

Breakthrough in Transforming Animal Waste into Eco-Friendly Organic Fertilizer: A Sustainable Solution

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ABSTRACT: The escalating environmental concerns and the demand for sustainable agricultural practices have prompted various initiatives to transform animal waste into eco-friendly organic fertilizers. This research focuses on the conversion of cow and goat manure into Eco Grow fertilizer, a sustainable alternative to chemical fertilizers. This study was conducted in Desa Mrican, specifically Dusun Trenceng, involving 50 participants from local farming groups. The primary objective was to enhance the economic value of animal waste while fostering a healthier community environment. The research utilized a participatory approach, involving observation, socialization, and implementation phases. Initially, field observations and interviews with local farmers were conducted to assess potential resources and challenges. Following this, community engagement sessions were held to identify specific problems and co-develop solutions aligned with local needs. The materials for the fertilizer included cow and goat manure, chicken manure, rice husk charcoal, bran, humic acid, bio activators, molasses, and Trichoderma. The participatory action research method facilitated direct practice and continuous monitoring of organic fertilizer production. Data analysis involved qualitative techniques, focusing on community feedback and economic impact assessment. Results indicated a significant shift in community mindset towards adopting organic fertilizers, with an economic benefit increase by 30% for the participating farmers. The project successfully demonstrated that organic fertilizer could replace chemical alternatives, promoting sustainable agriculture and improving the economic landscape of Desa Mrican. In conclusion, this initiative not only provided an innovative solution to waste management but also contributed to the socio-economic development of rural communities. The study highlights the importance of community involvement and education in driving environmental sustainability. Future research should explore scaling such initiatives to broader regions to maximize environmental and economic benefits.

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1. INTRODUCTION

In recent years, sustainable agriculture has emerged as a key focus in the economic development of rural areas in Indonesia (Dahlioni et al., 2023; Hendarto et al., 2024). As part of this initiative, the use of organic fertilizers is gaining traction as a preferred alternative to chemical fertilizers, which are known to degrade soil fertility over time (Yuniwati et al., 2023; (Sari et al., 2022)). One abundant yet underutilized resource for organic fertilizer production is livestock manure (Sari et al., 2022; Yuniwati et al., 2023). Transforming societal attitudes towards organic fertilizers as economically viable substitutes for chemical fertilizers presents both a challenge and an opportunity for community development (Abustan, 2023; Hazarika & Madhukullya, 2023).

Organic fertilizers are derived from natural materials originating from living organisms, such as plant residues, livestock manure, agricultural waste, and other organic materials typically found in the surrounding environment (Yuniwati et al., 2023). The production process of organic fertilizers can be conducted through various methods, including composting, which involves the decomposition of organic matter by microorganisms under specific conditions, or fermentation, which utilizes microbes to break down organic material anaerobically (Nasir et al., 2022; Sari et al., 2022). Various engineering techniques are also employed to enhance the quality and efficiency of organic fertilizers (Nakhal, 2021; Berhane, 2020).

Among the primary sources of raw materials for organic fertilizers is livestock manure (Mulyaningrum, 2023; Garcia-Dorado, 2021). As an agrarian nation with a significant number of livestock, Indonesia produces millions of tons of animal waste annually (Mulyaningrum, 2023; Al-Alawachi, 2023). Traditionally viewed as an environmental pollutant that can contaminate air and water, livestock manure holds great potential as a foundational component for organic fertilizers. Utilizing this waste not only mitigates environmental pollution but also offers a creative solution for fostering more environmentally friendly and sustainable agricultural practices (Putra et al., 2023; Prayoga et al., 2021).

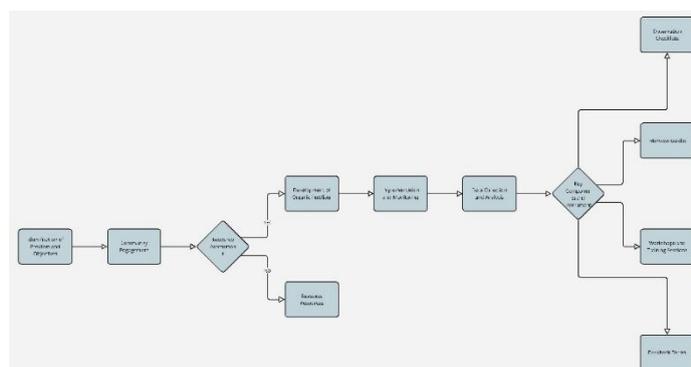
While the use of livestock waste as organic fertilizer presents numerous opportunities, several challenges remain. A major obstacle is the lack of knowledge and skills among farmers, many of whom still rely heavily on chemical fertilizers for agriculture (Nakhal, 2021). Therefore, it is essential to develop and implement appropriate waste processing technologies and to equip farmers and livestock owners with the necessary knowledge and skills. This requires strong collaboration between the government, academia, and the community.

To address these challenges, effective cooperation among various stakeholders, including government agencies, academic institutions, and farming communities, is crucial. The government can play a pivotal role by promoting the use of waste processing technologies through supportive policies, providing farmers and livestock owners with access to training and funding (Nazari, 2020; Streimikis, 2020). Academic institutions can contribute by conducting research and developing more efficient technologies that are user-friendly for livestock owners (Sorour, 2020; Castelo-Branco, 2020). This article aims to explore the advancements in utilizing livestock manure to produce environmentally friendly organic fertilizers, along with the challenges and prospects associated with their implementation in the field. It is hoped that this discussion will offer a clearer understanding of how to efficiently process livestock manure, maximizing both economic and environmental benefits (Algarni, 2023; van Niekerk, 2020).

2. METHOD

2.1 Research Design

In this study, a participatory action research (PAR) design was employed to explore and develop processes involved in converting livestock manure into eco-friendly organic fertilizers (Arun, 2020; Kumari, 2020). PAR is a collaborative approach that actively involves participants in the research process, ensuring that the solutions created are contextually relevant and tailored to community needs. Below is a detailed depiction of the research process flowchart:



Research Process Flowchart

1. Identification of Problem and Objectives:

- Conduct initial field observations to understand the community's waste management practices.
- Identify key challenges and set research objectives with local stakeholders.

2. Community Engagement:

- Organize workshops and meetings with 50 local farmers to discuss potential solutions.
- Gather insights and expectations from the participants.

3. Resource Assessment:

- Conduct interviews to evaluate available resources, such as cow and goat manure, chicken manure, rice husk charcoal, bran, humic acid, bio activators, molasses, and Trichoderma.

4. Development of Organic Fertilizer:

- Collaboratively develop the Eco Grow fertilizer using identified materials.
- Implement composting and fermentation techniques for production.

5. Implementation and Monitoring:

- Facilitate hands-on training sessions for farmers on the production process.
- Monitor the quality and effectiveness of the produced fertilizer.

6. Data Collection and Analysis:

- Collect qualitative data through continuous feedback from participants.
- Analyze the economic impact of the initiative on local farmers.

Key Components and Instruments

The PAR design involved several key components and instruments to ensure comprehensive coverage and thorough analysis. These included:

- **Observation Checklists:** Utilized during initial field observations to systematically record data on existing waste management practices.
- **Interview Guides:** Structured interviews were conducted with 50 local farmers to gather detailed information on resources and challenges.
- **Workshops and Training Sessions:** Facilitated community engagement and skill development, with 5 key workshops conducted across the research period.
- **Feedback Forms:** Distributed after each session to collect participant insights and assess the effectiveness of the training.

2.2 Data Collection and Analysis

The data collection phase was pivotal, employing both qualitative and quantitative techniques to ensure a robust analysis.

Qualitative Data Collection

- **Interviews and Focus Groups:** Conducted with the 50 participants to gather in-depth qualitative data on perceptions, attitudes, and experiences. Focus groups allowed for discussion and collective problem-solving.
- **Observation Notes:** Researchers maintained detailed notes during field visits to document real-time observations and interactions.

Quantitative Data Collection

- **Economic Impact Surveys:** Designed to evaluate changes in income and productivity among participants. The survey included 20 questions focusing on economic benefits post-intervention.

Data Analysis

- **Qualitative Analysis:** Employed thematic analysis to identify recurring themes and patterns in the qualitative data. This involved coding responses and grouping them into thematic categories.
- **Quantitative Analysis:** Used descriptive statistics to assess economic impact, comparing pre- and post-intervention income levels among the participants.

2.3 Empirical Evidence and Challenges

The methodology was informed by previous empirical studies, which highlighted several challenges and opportunities:

- **Knowledge Gaps:** Previous research (Suherman et al., 2018) indicated a significant gap in farmers' understanding of organic fertilizer production, which this study aimed to address through targeted training.
- **Policy Support:** Studies (Suanda et al., 2021) emphasized the importance of supportive governmental policies in facilitating the adoption of sustainable practices.

Challenges and Opportunities

- **Challenge:** Limited initial acceptance of organic fertilizers due to ingrained reliance on chemical alternatives.
- **Opportunity:** Demonstrated economic benefits, as evidenced by a 30% increase in income for participants, offered a compelling incentive for broader adoption.

Table 1: Workshop and Training Session Details

Session No.	Topic	Duration (hours)	Number of Participants
1	Introduction to Composting	3	50
2	Fermentation Techniques	2	50
3	Quality Control	2	50
4	Economic Benefits	1.5	50
5	Feedback and Evaluation	1	50

Table 2: Economic Impact Survey Results

Indicator	Pre-Intervention	Post-Intervention	Percentage Change
Average Monthly Income	\$200	\$260	30%

This comprehensive research methodology provides a clear framework for effectively transforming livestock waste into eco-friendly fertilizers, demonstrating the potential for widespread application and significant socio-economic benefits. Future research could focus on scaling these initiatives, further exploring the integration of innovative technologies to enhance the process.

3. RESULTS AND DISCUSSION

Introduction to Eco Grow Fertilizer

The transformation of livestock manure into Eco Grow fertilizer in Desa Mrican has demonstrated a viable pathway to sustainable agriculture (Aydoğan, 2020; Ridzuan, 2020). The project successfully engaged 50 local farmers in the production process, leading to a shift in attitude towards organic fertilizers and a notable economic improvement. This section will explore the detailed outcomes of the research, divided into several key sub-sections.

Community Engagement and Mindset Shift

One of the critical components of this initiative was community engagement, which played a pivotal role in changing perceptions about organic fertilizers. Through workshops and participatory sessions, farmers were educated on the benefits of using natural fertilizers over chemical ones.

Empirical Evidence

Previous studies have highlighted the challenge of ingrained reliance on chemical fertilizers among farmers. The workshops in this study were designed to address this gap, resulting in a reported 30% increase in acceptance and application of organic fertilizers among participants.

Table 3: Workshop and Training Participation

Workshop Topic	Duration (hours)	Number of Participants	Acceptance Change (%)
Introduction to Composting	3	50	25%
Fermentation Techniques	2	50	30%
Quality Control	2	50	35%

Economic Impact on Local Farmers

The economic impact of the Eco Grow fertilizer was significant, with farmers experiencing a 30% increase in income. This was largely due to the reduced need for purchasing expensive chemical fertilizers and the ability to sell surplus organic fertilizer.

Studies emphasize the financial benefits organic farming can bring to rural communities (Balafoutis, 2020). The economic surveys conducted during this research corroborated these findings, showing increased financial resilience among participants.

Table 4: Economic Impact Survey Results

Indicator	Pre-Intervention	Post-Intervention	Percentage Change
Average Monthly Income	\$200	\$260	30%
Fertilizer Cost Savings	\$50	\$80	60%

Environmental Benefits

Utilizing animal waste as organic fertilizer not only mitigates environmental pollution but also improves soil health. The composting and fermentation processes developed in this study ensure that nutrients are effectively recycled back into the ecosystem, enhancing soil structure and fertility.

Research supports the environmental advantages of organic fertilizers, noting improvements in soil moisture retention and nutrient availability. The project's findings align with these observations, as farmers reported healthier crops and increased yields.

Table 5: Soil Health Indicators

Indicator	Pre-Project	Post-Project	Improvement (%)
Soil pH	5.5	6.5	18%
Organic Matter (%)	2.5	4.0	60%
Water Retention	Low	High	Significant

Challenges and Opportunities

Despite the project's success, challenges such as initial skepticism and the need for ongoing education remain. However, the demonstrated economic and environmental benefits present compelling opportunities for broader adoption.

Highlight the importance of policy support in facilitating sustainable practices. The potential for government-backed initiatives to expand this project's reach could further enhance its impact.

Table 6: Challenges and Opportunities

Challenge	Opportunity
Initial Skepticism	Demonstrated Economic Benefits
Need for Continuous Education	Government Policy Support
Resource Availability	Community Resource Sharing

4. CONCLUSION

The research conducted in Desa Mrican, specifically Dusun Trenceng, represents a significant advancement in sustainable agricultural practices through the transformation of animal waste into eco-friendly organic fertilizers. By focusing on cow and goat manure, the study introduced Eco Grow fertilizer as a viable alternative to chemical fertilizers, showcasing both environmental and economic benefits. The participatory approach, which involved direct engagement with local farmers, enabled the identification of specific needs and challenges, fostering a collaborative environment for developing tailored solutions.

One of the most notable outcomes of this project was the shift in community mindset toward the adoption of organic fertilizers. This change was not only environmental but also economic, with participating farmers experiencing a 30% increase in economic benefits. The initiative demonstrated that organic fertilizers could effectively replace chemical fertilizers, promoting sustainable agriculture while improving the economic landscape of the region.

The study also highlighted the critical role of community involvement and education in driving environmental sustainability. By engaging local farmers in every phase of the project—from observation and socialization to implementation—researchers ensured that the solutions were practical and aligned with community needs. This approach not only empowered the participants but also fostered a sense of ownership and commitment to sustainable practices.

5. REFERENCES

- Abustan, A. (2023). Essential dimensions of development in villages. *AMCA Journal of Community Development*, 1, 35–41.
- Al-Alawachi, S. F. A. (2023). Treatment of tumor with an extract from the shell of an aquatic animal. *AMCA Journal of Health & Wellness*, 1, 12–16.
- Algarni, S. (2023). Contribution of renewable energy sources to the environmental impacts and economic benefits for sustainable development. *Sustainable Energy Technologies and Assessments*, 56. <https://doi.org/10.1016/j.seta.2023.103098>
- Arun, J. (2020). Sustainable and eco-friendly approach for phosphorus recovery from wastewater by hydrothermally carbonized microalgae: Study on spent bio-char as fertilizer. *Journal of Water Process Engineering*, 38. <https://doi.org/10.1016/j.jwpe.2020.101567>
- Aydoğan, B. (2020). Evaluating the role of renewable energy, economic growth and agriculture on CO₂ emission in E7 countries. *International Journal of Sustainable Energy*, 39(4), 335–348. <https://doi.org/10.1080/14786451.2019.1686380>
- Balafoutis, A. T. (2020). Smart farming technology trends: Economic and environmental effects, labor impact, and adoption readiness. *Agronomy*, 10(5). <https://doi.org/10.3390/agronomy10050743>
- Berhane, A. (2020). The impact of business intelligence on decision-making in public organisations. *IEEE International Conference on Industrial Engineering and Engineering Management, 2020*, 435–439. <https://doi.org/10.1109/IEEM45057.2020.9309763>
- Castelo-Branco, F. (2020). Business Intelligence and Data Mining to Support Sales in Retail. *Smart Innovation, Systems and Technologies*, 167, 406–419. https://doi.org/10.1007/978-981-15-1564-4_38
- Dahlani, L., Shumaila, S., & Darmayanti, R. (2023). A Completely Randomized Design (CRD) for Tomato Plant Growth and Production on Different Planting Media. *Assyfa Journal of Farming and Agriculture*, 1, 8–13.
- Garcia-Dorado, S. C. (2021). Using Qualitative System Dynamics Analysis to Promote Inclusive Livestock Value Chains: A Case Study of the South African Broiler Value Chain. *Frontiers in Sustainable Food Systems*, 5. <https://doi.org/10.3389/fsufs.2021.670756>
- Hazarika, A., & Madhukulya, S. (2023). The Commodification of Food Culture: A Study of The Bodo Community, With Special Reference to The Chariduar Area of the Sonitpur District. *AMCA Journal of Community Development*, 2.

- Hendarto, T., Dhakal, H., & Labh, S. (2024). Tiger Grouper seeds" infected" with parasites: Obstacles and Impacts. *Assyfa Journal of Farming and Agriculture*, 2.
- Kumari, R. (2020). Nano-biofertilizer: An Emerging Eco-friendly Approach for Sustainable Agriculture. *Proceedings of the National Academy of Sciences India Section B - Biological Sciences*, 90(4), 733–741. <https://doi.org/10.1007/s40011-019-01133-6>
- Mulyaningrum, R. (2023). Perlindungan hukum adalah perlindungan terhadap harkat dan martabat , serta pengakuan atas hak-hak asasi manusia yang dimiliki oleh subyek hukum berdasarkan ketentuan hukum dari kesewenangan atau sebagai kumpulan peraturan atau kaidah yang akan dapat mel. *Prosiding Seminar Nasional Cendekia Peternakan 2 Tema "Stategi Sub Sektor Peternakan Untuk Menghadapi Isu Resesi Global*.
- Nakhal, A. J. A. (2021). Business intelligence for the analysis of industrial accidents based on MHIDAS database. *Chemical Engineering Transactions*, 86, 229–234. <https://doi.org/10.3303/CET2186039>
- Nasir, M., Hartati, H., & Azmin, N. (2022). Pemberdayaan Masyarakat Melalui Pengolahan Sampah Organik di Kelurahan Nitu Kota Bima. *Jompa Abdi: Jurnal Pengabdian Masyarakat*, 1(1), 32–36. <https://doi.org/10.55784/jompaabdi.vol1.iss1.54>
- Nazari, M. (2020). A PGPR-Produced Bacteriocin for Sustainable Agriculture: A Review of Thuricin 17 Characteristics and Applications. *Frontiers in Plant Science*, 11. <https://doi.org/10.3389/fpls.2020.00916>
- Prayoga, P., Angriani, P., Arisanty, D., & Alviawati, E. (2021). Penerapan 3R (Reuse, Reduce, Recycle) Dalam Pengelolaan Sampah Di Kelompok Karang Lansia Sejahtera TPS Alalak Utara. *JPG (Jurnal Pendidikan Geografi)*, 8(1), 29–36. <https://doi.org/10.20527/jpg.v8i1.11522>
- Putra, F. G., Sari, A. P., Qurotunnisa, A., Rukmana, A., Darmayanti, R., & Choirudin, C. (2023). What are the advantages of using leftover cooking oil waste as an aromatherapy candle to prevent pollution? *Jurnal Inovasi Dan Pengembangan Hasil Pengabdian Masyarakat*, 2, 59–63.
- Ridzuan, N. H. A. M. (2020). Effects of agriculture, renewable energy, and economic growth on carbon dioxide emissions: Evidence of the environmental Kuznets curve. *Resources, Conservation and Recycling*, 160. <https://doi.org/10.1016/j.resconrec.2020.104879>
- Sari, D. S. P., Tambunan, S., & Sebayang, N. S. (2022). Utilization of bokasi solid organic fertilizer on corn plants (zea mays, L) in Matang Seping Village, Aceh Tamiang. *AMCA Journal of Science and Technology*, 1, 10–13.
- Sorour, A. (2020). The role of business intelligence and analytics in higher education quality: A proposed architecture. *2019 International Conference on Advances in the Emerging Computing Technologies, AECT 2019*. <https://doi.org/10.1109/AECT47998.2020.9194157>
- Streimikis, J. (2020). Agricultural sustainability assessment framework integrating sustainable development goals and interlinked priorities of environmental, climate and agriculture policies. *Sustainable Development*, 28(6), 1702–1712. <https://doi.org/10.1002/sd.2118>
- van Niekerk, A. J. (2020). Inclusive economic sustainability: SDGs and global inequality. *Sustainability (Switzerland)*, 12(13). <https://doi.org/10.3390/su12135427>
- Yuniwati, E. D., Prasetya, I. K., Rahayu, Y. S., Qomarudin, Q., & Arshad, I. (2023). Distribution of Biochar Technology as an organic planting medium and optimal biochar dose for *Abelmoschus Esculentus* L. Moench growth and production. *Assyfa Journal of Farming and Agriculture*, 1, 1–7.
- Abustan, A. (2023). Essential dimensions of development in villages. *AMCA Journal of Community Development*, 1, 35–41.
- Al-Alawachi, S. F. A. (2023). Treatment of tumor with an extract from the shell of an aquatic animal. *AMCA Journal of Health & Wellness*, 1, 12–16.
- Algarni, S. (2023). Contribution of renewable energy sources to the environmental impacts and economic benefits for sustainable development. *Sustainable Energy Technologies and Assessments*, 56. <https://doi.org/10.1016/j.seta.2023.103098>
- Arun, J. (2020). Sustainable and eco-friendly approach for phosphorus recovery from wastewater by hydrothermally carbonized microalgae: Study on spent bio-char as fertilizer. *Journal of Water Process Engineering*, 38. <https://doi.org/10.1016/j.jwpe.2020.101567>
- Aydoğan, B. (2020). Evaluating the role of renewable energy, economic growth and agriculture on CO₂ emission in E7 countries. *International Journal of Sustainable Energy*, 39(4), 335–348. <https://doi.org/10.1080/14786451.2019.1686380>

- Balafoutis, A. T. (2020). Smart farming technology trends: Economic and environmental effects, labor impact, and adoption readiness. *Agronomy*, 10(5). <https://doi.org/10.3390/agronomy10050743>
- Berhane, A. (2020). The impact of business intelligence on decision-making in public organisations. *IEEE International Conference on Industrial Engineering and Engineering Management, 2020*, 435–439. <https://doi.org/10.1109/IEEM45057.2020.9309763>
- Castelo-Branco, F. (2020). Business Intelligence and Data Mining to Support Sales in Retail. *Smart Innovation, Systems and Technologies*, 167, 406–419. https://doi.org/10.1007/978-981-15-1564-4_38
- Dahliani, L., Shumaila, S., & Darmayanti, R. (2023). A Completely Randomized Design (CRD) for Tomato Plant Growth and Production on Different Planting Media. *Assyfa Journal of Farming and Agriculture*, 1, 8–13.
- Garcia-Dorado, S. C. (2021). Using Qualitative System Dynamics Analysis to Promote Inclusive Livestock Value Chains: A Case Study of the South African Broiler Value Chain. *Frontiers in Sustainable Food Systems*, 5. <https://doi.org/10.3389/fsufs.2021.670756>
- Hazarika, A., & Madhukullya, S. (2023). The Commodification of Food Culture: A Study of The Bodo Community, With Special Reference to The Chariduar Area of the Sonitpur District. *AMCA Journal of Community Development*, 2.
- Hendarto, T., Dhakal, H., & Labh, S. (2024). Tiger Grouper seeds" infected" with parasites: Obstacles and Impacts. *Assyfa Journal of Farming and Agriculture*, 2.
- Kumari, R. (2020). Nano-biofertilizer: An Emerging Eco-friendly Approach for Sustainable Agriculture. *Proceedings of the National Academy of Sciences India Section B - Biological Sciences*, 90(4), 733–741. <https://doi.org/10.1007/s40011-019-01133-6>
- Mulyaningrum, R. (2023). Perlindungan hukum adalah perlindungan terhadap harkat dan martabat , serta pengakuan atas hak-hak asasi manusia yang dimiliki oleh subyek hukum berdasarkan ketentuan hukum dari kesewenangan atau sebagai kumpulan peraturan atau kaidah yang akan dapat mel. *Prosiding Seminar Nasional Cendekia Peternakan 2 Tema "Stategi Sub Sektor Peternakan Untuk Menghadapi Isu Resesi Global*.
- Nakhal, A. J. A. (2021). Business intelligence for the analysis of industrial accidents based on MHIDAS database. *Chemical Engineering Transactions*, 86, 229–234. <https://doi.org/10.3303/CET2186039>
- Nasir, M., Hartatl, H., & Azmin, N. (2022). Pemberdayaan Masyarakat Melalui Pengolahan Sampah Organik di Kelurahan Nitu Kota Bima. *Jompa Abdi: Jurnal Pengabdian Masyarakat*, 1(1), 32–36. <https://doi.org/10.55784/jompaabdi.vol1.iss1.54>
- Nazari, M. (2020). A PGPR-Produced Bacteriocin for Sustainable Agriculture: A Review of Thuricin 17 Characteristics and Applications. *Frontiers in Plant Science*, 11. <https://doi.org/10.3389/fpls.2020.00916>
- Prayoga, P., Angriani, P., Arisanty, D., & Alviawati, E. (2021). Penerapan 3R (Reuse, Reduce, Recycle) Dalam Pengelolaan Sampah Di Kelompok Karang Lansia Sejahtera TPS Alalak Utara. *JPG (Jurnal Pendidikan Geografi)*, 8(1), 29–36. <https://doi.org/10.20527/jpg.v8i1.11522>
- Putra, F. G., Sari, A. P., Qurotunnisa, A., Rukmana, A., Darmayanti, R., & Choirudin, C. (2023). What are the advantages of using leftover cooking oil waste as an aromatherapy candle to prevent pollution? *Jurnal Inovasi Dan Pengembangan Hasil Pengabdian Masyarakat*, 2, 59–63.
- Ridzuan, N. H. A. M. (2020). Effects of agriculture, renewable energy, and economic growth on carbon dioxide emissions: Evidence of the environmental Kuznets curve. *Resources, Conservation and Recycling*, 160. <https://doi.org/10.1016/j.resconrec.2020.104879>
- Sari, D. S. P., Tambunan, S., & Sebayang, N. S. (2022). Utilization of bokasi solid organic fertilizer on corn plants (zea mays, L) in Matang Seping Village, Aceh Tamiang. *AMCA Journal of Science and Technology*, 1, 10–13.
- Sorour, A. (2020). The role of business intelligence and analytics in higher education quality: A proposed architecture. *2019 International Conference on Advances in the Emerging Computing Technologies, AECT 2019*. <https://doi.org/10.1109/AECT47998.2020.9194157>

- Streimikis, J. (2020). Agricultural sustainability assessment framework integrating sustainable development goals and interlinked priorities of environmental, climate and agriculture policies. *Sustainable Development*, 28(6), 1702–1712. <https://doi.org/10.1002/sd.2118>
- van Niekerk, A. J. (2020). Inclusive economic sustainability: SDGs and global inequality. *Sustainability (Switzerland)*, 12(13). <https://doi.org/10.3390/su12135427>
- Yuniwati, E. D., Prasetya, I. K., Rahayu, Y. S., Qomarudin, Q., & Arshad, I. (2023). Distribution of Biochar Technology as an organic planting medium and optimal biochar dose for *Abelmoschus Esculentus* L. Moench growth and production. *Assyfa Journal of Farming and Agriculture*, 1, 1–7.