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Impact Of Production Waste Utilisation (Reuse And Recycle) On Circular Economy: A Case Study Of Waste Management In Food & Beverage Industry

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Abstract

This research examines the implementation of circular economy in the dairy processing industry through the utilization of production waste. With waste volumes reaching 700 tons per year and handling costs of IDR 180 million, the dairy industry faces significant challenges in waste management. This study uses a case study approach to analyse the effectiveness of a program to reuse and recycle dairy production waste into economically valuable animal feed. The research methodology used descriptive analysis of pre- and post-program operational data as well as evaluation of socio-environmental impacts. The results showed that the implementation of circular economy not only significantly reduced waste handling costs, but also created added value for all stakeholders in the dairy industry value chain. The program successfully transformed the waste burden into productive resources, supported environmental sustainability, and improved the welfare of partner farmers through the provision of quality animal feed at affordable prices. The study generated a circular economy implementation framework that can be replicated by similar industries, emphasizing the importance of innovation and collaboration in creating sustainable solutions to industrial waste management challenges.

Keywords
Circular economy, industrial waste, reuse, recycle

1. Introduction

In recent decades, the food and beverage industry has faced increasingly complex challenges related to waste management and environmental sustainability. The concept of circular economy has emerged as a new paradigm that offers solutions to these problems (Wijaya and Sutanto, 2021). Amid the rapid development of the food and beverage industry in Indonesia, the volume of production waste generated continues to increase significantly, creating an increasingly heavy operational and environmental burden for companies. This situation is exacerbated by the increasing cost of handling waste, which reaches 180 million rupiah per year, as well as the upward trend in the price of fresh milk from farmers, which continues to creep up.

The problem is made even more complex by the pressure from various stakeholders (Citarum Harum Program Implementation Report, West Java Provincial Government, 2020). On the one hand, companies must fulfil increasingly stringent environmental regulations, while on the other hand, they must also maintain operational efficiency and profitability. Dairy farmers, as key partners in the supply chain, also face the challenge of increasing animal feed costs which have a direct impact on the selling price of fresh milk to the industry. This situation creates a double pressure that requires innovative and sustainable solutions.

In this context, the implementation of a circular economy through the utilization of production waste in the food industry is highly relevant. With an average waste generation of 700 tons per year, there is great potential to shift the paradigm of waste management from a burden to a valuable resource. This approach not only promises cost efficiency but also opens up opportunities to create added value for all stakeholders in the food and beverage industry value

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chain. The same thing was conveyed by Amir Latif in his journal on the Potential of Cattle Waste Management Based on Circular Economy where various benefits from energy savings and increased added value for other stakeholders from the resulting organic fertilizer were mentioned (2022).

2. Objectives

The primary objectives of this research are to assess the implementation of circular economy practices within the dairy processing industry and to evaluate the resultant operational efficiency improvements, including waste handling time and cost savings. The study aims to analyze the economic benefits for both the dairy company and partner farmers, focusing on cost reductions and profit margin enhancements. It seeks to measure the environmental impact, particularly regarding carbon emissions reduction and resource conservation. The research will also explore social outcomes, emphasizing community empowerment and the strengthening of partnerships with local stakeholders. The study aims to identify key success factors for effective circular economy implementation and provide actionable recommendations to enhance sustainability within the industry and its applicability to similar sectors.

3. Literature Review

The concept of circular economy has undergone significant evolution since it was first introduced in the 1970s. Research conducted by Susanto and Prasetyo (2022) explains how the circular economy has evolved from a mere waste management concept to a comprehensive paradigm that covers all aspects of the production value chain. In the context of the dairy processing industry, this approach is becoming increasingly relevant given the complexity of the challenges faced by the sector.

A study conducted by Widodo et al. (2023) revealed that the implementation of circular economy in the food industry can result in operational cost savings of up to 40% while significantly reducing environmental impacts. This finding was reinforced by Rahmawati and Junaedi's (2023) study which showed a positive correlation between the adoption of circular economy practices with improved operational efficiency and stakeholder satisfaction.

In the context of the dairy industry, Hartono et al. (2024) identified several key success factors for circular economy implementation, including management commitment, active stakeholder engagement, and availability of appropriate technology. Their research also emphasized the importance of a collaborative approach in managing the transition towards a more sustainable business model.

The social aspect of the circular economy received special attention in the study conducted by Nugroho and Santoso (2023), who underlined the importance of community empowerment and education in creating a sustainable circular economy ecosystem. These findings are in line with the triple bottom line concept introduced by Elkington and further developed by Indonesian researchers such as Wijaya and Sutanto (2021).

4. Methods

This research utilizes a descriptive quantitative and qualitative method approach to gain a comprehensive understanding of the implementation of circular economy in the dairy processing industry. The choice of this methodology is based on the complexity of the issue that requires in-depth analysis from various perspectives, as recommended by Supriyadi and Wibowo (2023) in their study on circular economy research methodology.

The data collection process was conducted over a period of one full year, covering various aspects of the company's operations and its impacts on stakeholders. Primary data was obtained through direct observation, in-depth interviews with the company, surveys of partner farmers, and documentation of the program implementation process.

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observations were conducted in three main locations: the company location (waste treatment facility), partner farms, and the location of the biscuit and snack waste management into animal feed.
Quantitative data were analyses by comparing data from the company before and after program implementation. The analysis process included:

1. Evaluation of operational performance before and after program implementation
2. Cost-benefit analysis from the perspective of the company and farmers
3. Environmental and social impact assessment through social
4. Evaluation of program sustainability using the Triple Bottom Line framework

5. Result

5.1 Operational Impact

The implementation of the circular economy program has shown significant results in various aspects of the company's operations. The transformation of production waste into animal feed has reduced the volume of waste to
meanwhile, secondary data was collected from internal company reports, regulatory documents, and publications related to the dairy industry.
In-depth interviews were conducted with several company representatives, including the head of the factory, production manager, head of waste management, and coordinator of the farmer partnership program. Surveys were conducted with farmer partners involved in the biscuit and snack production waste utilization program. Field
managed by 60%, far exceeding the initial target of 40%. This reduction has a direct impact on the company's operational efficiency, with savings in waste handling costs reaching IDR 180 million per year.
Operational data shows efficiency improvements in several key aspects:

- Reduction of waste handling time from 48 hours to 24 hours per production batch
- 45% reduction in waste storage space requirement
- Optimized use of human resources by reallocating 30% of the workforce to the main production process
- Increased animal feed production capacity from waste to 420 tons per year

5.2 Economic Impact

The economic impact analysis showed multiple benefits for both the company and the partner farmers. The company recorded significant savings through:

- Elimination of total waste transport costs worth IDR 180 million per year
- Reduction of production cost (COGM) by 67.5 IDR per kilogram
- Savings in fresh milk procurement costs of IDR 225 per kilogram

Meanwhile, partner farmers obtained economic benefits in the form of:

- Reduction of animal feed costs up to 35% of normal costs
- Increased average profit margin by 18%
- Income stabilization through long-term milk sales contracts

5.3 Environmental Impact

The implementation of the program showed a positive impact on environmental aspects, as measured through various indicators:

1. Carbon Emission Reduction:
    - 45 tons per year reduction in CO2 emissions from elimination of waste transportation
    - Reduction of carbon footprint by 30% of total company operations
    - Optimization of energy use in the waste treatment process
2. Resource Conservation:
    - Water savings of 25% through recycling system
    - Reduction in the use of chemicals in waste treatment by 40%
    - Re-utilization of 90% of organic material into animal feed
3. Environmental Quality:
    - Improved groundwater quality around production facilities
    - Reduction in local landfill load
    - Improved compliance with environmental standards by 95%

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5.4 Social Impact

The program resulted in various measurable positive social impacts:

1. Community Empowerment:
   - Waste management training for 150 partner farmers
   - Creation of 25 new jobs in waste management
   - Technical capacity building of local communities
2. Farmer Welfare:
   - Increased average income of farmers by 22%
   - Business stability through guaranteed feed supply
   - Development of business management skills
3. Community Relations:
   - Strengthened partnership between the company and farmers
   - Increased community trust in the company's operations
   - Establishment of a stakeholder communication forum

6. Discussion

6.1 Numerical Results

The implementation of a circular economy approach achieved significant impacts as measured across several aspects:

1. Operational Efficiency
   This program reduced waste processing time from 48 hours to 24 hours per production batch, maximizing waste storage space usage by 45%, and reallocating 30% of the workforce to core production processes. The transformation of production waste into animal feed enabled the company to achieve a feed production capacity of 420 tons per year.

Table 1. Operational Efficiency

Indicator	**Before Program**	**After Program**	**Improvement**
Waste Processing Time	48 hours	24 hours	50%
Waste Storage Space	100%	55%	45%
Feed Production Capacity	0 tons	420 tons/year	100%
Workforce Reallocation	0%	30%	30%

2. Economic Savings
   In the economic aspect, achieved savings included the elimination of waste transportation costs amounting to IDR 180 million per year and a reduction in production cost (COGM) by IDR 67.5 per kilogram. Fresh

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procurement costs also decreased by IDR 225 per kilogram, while partner farmers could save up to 35% in feed costs, increasing their average profit margin by 18%.

Table 2. Economic Savings

Indicator	**Cost Savings**
Waste Transportation	IDR 180 million/year
Reduction in Production Cost	IDR 67.5/kg
Fresh Milk Cost Savings	IDR 225/kg
Farmer Feed Savings	35% of normal cost

3. Environmental Impact
   Environmental impact indicators showed a reduction in CO_2 emissions by 45 tons per year, a 30% decrease in the company's carbon footprint, and a 25% water savings through recycling systems and a 40% reduction in chemical usage for waste processing.

Table 3. Environmental Impact

Indicator	Savings
CO_2 Emissions	45 tons/year
Carbon Footprint Reduction	30%
Water Savings	25%
Chemical Use Reduction	40%

6.2 Innovation in Circular Economy Implementation

The success of this program is inseparable from the innovative approach applied in transforming waste into valuable resources. As stated by Pratama and Wijaya (2023), innovation in circular economy covers not only technological aspects but also business models and partnership structures. In this case, innovation manifests in three main dimensions:

1. Technological Innovation: The program developed an efficient and environmentally friendly waste treatment method, using a combination of fermentation and nutrient enrichment technologies to produce high-quality animal feed. The process was designed taking into account resource limitations and technological adaptability at the farmer level.
2. Business Model Innovation: The development of a business model that integrates waste management with the milk production value chain creates synergies that benefit all parties. This model not only reduces operational costs but also creates new revenue streams through the production of animal feed.
3. Partnership Innovation: The partnership structure developed enables equitable benefit sharing between the company and farmers. The system includes transparent risk and profit sharing mechanisms, as well as effective communication channels between all stakeholders.

6.3 Program Sustainability

The analysis of program sustainability revealed several key factors that support long-term sustainability:

1. Alignment of Interests:
2. The program successfully aligns the interests of various stakeholders, creating a win-win situation that encourages long-term commitment. Companies benefit from operational efficiency and cost reduction, while farmers gain access to quality animal feed at affordable prices.
3. Operational Independence: The system developed is designed to operate independently with minimal dependence on external support. This includes local capacity building and effective knowledge transfer to partner farmers.
4. Adaptability: The program has the flexibility to adapt to changing market and regulatory conditions. The modular structure of the program allows for adjustments without disrupting the fundamentals of the system.

7. Conclusion

Research on the implementation of the circular economy in waste management of the dairy processing industry has led to some important conclusions that demonstrate the significant success of this approach. The transformation of production waste into animal feed has proven to have a comprehensive positive impact, covering economic, environmental and social aspects in accordance with the triple bottom line principle.

From an economic perspective, the program has achieved significant operational efficiency with a reduction in waste handling costs of up to IDR 180 million per year and a reduction in production costs (COGM) of IDR 67.5 per

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kilogram. This achievement is reinforced by the increase in economic value for partner farmers through reduced animal feed costs and an increase in average profit margins by 18%.

In the environmental aspect, the implementation of the program has resulted in a 60% reduction in waste volume from a total of 700 tons of waste per year, which directly contributes to a reduction in environmental burden. This success is also reflected in improved compliance with environmental regulations and a reduction in the carbon footprint of the company's operations.

From a social perspective, the program has created a sustainable partnership model between the industry and farmers, characterized by improved farmer welfare and strengthened local community capacity. Community empowerment through training and technical assistance has resulted in improved skills and independence of farmers in managing their businesses.

The circular economy model developed in this research shows high replication potential for similar industries and other sectors that face similar challenges in waste management. The success of this program provides tangible evidence that a circular economy approach can be an effective solution in addressing the sustainability challenges of modern industries.

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