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A systematic review of composting as circular economy in waste management and sustainability in Ghana

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Abstract
This systematic review critically examines the role of composting within the circular economy framework for waste management and sustainability in Ghana. By synthesizing existing literature, the study aims to provide insights into the cultural, economic, and environmental dimensions of composting, offering a comprehensive understanding of its potential impact. The study analyses the economic viability and challenges associated with integrating composting into waste management strategies. Investigate the environmental sustainability of composting, focusing on its contribution to reducing greenhouse gas emissions and improving soil health. The findings identified cultural barriers influencing the acceptance of composting, emphasizing the need for culturally sensitive approaches. It explored economic factors impacting the scalability and success of composting initiatives, including financial constraints and market dynamics. It examined the environmental benefits of composting, with a specific focus on reducing greenhouse gas emissions and enhancing soil health. The findings will contribute to the development of targeted strategies for promoting composting within the circular economy in Ghana. It concludes by providing an overview of composting in the context of the circular economy in Ghana. The synthesized information offers valuable insights for creating sustainable and culturally relevant waste management solutions, contributing to the broader goals of environmental conservation and circular economy practices in the region.
Keywords: Composting, Circular economy, Waste management, Sustainability

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1. Introduction

The escalating global challenge of waste management, coupled with the imperative to foster sustainable practices, has spurred the exploration of innovative solutions (Bibri et al., 2023). In this context, composting emerges as a pivotal component of the circular economy paradigm, transforming organic waste into a valuable resource (Esposito et al., 2020). As urbanization and population growth intensify, so does the volume of waste generated (Achankeng, 2003, October). Traditional waste disposal methods, often linear and unsustainable, contribute to environmental degradation (Crocett et al., 2022). Composting, as a circular approach, presents an alternative that aligns with principles of sustainability and resource efficiency. The circular economy emphasizes

a regenerative system where resources are reused, recycled, and repurposed to minimize waste and environmental impact (Kristensen & Mosgaard, 2020). Composting exemplifies this circularity by converting organic waste into nutrient-rich compost, closing the loop in the organic matter lifecycle (Kaszycki et al., 2021). Composting is a biological process that converts organic matter into humus, a nutrient-rich soil amendment. It is a natural process that occurs in the environment, but it can also be accelerated by human intervention (Yadav & Garg, 2011). Composting is a key component of the circular economy, as it allows organic waste to be diverted from landfills and incinerators and returned to the soil, where it can be used to grow new food and other crops (Mihai et al., 2023).

This process not only diverts organic waste from landfills but also creates a valuable end product that enhances soil health and fertility. This cycle helps to reduce the amount of waste that is generated and sent to landfills, which can have a number of environmental and economic benefits (Ayilara et al., 2020). Landfills are the third-largest source of human-related methane emissions, a greenhouse gas that is 25 times more potent than carbon dioxide (Draughon et al., 2019). When organic waste is sent to landfills, it decomposes and produces methane. Incinerators also produce greenhouse gas emissions, as well as other pollutants, such as dioxins and furans. Composting also helps to reduce the need for synthetic fertilizers, which can be expensive and harmful to the environment.

Ghana is a developing country in West Africa. It has a population of over 31 million people and a rapidly growing economy. As a result, Ghana is facing a number of challenges, including waste management and sustainability (Douti et al., 2017). According to Lin et al., (2018), composting has the potential to address both of these challenges aforementioned. Conventional waste management methods, including landfilling and incineration, are associated with environmental drawbacks and limited resource recovery (Menikpura et al, 2013). Composting offers an eco-friendly alternative, addressing the shortcomings of linear waste disposal models. Composting contributes to waste reduction, mitigates greenhouse gas emissions, and conserves landfill space (Ayilara et al., 2020). Moreover, the resulting compost serves as a sustainable soil amendment, promoting agricultural productivity and fostering a closed-loop system. The primary aim of this review is to systematically explore and analyze the role of composting in waste management within the circular economy context, with a specific focus on its application and implications in the Ghanaian context. Understanding the nuances of composting as a circular economy strategy is essential for informing policy, guiding sustainable practices, and fostering a transition towards more resilient and environmentally friendly waste management systems.

2. Composting for Sustainability in Ghana

Composting has the potential to help Ghana achieve a number of sustainability goals. For example, composting can help to:

2.1 Reduce greenhouse gas emissions

Composting plays a vital role in mitigating greenhouse gas (GHG) emissions by diverting organic waste from landfills, where it would otherwise decompose anaerobically, releasing methane—a potent greenhouse gas (Ayilara et al., 2020).

Organic waste in landfills undergoes anaerobic decomposition, producing methane. Per the findings of Erses et al., (2008), they asserted that, composting, on the other hand, facilitates aerobic decomposition, where microorganisms break down organic matter in the presence of oxygen, significantly reducing methane emissions. By diverting organic waste from landfills, composting prevents the release of methane, a gas with approximately 25 times the warming potential of carbon dioxide over a 100-year period (Awasthi et al, 2018, Sánchez et al., 2015). This mitigation effect is a crucial strategy in combating climate change. Composting, when managed properly, can reduce nitrous oxide emissions. Nitrous oxide is another potent greenhouse gas produced during the decomposition of organic nitrogen. Compost provides a stable environment for nitrogen transformation, minimizing nitrous oxide release (Wang et al., 2019).

Compost acts as a carbon sink, sequestering carbon from organic matter in a stable form (Jeong et al., 2019). This sequestration helps offset the release of carbon dioxide (CO_2) from other decomposition processes, contributing to a net reduction in greenhouse gas emissions. The application of compost to soil enhances its structure and water retention capacity. Healthy soils foster the growth of vegetation, which, in turn, absorbs and stores carbon dioxide during photosynthesis, further mitigating atmospheric CO_2 levels (Rossi et al., 2023) .

Efficient composting processes, including proper aeration and moisture control, promote the dominance of microorganisms that thrive in aerobic conditions (Oshins et al., 2022). This reduces the likelihood of methane-producing anaerobic microorganisms, contributing to lower overall GHG emissions.

Beyond GHG emission reduction, composting provides co-benefits, such as reduced reliance on synthetic fertilizers, improved soil fertility, and decreased landfill usage. These co-benefits contribute to a more sustainable and circular economy (Haq et al., 2012).

2.2 Improve soil health

Composting serves as a sustainable practice not only in waste management but also in enhancing soil health. Compost is a nutrient-rich organic amendment, containing essential elements like nitrogen, phosphorus, and potassium. When added to soil, compost provides a balanced and slow-release source of nutrients, promoting plant growth and overall soil fertility (Shaji et al., 2021).

The organic matter in compost improves soil structure by binding soil particles together, creating aggregates. This enhances soil porosity, aeration, and water infiltration, critical factors for root development and nutrient uptake by plants (Bronick & Lal, 2005).

Compost acts as a sponge in the soil, enhancing water retention in sandy soils and improving drainage in clayey soils. This helps maintain optimal soil moisture levels, reducing the risk of both drought stress and waterlogging (Golabi et al., 2013). Improved soil structure resulting from compost application reduces the risk of soil erosion. The stable aggregates formed by organic matter help anchor soil particles, preventing loss through water runoff. Compost introduces a diverse community of beneficial microorganisms to the soil, including bacteria, fungi, and actinomycetes. These microorganisms contribute to nutrient cycling, disease suppression, and the creation of a healthy soil microbiome (De Corato, 2020).

Compost has a natural buffering capacity, helping to regulate soil pH (Latifah et al., 2018). This is particularly beneficial in acidic or alkaline soils, ensuring an environment conducive to nutrient availability and uptake by plants. The presence of certain beneficial microorganisms in compost can suppress harmful pathogens, reducing the incidence of soil-borne diseases. This natural disease suppression is an eco-friendly alternative to chemical treatment (De Corato, 2020).

Compost plays a role in weed suppression. A well-maintained soil enriched with compost creates a competitive advantage for desired plants, reducing the establishment and growth of weeds (Mehta et al., 2014). Composting aligns with sustainable agriculture by promoting practices that minimize environmental impact, reduce reliance on synthetic fertilizers, and improve overall soil resilience. The interplay of nutrient enrichment, microbial activity, and structural improvement positions composting as a cornerstone in sustainable soil management practices.

2.3 Increase food security

Composting delves into the integral role in advancing food security, emphasizing its multifaceted contributions to sustainable agriculture and global food systems. Compost, rich in organic matter and essential nutrients, acts as a natural fertilizer, enhancing soil fertility. Improved soil fertility translates to increased agricultural productivity and higher yields, thus bolstering food security (Ahmed et al., 2023).

Composting facilitates the recycling of organic waste into valuable nutrients for crops. This closed-loop nutrient cycle reduces dependency on external inputs and supports resource-efficient agriculture, particularly in regions with limited access to synthetic fertilizers. Composting offers a cost-effective solution for smallholder farmers, who often face financial constraints. The utilization of compost allows these farmers to enhance soil fertility without the high costs associated with chemical fertilizers. Compost improves soil structure and water retention, enhancing the soil's resilience to drought (Besharati et al., 2022). This is especially crucial in regions vulnerable to water scarcity, where compost-amended soils better withstand periods of low rainfall, supporting continuous crop production.

Composting can be locally implemented, allowing communities to produce their own nutrient-rich soil amendments. This localized approach reduces the dependence on external resources and fosters community resilience by promoting self-sufficiency in soil fertility management. Composting is particularly impactful in community and household gardens. It provides a low-cost, accessible method for individuals and communities to enhance the productivity of small-scale agricultural endeavors, directly contributing to local food security (Weidner et al., 2019). Composting emerges as a transformative practice with the potential to address food security challenges on multiple fronts. From enhancing soil fertility and mitigating environmental degradation to empowering smallholder farmers, composting stands as a sustainable and accessible solution with far-reaching implications for global food systems.

2.4 Create jobs

Composting initiatives can serve as catalysts for job creation in Ghana, offering socio-economic benefits alongside environmental sustainability. Establishing community-based composting centers creates jobs in waste collection, sorting, and compost production (Handoyo et al., 2020). These centers can be managed by local residents, fostering a sense of ownership and community engagement. Larger-scale composting facilities require skilled labor for operations, monitoring, and maintenance. By investing in training programs, Ghana can develop a workforce equipped with the expertise to manage these facilities efficiently.

Investing in research and development related to composting techniques and applications can stimulate job growth. Researchers, scientists, and innovators can contribute to advancements in sustainable waste management practices. Implementing educational programs and vocational training in composting techniques can equip individuals with the skills needed to participate in the growing composting industry. This approach aligns with

capacity-building initiatives, empowering communities with valuable expertise. Collaborating with non-governmental organizations (NGOs) and international organizations can attract funding and expertise to support job creation initiatives in the composting sector. This collaboration can enhance the scalability and impact of composting projects.

Adopting a strategic approach to composting in Ghana has the potential not only to address waste management challenges and promote environmental sustainability but also to significantly contribute to job creation, fostering economic growth and community development.

3. Challenges to Composting in Ghana

3.1 Lack of awareness and knowledge about composting

One significant challenge in composting is the limited awareness among the public about the benefits and processes of composting. Many individuals may not be familiar with composting as a sustainable waste management solution (Danso et al., 2009). The lack of comprehensive education programs about composting contributes to the gap in knowledge. There is a need for targeted initiatives to inform communities about the importance of composting, its environmental advantages, and practical implementation methods (Redman & Redman, 2014). Cultural factors and established waste disposal behaviors may hinder the adoption of composting (Kosoe et al, 2019). Overcoming these barriers requires culturally sensitive educational campaigns that emphasize the relevance of composting within the local context.

The availability and accessibility of information on composting techniques may be restricted, particularly in rural areas (Danso et al., 2009). Efforts should be made to disseminate information through various channels, including community workshops, media, and educational materials. Individuals may lack the necessary skills and knowledge to implement composting practices effectively. Establishing training programs, workshops, and demonstrations can empower communities with the practical know-how needed for successful composting.

The absence of robust government initiatives and policies to promote composting exacerbates a major challenge. Advocacy for the integration of composting into national waste management strategies is crucial to creating a supportive environment (Ofosu-Budu et al., 2015). Implementing small-scale composting demonstration projects can be an effective strategy. These projects showcase the tangible benefits of composting, making it more accessible and understandable for the community. Introducing composting topics into the school curriculum can instil environmental awareness and practices from an early age. This not only educates the younger generation but also influences household behaviors through intergenerational learning (Matsekoleng, 2021).

Leveraging social media platforms and technological tools can enhance outreach efforts. Engaging content, tutorials, and virtual workshops can be shared widely, reaching diverse audiences and fostering a culture of composting (Jacobson et al., 2015). Actively involving communities in the development and implementation of composting initiatives ensures a bottom-up approach. This participatory model fosters a sense of ownership and encourages sustained adoption of composting practices (De Boni et al., 2022).

In conclusion, addressing the lack of awareness and knowledge about composting in Ghana requires a comprehensive and culturally sensitive approach. Through targeted education, community engagement, and collaborative efforts, it's possible to overcome these challenges and promote the widespread adoption of composting practices.

3.2 Lack of infrastructure and equipment

The lack of dedicated composting facilities poses a significant challenge (Eriksen-Hamel & Danso, 2012). Investing in the establishment of community composting centers or upgrading existing waste facilities can provide the necessary infrastructure. Effective composting requires organized waste collection systems. Insufficient collection infrastructure can be addressed by implementing structured waste pickup schedules and community collection points, ensuring a steady supply of organic waste for composting. Transporting organic waste from collection points to composting sites can be a logistical hurdle. Investing in suitable transportation means, such as small-scale collection vehicles, can streamline the process and reduce the reliance on manual labor (Oduro, 2019). Limited financial resources may impede the acquisition of necessary infrastructure and equipment. Seeking partnerships with governmental bodies, private enterprises, and international organizations can provide funding and support for infrastructure development.

Insufficient knowledge on composting equipment operation and maintenance is a common challenge (Kyere et al., 2019). Training programs for local communities and waste management personnel can build the necessary skills for the proper use and upkeep of composting infrastructure. Empowering communities to take the lead in developing composting infrastructure fosters a sense of ownership. Community-led initiatives can identify local needs, allocate resources effectively, and ensure sustainable infrastructure management (Zhang & Tian, 2023). Implementing modular and scalable composting solutions allows for flexible expansion based on evolving needs. This approach accommodates varying community sizes and waste generation rates, promoting

adaptability. Collaborating with private enterprises for the development and maintenance of composting infrastructure can be mutually beneficial. Public-private partnerships can leverage the expertise and resources of both sectors to address infrastructure challenges (Yeboah, 2017). Exploring low-cost and locally available technologies for composting can be a practical approach. Simple, manual composting methods can be effective in certain contexts, requiring minimal infrastructure and equipment.

By strategically addressing the lack of infrastructure and equipment through a combination of community engagement, capacity building, and collaborative partnerships, Ghana can overcome these challenges and foster a more robust and sustainable composting ecosystem.

3.3 Cultural barriers

Cultural norms often influence traditional waste disposal practices, which may not align with composting (Amoah et al., 2023). Addressing this challenge involves promoting composting as an evolution of waste management that respects cultural values while offering environmental benefits. Cultural perceptions of waste as something to be discarded rather than utilized for composting can hinder adoption (Metson & Bennett, 2015). Education campaigns should emphasize the transformation of waste into a valuable resource, aligning with cultural values of sustainability. Certain cultural practices involve the disposal of organic materials in specific ways due to rituals or ceremonies. Sensitivity to these practices is essential, and educational efforts should explore how composting can coexist with cultural traditions (Applewhite, 2023).

In some cultures, handling waste, even for beneficial purposes like composting, may carry stigma (Oteng-Ababio, 2013). Promoting the social value of composting as a community-building and environmentally conscious activity can help shift perceptions. Gender roles may influence waste management responsibilities. Engaging with both men and women in the community ensures that composting initiatives consider and respect diverse roles, encouraging broader participation. Engaging community leaders and involving community members in decision-making processes can facilitate the acceptance of composting initiatives. This participatory approach ensures that cultural perspectives are considered in the planning and implementation stages. Effective communication is vital. Using culturally appropriate language, visuals, and communication channels ensures that the information about composting resonates with the local community and addresses cultural barriers (Amoah et al., 2023). Highlighting the agricultural benefits of composting aligns with cultural contexts where farming plays a significant role. Positioning compost as a natural and beneficial soil amendment can bridge the gap between cultural practices and sustainable waste management. Conducting community-based composting demonstrations allows individuals to see the practical aspects and benefits firsthand (Oteng-Ababio, 2013).. This hands-on approach helps overcome cultural resistance by showcasing the positive outcomes of composting. Acknowledging and respecting traditional knowledge related to soil fertility and waste management fosters a collaborative approach. Integrating cultural wisdom with modern composting techniques enhances the acceptability of composting practices. Building trust and fostering a long-term relationship with communities through continuous engagement and dialogue are crucial. This ongoing interaction allows for the mutual exchange of knowledge and the gradual acceptance of composting practices.

By recognizing and addressing cultural barriers through a combination of respectful engagement, localized education, and integrating composting into existing cultural practices, Ghana can create a more inclusive and culturally sensitive approach to sustainable waste management.

3.4 Economic barriers

The upfront costs associated with setting up composting facilities and acquiring necessary equipment can be a barrier (Mittal et al., 2018). Seeking financial support through grants, subsidies, or partnerships can alleviate this challenge and make composting more accessible. Ongoing operational expenses, including labor, maintenance, and monitoring, may strain financial resources. Implementing cost-effective practices, optimizing resource use, and exploring revenue-generating opportunities, such as compost sales, can help offset these expenses. Providing training programs for community members and waste management personnel requires funding. Collaboration with governmental bodies, non-profit organizations, or international agencies can secure the necessary resources for education and skill-building initiatives. Limited market access for compost products may hinder the economic sustainability of composting initiatives. Developing marketing strategies, creating partnerships with agricultural cooperatives, and exploring niche markets can enhance the economic viability of compost production.

Investing in composting infrastructure development, such as collection points and transportation, can strain municipal budgets (Owusu-Sekyere et al., 2015). Leveraging public-private partnerships, seeking international aid, or exploring innovative financing models can overcome financial barriers. Striking a balance between economic viability and environmental sustainability is crucial. Implementing composting practices that are both economically feasible and ecologically sound ensures the long-term success of waste management initiatives. Providing incentives for businesses and entrepreneurs engaged in composting can stimulate economic interest.

Tax breaks, subsidies, or recognition programs can encourage private sector involvement in composting activities. Implementing cost-effective outreach and awareness campaigns ensures that the benefits of composting are communicated without straining financial resources. Leveraging community networks, social media, and existing communication channels can be cost-efficient. Exploring community-based funding models, such as cooperative savings, crowdfunding, or community grants, can empower local residents to contribute to composting initiatives and ensure financial sustainability. Establishing partnerships within the circular economy framework can create economic synergies. Collaborating with businesses that can utilize compost by-products or exploring synergies with other waste management initiatives can enhance the overall economic impact.

By strategically addressing economic barriers through a combination of financial support, innovative financing models, and community empowerment, Ghana can create a more economically sustainable environment for composting initiatives.

4. Conclusion

In conclusion, promoting composting in Ghana requires a comprehensive and integrated approach that addresses various challenges. From cultural and economic barriers to infrastructure limitations, tackling these issues is essential for fostering a sustainable and widespread adoption of composting practices. Emphasizing the compatibility of composting with cultural values and traditions is crucial. Tailoring educational programs, respecting local knowledge, and involving communities in decision-making processes can help overcome cultural barriers. To enhance economic viability, exploring innovative financing models, engaging with the private sector, and creating incentives for businesses and entrepreneurs are essential. Balancing economic and environmental goals ensures the long-term success of composting initiatives. Overcoming infrastructure challenges involves strategic investments, community involvement, and leveraging public-private partnerships. Implementing modular and scalable approaches ensures flexibility and adaptability to diverse community needs. Addressing the lack of awareness and knowledge necessitates robust education and awareness campaigns. Utilizing community-based demonstrations, integrating composting into school curricula, and employing localized communication strategies are effective methods. Engaging communities as active participants in composting initiatives is key. Involving local leaders, and fostering community-led development contribute to a sense of ownership and long-term success. Advocacy for government support, policy integration, and the inclusion of composting in national waste management strategies are vital. Government initiatives can provide the necessary regulatory frameworks and financial backing to drive sustainable composting practices. By addressing these aspects collectively and collaboratively, Ghana can create an environment where composting becomes an integral part of waste management, contributing to environmental sustainability, economic development, and improved community well-being. The journey toward widespread composting adoption is a shared effort that involves individuals, communities, businesses, and governmental bodies working together for a more sustainable future.Composting is a sustainable and circular economy approach to waste management. It has the potential to help Ghana achieve a number of sustainability goals, such as reducing greenhouse gas emissions, improving soil health, increasing food security, creating jobs, and reducing poverty. There are a number of challenges to composting in Ghana, but these challenges can be overcome with education, investment, and support. The Ghanaian government, businesses, and individuals should work together to promote and support composting in Ghana.

5. Recommendations

The following recommendations are made to promote and support composting in Ghana:

- The Ghanaian government should develop and implement a national composting strategy. This strategy should include measures to raise awareness about composting, provide training and resources to composters, and develop infrastructure and markets for compost.

- Businesses should be encouraged to compost their food waste. This can be done by providing tax breaks or other incentives to businesses that compost.

- Individuals should be encouraged to compost their food waste at home. This can be done by providing composting bins and educational materials to individuals.

- Schools and universities should teach students about composting. This can be done by incorporating composting into the curriculum and by starting composting programs on school campuses.

By implementing these recommendations, Ghana can become a leader in composting and achieve its sustainability goals. This holistic approach, incorporating cultural sensitivity, economic viability, and community engagement, will contribute to sustainable waste management practices and environmental conservation.

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