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Low-Carbon Development (LCD) in Indonesia's Poultry Farming Sector for the Support of Green Economy

Febrineal Sandewa[1*)], Trismawan Djonisajoko[2], Edi Permadi[3], Ibrahim Musa Gani[4]
[1] Community Figures of Sumatera Barat, Indonesia
[2,3]Lembaga Ketahanan Republik Indonesia
[4] Economics Department, Isa Kaita College of Education Dutsinma Katsina State, Nigeria

(*) Corresponding Author: febrineal.sandewa@gmail.com

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Abstract

Purpose: This article aims to identify the current state of Low-Carbon Development (LCD) within Indonesia's poultry sector, outline the challenges encountered, and explore strategic measures to enhance its implementation in support of the green economy.

Design/Methodology/Approach: This study adopts a descriptive-analytical method with a qualitative approach. Analytical tools such as PESTLE, SWOT, and the National Resilience approach are employed to assess the challenges, opportunities, and strategies for implementing LCD.

Findings: Although various policies have been implemented, including the use of biodigester technology and government incentives, significant barriers persist, such as high operational costs, technological limitations, and inadequate education. Stronger policy support, financial incentives, and cross-sector collaboration are essential for a successful transition towards a green economy.

Originality/Value: This article provides a comprehensive perspective on how Indonesia's poultry sector can overcome LCD challenges by leveraging modern technology and fostering cross-sector collaboration.

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INTRODUCTION

The phenomenon of countries strengthening global commitments to reduce emissions has persisted since treaty of Paris in 2015, which established a long-term temperature goal and targets. Specifically, the primary goal of the Paris Agreement is to limit global temperature rise to well below 2°C (3.6°F), above pre-Industrial levels with an aspirational target of 1.5°C (2.7°F), in order to prevent more severe climate impacts. Climate change has emerged as a significant global issue, driven by the increasing concentration of Greenhouse Gas (GHG) emissions. As illustrated in Figure 1, Indonesia ranks among the largest GHG emitters globally, primarily due to deforestation and forest degradation. Furthermore, the impacts of climate change are being felt regionally, manifested in rising temperatures, extreme weather events, and rising sea levels, all of which pose substantial threats to ecosystems and human livelihoods, particularly in island nations such as Indonesia.

Poultry farming sector in Indonesia is one of the sectors that is specifically vulnerable to GHG emissions changes. The extreme temperature fluctuations have disrupted productivity and increased the risk of diseases to affect the birds. Poultry farming is of considerable importance, as it is contribution to economic growth is evident; however, certain issues such as waste management, (which include manure, feed, and hygiene), may undermine the efforts to achieve carbon emission reduction targets. In response to this global challenge, Indonesia was actively participated in United Nation Climate Change Conference COP28 held in Dubai UAE, with the aim of finding ways to reduce carbon emissions, particularly through enhanced management of Forests and Other Land Uses (FOLU), and accelerating the transition to Renewable Energy, which includes the utilisation of livestock waste.

Deforestation does not only contributes to global warming but also impacts the agricultural sectors such as poultry farming sector through local climate changes that causes the unavailability of feed and hygiene water for the birds in the sector. Considering Indonesia's National Resilience Index from 2017 to 2023, which indicates significant robustness, the challenges related to sustainability and national stability, such as deforestation and emissions, should be addressed effectively by the government (Daihani, 2024). These challenges, which include declining productivity and an increased risk of natural disasters such as floods and droughts, require serious attention. Moreover, deforestation often leads to other environmental issues, such as desertification and soil erosion, as well as the displacement of indigenous communities who rely on forests for their livelihoods. Therefore, structured mitigation and adaptation efforts are imperative to maintaining sustainability and national stability amidst complex environmental challenges.

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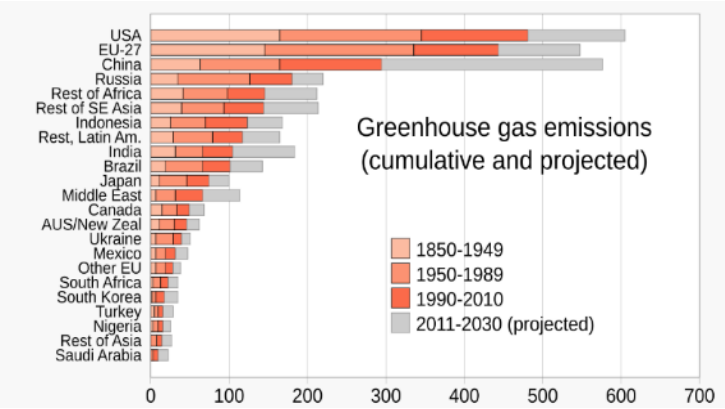

Source: wikimedia.org

Figure 1: Cumulative greenhouse gas emissions by country

Sovacool et al., (2011) assert that energy security involves ensuring availability, affordability, reliability, efficiency, environmental sustainability, proactive governance, and social acceptance of energy services for end users; however, the reality is that many nations struggle to achieve all these elements concurrently. Despite emission mitigation efforts through programmes such as REDD+ being pursued since 2010, challenges persist. On a global scale, Indonesia's poultry farming sector contributes approximately 18% of total anthropogenic GHG emissions, surpassing the transport sector, which accounts for 13.1% of GHG emissions. This includes methane (CH_4) emissions generated from enteric fermentation and livestock waste management. Data indicate that methane emissions from the livestock sector amount to 1,189.6 Gg CH_4 annually, with a significant share stemming from beef cattle (Saputra, 2019).

Moreover, despite the growth in livestock farming, including cattle, buffalo, goats, sheep, and poultry in Indonesia, improper management can significantly contribute to GHG emissions, particularly through methane (CH_4) production. To address this, the government must implement structured management practices. The urgency of such management becomes more apparent considering the emissions of nitrous oxide (N_2O) resulting from waste handling and the use of organic fertilisers. Data indicate that methane emissions from the livestock sector reach 1,189.6 Gg CH_4 annually, with beef cattle being the primary contributor at 796.8 Gg CH_4 (Saputra, 2019).

A similar trend is evident in poultry farm management, as illustrated in Figure 2, where the total chicken population rose from 2,889,207,954 birds in 2021 to 3,168,325,176 birds in 2022. This growth in broiler chicken populations reflects an increase in poultry production to support domestic protein needs. The economic growth from the poultry sector in Indonesia is demonstrated by its contribution to the Gross Domestic Product (GDP), amounting to Rp 167.63 trillion during the 2021-2022 period. However, considering the impact of greenhouse gas emissions, effective and structured waste management is essential. Nitrous oxide (N_2O) emissions from poultry waste account for 14.48% of total greenhouse gas emissions, while methane produced from enteric fermentation has a greater global warming potential than carbon dioxide. Therefore, effective management is necessary to mitigate these emissions and achieve sustainable development.

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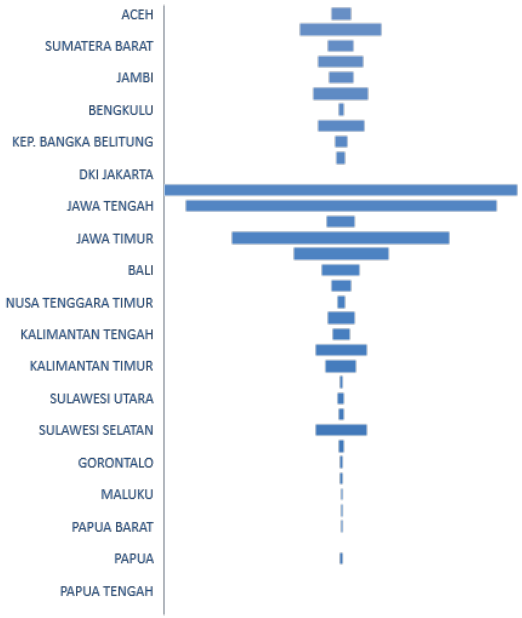
Given the aforementioned circumstances, it is evident that Indonesia, with its heavy reliance on natural resources, faces increasingly complex environmental challenges. Waste management within the livestock sector presents a major challenge, as emissions of N_2O and methane can accelerate global warming. Thus, in line with Law No. 32 of 2009 on Environmental Protection and Management, the balance between economic production growth and environmental considerations must be continually strengthened to minimise negative impacts such as increased emissions and pollution. Although Low-Carbon Development (LCD) has been integrated into the National Medium-Term Development Plan (RPJMN) 2020-2024 and reinforced by Presidential Regulation Number 98 of 2021, the implementation within the poultry farming sector still faces significant challenges related to waste management that need to be addressed urgently.



Source: data processed by the author from sources bps.go.id (2024)

Figure 2: Population of Broiler Chickens by Province (Head), 2021-2023

The objective of this paper is to identify the current state of LCD in the poultry farming sector, and also to outline the challenges encountered, and explore strategic measures to support the green economy in Indonesia. The theoretical explanations provided are intended to contribute to formulating strategies for enhancing LCD in the poultry farming sector and to encourage practical strategic explorations.

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Literature Review

The concept of the green economy, as discussed by Loiseau et al. (2016); UNEP (2011), and Edwards (1980) implementation theory, is employed in this study to address the challenges and opportunities associated with implementing LCD in Indonesia's poultry farming sector (Goodin, 2013; United Nations Environment Programme, 2021). The emphasis on the green economy highlights the adoption of sustainable practices and collaboration between state and non-state actors in confronting ecological crises, with consideration for natural capital and ecological conditions to mitigate environmental risks and ensure social equity, making it an essential topic of discussion. Furthermore, according to the 2023 Climate Action Tracker report, despite the integration of LCD, Indonesia is still classified as "Critically Insufficient" in meeting climate mitigation targets. This indicates that while reports show emission reductions exceeding the 2022 target of 91 million tonnes of CO2, reaching 91.5 million tonnes (Ministry of Energy and Mineral Resources, 2023), and renewable energy capacity at 12,736.7 MW, these achievements are still insufficient to meet the ambitious commitments of the Paris Agreement. Therefore, the relevance of implementation theory is employed to highlight communication, resources, attitudes, and bureaucratic structures as key policy factors for analysing LCD implementation.

Low-Carbon Development (LCD) in Indonesia's Poultry Farming Sector

Indonesia's policy efforts, such as Law No. 32/2009 on Environmental Protection and Management and Presidential Regulation No. 98/2021 on Carbon Economic Value, demonstrate a commitment to regulating emissions across various sectors, including livestock farming. Poultry waste holds significant potential for supporting the green economy, serving both as an organic fertiliser rich in nitrogen, phosphorus, and potassium, and as a renewable energy source through anaerobic digestion. The biogas production process from poultry waste can yield 60-70 m^3 of biogas per tonne of waste, which can be utilised for electricity or heat production. This utilisation not only helps reduce dependency on chemical fertilisers and fossil energy but also plays a role in mitigating greenhouse gas emissions and promoting more sustainable waste management practices. The development of low-carbon initiatives (LCD) in the livestock sector in Indonesia continues to progress, particularly through biogas utilisation. A notable example of this effort is PT Greenfields Dairy Indonesia, which constructed a biogas reactor with a 12,000 m^3 capacity in Blitar, East Java, producing 7,200 m^3 of biogas daily, converted into approximately 15,800 kilowatts of electricity. Nevertheless, data on the total number of livestock industries nationwide that have adopted biogas management technology remains limited, as most small and medium-sized farms currently employ it primarily for local energy needs.

Challenges in Meeting Low-Carbon Development (LCD) in Indonesia's Poultry Farming Sector.

The challenges in achieving LCD in Indonesia's poultry sector encompass various obstacles such as technological limitations, restricted access to quality resources, and high operational costs. Referring to Goodin (2013), policy implementation theory, emphasis on communication, resources, attitudes, and bureaucratic structures is essential for successful implementation. However, challenges related to investment and supportive

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infrastructure, as well as policies that do not fully promote the adoption of low-emission and environmentally sustainable practices, remain significant. Additionally, issues such as limited access to modern technology and adequate training, fluctuations in feed prices, disease outbreaks, weak law enforcement, and the adoption of advanced technologies present further hurdles. The implementation of modern technologies, including the Internet of Things (IoT), big data, and artificial intelligence, which enable real-time monitoring of farm conditions, poses additional challenges. Ideally, IoT should facilitate feed optimisation and improve livestock health (Mpeqa et al., 2023).

Therefore, collaboration between the public sector, private sector, and civil society is imperative to accelerating the adoption of sustainable practices (Ardiansyah & Ekadewi, 2022). Initiatives such as training programmes and research involving educational institutions to promote efficient management practices, encourage innovation, and stimulate the necessary investments to expedite the transition to a green economy are essential (Antwi-Agyei & Stringer, 2021; Permatasari et al., 2020). Additionally, the development of an inclusive regulatory framework, the availability of modern technology, and incentives for converting production waste into renewable energy are imperative for effective progress.

METHODS

The qualitative research method adopted in this study, as described by Creswell & Poth (2024), utilises a descriptive-analytical approach, incorporating theoretical frameworks such as the National Resilience approach, PESTLE, and SWOT to provide a comprehensive understanding of the existing challenges and opportunities. This evaluation includes strengths such as LCD within Indonesia's poultry sector.

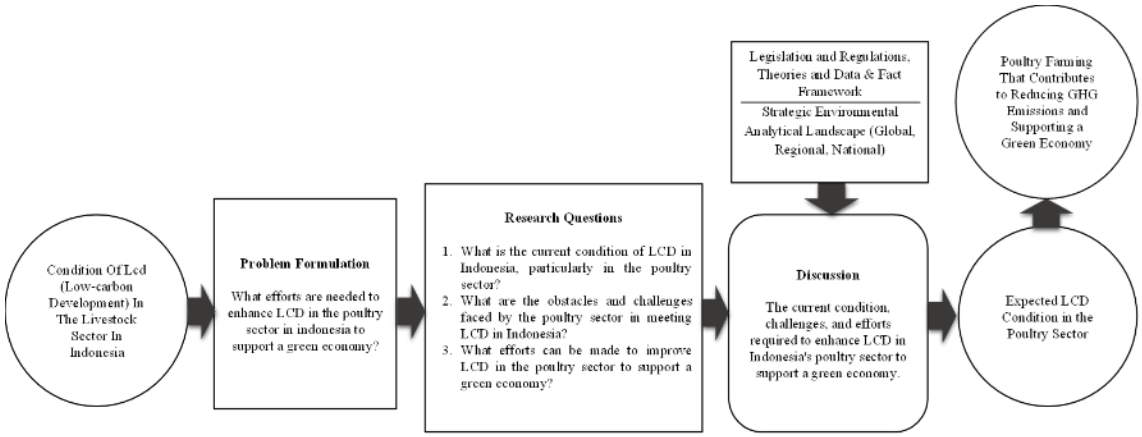

Figure 1: Conceptual Research Framework

Data collection techniques involve document review, policy reports, and relevant literature studies, which are processed through thematic analysis to identify key patterns and relationships among themes supporting the research. The National Resilience approach encompasses eight aspects: Geography, Demography, Natural Resources, Ideology, Politics, Economy, Socio-culture, and Defence and Security. Meanwhile, PESTLE is employed to analyse external factors—political, economic, social, technological, legal, and environmental—to offer a thorough overview of prevailing

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issues and challenges. This analysis is complemented by SWOT to assess strengths, weaknesses, opportunities, and threats, and formulate relevant strategies such as ST, SO, WO, and WT. Scenario Building and Planning (SBP) further enhances this approach by developing future scenarios (Budych-Gorzna et al., 2016), enabling adaptive strategic planning amidst uncertainties, as illustrated in Figure 1.

RESULT AND DISCUSSION

Current State of Low-Carbon Development (LCD) in Indonesia's Poultry Farming Sector

The Indonesian government has implemented various policies and initiatives to support LCD in the poultry sector. These policies include regulations on energy conservation and incentives for farmers adopting environmentally friendly technologies. The government also promotes the use of renewable energy and improved waste management through regulations that encourage sustainable farming practices. These initiatives aim to reduce greenhouse gas emissions in line with the targets set by the Nationally Determined Contributions (NDC), which aim for a 29% reduction in emissions through domestic efforts and up to 41% with international support by 2030.

Poultry farming practices in Indonesia have demonstrated efforts to mitigate environmental impact through energy and waste management. For instance, the use of biodigester technology to convert poultry waste into biogas as an alternative energy source has proven effective in reducing methane emissions and lowering energy costs (see Figure 2).

Figure 2: Implementation of Biodigesters in Ruminant Farming (Cattle and Similar Livestock)

Several regions in Indonesia have successfully implemented biodigester technology, such as Bandung, which has processed kitchen waste since 2013, and Jimbaran Village in Pasuruan, which has plans to utilise biogas to meet community energy needs (Farrah et al., 2021; Rianawati et al., 2018). In Bangunjiwo Village, Bantul,

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portable biodigesters are used to reduce food waste and generate renewable energy, enhancing agricultural productivity and reducing costs (Wijaya et al., 2023). However, the adoption of biodigesters in poultry farming remains suboptimal. In Karo Regency, North Sumatra, biogas technology is employed to support the use of organic fertilisers, and solar panels at poultry farms have helped power equipment, thereby reducing electricity costs and carbon emissions (Ginting & Rauf, 2017).

Table 1: Analysis of the Three-Method Approach on the Current State of LCD

National Resilience Analysis	SWOT Analysis	PESTLE Analysis
Geographically, there is potential for green technology (biodigesters, solar panels).	Strengths: The importance of government support for renewable energy potential.	Political Aspect: Policies on environmentally friendly technology, and Economic Aspect: Reduction in operational costs and financial incentives.
Demographically, there is market potential and efficiency challenges.	Weaknesses: Limitations in implementation and funding constraints.	Social Aspect: Training for farmers and adoption of sustainable practices
Considering the wealth of renewable energy resources, management is needed for energy resilience	Opportunities: Market for renewable energy, global awareness	Technological and Environmental Aspects: Innovation and management of production waste.
Ideologically, sustainable development aligns with Indonesia's national ideals and goals	Threats: Political uncertainty, international competition.	Legal Aspect: Regulations on energy and waste efficiency.

Through the three analytical approaches supporting the stability and sustainability of the current poultry sector, as outlined in Table 1, it can be explained that these combined approaches enable the poultry sector in Indonesia to be managed with more targeted and sustainable strategies. The integration of geographic and demographic potential, policy support, the adoption of environmentally friendly technologies, and the strengthening of competitiveness by considering both internal and external factors are key components of this approach. Edwards (1980) implementation theory is relevant as it emphasises the importance of communication, resources, attitudes, and bureaucratic structures as critical factors in the policy application of LCD. Additionally, the concept of the green economy, as discussed by Loiseau et al. (2016); UNEP (2011), highlights the significance of sustainable practices and the collaboration between state and non-state actors in addressing ecological crises.

Therefore, the implementation of innovative technologies, such as sensor-based feed management systems that monitor real-time feed consumption, can enhance resource efficiency and poultry health. Government support in the form of incentives and subsidies, such as assistance for purchasing environmentally friendly technology and tax reductions, is imperative for promoting the widespread adoption of these technologies. Training programmes and mentorship must also be provided to ensure farmers possess the necessary skills to operate such technologies effectively. This approach will facilitate the optimal integration of LCD practices, support the sustainability of the poultry sector, and contribute to meeting national emission targets in line with green economy principles.

Constraints and Challenges in Achieving Low-Carbon Development (LCD)

Efforts to achieve LCD within the poultry sector face significant challenges, including financial constraints and limited access to technology (Widagdo, 2016). The

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initial costs of adopting environmentally friendly technologies such as biodigesters and solar panels often pose barriers for small to medium-sized farmers (Budiman, 2021). Although government subsidies and incentives are available, these forms of assistance are insufficient to cover the investment and maintenance costs associated with such technologies. Consequently, the adoption of low-carbon technologies progresses slowly, with many farmers opting for more affordable conventional methods.

In addition to financial issues, the lack of knowledge and access to training on low-carbon techniques represents a significant barrier. Small and medium-scale farmers often lack sufficient education on the benefits and operation of environmentally friendly technologies, resulting in hesitancy to transition from traditional methods. This challenge is further exacerbated by inconsistent regulations and weak enforcement, which hinder efforts towards LCD. To address the issue of regulatory inconsistency, a holistic solution is required, encompassing education, financial support, broader access to technology, and sustainably supportive policies. Such measures are essential for enabling the poultry sector to contribute effectively to the transition towards a green economy.

Referring to Table 2, which outlines the National Resilience, SWOT, and PESTLE approaches, this study emphasises the importance of integrating strategies to address the challenges of LCD in the poultry sector. These approaches align with the green economy concept proposed by Loiseau et al. (2016); UNEP (2011) as well as Edwards (1980) implementation theory. The green economy concept underscores sustainable practices and cross-actor collaboration to tackle ecological crises, aligning with the PESTLE approach in highlighting the need for consistent and supportive political regulations and cooperation. Additionally, Edwards' implementation theory aids in analysing the need for effective communication, resources, attitudes, and robust bureaucratic structures, which are closely linked to the National Resilience and SWOT approaches in supporting energy resilience and overcoming weaknesses related to knowledge and technological access. The Climate Action Tracker (2023) report categorises Indonesia as "Critically Insufficient" in climate mitigation, indicating that while progress has been made in emission reductions and renewable energy advancements, these efforts remain inadequate. Therefore, implementation theory is pertinent in providing guidance for more effective integration of LCD, particularly through increased financial support, education, and cross-sector collaboration to meet targets aligned with international climate commitments.

Table 2: Analysis of the Three-Method Approach on Constraints and Challenges

Approach	Main Constraints	Solutions
National Resilience Analysis	Financial constraints and limited access to subsidies and environmentally friendly technologies.	Increase subsidies, financial assistance, and education to strengthen energy and food resilience.
SWOT Analysis	Weaknesses in farmer education and training, as well as minimal adoption of innovative technologies.	Enhance training programmes and address internal weaknesses through capacity-building strategies and market opportunities.
PESTLE Analysis	Inconsistent regulations, weak law enforcement, and economic and social challenges in technology adoption.	Improve regulations, ensure consistent law enforcement, and strengthen collaboration among actors for political and social support

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Enhancing LCD in the Poultry Farming Sector to Support the Green Economy

Various efforts are essential to promote LCD within the poultry farming sector as part of the transition towards a green economy. One critical step involves government incentives and policy adjustments to encourage the adoption of environmentally friendly technologies (Zerssa et al., 2021). Subsidising low-carbon technologies such as biodigesters and solar panels, as well as offering tax reductions for poultry farmers who implement sustainable practices, can expedite the adoption of these innovations. Strengthening regulations and ensuring consistent law enforcement are also vital for the effective implementation of LCD (Mpeqa et al., 2023).

International cooperation plays a significant role in supporting LCD implementation, including technology transfer and financial aid from developed countries. Programmes that facilitate the transfer of technology and modern knowledge assist local poultry farmers in accessing more efficient practices for emission reduction (Suo & Cao, 2021). Training and education for farmers are also imperative to enhance their skills in applying sustainable practices, such as low-emission technology use and waste management. Successful examples from countries like Denmark and the Netherlands, along with local initiatives harnessing biogas, can serve as implementation models for Indonesia. Public-private partnerships are also recommended for long-term investment, with private entities providing technology and capital, while the government supports a conducive regulatory framework. Promoting eco-labelling and certification of low-carbon poultry products can raise consumer awareness and demand for eco-friendly products, thereby strengthening the sector's competitiveness within Indonesia's green economy.

Table 3: Analysis of the Three-Method Approach for Enhancing LCD

Approach	Main Constraints	Solutions
National Resilience Analysis	Financial constraints and limited access to subsidies and environmentally friendly technology.	Increase subsidies, financial assistance, and educational initiatives to strengthen energy and food resilience
SWOT Analysis	Weaknesses in farmer education and training, along with minimal adoption of innovative technologies.	Enhance training programmes and address internal weaknesses through capacity-building strategies and market opportunities.
PESTLE Analysis	Inconsistent regulations, weak law enforcement, and economic and social challenges in technology adoption.	Improve regulatory frameworks, ensure consistent law enforcement, and foster cross-sector collaboration for political and social support.

Referring to Table 3, the National Resilience, SWOT, and PESTLE approaches play imperative roles in supporting the enhancement of LCD within the poultry sector. The National Resilience approach emphasises the importance of providing incentives, subsidies for low-carbon technology, and regulatory strengthening to ensure improved energy and food resilience. Furthermore, the SWOT analysis helps identify strengths, weaknesses, opportunities, and threats in the adoption of environmentally friendly technology, with proposed solutions such as training, technology transfer, and mitigation strategies to optimise existing potential. Meanwhile, the PESTLE approach focuses on analysing external factors—including political, economic, social, technological, environmental, and legal aspects—necessary to support LCD policy and implementation. Proposed solutions include international collaboration, consistent regulatory

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improvements, and product certification promotion, which can bolster political and social support. These approaches align with the green economy concept outlined by Loiseau et al. (2016); UNEP (2011), as well as Edwards (1980) implementation theory, which emphasises the importance of communication, resources, and effective bureaucratic structures to ensure policy success. Integrating these three approaches provides a strategic pathway to advancing the poultry sector's transition towards a sustainable green economy.

CONCLUSION

The implementation of LCD in Indonesia's poultry sector continues to face significant challenges, including technological limitations, high investment costs, and a lack of education and training for farmers. Although policies such as subsidies and incentives have been introduced, their impact has not been fully optimised. To achieve emission reduction targets, a more integrated approach is needed, involving enhanced farmer knowledge, stronger financial support, and consistent regulation. The findings of this study emphasise that collaboration among the government, industry stakeholders, and the community must be strengthened to support the adoption of low-carbon technologies.

Future research should explore innovative solutions through primary data collection via surveys or direct interviews to gain a more accurate understanding of challenges and opportunities in the field. Such studies should also assess the long-term economic impacts of low-carbon technology implementation on small and medium-sized farmers. The government is encouraged to reinforce regulations, provide comprehensive support to farmers, and promote public education on environmentally friendly products. Cross-ministerial collaboration is essential for providing incentives, training, overseeing implementation, and promoting investment in low-carbon technology. Universities and the National Research and Innovation Agency (BRIN) should support research and the development of more efficient and affordable technologies, while the Ministry of Trade should facilitate market access through promotion and the application of widely recognised green labelling standards. Thus, the practical implications of this research underscore the need for more adaptive and coordinated policies to ensure effective and sustainable LCD implementation in the poultry sector.

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