelerates market information acquisition and data-driven decision-making, which has an impact on increasing competitiveness and environmental efficiency. In addition, developing digital capabilities can create sustainable competitive advantages for MSMEs if supported by the right skills and adaptive organizational strategies. Green financing was chosen as a predictor because of the importance of financial support focused on environmentally-oriented projects to minimize initial cost barriers and investment risks in circular economy activities;

green financing encourages clean technology innovation and provides capital for reuse and recycle initiatives, thereby strengthening the implementation of circular business models.

The business collaboration was chosen because interactions between economic actors such as suppliers, consumers, financial institutions, and other stakeholders strengthen MSMEs' capacity to share knowledge, resources, and broader market access, thereby encouraging the implementation of circular economy practices. These interactions have been proven to strengthen innovation, improve resource efficiency, and create sustainable mutual benefits. The relationship between these three predictors is mutually reinforcing: digital navigation improves the ability of MSMEs to utilize green financing more clearly and transparently through data-driven systems, while business cooperation expands the support network and access to capital and digital technology needed to accelerate the transition to circular economy practices. This study suggests that the combination of these three factors will produce a stronger synergistic effect on the success of circular economy adoption than each factor individually (Knight et al., 2022).

Research Hypotheses:

- H1: The effective implementation of digital navigation in food sector MSMEs will increase production and distribution efficiency, which in turn will strengthen food security and sustainability in Indonesia.
- H2: Green financing provided by financial institutions will increase the adoption of circular economy practices in food sector MSMEs, with positive impacts on waste reduction and more efficient resource use.
- H3: Business cooperation between sectors (SMEs, government, private sector) in the adoption of a circular economy will accelerate the implementation of business models that support food security and environmental sustainability.

RESULTS

Small and Medium Enterprises (SMEs) play a crucial role in supporting local economic growth and job creation in Batu City and Bali Province. Both regions, which excel in tourism, agriculture, and creative industries, heavily rely on SMEs as community-driven economic engines.

In Batu City, SMEs focus on agribusiness, processed foods, handicrafts, small accommodations, and tourism services. Many SME entrepreneurs are beginning to adopt digital technologies and circular economy principles, such as agricultural waste management. Meanwhile, in Bali, SMEs thrive in the creative industries and tourism sectors, offering products like silver crafts, local cuisine, and accommodation services. SME players in Bali have also integrated e-commerce and digital payments, and are beginning to embrace green business practices and the circular economy.

Although their key sectors differ, both regions share a similar trend in adopting digital technology, accessing environmentally-friendly funding, fostering inter-business collaboration, and implementing sustainable business models based on the circular economy.

This study uses the Partial Least Squares (PLS) SEM method. The models analyzed in this study include five main constructs, namely digital navigation, environmentally friendly financing, business collaboration, circular economy, and food security. Each construct is formed by specific indicators, and the relationships between constructs are visualized in a structural model to see the direct or indirect effects on food security.

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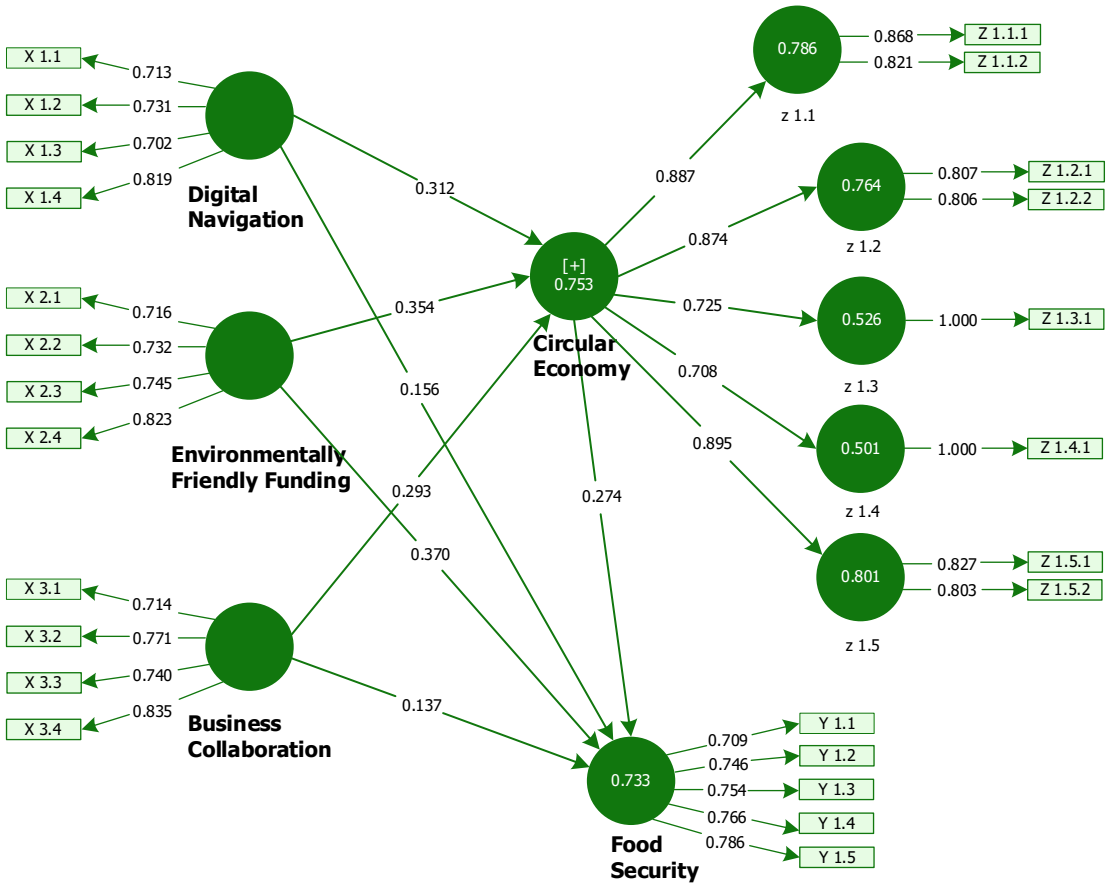

Figure 1. Outer loading research item value.

a. Evaluation of the measurement model (outer model)

Analysis of the measurement model is used to evaluate the validity and reliability of the construct. The reflective size is considered valid if the correlation is more than 0.60 (Hair et al., 2021). Three aspects in assessing the outer model are convergent validity, discriminant validity, and composite reliability.

Convergent validity

Convergent validity evaluates the relationship between latent variables and their indicators, measured by factor loading. The research instrument is considered valid if the outer loading value is more than 0.70 (Cheung et al., 2024).

All indicators in this research model meet the convergent validity criteria, indicating that indicators can represent constructs well for further analysis of SEM -based PLS. Convergent validity is also assessed through the Average Variance Extracted (AVE), which is considered valid if more than 0.50 (Cheung et al., 2024). AVE findings can be seen in Table 8.

Table 8. Results of Average Variance Extracted (AVE).

Variable	Cut Off	AVE	Result
Digital navigation	0.50	0.552	Valid
Environmentally friendly funding	0.50	0.570	Valid
Business collaboration	0.50	0.610	Valid
Circular economy	0.50	0.526	Valid
Food security	0.50	0.567	Valid

This shows that the variant described by the indicators in each construct is greater than the measurement error, so this instrument is feasible for further analysis with PLS-based structural modeling.

Discriminant Validity

Valid if the loading indicator on the construct is higher than in other constructs, as seen in Table 9.

Table 9. Discriminant validity test results (cross-loading).

Item	Digital navigation	Environmentally friendly funding	Business collaboration	Circular economy	Food security
X1.1	0.713	0.536	0.395	0.496	0.503
X1.2	0.731	0.534	0.523	0.578	0.553
X1.3	0.702	0.595	0.538	0.635	0.545
X1.4	0.819	0.651	0.561	0.625	0.635
X2.1	0.535	0.716	0.463	0.496	0.585
X2.2	0.565	0.732	0.551	0.672	0.609
X2.3	0.598	0.745	0.575	0.615	0.580
X2.4	0.660	0.823	0.520	0.630	0.664
X3.1	0.516	0.544	0.774	0.550	0.585
X3.2	0.527	0.544	0.771	0.583	0.521
X3.3	0.530	0.542	0.740	0.560	0.547
X3.4	0.565	0.556	0.835	0.659	0.563
Z1.1.1	0.661	0.633	0.698	0.868	0.617
Z1.1.2	0.566	0.578	0.493	0.821	0.574
Z1.2.1	0.544	0.583	0.488	0.807	0.495
Z1.2.2	0.548	0.563	0.517	0.806	0.607
Z1.3.1	0.601	0.585	0.573	0.725	0.582
Z1.4.1	0.551	0.532	0.530	0.708	0.571
Z1.5.1	0.595	0.612	0.556	0.827	0.611
Z1.5.2	0.509	0.575	0.508	0.803	0.570
Y1.1	0.572	0.602	0.525	0.585	0.709
Y1.2	0.555	0.632	0.550	0.616	0.746
Y1.3	0.590	0.593	0.498	0.615	0.754
Y1.4	0.591	0.634	0.597	0.620	0.766
Y1.5	0.532	0.576	0.493	0.561	0.786

Indicators of Z1.1.1 on the Circular Economic Construct (Loading 0.868) and Y1.5 in Food Security (Loading 0.786) show discriminant validity is fulfilled.

Composite Reliability

A construct is considered reliable if the value of Cronbach's Alpha and Composite Reliability > 0.60 (Cheung et al., 2024). The test results can be seen in Table 10.

Table 10. Cronbach's Alpha test results and composite reliability.

Variable	Cronbach's Alpha	Composite Reliability	Cut off	Results
Digital navigation	0.728	0.831	0.60	Reliable
Environmentally friendly funding	0.748	0.841	0.60	Reliable
Business collaboration	0.786	0.862	0.60	Reliable
Circular economy	0.871	0.899	0.60	Reliable
Food security	0.809	0.867	0.60	Reliable

The test results show that all variables have Cronbach's Alpha and Composite Reliability (CR) above 0.60, so the construct is declared reliable. The reliability values of each variable are: digital navigation (α = 0.728; CR = 0.831), environmentally friendly funding (α = 0.748; CR = 0.841), business collaboration (α = 0.786; CR = 0.862), circular economy (α = 0.871; CR = 0.899), and food security (α = 0.809; CR = 0.867) Research instruments are consistent and trustworthy.

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b. Evaluation of Structural Model (Inner Model)

Testing inner models in SEM is carried out through R-Square (R^2), Q-Square (Q^2), and Goodness of Fit (GoF). The coefficient of determination (R^2) is the main measure for assessing how much the endogenous variable can be explained by the exogenous variable; The higher the value, the better the predictive model of the model, Table 11.

Table 11. The results of the inner model evaluation with the coefficient of determination (R^2).

Influence			R^2
Digital navigation	→	Circular economy	0.753
Environmentally friendly funding			
Business collaboration			
Digital navigation	→	Food security	0.733
Environmentally friendly funding			
Business collaboration			
Circular economy			

The circular economy has R^2 = 0.753, and food security R^2 = 0.733, showing that more than 70% of the variance is explained by exogenous variables. This value confirms the model has a strong predictive power in supporting the transformation of the green economy and digital food security.

Evaluation of structural models through predictive relevance (Q^2)

Q^2 measures the ability of the model to predict endogenous variables. The positive Q-Square value indicates the model has a good predictive ability. See equation 1.

$$Q^2 = 1 - (1 - R_1^2) \times (1 - R_2^2) \quad (1)$$

- = 1 – (1 – 0,753) x (1 – 0,733)
- = 1 – (0,247) x (0,267)
- = 1 – 0,066
- = 0,934

The Q^2 value of 0.934 shows that the model has a very high predictive relevance. That is, the structure of the model that was built is very good in predicting endogenous variables (circular economy and food security). In the context of PLS, the value of $Q^2 > 0.35$ is classified as strong, so this value shows the model is very good for predicting the relationship between the variables studied.

Evaluation of structural models through Goodness of Fit (GoF)

Table 12 shows the value of GoF, calculated using the formula (Cheung et al., 2024) through the average quadratic root multiplication of AVE and the average R^2.

Table 12. The results of the evaluation of goodness of fit.

Variable	R^2	AVE
Digital navigation	0	0.552
Environmentally friendly funding	0	0.570
Business collaboration	0	0.610
Circular economy	0.753	0.526
Food security	0.733	0.567
Average	0.743	0.565

Equation 2 shows the calculation of GoF value.

$$\text{Gof} = \sqrt{\text{AVE} \times R^2} \quad (2)$$

- $= \sqrt{0{,}565 \; x \; 0{,}743}$

- = 0.648

The GoF value of 0.648 exceeds the large GoF category (0.36), so the model is declared very good and has a high global suitability of data.

Based on the results of SEM, this study shows the important role of MSMEs in local economic growth in Batu and Bali, with a focus on the adoption of digital technology and circular economy principles. In Batu, MSMEs are increasingly adopting agricultural waste management, which is in line with the findings of Cheung et al. (2024) regarding the application of the circular economy. However, this study makes a new contribution by highlighting the utilization of waste in agribusiness. In Bali, MSMEs are integrating e-commerce and digital payments, as well as environmentally friendly practices, which supports the findings of Hair et al. (2021) on digital transformation in the tourism sector, but adds depth to the application of the circular economy in the creative industry.

DISCUSSION

Analysis of Digital Navigation on the Circular Economy

Digital navigation accelerates the circular economy by utilizing technologies such as artificial intelligence (AI), the Internet of Things (IoT), blockchain, and big data to improve resource management and sustainability. This is particularly important in addressing environmental crises, with MSMEs (Micro, Small, and Medium Enterprises) benefiting from increased resilience and competitiveness. Digital navigation enables organizations to design efficient and sustainable strategies by collecting real-time data on product life cycles. Technologies such as IoT and big data optimize recycling and material reuse, supporting the transition from a linear to a circular economy, making digitization a key enabler.

In industry, digital navigation identifies reusable waste and maps material and energy flows, supporting circular business models and ensuring supply chain transparency through blockchain. It also helps achieve sustainability goals more effectively. Digital navigation encourages environmentally friendly product design by simulating reuse and waste reduction. CAD and AI offer solutions for developing circular products, enabling companies to minimize waste through precise digital planning. Additionally, digital transformation encourages consumer engagement in the circular economy by providing sustainability information, raising awareness, and driving purchasing decisions. This also creates a collaborative ecosystem between producers and consumers.

Companies that use digital navigation gain a competitive advantage in the green market, with digital platforms helping in the management of recycled and remanufactured inventory, reducing costs and carbon emissions, and aligning with the principles of the circular economy. Digital transformation is essential for corporate sustainability. Digital navigation also supports real-time monitoring of product life cycles, extends product life, simplifies data-driven decision-making, facilitates product-as-a-service models, and enhances the effectiveness of the circular economy. This encourages cross-sector collaboration within circular ecosystems, integrates systems between companies, and accelerates the implementation of circular principles.

Data analysis in digital navigation facilitates predictive decision-making, such as AI predicting market demand for recycled products, reducing overproduction and waste, and strengthening circular economy strategies. Digital navigation also supports workforce training in circular economy practices, makes educational content available globally, and supports a shift in organizational culture towards sustainability.

Based on the analysis of digital navigation on the circular economy, it confirms the importance of digital navigation in accelerating the transition to a circular economy, in line with the findings of Bocken et al. (2016). Technologies such as AI, IoT, blockchain, and big data play a major role in resource management and sustainability. There is a new dimension that shows how these technologies can strengthen the resilience and competitiveness of MSMEs, which has not been explored much before. This differs from the research by Rabbi & Amin (2024), which emphasizes consumer involvement in the circular economy without discussing the contribution of digitalization. This study also broadens the understanding of how digital navigation supports environmentally friendly product design. Bocken et al. (2016) have already touched on the role of CAD and AI, but this study also highlights how digital planning can reduce waste and increase production efficiency, providing a new focus on reducing the environmental impact of the manufacturing industry. In addition, the results of the study show that digital navigation not only improves sustainability in industry but also accelerates cross-sector collaboration. Martin et al. (2024) discusses digital transformation in the product-as-a-service model, but this study finds that system integration between companies driven by digital navigation can accelerate the principles of the circular economy. The results of this study also support the ideas of Schöggl et al. (2023) regarding data analytics in predictive decision-making. AI in digital navigation helps predict demand for recycled products, reduce overproduction, and

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strengthen circular economy strategies. A new aspect found in this study is how digital navigation can train workers and develop educational content to support organizational cultural change towards sustainability. This innovation has not been widely discussed in the literature, which focuses more on technology in business than on human resource training. Overall, this research shows that digital navigation is not just a technological tool, but a key driver that accelerates the transition towards a more efficient, transparent, and sustainable circular economy.

H1 accepted: Digitalization can improve transparency, coordination, and efficiency in sustainable supply chains. Digital technologies such as big data, blockchain, and the Internet of Things (IoT) accelerate information acquisition and data-driven decision-making, which impacts competitiveness and environmental efficiency.

Analysis of Environmentally Friendly Financing for the Circular Economy

Green financing is essential for the circular economy, providing the capital needed for sustainable infrastructure, recycling technologies, and zero-waste production systems. Without adequate funding, innovations in green technologies and sustainable models cannot be scaled up to achieve significant environmental impact. Green financing allocates funds to support environmental sustainability and conservation, which are essential for the circular economy transition. This includes promoting resource efficiency and recycling technologies, which businesses need to develop circular models. Financial institutions play a strategic role in financing the circular economy sector. Green bonds are an effective tool for financing circular projects, attracting ESG-focused investors, and supporting waste management, energy efficiency, and recycling facilities, creating a sustainable investment cycle. The trend of issuing green bonds is driving the growth of circular economy projects.

Green financing also supports MSMEs by reducing capital constraints, facilitating access to environmentally friendly technologies, and sustainable production systems. Green microfinance and subsidies are key for MSMEs to adopt circular economy principles. Sustainable financing assesses climate and environmental risks, allocating funds to circular models that offer long-term resilience and reduce risk. This transfer of funds strengthens the financial viability of circular businesses. Government funding programs, such as subsidies and tax incentives, are essential in supporting circular economy initiatives. These programs help build the necessary infrastructure, such as recycling centers and circular logistics systems.

Banks are integrating environmental criteria into credit assessments, providing companies with higher sustainability scores with more favorable financing terms, encouraging the adoption of circular production models. Investors are increasingly funding sustainable companies, improving long-term valuations for companies with circular portfolios, and creating market incentives for circular innovation. Green financing facilitates collaboration between governments, the private sector, and communities, improving the efficiency and scalability of circular projects. Green financing strengthens the circular economy by aligning innovation, efficiency, and sustainability, and with committed support from financial institutions and policymakers, it facilitates the transition to a regenerative economic future.

Based on an analysis of environmentally friendly funding on the circular economy, it highlights the importance of green financing in supporting the circular economy, in line with the findings of Kumar et al. (2025), which emphasize funding for green infrastructure and technology. However, it broadens the understanding by showing how this financing also supports MSMEs that were previously limited by capital constraints. Without adequate financing, green technology innovation cannot develop on a large scale, limiting the positive impact of the circular economy. These findings complement the research of Kumar et al., which focused more on large sectors and did not discuss the role of MSMEs in this transition. Furthermore, the study found that instruments such as green bonds are effective for financing circular economy projects, such as waste management and energy efficiency. This is in line with Aitola et al. (2022), but this study introduces a more detailed approach on how green bonds attract ESG investors, supporting circular economy projects in MSMEs. This financing is not only for large sectors, but also provides access for MSMEs to adopt more efficient and sustainable circular economy principles. In addition, the results of this study emphasize the importance of green microfinance and subsidies to help MSMEs overcome capital constraints. These findings complement Aitola & Abdillah (2025), which highlights financing for MSMEs, but this study emphasizes the role of the government in providing subsidy programs and tax incentives that encourage the adoption of a circular economy among MSMEs. Based on the results of the study, it was also found that banks have begun to integrate environmental criteria into credit assessments, in line with Abdullah (2017). This study adds insight by showing how these changes in financing policies encourage the implementation of circular production models in MSMEs. Financial institutions have a strategic role in supporting circular innovation by providing access to financing and market incentives. This study reinforces the findings of Essabane et al. (2022), which emphasize the importance of cross-sector collaboration. The results of this study show that synergy between the government, the private sector, and the community accelerates the transition to a regenerative economy with the continued support of financial institutions and policymakers.

H2 accepted: Green financing is important in supporting environmentally oriented project investments. Although challenges remain, such as low ESG literacy among MSMEs and small financial institutions, green financing can accelerate the adoption of clean technologies and efficient resource management initiatives.

Analysis of Business Collaboration on the Circular Economy

Business cooperation is essential for the circular economy, enabling MSMEs to optimize resource use through industrial symbiosis, where one company's waste becomes another company's raw material. This model creates a closed-loop system, reducing waste and increasing resource value, while facilitating the exchange of knowledge and technology and accelerating sustainable innovation. Inter-company cooperation facilitates efficient resource management, enabling the sharing of technology, networks, and practices that support the principles of reduce, reuse, and recycle. The transition to a circular model is accelerated when businesses collaborate rather than operate separately. Partnerships with environmentally conscious suppliers are essential to creating an efficient, low-waste circular supply chain, including the use of recycled materials and energy-efficient logistics. Such collaboration reduces barriers to the implementation of a circular economy.

Industrial symbiosis, an important form of collaboration, allows waste from one company to become a resource for another, conserving resources and creating new economic value. This practice is a cornerstone of the circular economy. Business partnerships also facilitate product life cycle tracking and transparency, which improves decision-making and waste management, crucial for building consumer trust in sustainability claims.

Collaboration supports service-based models, such as products as a service, which reduce raw material consumption and extend product life cycles through shared services. Collaboration in training and certification programs improves human resource competencies in sustainability, strengthening the circular economy transformation at the strategic and operational levels.

Based on the Analysis of Business Collaboration on Circular Economy, this study highlights the importance of business collaboration in accelerating the transition to a circular economy, in line with the findings of Agustina & Rach-mawati (2025), which emphasize the importance of cooperation with sustainability-oriented suppliers for an efficient supply chain. However, this study broadens the perspective by emphasizing that this collaboration is not limited to company-supplier relationships, but also includes the exchange of knowledge and technology between companies to drive innovation. This differs from previous studies that focused more on vertical relationships in the supply chain. The results of this study also found that industrial symbiosis, where waste from one company is used as raw material by another company, is key to creating a closed-loop system that reduces waste and increases the value of resources. These findings support the research of Dwi Asri Leolita (2025), but this study adds that this symbiosis also creates new economic opportunities that benefit many sectors, not just the environment. Furthermore, this study shows that collaboration between companies helps manage resources more efficiently by sharing technology and recycling practices. This study emphasizes the importance of knowledge sharing to accelerate the adoption of a circular economy, a new contribution that distinguishes this study from Bocken et al. (2016), which focuses more on product lifecycle transparency. It also found that service-based models, such as product-as-a-service, can reduce material consumption and extend product lifecycles. These findings support the research of Kudhori et al. (2025), but the existence of collaboration between companies in this model can accelerate the transition to a circular economy in a more coordinated manner across sectors.

H3 accepted: Cross-sector collaboration is essential to accelerate the adoption of the circular economy. Collaboration between economic factors such as MSMEs, the government, and the private sector can increase innovation, resource efficiency, and create mutual benefits in implementing circular economy practices.

CONCLUSIONS

Based on the results of this study, it appears that circular economy business models can improve food security and the sustainability of MSMEs in the food sector, especially in Bali and Batu City. The application of circular economy principles involving waste reduction, resource optimization, and the use of digital technology and green financing has proven effective in improving operational efficiency and reducing costs. Despite this progress, challenges such as limited access to technology and financing still need to be addressed to encourage wider adoption.

Further research should adopt a mixed-method approach and longitudinal analysis to understand the long-term impacts of circular economy implementation. Additionally, the development of consistent circular economy metrics and further exploration of government policies, infrastructure, and training to support MSMEs are essential to accelerate the transition toward more sustainable business models.

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ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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КРУГОВА ЕКОНОМІЧНА БІЗНЕС-МОДЕЛЬ ДЛЯ СТАЛОГО РОЗВИТКУ МАЛИХ І СЕРЕДНІХ ПІДПРИЄМСТВ, ЩО ГАРАНТУЄ БЕЗПЕКУ ХАРЧУВАННЯ

У цьому дослідженні розроблено бізнес-модель на основі циркулярної економіки, спрямовану на підвищення продовольчої безпеки та сталого розвитку малих і середніх підприємств (МСП) у харчовій галузі. Дослідження присвячене тому, як цифрова навігація, зелене фінансування та бізнес-співпраця можуть оптимізувати використання ресурсів, мінімізувати відходи та підвищити ефективність ланцюгів постачання в харчовій промисловості. Результати показують, що МСП в Бату й Балі почали впроваджувати цифрові технології та принципи циркулярної економіки, сприяючи місцевій продовольчій безпеці й сталому розвиткові. Понад 70% факторів, що впливають на практики циркулярної економіки та продовольчу безпеку, пов'язані із зовнішніми чинниками, такими як зелене фінансування й бізнес-співпраця. Дослідження підкреслює позитивний вплив упровадження цифрових інструментів, таких як електронна комерція й технології оптимізації виробництва, на операційну ефективність. Крім того, міжгалузева співпраця була визначена як ключовий чинник, що сприяє створенню стійких бізнес-моделей, покращуючи й продовольчу безпеку, й екологічні результати. Дослідження підкреслює важливу роль зеленого фінансування в забезпеченні необхідного капіталу для малих і середніх підприємств (МСП) для впровадження практик циркулярної економіки, особливо для зменшення відходів і підвищення енергоефективності. Незважаючи на прогрес, залишаються виклики щодо доступу до зеленого фінансування, навчання та інклюзивних механізмів фінансування. Крім того, хоча практики циркулярної економіки набувають поширення, для їх ширшого впровадження необхідна сильніша інституційна підтримка, включаючи технічну допомогу та покращений доступ до цифрових інструментів. У висновку дослідження зазначено, що малі та середні підприємства в харчовій галузі повинні інтегрувати цифрову навігацію, зелене фінансування та ділову співпрацю для зміцнення продовольчої безпеки й сталого розвитку. Бізнес-моделі, засновані на циркулярній економіці, виявилися ефективними для зменшення відходів та оптимізації ресурсів, але для сприяння всебічному та інклюзивному переходові необхідна додаткова підтримка. Результати дослідження вказують на важливість політичних заходів, міжгалузевих партнерств і цільових фінансових рішень для поширення цих практик у харчовій галузі.

Ключові слова: цифрова навігація, зелене фінансування, бізнес-співпраця, циркулярна економіка, продовольча безпека, зменшення відходів, оптимізація ресурсів, ефективність ланцюгів постачання, сталий розвиток малих і середніх підприємств

JEL Класифікація: O30, O31