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Circular Economy in The Agriculture Sector: A Case Study of West Kalimantan Province

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Abstract. This article explores the implementation of circular economy principles in the agricultural sector, with a focus on West Kalimantan Province. An example provided discusses the process of converting animal waste into organic fertilizer through a series of drying and granulation stages, highlighting the sustainable approach adopted by the 'Usaha Bersama' farmer group. By repurposing agricultural byproducts and waste, the circular economy model aims to reduce waste accumulation, minimize pollution, and enhance resource efficiency in agriculture. The study emphasizes the economic and environmental benefits of adopting circular economy practices, such as creating economic opportunities, improving soil health, and increasing crop yields in West Kalimantan. Through a case study approach, the article demonstrates how circular economy principles can be effectively applied to address both economic and environmental challenges in the agricultural sector.

Keywords: Circular Economy; Organic Fertilizer; Agricultural Sustainability

1. Introduction

The Circular Economy (CE) is an economic model designed to maximize the use of resources and minimize waste by creating closed-loop systems where materials, products, and resources are reused, recycled, and regenerated for as long as possible (Heidbrink, 2023; Margarita and Noriega, 2023). This approach contrasts sharply with the traditional linear economy, which follows a 'take-make-dispose' pattern, leading to rapid depletion of natural resources and increased environmental pollution (Sánchez, 2023). The CE aims to decouple economic growth from the consumption of finite resources, thereby promoting sustainable development (Zhidebekkyzy et al., 2023). It incorporates the 5R principles: Reduce, Reuse, Recycle, Recovery, and Repair, to ensure minimal waste generation and optimal resource utilization (Popa, 2023). The CE model is gaining traction globally, with significant legislative support, technological innovations, and new business models that emphasize high usability, ease of repair, and reuse of products.

The circular economy (CE) in agriculture is a transformative approach that aligns with the Sustainable Development Goals (SDGs) by promoting resource efficiency, waste reduction, and sustainable practices. CE aims to replace the traditional linear model of production with a closed-

loop system where resources are reused, recycled, and regenerated, thus minimizing environmental impact and fostering economic growth (Zapucioiu and Sterie, 2023). Agriculture plays a crucial role in this transition, contributing significantly to the recycling of materials in Europe, although the agri-food sector's contribution remains limited (Brain and Awiti, 2023). The adoption of sustainable irrigation techniques, such as solar and drip irrigation, can reduce water wastage and enhance soil health, which is vital for sustainable agricultural productivity (Lachkepiani and Lomishvili, 2022). Technologies like anaerobic digestion and composting are pivotal in managing agricultural waste, adding value, and reducing environmental contaminants (Cassettari, 2023). The integration of circular principles in agriculture can also mitigate greenhouse gas emissions, which are substantial in conventional farming practices, by employing carbon sequestration methods like biochar. Moreover, circular agriculture emphasizes the regeneration of ecosystems, effective land use, and the production of quality food, contributing to food security and economic resilience. Despite the challenges, the transition to a circular economy in agriculture is essential for achieving multiple SDGs, including those related to poverty reduction, sustainable economic growth, and environmental sustainability. Romania's progress in increasing the recycling rate of municipal waste and the share of renewable energy in agriculture exemplifies the positive trajectory towards CE and sustainable development.

This article aims to achieve several objectives. Firstly, it aims to explain the concept of the circular economy. Secondly, the article explores the implementation of circular economy principles within the agricultural sector. Thirdly, it identifies specific challenges and opportunities in West Kalimantan. By analyzing the current agricultural conditions in the province, the article illustrates the potential benefits of adopting circular economy practices to improve the sustainability and resilience of the local agricultural sector. Additionally, the article aims to provide practical recommendations for managing agricultural resources using circular economy strategies. These recommendations will focus on reducing negative environmental impacts and enhancing the economic well-being of local communities. Lastly, the article emphasizes the role of the circular economy in supporting sustainable development. It shows how the adoption of circular economy practices in agriculture can contribute to achieving sustainable development goals (SDGs), particularly in terms of promoting sustainable agricultural practices and environmental conservation. Through these objectives, the article hopes to provide a comprehensive understanding of the importance of the circular economy in agriculture and its potential to support sustainable development in West Kalimantan.

2. Research Method

This study utilizes a qualitative research design to explore the implementation of circular economy principles in the agricultural sector of West Kalimantan Province. The research adopts a case study approach, focusing on the 'Usaha Bersama' farmer group's sustainable practices, particularly their process of converting animal waste into organic fertilizer. Data collection methods include a detailed case study analysis, a comprehensive literature review, and semi-structured interviews with key stakeholders such as farmers, local government officials, and representatives from agricultural organizations. The case study analysis documents the drying and granulation stages of fertilizer production, while the literature review contextualizes these practices within broader academic and practical frameworks. Interviews provide qualitative data on the challenges and opportunities associated with implementing circular economy principles in agriculture.

Data analysis involves thematic analysis to identify and analyze key themes related to the benefits and challenges of adopting circular economy practices. Comparative analysis is also employed to highlight similarities and differences in the implementation of these principles in various contexts. The research aims to answer several questions: How are circular economy principles being implemented in the agricultural sector of West Kalimantan Province? What specific challenges do farmers face in adopting these practices? What economic and environmental benefits do these practices bring to the local agricultural sector? How can collaboration among stakeholders enhance the implementation of circular economy principles in agriculture?

The expected outcomes include detailed documentation of the sustainable practices employed by the 'Usaha Bersama' farmer group, insights into the economic and environmental impacts of circular economy practices, identification of key challenges and potential solutions for promoting sustainable agricultural practices, and practical recommendations for stakeholders to support the adoption of circular economy principles in the agricultural sector. The validity and reliability of the research are ensured through triangulation, cross-verifying data from multiple sources, and the use of thematic and comparative analysis methods to strengthen the robustness of the findings.

3. Results and Discussion

3.1. Agricultural Profile in West Kalimmantan Province

The agricultural sector of West Kalimantan Province plays a crucial role in its economic framework, exhibiting a diverse array of activities and notable regional disparities. This sector encompasses both fundamental and ancillary elements, with certain regions, such as Sambas, Bengkayang, Landak, Mempayah, Sanggau, Ketapang, Sintang, Kapuas Hulu, Sekadau, and Kayong Utara, being classified as having a fundamental agricultural sector, while others, like Kubu Raya, Pontianak, and Singkawang, are considered non-basic (Nurulhuda *et al.*, 2021). Despite its significance, the province grapples with challenges like subpar productivity and pervasive poverty, where agricultural output substantially influences poverty rates, albeit with agricultural employment exhibiting a negligible impact on poverty alleviation (Nasrun, Fariastuti and Indra, 2020).

Key agricultural commodities include rice, corn, soybean, cassava, aloe, papaya, pineapple, olive, palm, rubber, pepper, coconut, cattle, goats, and free-range chicken, each necessitating specific technological interventions to optimize production (Burhansyah, 2017). In Sekadau Regency, food crops and plantations emerge as the progressive sub-sectors, with corn, rice, sweet potatoes, pepper, rubber, and oil palm dominating the landscape (Hernovianty *et al.*, 2022). Coconut cultivation, particularly in Bengkayang, Mempawah, and Sambas, exhibits varying degrees of market integration, underscoring the imperative for enhanced infrastructure and dissemination of market information (Maswadi *et al.*, 2021).

The traditional agrarian landscape, heavily reliant on forest ecosystems, undergoes a metamorphosis marked by dwindling forested areas and expanding agricultural plots, thereby impacting traditional practices such as shifting cultivation (Wicaksono and Nakagoshi, 2012). Over the past four decades, the economic trajectory has witnessed a decline in agricultural productivity, concomitant with a pivot towards trade and manufacturing sectors (Agustiar, 2013). In border regions like Badau District, strategies for agricultural advancement pivot on leveraging

regional strengths and capitalizing on growth opportunities, with a pronounced emphasis on technological integration within farming practices (Imelda, 2018).

Investments, both domestic and foreign, alongside labor dynamics, wield considerable influence on the agricultural GDP, albeit with foreign investments demonstrating an ostensibly insignificant direct impact (Bo, 2017). Endeavors to bolster rice productivity in challenging terrains, such as tidal swamps, entail the introduction of high-yielding varieties, among which the Padjadjaran variety shows promising potential (Sution and Agus, 2020).

3.2. Environmental Conditions and Ecological Challenges

The agricultural sector in West Kalimantan faces numerous environmental and ecological challenges that impact its productivity and sustainability. One significant issue is the cultivation of rice in tidal swamps, where farmers contend with waterlogging, high soil acidity, poor nutrient levels, saltwater intrusion, and Fe toxicity. To address these challenges, high-yielding rice varieties like Padjadjaran have been introduced to improve productivity (Sution and Agus, 2020). Additionally, the extensive use of land for oil palm plantations, covering 1.89 million hectares, has led to deforestation and carbon release, exacerbating global warming. Smallholder plantations, which constitute 54.7% of the oil palm area, often suffer from low productivity due to unsustainable practices (Supriyanto *et al.*, 2023). The conversion of forest areas to agricultural land further contributes to climate change. In Labian Village, sustainable agriculture practices are being promoted to combat deforestation (Maharani *et al.*, 2021). The agricultural sector's economic potential varies across regions, with areas like Sambas and Bengkayang showing progressive growth, while regions like Sintang and Melawi experience slower growth (Nurulhuda *et al.*, 2021). Traditional land clearing methods, such as burning, remain prevalent despite government efforts to promote environmentally friendly alternatives, leading to uncontrolled fires and environmental degradation (Daeli *et al.*, 2021)(Gorda, Dolorosa and Radian, 2022). The sustainability of certified pepper seedlings is also challenged by ecological factors like drought and low farmer awareness, necessitating improved management practices (Widarti, Youlla and Setiawan, 2022). Shifting cultivation, a traditional practice, is under threat from large-scale land acquisitions for industrial plantations, causing conflicts and reducing land availability for subsistence farming (Maring, 2020). Rice production sustainability is further hindered by factors such as inaccurate rainy seasons, chemical fertilizer use, and pest pressures, highlighting the need for targeted interventions (Ekawati *et al.*, 2017). Participatory spatial planning and mapping are essential for empowering rural communities to make informed decisions about land use, including whether to engage in oil palm cultivation (Vos and Khairnur, 2019). These multifaceted challenges underscore the need for integrated and sustainable approaches to agricultural development in West Kalimantan.

3.3. Existing Circular Economy Practices

The application of circular economy (CE) principles to agriculture is being explored and implemented in various countries, showcasing diverse strategies and benefits. In Rwanda, the adoption of CE principles in agriculture is evident through efforts to improve waste management and the use of human waste fertilizers, although challenges such as low waste sorting rates and the prevalence of traditional pit latrines remain (Sangwa, 2023). In the European Union, rural municipalities like Almócita are setting examples by integrating the 3Rs (reduce, reuse, recycle) into their agricultural practices, which has positively impacted local sustainable development and

can be extrapolated to other regions facing depopulation (Rauw *et al.*, 2022). In Brazil, Germany, Japan, Mexico, Morocco, Portugal, and Taiwan, CE principles are being applied to manage water resources in agriculture, with legislation and better management practices identified as key factors in ensuring water security and promoting sustainable water use (Dziedzic *et al.*, 2022). In Canada, a holistic approach to measuring CE at the micro-level in egg production has been developed, resulting in practical tools and performance indicators to enhance economic circularity on farms (Cassettari, 2023). Lastly, in the European Union, agriculture contributes significantly to the recycling of materials, although the overall circularity in the agri-food sector remains low, highlighting the need for policy interventions to enhance resource efficiency and sustainability (Rukundo *et al.*, 2021). These examples illustrate the varied and innovative applications of CE in agriculture across different countries, each addressing unique local challenges and opportunities.

An example of the application of a circular economy in agriculture in Western Kalimantan can be illustrated through the integration of livestock and crop production systems, which maximizes resource efficiency and minimizes waste. In this model, agricultural by-products such as crop residues and livestock manure are not discarded but are instead repurposed to create valuable inputs for other processes. For instance, livestock manure can be processed into organic fertilizer, which is then used to enrich the soil for crop production, thereby closing the nutrient loop and reducing the need for synthetic fertilizers (Nattassha *et al.*, 2020; Cassettari, 2023; Latif, Cahyandito and Utama, 2023a). This approach not only enhances soil fertility but also mitigates environmental pollution by reducing waste discharge into the environment (Pasaribu, 2016). Additionally, the use of biogas technology to convert livestock manure into energy further exemplifies the circular economy model, providing renewable energy for farm operations and reducing reliance on fossil fuels (Latif, Cahyandito and Utama, 2023b).

The implementation of such systems requires strong collaboration among various stakeholders, including farmers, local governments, and private enterprises, to ensure effective waste management and market access for organic products (Hẹn, Thành and Công, 2021; Rauw *et al.*, 2022). Moreover, innovative irrigation techniques, such as drip and sprinkler systems, can be employed to optimize water use, further supporting sustainable agricultural practices (Nattassha, Simatupang and Handayati, 2019). The success of these circular economy practices in Western Kalimantan hinges on continuous education and support for farmers, as well as the development of robust marketing strategies to promote the sale of organic fertilizers and other by-products (Banzato, 2016; Ilhamsyah and Harkim, 2021). Overall, the integration of circular economy principles in agriculture not only fosters environmental sustainability but also enhances economic resilience for local farming communities.

One example of the application of a circular economy is the production of granular fertilizer by the "Usaha Bersama" farmer group (Rizieq *et al.*, 2024). The process of making this granular fertilizer is illustrated in Figure 1 below.



Figure 1. The circular economy principle presented for the example of organic fertilizer from animal waste processing

The figure illustrates a circular economy model for the granular organic fertilizer drying process, highlighting a sustainable approach to agricultural waste management. This model integrates various stages, starting from the collection of animal waste and culminating in the production of granular organic fertilizer, demonstrating how resource efficiency and waste minimization can be achieved in agriculture.

The process begins with the collection of animal waste, a common by-product in livestock farming. Instead of disposing of this waste, it is repurposed as a raw material for organic fertilizer production. The initial stage involves a manual drying process, where the animal waste is partially dried to reduce moisture content. This step is crucial for preparing the waste for further processing and ensuring the efficiency of the subsequent drying stages.

Following the manual drying, the partially dried waste is transferred to a UV dryer house. Here, the waste undergoes a more controlled and efficient drying process using UV technology. This step ensures that the moisture content is further reduced to optimal levels, making the waste suitable for granulation. The use of UV drying technology not only speeds up the drying process but also helps in maintaining the quality of the organic material by preventing contamination.

Once adequately dried, the material is moved to a granule mixer. In this stage, the dried waste is mixed and processed to form granular particles. This granulation process enhances the physical properties of the organic fertilizer, making it easier to handle, store, and apply to agricultural fields. The granulated material is then subjected to a final drying process, ensuring that the granules achieve the desired consistency and moisture content.

3.4. Barriers to implementing circular economy in Agriculture

Farmers face several key challenges in implementing circular economy (CE) principles in their operations, which span across economic, technological, social, and policy dimensions. Financial constraints are significant, as the high costs associated with CE implementation, including long-term investment in circular models and technologies, pose a major barrier (Acharya, 2023). Additionally, technical and technological capabilities are often insufficient, with a lack of circular design and innovative packaging to reduce waste being a critical issue (Delouyi,

Ranjbari and Esfandabadi, 2023). Organizational challenges also arise from the complex process of restructuring existing business models into circular ones, compounded by weak awareness and understanding of sustainable development concepts among stakeholders(Pannila *et al.*, 2022). Social barriers include cultural resistance and public perceptions, which can hinder the acceptance of alternative practices such as wastewater reuse for irrigation(Piao *et al.*, 2023). Policy and institutional barriers are also prevalent, with inadequate enforcement of legislation and lack of coordinated policy efforts across different levels of government being notable obstacles (Vlasenko, Stanislavyk and Kovalenko, 2022). Furthermore, the informal nature of many agricultural systems, particularly in developing countries, complicates the adoption of CE practices. The need for inclusive, multi-stakeholder collaboration and policy coordination is critical to navigate these complexities and foster a transition to sustainable circular economies (Pannila *et al.*, 2022). Lastly, the entrenched reductionist traditions in agricultural research and education systems pose epistemological barriers, making it difficult to accommodate the holistic approaches required for CE and agroecology . Addressing these multifaceted challenges requires a concerted effort from governments, policymakers, and all stakeholders within the agricultural value chain to create enabling environments for CE adoption .

4. Conclusion and Policy Implication

The implementation of a circular economy in agriculture in West Kalimantan offers various benefits, addressing both economic and environmental challenges. By utilizing agricultural by-products and waste as resources for other processes, the circular economy helps reduce waste and enhance resource efficiency, which is crucial for sustainable development. This approach not only mitigates environmental issues such as waste accumulation and pollution but also creates economic opportunities by transforming waste into valuable products, such as organic fertilizers, which can improve soil health and crop yields. The agricultural sector, particularly food crops and plantations, plays a significant role in poverty alleviation in West Kalimantan by boosting output growth, employment, and household income distribution.

To address the challenges in implementing circular economy principles in farming operations, a comprehensive strategy must be devised. This requires a multi-pronged approach involving collaborative efforts, supportive policies, financial incentives, research and development, and education and extension services tailored to farmers' needs.

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