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Sustainable Agriculture to Support SDGs Through Innovation of Organic Fertilizer from Livestock Waste

Pertanian Berkelanjutan untuk Mendukung SDGs melalui Inovasi Pupuk Organik dari Limbah Ternak

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Abstract

Sustainable agriculture plays an important role in achieving sustainable development goals (SDGs). The use of organic fertilizers is increasingly important to increase agricultural productivity that is environmentally friendly and reduce farmers' operational costs. One of the strategies that can strengthen agriculture is innovation in the use of organic fertilizers made from livestock manure. This research aims to explore the potential for organic fertilizer innovation from livestock waste in supporting sustainable agriculture and the achievement of the SDGs. This research will analyze the economic, social, and environmental benefits of using organic fertilizers, and identify the main challenges faced in its implementation The research method used is qualitative research with data collection through interviews, questionnaire distribution, and field observation. The data collected is on the income and economic growth of five farmers in Jambi City from February to July 2024. The analysis stages are carried out through primary data collection, data analysis, and interpretation of results. The study results show that using organic fertilizers can increase the productivity of farmers' crops by up to 20%. The social implications of using organic fertilizers include improving farmers' welfare through improved soil quality and higher crop yields, which directly impact income and economic stability. In addition, the use of organic fertilizers also reduces farmers' operational costs by up to 30%. This study concludes that the use of organic fertilizers is a strategic step in realizing sustainable and environmentally friendly agriculture in the future.

Keywords : *organic fertilizer, SDGs, sustainable agriculture*

Abstrak

Pertanian berkelanjutan memainkan peran penting dalam mencapai tujuan pembangunan berkelanjutan (SDGs). Penggunaan pupuk organik semakin penting dalam upaya meningkatkan produktivitas pertanian yang ramah lingkungan dan mengurangi biaya operasional petani. Salah satu strategi yang dapat memperkuat pertanian adalah inovasi dalam penggunaan pupuk organik yang terbuat dari kotoran ternak. Penelitian ini bertujuan untuk mengeksplorasi potensi inovasi pupuk organik dari limbah ternak dalam mendukung pertanian berkelanjutan dan pencapaian SDGs. Penelitian ini akan menganalisis manfaat ekonomi, sosial, dan lingkungan dari penggunaan pupuk organik, mengidentifikasi tantangan utama yang dihadapi dalam implementasinya Metode penelitian yang digunakan adalah penelitian kualitatif dengan pengumpulan data melalui wawancara, distribusi kuesioner dan observasi lapangan. Data yang terkumpul merupakan data pendapatan dan pertumbuhan ekonomi lima petani di Kota Jambi selama periode Februari hingga Juli 2024. Tahapan analisis dilakukan melalui pengumpulan data primer, analisis data, dan interpretasi hasil. Hasil penelitian menunjukkan bahwa penggunaan pupuk organik dapat meningkatkan produktivitas tanaman petani hingga 20%. Implikasi sosial dari penggunaan pupuk organik termasuk meningkatkan kesejahteraan petani melalui peningkatan kualitas tanah dan hasil panen yang lebih tinggi, yang secara langsung berdampak pada pendapatan dan stabilitas ekonomi. Selain itu, penggunaan pupuk organik juga mengurangi biaya operasional petani hingga 30%. Penelitian ini menyimpulkan bahwa penggunaan pupuk organik merupakan langkah strategis dalam mewujudkan pertanian yang berkelanjutan dan ramah lingkungan di masa depan.

Kata kunci: pertanian berkelanjutan, pupuk organik, SDGs

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Introduction

Sustainable agriculture has become a key focus in global efforts to achieve the Sustainable Development Goals (SDGs). The agricultural sector plays a crucial role in ensuring food security, reducing poverty, and preserving the environment. However, conventional agricultural practices often contribute to land degradation, water pollution, and greenhouse gas emissions, directly threatening the achievement of the SDGs (Godfray et al., 2010). Therefore, innovations in sustainable agriculture become indispensable to address these challenges and ensure environmentally friendly and sustainable food production. Livestock waste is one resource that has great potential but is often underutilized. Globally, it is estimated that more than 1.3 billion tons of livestock waste are generated annually (Berek, 2018). This waste can pose a threat to the environment if not managed properly, but on the other hand, it can also be turned into nutrient-rich organic fertilizer, which can improve soil fertility and crop productivity (Aulia et al., 2024). Innovation in the management of livestock waste to be used as organic fertilizer can be a sustainable solution in supporting agriculture while reducing negative impacts on the environment.

Organic fertilizers from livestock waste have the potential to become a key component in sustainable agricultural systems. These fertilizers not only provide essential nutrients to plants, but also help improve soil structure, improve water absorption capacity, and promote beneficial soil microbial activity (Roidah, 2013). In addition, the use of organic fertilizers can also reduce dependence on chemical fertilizers that often cause water pollution and soil degradation (Berek, 2018). The use of organic fertilizer from livestock waste directly supports several SDG goals, including goal number 2 (Zero Hunger), number 12 (Responsible Consumption and Production), and number 13 (Climate Action). By promoting sustainable agriculture, this innovation can help reduce the environmental impact of agricultural activities, improve food security, and support sustainable management of natural resources (FAO, 2017). Furthermore, this innovation can also contribute to rural economic development through job creation in the agriculture and waste management sectors (Azzahra et al., 2022). Despite the huge potential of organic fertilizer from livestock waste, its application still faces various challenges. Some of these include farmers' low awareness of the benefits of organic fertilizer, limitations of efficient waste treatment technology, as well as distribution and marketing issues of organic fertilizer products (Nurdin et al., 2023). However, with the right policy and research support, these challenges can be overcome and open up great opportunities for the development of sustainable agriculture in the future.

Technological innovation in livestock waste treatment is key to improving the efficiency and effectiveness of organic fertilizer use. Technologies such as anaerobic fermentation, vermicomposting, and bioconversion by microorganisms have been proven to convert livestock waste into high-quality organic fertilizers with stable nutrient content and are safe for the environment (Mulijanti & Tedy, 2019). The application of this technology not only increases the added value of livestock waste but also reduces greenhouse gas emissions resulting from the decomposition of such waste. Entrepreneurship in the agricultural sector plays an important role in driving the adoption and scale-up of organic fertilizer innovations. Farmers, entrepreneurs, and agribusiness companies can collaborate to develop business models that utilize livestock waste as the main source of raw materials for organic fertilizer products (Abdullah et al., 2023). By integrating circular economy principles, this business model not only supports sustainability but also improves the profitability and economic well-being of rural communities.

Sustainable agriculture is a concept that integrates the needs of food production with environmental protection and the socio-economic well-being of farmers. The theory is based on the principle that agricultural practices should maintain long-term productivity without compromising the quality of natural resources (Lagiman, 2020). In this context, sustainable agriculture not only pursues increased crop yields but also focuses on reducing negative impacts on the environment, such as soil degradation, water pollution, and greenhouse gas emissions. Organic fertilizers, which are made from natural materials including livestock waste, are considered an important element in a sustainable agriculture system as they can improve soil fertility and maintain the balance of the ecosystem (Maula, 2023). Organic fertilizers act as one of the main components in achieving sustainable agriculture. Agricultural ecology theory emphasizes the importance of using organic matter to improve soil quality and long-term sustainability (Ardianto & Iskandar, 2022). Organic fertilizers help improve soil structure, increase the soil's capacity to retain water, and encourage the activity of beneficial

microorganisms. In addition, organic fertilizers can also reduce dependence on synthetic chemical fertilizers that often cause environmental problems, such as eutrophication and groundwater pollution (Godfray et al., 2010). Thus, the use of organic fertilizers not only supports sustainable food production but also plays an important role in maintaining environmental health.

The management of livestock waste into organic fertilizer is one form of innovation that is highly relevant in the context of sustainable agriculture. The circular economy theory provides a framework for understanding how waste can be transformed into valuable resources, reducing waste and improving the efficiency of resource use (Murdiono et al., 2021). In this case, livestock waste, which is often considered an environmental problem, can be transformed into nutrient-rich organic fertilizer through various processing technologies, such as composting, vermicomposting, and anaerobic fermentation (Destiasari et al., 2024). This innovation not only helps reduce the negative impact of livestock waste but also provides a sustainable source of nutrients for crops. Sustainable development theory emphasizes the importance of an integrated approach that includes economic, social, and environmental aspects to achieve the Sustainable Development Goals (SDGs) (Godfray et al., 2010). In this context, organic fertilizer produced from livestock waste not only contributes to goal number 2 (Zero Hunger) by increasing agricultural productivity but also supports goals number 12 (Responsible Consumption and Production) and number 13 (Climate Action) by reducing waste and greenhouse gas emissions. Therefore, innovations in the use of organic fertilizers from livestock waste are not only relevant for agricultural sustainability but also have far-reaching implications in supporting the achievement of various SDG targets.

This research aims to explore the potential of organic fertilizer innovation from livestock waste in supporting sustainable agriculture and the achievement of SDGs. Specifically, this research will analyze the economic, social, and environmental benefits of using organic fertilizers, identify the main challenges faced in its implementation, and provide recommendations for the development of policies and business strategies that can accelerate the adoption of this innovation at various farm scales (Andika, 2022).

Methods

This study uses a qualitative approach to deeply understand the phenomenon related to the innovation of the use of organic fertilizers from livestock waste in supporting sustainable agriculture and achieving the Sustainable Development Goals (SDGs). According to (Creswell, J, 2010), research is a research process to understand human or social problems by creating a comprehensive and complex picture that is presented in words, reports detailed views obtained from information sources, and is carried out in a natural setting. Qualitative data were collected through questionnaires, in-depth interviews, participatory observations, and document analysis.

The data obtained is data from CV. Bintang Semesta Agrotama an organic fertilizer-producing company in Jambi City and five farmers in Jambi City have been using organic fertilizers from February to July 2024. This analysis process involves several stages, namely primary data collection, data analysis, and interpretation of the results. The validity of the findings is maintained through data triangulation, where data from interviews, observations, and documents are compared to ensure consistency and credibility. The research subjects were selected purposively, with the main criteria being those who have direct experience in the application of organic fertilizer innovations from livestock waste and are relevant to the research objectives. To analyze the economic benefits of using organic fertilizers, it can be calculated through the following formula.

Price Difference =Ha - Hb

As a qualitative study, the results of this study may not be generalized to a wider population. However, the resulting findings can provide useful insights for understanding specific contexts and can be the basis for further quantitative research or broader policy development.

Results & Discussion

The process of processing livestock waste into organic fertilizer (Figure 1) begins with the collection of livestock waste, such as manure from cows, goats, or chickens, from pens or farm areas. This waste is then transferred to a processing facility, where the waste is collected in containers or shelters to facilitate further processing. Next, the livestock waste is mixed with additional organic materials such as crop residues, bran, or sawdust to achieve an optimal carbon-nitrogen (C/N) ratio and accelerate the decomposition process. The mix ratio between livestock waste and additives is usually adjusted to achieve an optimal carbon-nitrogen (C/N) balance. The ideal C/N ratio is often around 25-30:1. After mixing, the mixture goes through a fermentation or composting process in special piles or reactors. During fermentation, the mixture is kept under aerobic conditions with ideal temperature, humidity, and pH settings to support microorganism activity. This process requires sufficient aeration and regular stirring to ensure even decomposition. After the fermentation process is complete, the compost is checked to ensure its maturity and quality. Mature compost should be free from foul odor and have a homogeneous texture. After reaching maturity, the organic fertilizer is packed in sacks or containers for distribution and stored in a dry place until ready for use. Compost is stored in a dry place and protected from excess moisture until ready for distribution. Good storage helps maintain the quality of the compost and prevents deterioration.

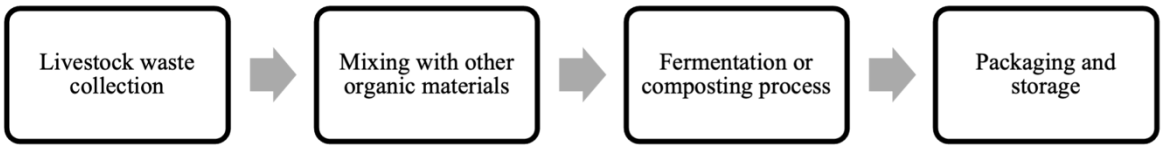

Figure 1. Process of making organic fertilizer

Organic fertilizer, which has gone through the composting process, is seen in granular or powder form. It has a crumbly texture and a dark brown color, indicating that the fertilizer is mature and ready for use. There is no foul odor, and the product appears homogeneous and free of foreign materials. Organic fertilizer is transferred into sacks or packaging containers. The worker in the picture uses a shovel-like tool to transfer the fertilizer into the sacks. Sacks are usually made of durable materials, such as polyethylene or mesh, designed to protect the fertilizer from moisture and contamination. Some of the packed sacks can be seen neatly stacked, ready for storage or distribution. Storage is done in a dry area and avoids excess moisture to maintain the stability and quality of the organic fertilizer until it reaches the consumers.

Result of Field Observations and Interviews with Farmers who use Organic Fertilizers

Farmers in Jambi have started to switch to using organic fertilizers. In addition to more affordable prices and easy application, organic fertilizers also reduce the risk of pollution and improve soil microbial activity. The application of organic fertilizer on agricultural land usually starts with spreading the fertilizer across the entire area of the land to be planted. Organic fertilizers can be spread evenly using various methods, such as manual spreading by hand or tools such as shovels, or using an automatic fertilizer spreading machine for larger fields. These spreading techniques ensure that the organic fertilizer is well mixed on the soil surface so that the nutrients can be optimally absorbed by the plants. The frequency of organic fertilizer application depends on the type of crop and soil conditions. Generally, organic fertilizers are applied before planting as part of soil preparation and can also be applied during crop growth to provide additional nutrients. Applications are usually made 2-3 times a year, or according to the specific needs of the crop and soil test results. Regular application of organic fertilizers helps improve soil health, improves soil structure, and supports optimal plant growth.

The farmers reported that the use of organic fertilizers significantly reduced dependence on chemical fertilizers while increasing yields by 20%. The increased yields of the five farmers are depicted in the following bar chart that has been viewed from February to July in 2024.

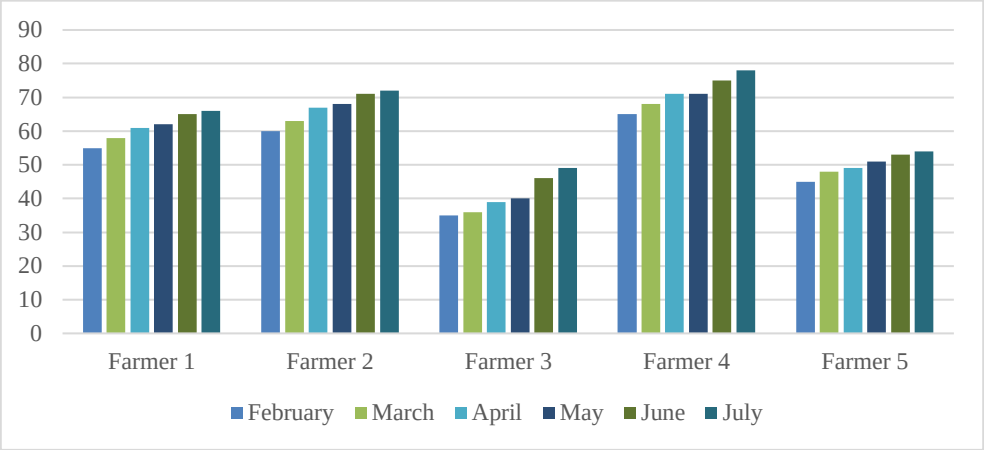

Figure 2. Agricultural Yields (in ton) Five Farmers in 2024

The use of organic fertilizers not only reduces the cost of purchasing chemical fertilizers but also improves soil health and supports more productive plant growth. With increased yields, farmers experience greater economic returns and long-term benefits from more sustainable soil management. Farmers report that the use of organic fertilizers provides significant benefits, including improved soil quality and reduced production costs. Organic fertilizers help improve soil structure, increase water retention capacity, and support healthier plant growth, thereby reducing reliance on chemical inputs and lowering costs.

The use of organic fertilizers increases farmers' welfare by improving soil quality and crop yields, which in turn reduces production costs and increases income. Organic fertilizers support healthier and more productive plant growth, reducing dependence on expensive chemical fertilizers. In addition, the use of organic fertilizers helps create a cleaner and healthier working environment and reduces the negative impact on farmers' health from chemical exposure. However, farmers face challenges in obtaining livestock waste feedstock consistently and using efficient processing equipment. To overcome these constraints, they recommend increased technical support and better access to processing equipment. This is expected to improve the efficiency of the organic fertilizer production process and expand the adoption of this method among farmers.

Analysis of the Economic Benefits of Organic Fertilizer

Observations and interviews show that the use of organic fertilizer from livestock waste provides significant economic benefits to farmers and entrepreneurs. Based on the data, farmers reported a reduction in production costs of up to 30% and an increase in yields by 15-20%. This can be seen by comparing the price of chemical fertilizer and organic fertilizer where the price of chemical fertilizer for 50 kg has a price range of IDR 250,000, while the price of organic fertilizer for 50 kg has a price range of IDR 175,000 so that the reduction in production costs reaches 30%. The calculation is as follows:

Price Difference =Ha - Hb
= IDR 250,000 - IDR 175,000
= IDR 75,000

Percentage of Decrease = (Price Difference /Ha) x 100%
= (Rp 75,000 / Rp 250,000) x 100%
= 0,3 x 100%
= 30%

This suggests that organic fertilizer not only reduces dependence on more expensive chemical fertilizers but also increases productivity. Interviews with entrepreneurs confirm that this innovation opens up new business opportunities in the processing of livestock waste into fertilizer, which can lead to job creation and local economic growth. Therefore, organic fertilizer not only provides direct benefits to farmers but also supports the local economy through increased processing industries.

Organic fertilizers offer significant economic benefits by reducing the cost of purchasing chemical fertilizers and increasing crop yields. By sustainably improving soil quality and fertility, organic fertilizers enable farmers to reduce spending on chemical inputs and achieve higher productivity. In addition, the use of organic fertilizers can reduce soil maintenance costs and improve soil structure, which supports more efficient plant growth and reduces crop losses. These economic benefits help increase farm profitability and support farmers' financial sustainability in the long term.

Social Implications and Farmer Welfare

Findings from interviews with farmers indicate that the use of organic fertilizer brings significant social benefits. Farmers reported improved soil quality and crop health, which contributed to their well-being. The training and support programs that farmers receive also improve their knowledge and skills in soil management and organic fertilizer use. However, challenges such as limited access to raw materials and processing technology point to the need for further support from the government and private sector. Broader education programs and better access to technology can increase the adoption of organic fertilizer and strengthen its positive social impact.

The social implications of using organic fertilizer include improved farmer welfare through improved soil quality and higher crop yields, which directly impact their income and economic stability. In addition to financial benefits, the use of organic fertilizers also contributes to farmers' health and safety by reducing exposure to harmful chemicals. This practice supports cleaner and greener agriculture, creates a healthier work environment, and strengthens communities through improved food security and local economic opportunities.

Environmental Impact and Contribution to SDGs

It was observed that the use of organic fertilizers contributes positively to the environment by improving soil quality and reducing greenhouse gas emissions. Organic fertilizers help improve soil structure, reduce erosion, and increase water absorption capacity. Reduced methane emissions from livestock waste processed into organic fertilizer also contribute to climate change mitigation, supporting SDG 13 (Climate Action). These data are consistent with literature showing that organic fertilizer can reduce agriculture's carbon footprint and improve ecosystem health. As such, this innovation supports several SDG goals, including SDG 2 (Zero Hunger) and SDG 12 (Responsible Consumption and Production).

The use of organic fertilizers has a positive environmental impact by improving soil quality, reducing erosion, and improving water absorption capacity, which supports ecosystem health. By reducing dependence on chemical fertilizers, organic fertilizers reduce the risk of water and soil pollution and greenhouse gas emissions, supporting climate change mitigation. Its contributions to the Sustainable Development Goals (SDGs) include SDG 2 (No Hunger) by increasing crop yields and SDG 12 (Responsible Consumption and Production) by promoting sustainable agricultural practices and more efficient waste management.

Challenges and Implementation and Business Development Strategy

Findings from interviews and observations identified several main challenges in the implementation of organic fertilizer. Farmers face difficulties in obtaining livestock waste raw materials and efficient processing equipment. In addition, there is resistance to the change from the use of chemical fertilizers to organic fertilizers. Entrepreneurs also reported problems in the distribution and marketing of organic fertilizer. To overcome this challenge, stronger policy support is needed, such as subsidies for processing technology and incentives for farmers to switch to organic fertilizer. Improved distribution and marketing infrastructure, as well as better training programs, are also needed to overcome existing obstacles.

The main challenges in implementing organic fertilizer include difficulties in consistently obtaining livestock waste raw materials, as well as problems in product distribution and marketing. In addition, farmers' lack of awareness and knowledge regarding the benefits of organic fertilizers hinders wider adoption. To overcome these challenges, the business development strategy involves increasing technical support through farmer training and education, as well as developing a more efficient distribution infrastructure. Implementing subsidy or incentive programs to ease the transition to organic

fertilizers and expanding marketing campaigns are also important to increase adoption and ensure long-term business success.

Relationship between Findings and Sustainable Agriculture Theory

The research results support the theory of sustainable agriculture which emphasizes the importance of environmentally friendly management of natural resources and increasing productivity sustainably. The use of organic fertilizer from livestock waste is to the principles of sustainable agriculture by reducing dependence on external inputs and utilizing waste as a useful resource. These findings show that innovation in livestock waste processing can be an important part of a sustainable agricultural strategy that supports the achievement of the SDGs.

Findings regarding the use of organic fertilizer are in line with sustainable agriculture theory which emphasizes the importance of managing natural resources in an environmentally friendly and efficient manner. Organic fertilizers improve soil quality, support ecosystem health, and reduce dependence on chemical inputs, in line with the principles of sustainable agriculture that aim to increase productivity while maintaining ecological balance. Dengan memanfaatkan limbah ternak, pupuk organik mendukung pendekatan yang lebih holistik terhadap pertanian berkelanjutan, berkontribusi pada pencapaian Tujuan Pembangunan Berkelanjutan.

Conclusion

This research concludes that the use of organic fertilizer from livestock waste provides significant benefits from an economic, social, and environmental perspective. Economically, organic fertilizer reduces production costs and increases crop yields, which contributes to stable profits and local economic growth. From a social perspective, organic fertilizer improves farmers' welfare by improving soil quality and creating a healthier working environment. From an environmental perspective, organic fertilizer supports sustainable agricultural practices by reducing pollution and improving soil health, as well as contributing to the achievement of the Sustainable Development Goals (SDGs). However, challenges such as difficulties in obtaining raw materials where it is still very difficult to get animal manure raw materials when getting orders in large quantities, distribution problems where the expansion of the distribution of organic fertilizers so that it can reach all regions in Indonesia not only areas in Jambi Province, and the lack of awareness of farmers need to be overcome, there is a need for counseling on the benefits of using organic fertilizers for farmers. Recommendations include increased technical support, marketing development, and educational campaigns to facilitate wider and more effective adoption of organic fertilizer.

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