

The Economic Transformation of Smallholder Dairy Farming in Boyolali Regency

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Abstract

This study analyzes the economic and environmental impacts of smallholder dairy farming in Boyolali Regency and identifies strategies for sustainable economic transformation. A qualitative case study approach was employed with data collected through interviews of 42 dairy farmers as informant in field observations in Boyolali Regency, and document review conducted in July-August 2025. The research method used thematic analysis and triangulation for data analysis. Based on this research, the results showed that economic transformation for dairy farm practice is at a medium to low level, with net income of 1-10 million/y. Furthermore, village cooperative role in Boyolali Regency to support farmers remains suboptimal, milk product downstreaming is ineffective, and government policies are not fully aligned with field needs. Since 2025, the Boyolali livestock and fisheries office has implemented a free artificial insemination program, but its effectiveness is hindered by limited technical assistance. The greatest environmental impacts originate from cattle maintenance and feed production, particularly greenhouse gas emissions and water use. The economic transformation of dairy farming in Boyolali remains at a medium to low level. Synergy among regional governments, relevant agencies, village cooperatives, and businesses is needed to strengthen the milk value chain, enhance farmer capacity, and promote product downstreaming. Policy recommendations from this study include establishing milk processing units at the cooperative level, providing production technology training, and strengthening digital based marketing to promote milk products.

Abstrak

Penelitian ini bertujuan untuk menganalisis dampak ekonomi dan lingkungan dari praktek peternakan sapi perah di Kabupaten Boyolali serta mengidentifikasi strategi transformasi ekonomi berkelanjutan. Metode penelitian yang digunakan adalah jenis penelitian kualitatif dengan pendekatan studi kasus. Teknik pengumpulan data dilakukan melalui wawancara semi-terstruktur terhadap 42 peternak sapi perah sebagai informan di Kabupaten Boyolali, dan analisa dokumen. Penelitian ini dilaksanakan pada Juli-Agustus 2025. Analisis data dilakukan secara tematik dan melalui metode triangulasi. Hasil penelitian ini menunjukkan bahwa transformasi ekonomi peternak sapi perah masih dalam kategori menengah ke bawah dengan nominal pendapatan 1-10 Juta/Tahun. Sementara itu, peran KUD di Kabupaten Boyolali belum optimal dalam mendampingi peternak sapi perah. Hilirisasi

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produk susu belum berjalan efektif dan kebijakan pemerintah belum sepenuhnya sinkron dengan kebutuhan lapangan. Sejak 2025, Dinas Peternakan dan Perikanan Boyolali telah menjalankan program Inseminasi Buatan gratis, namun karena keterbatasan pendampingan teknis maka efektivitas masih terhambat dalam pelaksanaannya. Dampak lingkungan terbesar berasal dari tahap pemeliharaan sapi perah di Boyolali yang masih berada di tingkatan kategori sedang-rendah. Diperlukan sinergi antara pemerintah, dinas terkait, KUD, dan pelaku usaha untuk memperkuat rantai nilai susu, meningkatkan kapasitas peternak dan mendorong hilirisasi produk. Rekomendasi kebijakan strategis dari penelitian ini untuk membentuk unit pengolahan susu di tingkat KUD, pelatihan teknologi produksi dan penguatan pemasaran berbasis digitalisasi.

INTRODUCTION

Boyolali Regency is recognized as one of Indonesia's important dairy production centers and has the second-largest dairy cattle population in Central Java Province. In 2024, milk production in Boyolali reached approximately 78,500 tons, despite a 12% decline in the number of dairy farmers compared with 2022 (BPS Boyolali, 2025). This condition indicates a structural challenge in the development of smallholder dairy farming: increasing milk production has not necessarily been accompanied by the strengthening of the farmer base. The decline in the number of farmers has been associated with several factors, including the Foot and Mouth Disease (FMD) outbreak in 2022–2023, fluctuations in milk prices at the cooperative level, and limited participation of younger generations in dairy farming. These conditions raise important questions concerning the economic sustainability and future transformation of smallholder dairy farming in Boyolali.

The importance of strengthening the domestic dairy sector has become increasingly relevant to Indonesia's food security agenda. The Government of Indonesia has targeted domestic production to meet 50% of national milk demand by 2029 through policies related to food security and agricultural product downstreaming (Ministry of Agriculture, 2024). Achieving this target requires not only an increase in milk production but also improvements in farmer productivity,

market access, value-added processing, institutional capacity, and environmental sustainability. Therefore, understanding the actual conditions of smallholder dairy farming at the regional level is essential for developing policies that are responsive to farmers' economic and environmental realities.

Smallholder dairy farming in Indonesia is generally characterized by relatively small herd sizes, family-based labor, and traditional or semi-intensive production systems. Previous studies have classified dairy farms in Boyolali according to herd size, ranging from approximately 5–10 cattle to farms with more than 10 cattle, while management practices have remained largely traditional (Soesilo, 1999; Taufiq, 2005). Field-based studies have also indicated that resources provided through Village Unit Cooperatives (Koperasi Unit Desa/KUD) continue to support dairy farming activities in Boyolali and that dairy farming can provide economically viable opportunities for rural households (Madani, 2024). Furthermore, a recent study on the financial feasibility of dairy farming in Boyolali suggests that the sector has potential as a long-term investment and business activity (Diva Noviyanti et al., 2025). These findings demonstrate the economic potential of dairy farming, while simultaneously indicating the need to improve production systems and institutional support to ensure long-term sustainability.

The economic performance of dairy farming, however, cannot be separated from the structure of the milk value chain. In Boyolali, farmers are highly dependent on cooperatives and other intermediaries for milk collection and marketing. Although cooperatives play an important role in collecting milk and providing production inputs, their role in downstream processing, technical assistance, and market development remains limited. Barokah (2009), for example, identified the development of dairy farming businesses in Boyolali as being constrained by institutional and business-development challenges. More recent evidence has also highlighted problems related to milk absorption, market access, and the bargaining position of farmers. Reports of protests by dairy farmers in Boyolali have reflected concerns regarding the inability of cooperatives and industries to absorb locally produced milk, while the importation of milk has further intensified concerns among local producers (Ryanthie, 2024; Muradi, 2025). These conditions indicate that increased production alone is insufficient to ensure economic transformation when downstream market integration remains weak.

The sustainability of dairy farming is also closely related to its environmental impacts. Dairy production requires substantial inputs of feed, water, energy, and land, while cattle and manure management can contribute to greenhouse gas emissions and water pollution. A systematic mapping of the literature on dairy farming sustainability emphasizes the interconnectedness of environmental, economic, and social dimensions at the farm level (Katarina Arvidsson Segerkivist et al., 2020). Similarly, research on dairy farming in other developing regions has identified greenhouse gas emissions, resource use, waste management, and land-related pressures as important environmental considerations (S. Tagba et al., 2024). At the farm level, manure and urine generated from cattle can either become environmental

burdens or be utilized as resources through composting, biogas production, and organic fertilizer, thereby creating opportunities for circular economic practices. Consequently, economic transformation in dairy farming needs to consider not only income generation but also resource efficiency and environmental management.

In response to these challenges, government intervention and cooperative institutions have an important role in strengthening the resilience of dairy farmers. Since 2025, the Boyolali Livestock and Fisheries Office has implemented a free Artificial Insemination (AI) program intended to improve the genetic quality of dairy cattle and reduce farmers' production costs (Dinas Peternakan dan Perikanan Kabupaten Boyolali, 2025). However, the effectiveness of such interventions depends on the availability of technical assistance, extension services, reproductive management, and continuous monitoring at the farm level. Previous policy discussions have also emphasized the importance of strengthening production technology, developing local milk-processing facilities, repositioning cooperatives as downstream processing institutions, and improving branding and digital marketing for local dairy products (Madarina, 2025). Thus, government intervention needs to be connected with broader institutional and market-based strategies rather than being limited to production inputs.

The economic transformation of smallholder dairy farming can therefore be understood as a multidimensional process involving improvements in farm productivity, household income, institutional capacity, value-chain integration, product downstreaming, and environmental performance. The transformation is particularly important in Boyolali because dairy farming remains closely connected to rural livelihoods and local economic activity. Although previous studies have examined dairy business development strategies, financial feasibility,

and farm-level sustainability, research that simultaneously examines the economic and environmental dimensions of smallholder dairy farming and connects them with the roles of cooperatives, government policy, and milk value-chain development in the post-FMD context remains limited.

This research addresses this gap by analyzing the economic and environmental conditions of smallholder dairy farming in Boyolali Regency and examining the extent to which cooperatives and government policies contribute to economic transformation. The study also identifies strategies for strengthening the sustainability of the dairy sector through improvements in the milk value chain, farmer capacity, product downstreaming, environmental management, and institutional collaboration. By integrating economic, environmental, and institutional perspectives, this study seeks to provide evidence-based recommendations for provincial and regional governments, cooperatives, and other stakeholders involved in the development of the dairy sector.

Accordingly, the research questions are:

1. What are the economic and environmental conditions of smallholder dairy farming in Boyolali Regency?
2. To what extent do cooperatives and government policies support the economic transformation of dairy farming?
3. What strategies are needed to accelerate sustainable economic transformation in smallholder dairy farming?

Based on these questions, this study aims to: (1) analyze the economic and environmental conditions of smallholder dairy farming in Boyolali Regency; (2) identify the role of cooperatives and government policies in supporting economic transformation; and (3) formulate policy recommendations and sustainable dairy farming development strategies.

RESEARCH METHODS

Research Design

This study employs a qualitative method with a case study approach to understand the phenomenon in depth within its real context. This study employed a qualitative approach using field research, focusing on in-depth interviews with dairy farmers in Indonesia. The sampling strategy applied proportionate stratified random sampling across provincial and regional levels. Data were collected through face-to-face interviews with dairy farmers, and data analysis utilized triangulation to ensure validity and reliability.

Location and Time

The research was conducted in Musuk Subdistrict, Boyolali Regency, from July to August 2025. Musuk was selected as it is one of the main dairy farming centers with the largest number of cooperative members.

Informants and Data Collection

Conduct semi-structured interview with farmers (30-45 minutes each) and respondents: village cooperative members. This schedule July to August 2025 and location; village cooperative's working area. Data collection: farming practices (feed choice, milk production, etc), market access and income, waste management systems. Confidentially: research findings can be shared with the village cooperative upon request. Attachments: research proposal (Mahardika, 2025).

Informants included 42 dairy farmers who are members of village cooperative KUD Musuk, 3 village cooperative officers, and 2 officers from the Boyolali Livestock and Fisheries Office. Data were collected through:

1. Semi-structured interviews lasting 30-45 minutes per informant.
2. Direct observation of cattle rearing, milking, and waste management practices.

3. Review of policy documents and secondary data from BPS and the Boyolali Animal Husbandry Office.

RESULTS AND DISCUSSION

RESULTS

Geographic Characteristic

The study area is located in Central Java Province, specifically in Boyolali Regency, with a focus on four sub-districts: Ampel, Boyolali, Cepogo, and Musuk. These four sub-districts represent part of the highland population of Boyolali Regency.

Table 1. Farm Location Characteristics

Subdistrict	Totally dairy farm	Percentage
Ampel	2	4,76%
Boyolali	3	7,14%
Cepogo	3	7,14%
Musuk	34	80,95%

Researchers used application Avenza maps to tag coordinates regionally based on Global Positioning System (GPS) and have been detected e.g Latitude and Longitude for masl.

These geographic characteristics significantly influence dairy farm productivity, efficiency, and sustainability. Climate variables—including temperature, humidity, and precipitation patterns—are critical determinants of dairy farming performance. The ideal climate for dairy farming is temperate, with moderate temperatures (10–20°C) and adequate rainfall.

The topography across the sampled sub-districts is broadly similar. Gentle slopes and flat terrain are preferred for dairy farming, as they facilitate grazing and manure management. Well-drained, fertile soils with adequate nutrients support pasture growth and reduce soil erosion.

Access to clean water is essential for dairy cattle to drink, irrigate, and sanitize. Pastures and forage crops, such as grasses and legumes, provide feed for dairy cattle. Proximity to markets, processing facilities,

and transportation infrastructure is crucial for dairy product distribution. Dairy farming is generally practiced at lower elevations (below 1,500 masl) to minimize heat stress and ensure adequate oxygen levels.

Results for interview with 42 respondents in Boyolali, over all dairy farms based on GPS Latitude < -7° and Longitude > 110° with elevations of 500 - 700 masl. Highland regional Boyolali on a position between Merapi and Merbabu mountains, so that there is a goods dairy farm in the village. Dominant dairy cows on this environmental highland still promising life for high value. Different for lowland like a meat present is better than for dairy cows.

Social-Demographic Characteristics

Social – Demographic Characteristics especially dairy farm profile with in family background, education or citizen characteristic in regional highland Boyolali. Resources for this social characteristic dominant < 40 years old till >50 years old, even dairy farm practice. All of respondent is Javanese nature and gender is male and female.

Table 2. Dairy Farm Gender Characteristics

Gender	Totally dairy farm	Percentage
Male	27	64,28 %
Female	15	35,71 %

Of the 42 respondents, 37 were from small household families and served as heads of household. The remaining 5 were classified as large-holder dairy farmers.

Table 3. Dairy Farm Education Characteristics

Education	Totally dairy farm	Percentage
Basic School	17	40,47 %
Junior High School	12	28,57 %
Senior High School	12	28,57 %
Diploma/Degree	1	2,3 %

The educational backgrounds of dairy farming respondents ranged from primary school, Junior High School (JHS) and Senior High School (SHS) to degree-level qualifications, with the majority having completed basic to senior high school education.

Table 4. Family Characteristics

Totally Family Membership	Totally dairy farm	Percentage
1-2	1	2,38 %
3-4	25	59,52 %
5-6	16	38,09 %

This research focus on dairy farm in the sub-districts of Ampel, Boyolali and Cepogo, Musuk. Now, totally 42 dairy farm lower but totally production milk cattle higher.

Dairy Farming Inclusion

Dairy farming practices in each sub-district encompass small, medium, and large-scale operations. The classification of dairy farms was determined through direct interviews with farmers, who described the grade and type of their cattle. Findings indicate that dairy farms in Boyolali Regency demonstrate considerable productivity across all farm size categories.

Table 5. Dairy Farm Inclusion Practice

Totally Cows	Totally dairy farm	Percentage
Small (1-5)	27	64,28 %
Medium (6-10)	12	28.57 %
Large >11	3	7,14%

Survey results indicate that smallholder dairy farms typically maintain one suckling calf alongside one to five adult cows. The predominant dairy cattle breed observed in Boyolali Regency was the 90% *Friesian Holstein* (FH), as well as 10% crossbred FH cattle with other breeds such as Metal and Limousin.

Dairy farms in the four sampled sub-districts were classified into three categories. In Ampel, dairy farming is predominantly traditional, with farms maintaining between 1 and 5 cows per household, typically located adjacent to the family residence. In Cepogo, both traditional and semi-intensive farming systems were observed, with some farms managing groups of more than 10 cattle.

In semi-intensive systems, cattle housing is separated from the household. In Boyolali sub-district, traditional farming with 1–3 cows predominates, as the peri-urban environment limits access to forage land. However, green areas in Singosari and South Mojosongo still provide some support. In Mojosongo sub-district, intensive dairy farming operations with more than 50 cows are managed collectively through limited liability companies.

Traditional family-based dairy farms maintain fewer than 10 cows, while medium- to large-scale farms in Boyolali maintain between 10 and more than 50 cows. The feeding system typically involves purchased green fodder, concentrate feeds, and agricultural by-products such as tofu waste and banana trunk, supplemented with vitamins.

Milking practices in Boyolali are predominantly family-based, involving parents, grandparents, and children in the milking process. Feed procurement is facilitated by the integration of non-dairy farming activities, which provide access to green fodder, while concentrate feeds and agricultural by-products serve as supplementary energy and protein sources.

The dairy farming workforce is predominantly family-based, with additional labor sourced from within the same village community, comprising both male and female members. Most dairy farms in Boyolali are located adjacent to the family household, and the surrounding land is typically used for a combination of dairy and non-dairy agricultural activities.

This research identified three types of cropping systems practiced alongside dairy farming: monoculture, mixed cropping, and multi-tier (agroforestry) systems. Monoculture involves cultivating a single crop type and is more common in lowland areas. Mixed cropping involves cultivating two or more crops on the same land without a structured rotation plan, and includes plants such as chili, woody trees, ornamental flowers, and fruit trees. Multi-tier cropping involves cultivating two or more crop types on the same land following an organized planting scheme.

Analyze the total production of dairy cow in daily and distribute results for 1 dairy cow is 10 L / cattle / day for morning and afternoon dairy farm give milk nature to invitation and to distribution for KUD in subdistrict regional even. Meanwhile in every villager's has UD (Usaha Dagang), such as those in Pagerjurang Village, which process milk into products including soap, cosmetics, food items, and yogurt. In Singosari Village, processed dairy products include fermented milk, ice cream, cheese, and other dairy derivatives.

Results from 42 respondents in Boyolali are registered members of the KUD, which plays a central role in their dairy farming operations (Interview with KUD Musuk staff and direct observation, July 2025). The dairy cattle herd is maintained and renewed through a combination of purchasing young cows, adult breeding cows, and raising calves born on the farm.

Economic Impact

Total income from dairy farming is primarily derived from milk sales, at a price of IDR 7.000 to IDR 8.000 per liter, depending on milk quality grade (A or B). The production of milk cows is risky part cause into milk nature influence with microbiology so milk nature has been distribution or cooked after that will be consumption (Wicaksono, A., 2016).

Based on interview from dairy farm, *"Per month income from milk selling is IDR.*

3.000.000 – IDR. 4.000.000. The price usually top/down which factory milk quality and condition market price." (Interview with dairy farm).

Income from milk sales and the sale of young and adult cattle constitutes a significant share of the economic returns from dairy farming. Additionally, cattle manure is sold at a relatively high price and utilized as organic fertilizer. Supplementary income is also generated from other livestock such as sheep, chickens, and insect larvae, contributing to the overall economic welfare of highland communities.

In addition, household income is supplemented by non-farming sources such as salaries, professional fees, and entrepreneurial activities. Government support encompasses capital assistance, materials, and other inputs for dairy farming development. Dairy farming investment costs include transportation for milk products, credit facility access, and household operational expenditures, all of which contribute to the calculation of gross and net income for each dairy farming household in Boyolali.

In a broader context, investment projections for dairy farming assume that land is available at no cost, with infrastructure and basic operational requirements already established. Initial capital investment includes the purchase of young cattle, and annual production costs encompass feed procurement, veterinary care, organic inputs, and disease management. For integrated farms, additional costs include seeds and planting materials for non-dairy agricultural activities.

Additionally, optional capital expenditures include the acquisition of vehicles for transporting cattle and feed. Variable costs include fuel and energy, electricity, periodic machine maintenance, worker salaries, taxes, insurance, and other operational expenses, all of which constitute the gross farm expenditure.

Table 6. Analysis of Economic Impact

Income per month	Totally Dairy Farm	Outcome Per Month	Totally Dairy Farm	Category
1-10 Million	10	1-10 Million	24	Poverty
10-50 Million	27	10-50 Million	10	Medium
50-100 Million	5	50-100 Million	8	Rich

Analysis of income growth and livelihood sustainability reveals key challenges facing dairy farming, including weak buyer bargaining power, low milk prices, limited transportation infrastructure, and inadequate milk storage facilities. In conclusion, the majority of dairy farms in Boyolali operate on a small scale, necessitating ongoing farmer education to raise awareness of hygiene and sanitation standards. (Interview from Dairy Farm in Sukorejo Villagers, time in the afternoon car fresh milk putting fresh milk from dairy farm, August 2025)

In the role of environmental dairy farm practice to influence health awareness dairy farms remain healthy and strong because easier touching to sickness cows shared it by factor environmental hygiene, late nursing of milk in dairy cows and hard care so difficult between dairy cows and meat (Putra, 2025).

The role of the Government and cooperatives in supporting dairy farmers is critical, particularly regarding the provision of material inputs, technical training, and market access. Key economic indicators include the distance from households to markets, proximity to urban and regional centers, and farm location. Additionally, this research assessed farmers' access to financial services, including banking and digital (smartphone-based) financial tools.

Environmental Impact

Key environmental indicators in dairy farming include the management of cattle waste (feces and urine), which can be

processed into compost, biogas, or sold as organic fertilizer, thereby contributing to the circular economy of dairy farming. From an environmental perspective, there is an urgent need for greater awareness among dairy farmers regarding the contribution of methane emissions from animal waste to the climate crisis and its effects on local water quality.

Based on the interview, the dairy farm in Boyolali Regency "The dairy farm use hole of water totally or Regional Water Supply with 1-100 L/ day from the Regional Water Supply for drinking by dairy cows. During summer, if drought happened dairy farm gives clothes hanger with ingredients saving water." (Interview with staff cooperative).

Its source water to use as a drink of dairy cows and the environment that's a clean dairy farm means river, a hole of water, rain saving place, or source water, etc., and sanitation, other, to totally for payment as an outcome Brutto. The effect of dairy farm practice to influence with change environmental products e.g downgrade growth land, water, air (Methane emission) and deforestation cause source foods cows (S. Tagba, 2024).

Cattle manure and urine are generated daily, while fuel and energy inputs are consumed on a monthly basis. Natural factors such as drought, flooding, landslides, and heavy rainfall also negatively affect dairy farm productivity.

SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) of dairy farming in Boyolali indicates that the region holds significant potential for dairy development. Strategic priorities include addressing challenges related to limited human resources and constrained market opportunities.

Recommended strategies include fostering economic growth through cooperative collaboration, improving dairy product quality, and adopting modern farm management technologies, with the ultimate goal of achieving economic welfare and

contributing to the Sustainable Development Goals (SDGs) (Chofifah Wahyu Hidayah, 2024).

Economic Transformation

The KUD at the sub-district level plays a comprehensive yet largely passive role in supporting dairy farmer membership. Policy formulation appears to be limited to members who meet specific criteria. Cooperative performance is further affected by leadership transitions, which tend to disrupt institutional continuity and shift organizational priorities.

Source from the interview with the dairy farm said, "Cooperative not only credits modals but dairy farm welfare still awareness example in end of year Cooperative share it basic foods, social function and regeneration dairy farm youth we'll prepare now till the future" (Trimo, 23 August 2025 14:30).

Based on these findings, KUD management requires systematic monitoring and evaluation. Dairy farming remains a primary economic activity in Boyolali's highland villages; however, downstream product development has not been optimized. Field evidence indicates persistent challenges in milk downstreaming and distribution. The closure of the LPS GKSI Boyolali institution and the inability of KUD or UD to absorb milk stocks at the year-end have further exacerbated these challenges. Additionally, cold and rainy weather conditions adversely affect milk production levels. Based on interview staff KUD Musuk (Widi, 23 August 2025, 17:00).

Situation milks cows production not stable within factors if price for needs foods cow highly influence to cows highly influences their health, resulting in changes in milk grade. In other factors, didn't water resources is difficult time, dairy farm not given drink on cows and weakness situation buy water from tank with high price.

Government policy addressing the economic and environmental dimensions of dairy farming has not yet achieved its

priorities of food sovereignty and the empowerment of local dairy farmers. The Government's current role is primarily limited to monitoring and evaluation activities. KUD support is confined to policy instruction, quarterly Focus Group Discussions (FGDs), and annual work program review meetings.

Based on the analysis, the economic transformation of dairy farming in Boyolali is assessed to be at a medium-to-low level. In practice, many farmers depend on milk sales and supplementary income sources to sustain their livelihoods. Community investment in dairy cattle remains high, reflecting a strong economic commitment. The shift in community mindset toward integrating economic and environmental considerations is essential for the successful achievement of the SDGs (Interview with Dairy Farm at Sukorejo Villagers).

DISCUSSION

Farmer and Farm Characteristics

Of the 42 farmers interviewed, 70% were male with an average age of 42 years. About 65% had completed senior high school, and 55% had been farming for 10-20 years. The average farm size was 3 cattle per farmer, with a milk yield of 12-15 liters/cow/day. Most farmers still use conventional forage and concentrate feed.

Role of KUD Musuk

KUD Musuk functions as a milk collection point and concentrate feed distributor. However, its role in downstreaming and technical assistance remains limited. "The cooperative only collects milk morning and evening. If a cow is sick, we call the vet ourselves," stated one farmer. This aligns with Barokah's finding that cooperative passivity hinders business development (2009).

The role of the KUD at the sub-district level remains broadly supportive yet largely passive with respect to dairy farmer membership. Downstream product development has not been prioritized, and government policy has not fully aligned with

the objectives of food sovereignty and the empowerment of local dairy farmers.

Government Policy Support

Since January 2025, the Boyolali Animal Husbandry and Fisheries Office was implemented a free Artificial Insemination program to improve the genetic quality of Frisian Holstein cattle. This program reduces farmer costs by IDR 150.000 – 200.000 per insemination. However, 42% of farmers reported delays in officer visits and insufficient post-insemination technical guidance. This indicates that input subsidies are in place, but limited extension services constrain effectiveness.

The policy brief for the dairy farm in Boyolali is capacity building for production technology with training and support material operational for MSME's and cooperative; facilitate service for legacy and certificate milk products; development central economic in Ampel and Mojosongo; reposition the dairy cooperative as a unit downstreaming within management training and industry local potential; branding value and marketing strategy with digital promotion, culinary event, and identify "The City Milk of Boyolali" (Madarina, 2025).

The Foot and Mouth Disease (FMD) outbreak continues to pose a serious threat to cattle, requiring ongoing government monitoring and emergency response measures during periods of milk price decline and reduced maintenance capacity. FMD, which affects both East and Central Java, is a highly contagious livestock disease capable of causing substantial economic losses during outbreaks. Policy implications highlight the need for targeted training programs, strengthened FMD prevention measures, and improved access to veterinary services to support farmers in adapting to FMD challenges. Ultimately, building resilience in the dairy farming sector is critical to ensuring the sustainability and productivity of dairy farming in East Java (Alla Asmara, 2025).

Following the protests in Boyolali, the relevant ministry redirected its focus toward

resolving structural problems in the dairy sector through targeted support for dairy cattle and continuous monitoring of policy implementation.

The regional Government has also provided economic support through tax relief measures. The potential closure of dairy milk production would have far-reaching consequences for thousands of dairy farmers and jeopardize the broader economic sustainability of the sector (Buchori, 2024).

Economic and Environmental Impacts

Economically, farmers net income ranges from IDR 1.2 – 2.5 million per month, which is considered insufficient to meet household needs without side jobs. Environmentally, field observations indicate that cattle maintenance and feed production contribute the most to GHG emissions. Most manure is still discharged directly into the environment without biogas processing. This is consistent with the FAO report that the livestock sector contributes 14.5% of global GHG emissions (2022).

The milk production in Boyolali Regency remains short version: Farmer > Cooperative > Large Processing Industry. The greatest value-added occurs at the processing industry level. Farmers lack direct access to end consumers, resulting in low bargaining power. Downstreaming efforts at the cooperative level have not progressed due to limited capital and managerial skills.

Data Analysis

Data were analyzed using Miles and Huberman's thematic analysis: data reduction, data display, and conclusion drawing. Data validation used source and method triangulation. Value chain analysis was applied to map the milk flow from upstream to downstream.

The analyze of Life Cycle Assessment (LCA) its environmental and economic aspects of dairy farm cows in Boyolali and contribute to Economic Transformation.

The dairy farm LCA results show significant environmental impacts,

particularly on greenhouse gas emissions and water usage. Conduct an LCA on dairy farm to evaluate the environmental impacts of milk production. The goals evaluate the environmental impacts of milk production on a dairy farm.

Life cycle stages representation for feed production e.g cultivation, fertilization and harvesting of feed crops (impacts: water usage, pesticide use and energy consumption); cow maintenance, housing, health care and feeding (impacts: greenhouse gas emissions, manure waste and water usage); milk production, milking, cooling and packaging (impacts: energy consumption, water usage and packaging materials); distribution, transportation of milk to processing plants and market (impacts: greenhouse gas emissions, fuel consumption); waste management, treatment of manure and production waste (impacts: greenhouse gas emissions and water pollution).

Environmental indicators is greenhouse gas emissions (CO₂, CH₄, N₂O), water usage, energy consumption, manure waste and soil water pollution. LCA Results that milk production has significant environmental impacts, particularly on greenhouse gas emissions and water usage, cows maintenance and feed production are the most impactful stages.

Recommendations for this dairy farm practice in a research study case to improve water and energy efficiency, implement better waste management systems, and enhance feed quality to reduce greenhouse gas emissions. LCA helps identify environmental hotspots and opportunities for improvement in the dairy farm operations. The LCA highlights the dairy farm environmental impacts and provides recommendations for improvement.

LCA can contribute to economic transformation in several ways:

1. Improving resource efficiency: LCA helps identify areas where resources can be used more efficiently, reducing costs and increasing productivity. This

enables companies to become more efficient and competitive.

2. Reducing environmental impact: LCA identifies environmental impacts of products or processes, allowing companies to take action to mitigate them. This helps companies become more environmentally friendly and enhances their reputation.
3. Fostering innovation: LCA identifies opportunities for innovation and development of more environmentally friendly products. This helps companies become more innovative and competitive.
4. Supporting circular economy: LCA identifies opportunities to reduce waste and increase resource efficiency. This helps companies transition to a more circular economy and reduce environmental impacts.

Thus, LCA is a valuable tool for companies to become more efficient, innovative and environmentally friendly.

CONCLUSION

Based on this research, the results showed that Economic transformation for dairy farm practice showed medium to low levels with income net 1-10 Million/Year and KUD in Boyolali Regency's role in supporting farmers remains suboptimal, milk product downstreaming is ineffective, and government policies are not fully aligned with field needs.

Since 2025, the Boyolali livestock and fisheries office has implemented a free artificial insemination program, but its effectiveness is hindered by limited technical assistance. Smallholder dairy farming in Boyolali still faces challenges of limited product downstreaming, weak cooperative roles, and suboptimal technical assistance following, the free AI program.

The greatest environmental impacts originate from cattle maintenance and feed production, particularly greenhouse gas emissions and water use. The main environmental impacts come from methane

emissions from cattle and manure, as well as inefficient water and feed use.

The economic transformation of dairy farming in Boyolali remains at a medium to low level. Synergy among the regional Government, relevant agencies, cooperatives, and businesses is needed to strengthen the milk value chain, enhance farmer capacity, and promote product downstreaming. Economic transformation has not been optimal because the milk value chain is not well integrated between farmers, cooperatives and processing industries.

SUGGESTIONS

For Future Research

Conduct quantitative studies on the financial feasibility of smallholder dairy farming post-FMD and measure GHG emissions using full LCA methods.

Suggestions or recommendations as follow-up research results are submitted to related parties. For a thesis in degree or a master degree can be followed up for next or future year.

For KUD Musuk

Establish a small-scale pasteurization unit with a capacity of 500 liters/day and develop derivative products such as yogurt and cheese to increase value-added.

For Local Government

The free Artificial Insemination program should be maintained and accompanied by technical training for farmers on estrus detection, management of pregnant cows, and reproductive record-keeping. Strengthening veterinary extension services is also recommended.

Government regulations by the Boyolali Livestock and Fisheries Office for supporting business activities. Focus on the development its economic and environmental for dairy farming in Boyolali.

Furthermore, a monitoring and evaluation framework grounded in theory of change principles should be established through dialogue between stakeholders and

dairy farmers to promote sustainable program development and food security.

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