

Strengthening Young Farmers' Capacity in Implementing a Circular Economy through Zero-Waste for Sustainable Beef Cattle Farming in Tani Bhakti Village, Kutai Kartanegara

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Abstract

Efficient waste management becomes a key factor in reducing negative environmental impacts while improving the operational efficiency of livestock farming. This community service activity aims to enhance young livestock farmers' understanding and skills in Tani Bhakti Village, Loa Janan Subdistrict, Kutai Kartanegara Regency, in applying zero-waste, circular-economy principles in livestock waste management. This activity involved 20 young farmers from diverse backgrounds and genders. The activity included socialization, extension services, technical training, and direct demonstrations in processing livestock waste into value-added products, such as organic fertilizer and bioenergy. The method used was Participatory Action Research (PAR), which involved farmers as active participants at every stage of the activity. Evaluation was conducted through pre-test and post-test questionnaires to measure improvements in knowledge, as well as direct observation of the application of waste management techniques. The results showed that 90% of participants successfully improved their understanding of the circular economy, and 85% applied the acquired waste management techniques. The main constraints identified were limited technical understanding and access to technology. This community service activity successfully enhanced the operational sustainability of livestock farming and reduced environmental impacts.

Keywords: beef cattle farming, circular cconomy, young farmers, zero waste

Abstrak

Pengelolaan limbah yang efisien menjadi kunci dalam mengurangi dampak negatif terhadap lingkungan serta meningkatkan efisiensi operasional peternakan. Pengabdian kepada masyarakat ini bertujuan untuk meningkatkan pemahaman dan keterampilan peternak muda di Desa Tani Bhakti, Kecamatan Loa Janan, Kabupaten Kutai Kartanegara dalam penerapan prinsip circular economy berbasis zero waste pada pengelolaan limbah ternak. Kegiatan ini melibatkan 20 peternak muda yang terdiri dari berbagai latar belakang demografis dan jenis kelamin. Pelaksanaan kegiatan mencakup sosialisasi, penyuluhan, pelatihan teknis, dan demonstrasi langsung dalam pengolahan limbah ternak menjadi produk bernilai seperti pupuk organik dan bioenergi. Metode yang digunakan adalah Participatory Action Research (PAR), yang melibatkan peternak sebagai peserta aktif dalam setiap tahap kegiatan. Evaluasi dilakukan melalui kuisioner pre-test dan post-test untuk mengukur peningkatan pengetahuan, serta observasi langsung terhadap penerapan teknik pengelolaan limbah. Hasil kegiatan menunjukkan bahwa 90% peserta berhasil meningkatkan pemahaman mereka mengenai circular economy, dan 85% peserta berhasil mengaplikasikan teknik pengelolaan limbah yang diperoleh. Kendala utama yang ditemukan adalah keterbatasan pemahaman teknis dan akses terhadap teknologi. Pengabdian ini berhasil meningkatkan keberlanjutan operasional peternakan serta mengurangi dampak lingkungan.

Kata Kunci: *Peternak muda, circular economy, zero waste, peternakan sapi potong*

INTRODUCTION

The circular economy concept, which emphasizes sustainable resource utilization, waste minimization, and the revalorization of materials, has emerged as a central framework for addressing contemporary environmental challenges and enhancing production efficiency across diverse sectors, including livestock farming. In beef cattle production, adopting zero-waste practices is not limited to reducing waste output; rather, it encompasses advancing sustainable operations by efficiently managing feed resources, livestock waste, and other inputs (Stahel, 2016). A zero-waste cattle farming system entails transforming waste streams into value-added products, such as organic fertilizers and bioenergy, aligning with circular economy principles to establish environmentally responsible production systems while reducing dependency on external resources (Geissdoerfer et al., 2017). Empirical evidence further suggests that applying these principles in the beef cattle sector contributes to reducing greenhouse gas emissions, minimizing feed loss, and improving overall energy efficiency (Widiarta et al., 2025).

Tani Bhakti Village, located in the Loa Janan Sub-district of Kutai Kartanegara Regency, exemplifies an area with considerable potential for advancing zero-waste beef cattle farming. A substantial proportion of the local population is engaged in cattle rearing, with more than 75% of the 2,500 households depending primarily on this sector for their livelihoods (BPS Kabupaten Kutai Kartanegara, 2021). The village currently maintains a cattle population exceeding 4,000 head, positioning it as a potential hub for developing zero-waste cattle production systems. Despite these favourable conditions, the sector faces significant challenges, particularly concerning inefficient feed management and inadequate waste handling practices. These constraints have led to resource inefficiencies, increased operational costs, and adverse impacts on the local environment (Dinas Peternakan dan Kesehatan Hewan Kabupaten Kutai Kartanegara, 2021; Widiarta et al., 2021).

A central challenge in Tani Bhakti Village pertains to managing livestock waste. Manure, urine, and residual feed are frequently disposed of inappropriately, contaminating soil, water, and air resources. Current data indicate that approximately 60% of livestock waste in the village remains unmanaged, thereby posing a substantial risk of water resource pollution for local communities (Dinas Lingkungan Hidup dan Kehutanan Kabupaten Kutai Kartanegara, 2021). The inadequate livestock waste treatment contributes to elevated methane emissions, a potent greenhouse gas linked to climate change (Smith et al., 2020). Addressing these issues requires establishing systematic waste management strategies that convert livestock by-products into practical outputs, such as organic fertilizers, which enhance soil fertility while reducing dependency on synthetic chemical inputs (Memon et al., 2018; Silva et al., 2020).

The transition toward zero-waste beef cattle farming in Tani Bhakti Village also presents a strategic opportunity for young farmers to assume a pivotal role in driving environmentally sustainable livestock practices. Younger generations of farmers are generally more receptive to innovation and technological advancements, positioning them as key agents in adopting resource-efficient and sustainable production models (Parker et al., 2021). Community engagement initiatives in this context seek to provide targeted training for young farmers on waste management practices and the application of technologies that facilitate zero-waste livestock systems. Through adopting these practices, young farmers are expected to mitigate

resource inefficiencies, enhance operational productivity, and contribute to the establishment of environmentally responsible farming models (McAloon et al., 2017; Widiarta et al., 2025).

The practical implementation of zero-waste cattle farming in Tani Bhakti Village is projected to generate multidimensional benefits. Beyond the direct economic advantages for farmers, adopting circular economy principles through improved waste management and resource efficiency is anticipated to enhance environmental sustainability and strengthen the socio-economic resilience of the village. Importantly, this model has the potential to serve as a replicable framework for cattle farmers in other regions, thereby fostering the diffusion of sustainable practices across Indonesia's livestock sector. Ultimately, the advancement of zero-waste livestock systems represents a crucial step toward the realization of a more sustainable, environmentally friendly, and economically viable agricultural future.

METHOD

The Community Service Program, the approach adopted was Participatory Action Research (PAR), which emphasizes active collaboration between the implementation team and young farmers in Tani Bhakti Village, Loa Janan Sub-district, Kutai Kartanegara Regency. The implementation team, composed of lecturers and students from the Animal Science Study Program, Faculty of Agriculture, Universitas Mulawarman, supported applying a zero-waste beef cattle farming system. Young farmers were identified as the primary stakeholders in this program, given their substantial potential to act as change agents in advancing the adoption of circular economy principles within the beef cattle sector (Marku et al., 2024).

Preparation Stage

During the preparation stage, community service team worked collaboratively with young farmers to conduct problem identification and situational analysis. The main objective was to assess the specific needs of young farmers concerning the adoption of zero-waste systems, as well as the challenges they face in managing livestock waste and feed resources efficiently. Based on this analysis, the team developed a structured activity plan that actively involved young farmers as participants to be trained in applying circular economy principles to beef cattle production (Marku et al., 2024).

Implementation Stage

a. Awareness-Raising and Dissemination

The first activity involved awareness sessions introducing young farmers to the concepts of the circular economy and zero-waste livestock systems. The primary goal was to strengthen farmers' understanding of sustainable resource management, waste reduction, and feed efficiency. Key topics included the transformation of livestock waste into organic fertilizers and bioenergy and practical techniques for more efficient feed utilization (Kotyal, 2023).

b. Capacity-Building through Training and Demonstration

The second activity involved intensive training on livestock waste management and adopting appropriate technologies to support zero-waste practices. Young farmers received practical instruction on processing cattle manure and feed residues into value-added products such as organic fertilizers and bioenergy. In addition, they were introduced to tools and technologies designed to enhance the operational efficiency of beef cattle farming and minimize feed wastage (Kotyal, 2023).

c. Practical Assistance and Mentorship

The third component of implementation was hands-on assistance, in which the facilitation team introduced technologies that support zero-waste livestock farming, such as waste-processing equipment and feed-drying machinery. Direct mentorship was provided to ensure young farmers could adopt and effectively apply these technologies in their enterprises (Marku et al., 2024).

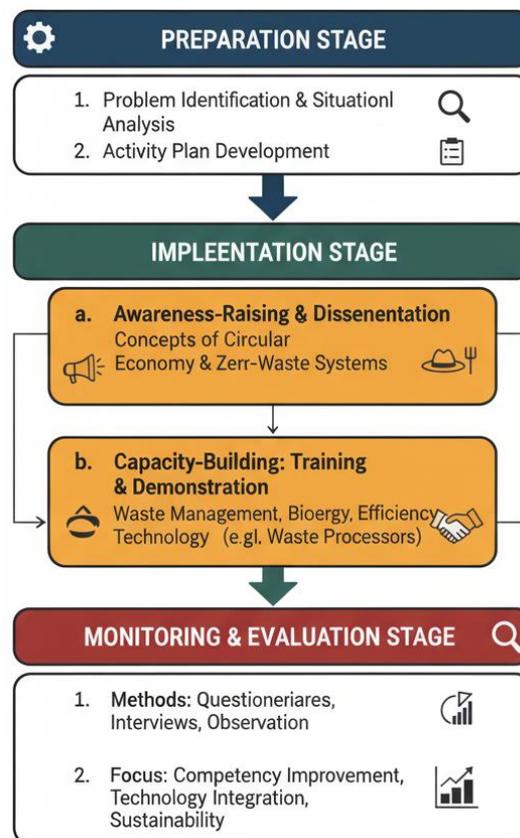


Figure 1. Stages of the Community Service Program

Monitoring and Evaluation

Monitoring and evaluation were integral to measuring the effectiveness of the program. These processes were conducted through questionnaires, interviews, and direct observations to assess changes in farming practices before and after program implementation. The evaluation specifically examined improvements in young farmers' waste and feed management competencies and their capacity to integrate the introduced technologies into their farming systems. The focus was on determining the extent to which the program contributed to reducing resource inefficiencies, enhancing sustainability, and strengthening the operational performance of beef cattle farming in the village (Marku et al., 2024).

RESULT AND DISCUSSION

Socialization of the Circular Economy Concept and Zero-Waste Cattle Farming

The socialization of the circular economy and zero-waste cattle farming was carried out to enhance the knowledge and awareness of young farmers in Tani Bhakti Village regarding the importance of sustainable resource management and waste reduction in beef cattle production systems. During this stage, the community engagement team delivered materials

that introduced the fundamental principles of the circular economy, with emphasis on livestock waste management, feed efficiency, and the reduction of resource wastage in cattle farming operations. A total of 20 young farmers participated in this interactive session, which was designed to combine knowledge transfer with active discussion and question-and-answer activities. The results indicated that 90% of participants were highly interested in the material presented. Participants who initially lacked understanding of the circular economy in beef cattle farming were subsequently able to explain the concept clearly, particularly about the conversion of livestock waste into value-added products such as organic fertilizers and bioenergy.



Figure 2. Knowledge Transfer Activities with Young Farmers

Source: Author's Documentation, 2025

The effectiveness of the socialization program was reflected in the participants' ability to identify and apply practical measures for improving resource use efficiency. One concrete example is the transformation of livestock waste into organic fertilizers, which enhances soil fertility for forage production while reducing reliance on synthetic chemical inputs. Young farmers were also introduced to waste management techniques to minimize feed losses and improve the overall operational efficiency of beef cattle farming systems. This understanding is consistent with zero-waste principles, which emphasize minimizing waste generation and maximizing the utility of existing resources (Geissdoerfer et al., 2017). Accordingly, the activity provided a theoretical foundation and practical knowledge that could be directly implemented in daily farming practices.

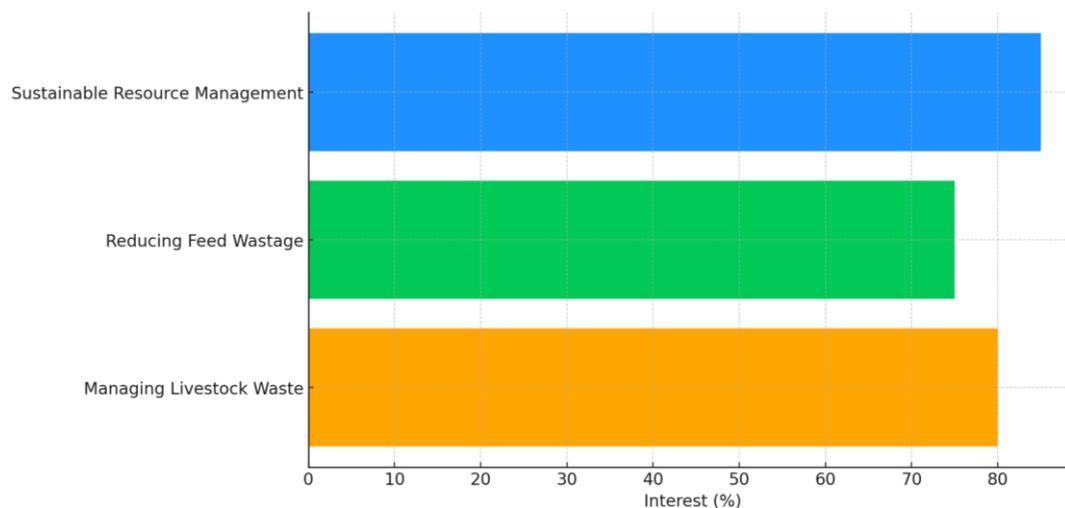


Figure 3. Participants' Interest in Socialization Materials

Source: Processed Primary Data, 2025

The socialization activities created an interactive platform between facilitators and participants, allowing young farmers to share experiences and discuss challenges in managing their farms. This participatory approach reinforces the principles of Participatory Action Research (PAR), which highlight the importance of farmers' active involvement in learning processes and in the adoption of innovative technologies (Parker et al., 2021). Integrating theoretical instruction with hands-on, practice-oriented learning enabled participants to gain more applied insights into the circular economy, particularly concerning livestock waste management and feed efficiency.

The socialization outcomes demonstrate that, beyond theoretical comprehension, young farmers were provided with concrete tools and actionable strategies to manage livestock waste more efficiently and sustainably. This finding confirms that the circular economy is not limited to abstract concepts, but can be operationalized through practical interventions focused on waste management, feed efficiency, and environmentally friendly technologies. Implementing zero-waste practices in beef cattle farming thus offers dual benefits: improving farm-level operational efficiency and contributing to long-term environmental sustainability.

Improving Farmers' Understanding of Circular Economy and Zero-Waste Principles

The community engagement program in Tani Bhakti Village, Loa Janan Subdistrict, Kutai Kartanegara Regency, strengthened young farmers' knowledge of livestock waste management within the broader circular economy framework and zero-waste principles. To evaluate changes in participants' understanding, a structured questionnaire was administered twice: initially, before the delivery of training materials (pre-test), and subsequently, after the completion of the training sessions (post-test) (Geissdoerfer et al., 2017). The questionnaire consisted of ten items addressing essential aspects of waste management, including the fundamentals of the circular economy, the utilization of livestock waste, biogas production, and the application of organic fertilizer.

A pre-experimental research design employing the one-group pre-test–post-test approach was utilized to measure the improvement in participants' knowledge objectively. Gap analysis was performed by comparing pre-test and post-test scores, allowing the researchers to identify

the extent of knowledge acquisition following the intervention (Geissdoerfer et al., 2017). The results revealed that the training effectively enhanced participants' comprehension of livestock waste management practices aligned with circular economy principles.

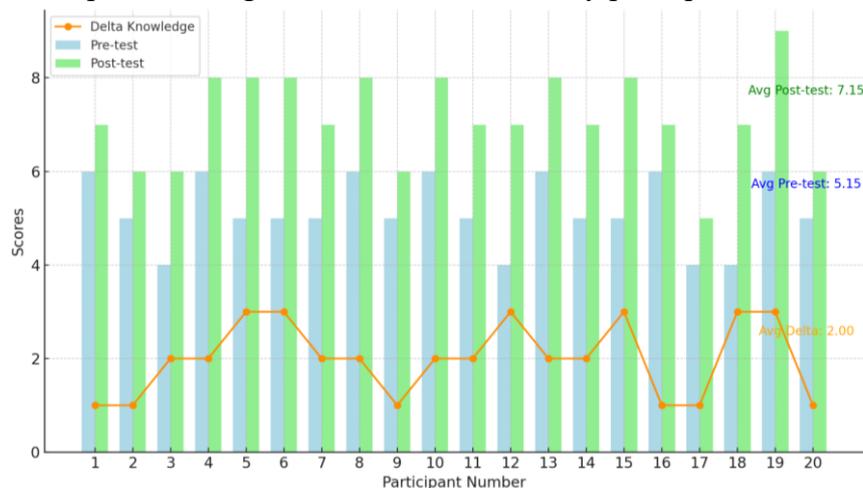


Figure 4. Results of Pre-Test, Post-Test, and Knowledge Gain

Source: Processed Primary Data, 2025

The pre-test and post-test comparison indicated marked improvements in knowledge across all participants. Among the 20 young farmers involved, 100% demonstrated measurable knowledge gains. Participants' scores increased by two points on average, reflecting a firmer grasp of sustainable waste management practices after the training. Notably, Participant 19 exhibited the most substantial improvement, with a three-point increase, underscoring the effectiveness of the training content in advancing participants' understanding of circular economy applications in livestock farming.

The distribution of knowledge gains further highlighted that most participants attained substantial progress. Based on Likert-scale assessment criteria, scores of 8.4-10 were categorized as very good, 6.8-8.3 as good, and 5.2–6.7 as fair (Geissdoerfer et al., 2017). According to this classification, 80% of participants achieved good or very good categories, while the remaining 20% fell into the fair category. These findings suggest that although most participants benefited significantly, certain training elements may warrant further reinforcement to ensure comprehensive understanding.

The training program effectively enhanced young farmers' knowledge of circular economy principles and livestock waste management. The results confirm the program's success in fostering community education while equipping participants with practical competencies in waste utilization. Moreover, the findings demonstrate the potential for circular economy principles to be systematically integrated into livestock farming practices, contributing to economic resilience and environmental sustainability through more efficient and ecologically sound waste management (Widiarta et al., 2025).

Enhancing Practical Skills in Livestock Waste Management

Livestock waste management techniques are not solely concerned with reducing environmental impacts but also with improving the operational efficiency of farms through the application of circular economy and zero-waste principles (McAloone et al., 2017). The training outcomes indicated a substantial improvement in participants' practical skills, with

most farmers successfully applying the techniques introduced during the sessions to their daily farming activities.

Overall, 85% of participants demonstrated the ability to implement the livestock waste management practices they had learned. Specifically, 60% utilized livestock manure, particularly cattle dung, to produce organic fertilizer that was subsequently applied to their farmland to improve soil fertility. The adoption of organic fertilizer not only reduced dependency on synthetic chemical fertilizers and contributed to more environmentally sustainable farming operations (McAloon et al., 2017). Meanwhile, 25% of participants processed livestock waste into bioenergy, which was then used to support farm energy requirements such as feed drying and animal heating. This practice revealed significant potential for improving resource-use efficiency and reducing operational costs.

The relatively lower adoption of bioenergy production (25%) highlights opportunities for further development, particularly in advancing technologies that enable more efficient conversion of livestock waste into renewable energy. While participants demonstrated considerable skill enhancement, additional training and ongoing mentoring are required to optimize the utilization of all available livestock waste streams.

Table 1. Adoption of Livestock Waste Management Techniques among Farmers

No	Waste Management Technique	Participants (%)	Description
1.	Organic Fertilizer Production	60%	Processing cattle manure into organic fertilizer
2.	Bioenergy Production	25%	Converting livestock waste into bioenergy
3.	Other Waste Management Methods	15%	Waste processing other than fertilizer and bioenergy

Source: Processed Primary Data, 2025

The training program has proven effective in strengthening the practical skills of young farmers in livestock waste management. Beyond enhancing operational efficiency, effective waste management also delivers positive environmental outcomes, reinforcing the principles of the circular economy and zero waste. The skills acquired through this training are expected to be applied sustainably, thereby improving farmers' welfare while supporting the long-term sustainability of the livestock sector in Tani Bhakti Village.

Constraints and Challenges in the Implementation of Zero-Waste Technology

The implementation of zero-waste technology in livestock waste management in Tani Bhakti Village shows promising results; however, several constraints and challenges must be addressed to ensure that its application can take place sustainably and effectively. One of the main challenges faced is farmers limited technical understanding and skills in operating new technologies. Although training has been provided, many farmers still find it challenging to utilize modern tools such as waste-processing machines or feed dryers. This is often due to the lack of in-depth understanding of how these tools work and how to integrate the technology into their daily routines (Hadi et al., 2020). The study by Hadi et al. (2020) shows that farmers with limited technical knowledge tend to be slower in adopting more efficient technologies even though they have received training.

Table 2. Constraints and Challenges in the Implementation of Zero-Waste Technology by Farmers

Constraint/Challenge	Description	Impact on Implementation
Limited Understanding and Skills	Some farmers have difficulty operating new technologies such as waste-processing machines and feed dryers.	Hinders optimal implementation of technology.
Limited Access to Technology	Farmers face difficulties in obtaining efficient and effective waste-processing tools due to limited funds and access to financing.	Restricts the scale of technology implementation.
Social and Cultural Factors	Some farmers are reluctant to change the traditional methods they have practiced for years.	Delays the adoption of new technologies.
Lack of Continuous Mentoring	After training, some farmers require further mentoring to ensure that the technology is applied sustainably.	Reduces the effectiveness of technology use.

Source: Processed Primary Data, 2025

In addition to technical understanding, limited access to technologies that support the implementation of zero waste is also a significant constraint. Many farmers find it difficult to obtain efficient and affordable waste-processing equipment due to financial constraints and limited market access. Composting machines or biogas processors require relatively high costs and are difficult to afford for smallholder farmers who do not have easy access to financing (Iskandar & Santoso, 2021). The study by Iskandar and Santoso (2021) highlights that financial limitations and access to technology are significant obstacles for small-scale farmers in implementing technologies that can improve the sustainability of their waste management.

Another challenge is related to social and cultural factors, where some farmers tend to be reluctant to abandon traditional waste management methods they have practiced for many years. This resistance to change is primarily influenced by ingrained habits and uncertainty regarding the effectiveness of new technologies in the local context (Suryani, 2022). In this regard, Suryani (2022) states that social and cultural factors play an important role in the success of adopting new technologies. It is important to develop strategies to reduce this resistance, such as raising awareness of the benefits of zero-waste technology through evidence-based approaches and real-world experience.

Limitations in technical mentoring are also an equally important issue. After the initial training, many farmers need further mentoring to ensure the technology is implemented correctly and sustainably. Without adequate support, the effectiveness of technology use will decline over time. In this regard, the study by Ramadhan et al. (2021) reveals that continuous mentoring programs can increase the success of implementing new technologies in the agricultural and livestock sectors, as they provide opportunities for farmers to learn further and solve problems that arise in the field.

CONCLUSION

Implementing this community engagement program has successfully enhanced young farmers' understanding and practical skills in applying circular economy principles based on zero-waste practices in Tani Bhakti Village. Through training and mentoring, farmers have

become capable of managing livestock waste more efficiently, reducing resource wastage, and improving the sustainability of livestock operations. Improvements in practical skills were evident, with 85% of participants successfully applying waste-processing techniques to produce value-added products such as organic fertilizer and bioenergy. Challenges in implementing technology remain concerning limited technical understanding and access to supporting equipment.

Further efforts are required to address these challenges, especially in overcoming constraints related to technical knowledge and accessibility to technologies that support zero-waste systems. Recommendations for future community engagement activities include long-term evaluations of the impacts of circular economy adoption in beef cattle farming, particularly regarding operational efficiency and environmental outcomes. Initiatives should be directed toward providing smallholder farmers with easier access to financing mechanisms in order to acquire the necessary technologies. For future community engagement programs, it is also crucial to involve a broader range of strategic partners capable of contributing technical expertise and financial resources to ensure the sustainability of zero-waste practices.

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