
CHALLENGES OF CONTEXTUALIZING LOW-CARBON DEVELOPMENT IN INDONESIA

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ABSTRACT

Climate change in Indonesia has triggered multidimensional disasters that are increasingly severe and difficult to predict, placing communities in vulnerable conditions. To address this, the Indonesian government has adopted the Low Carbon Development (LCD) paradigm, gradually integrating it into national and regional planning to pursue sustainable economic growth while minimizing carbon emissions. However, progress in low-carbon development remains limited. The gap is largely due to weak translation of LCD principles into sectoral programs, inadequate adaptive fiscal instruments, and poor alignment between regional development plans (RPJMD) and the LCD framework. This study aims to identify challenges from idea to plan to practice in the implementation of LCD policies in Indonesia and to propose a contextualized scheme for strengthening their application. Findings reveal three main challenges: (1) regional development orientation is still growth-centered rather than sustainability-oriented, (2) local governments have limited capacity to formulate and implement low-carbon programs, and (3) actor fragmentation and weak cross-sectoral and interregional coordination hinder integration. Furthermore, Indonesia's vast geography presents structural and distributional constraints that demand creative, context-specific solutions rather than being accepted as fixed barriers. Overall, while Indonesia possesses substantial potential in low-carbon development, realizing it requires reorienting development priorities, enhancing local capacities, and improving institutional coordination. A contextualized LCD scheme must therefore address these systemic challenges to align national and regional development agendas with global commitments, particularly the net zero emission target.

Keywords: low carbon; development; planning; net zero emission.

A. INTRODUCTION

Global climate change has posed alarming impacts on the future of the planet and life within it. The first report of the Intergovernmental Panel on Climate Change (IPCC), published in 1990, demonstrated evidence that human activities, particularly fossil fuel combustion and deforestation significantly contribute to global warming. Ongoing global warming has disrupted climate stability and ecosystems. Consequently, countries worldwide, including Indonesia, have committed to reducing greenhouse gas (GHG) emissions and limiting the impacts of global warming through international frameworks such as the Kyoto Protocol and the Paris Agreement, with more ambitious commitments made in subsequent years (IPCC, 2021).

Low Carbon Development (LCD) has emerged as a strategic concept that integrates climate change mitigation efforts with the pursuit of sustainable development. In Indonesia, LCD responds to the challenge of reducing GHG emissions, particularly carbon dioxide (CO₂), stemming from human activities. As a country with vast economic potential, Indonesia faces the dual challenge of sustaining economic growth while minimizing environmental degradation. Thus, LCD emphasizes emission reduction while ensuring inclusive and equitable socio-economic development (Sambodo et al., 2022). Indonesia, with its rich biodiversity and abundant natural resources, has been heavily affected by climate change, evident in the increased frequency of natural disasters, shifts in rainfall patterns, declining natural resource quality, and threats to food and water security. The energy, forestry, and agricultural sectors are the main contributors to GHG emissions, with the energy sector being the largest. To address this, Indonesia has pledged to reduce emissions by 29% by 2030 and to achieve Net Zero Emissions (NZE) by 2060 (Sambodo et al., 2022). Achieving these targets requires significant policy measures. However, the energy sector remains dependent on fossil fuels, which accounted for about 35% of total GHG emissions in 2020. Rising consumption of coal, oil, and natural gas drives CO₂ emissions, harmful to both the environment and public health. A transition toward renewable energy, such as solar, wind, and biomass along with improved

energy efficiency in transportation and industry, is therefore crucial (Setiawan et al., 2021).

The forestry sector also contributes significantly to emissions, primarily due to deforestation, land clearing for agriculture, and land-use change. Efforts such as forest and peatland restoration, protection of primary forests, and controlling deforestation are essential in reducing emissions from this sector. Likewise, agriculture contributes through chemical fertilizer use and methane emissions from livestock. Indonesia holds strong potential to reduce emissions through sustainable farming practices, efficient fertilizer management, and agroforestry, which simultaneously enhance food security and soil quality (Adetama et al., 2022). Nevertheless, the main challenge lies in effective policy implementation. Stronger coordination between central and regional governments, along with private sector engagement, is essential. The private sector plays a critical role in financing low-carbon technologies and supporting energy, transport, and industrial transformation (Sambodo et al., 2022). The transport sector also remains a major emitter, with growing motorization in urban areas driving air pollution and GHG emissions. Promoting sustainable transport solutions, such as electric vehicles and efficient public transportation systems offers important pathways for emission reduction (Setiawan et al., 2021).

Effective governance is vital for Indonesia to realize its LCD agenda. Achieving NZE by 2060 requires coordinated policy mechanisms across sectors, including green investment incentives, carbon pricing schemes, and support for low-carbon innovation (Patunru & Yusuf, 2016). A cross-sectoral and integrated approach is needed, ensuring that action plans not only cut emissions but also deliver co-benefits such as better quality of life, job creation, and economic competitiveness. Low-carbon strategies must also integrate social dimensions, including gender equality and the empowerment of vulnerable groups in addressing climate impacts (Yuliana et al., 2022).

A comprehensive LCD approach is expected to foster an inclusive and resilient green economy. Through energy transition, sustainable natural resource management, and institutional strengthening, Indonesia can pursue more

ambitious emission reductions while contributing to global sustainable development goals (Setiawan et al., 2021). However, success requires active participation from all stakeholders, government, society, the private sector, and international partners. Collaboration across actors will enable Indonesia to face climate challenges while seizing new opportunities from the transition toward a low-carbon economy (Sudarwanto & Daryanti, 2025).

Overall, low-carbon development in Indonesia is not merely an effort to cut emissions but also a strategic step toward securing a better future for the next generation. With appropriate policies, effective implementation, and broad participation, Indonesia can realize a sustainable development vision that harmonizes economic, social, and environmental dimensions (Yuliana et al., 2022). Importantly, Indonesia faces highly contextual challenges in implementing the LCD agenda. While national-level frameworks such as Low Carbon Development Indonesia (LCDI) and integration into the National Long-Term and Medium-Term Development Plans (RPJPN and RPJMN) have been established, local-level adaptation and operationalization remain uneven and encounter technical, institutional, and socio-economic barriers. These gaps form the central focus of this study: examining how national and regional low-carbon development planning is designed, implemented, and contextualized.

B. RESEARCH METHODS

This research employs a qualitative-descriptive approach, with a primary focus on analyzing low carbon development (LCD) policies in Indonesia. This approach was chosen to gain an in-depth understanding of how the paradigm of low carbon development is translated from ideas and planning into actual policy practices at both national and regional levels. The study does not aim for statistical generalization; rather, it seeks to identify thematic patterns and contextual challenges that emerge in the implementation of LCD across strategic sectors such as energy, forestry, agriculture, and transportation.

Data collection was carried out through a desk study of relevant secondary sources. The main documents analyzed include national regulations such as the

National Long-Term Development Plan (RPJPN) 2025–2045, the National Medium-Term Development Plan (RPJMN) 2025–2029, and various technical reports from the Ministry of National Development Planning (Bappenas), the Ministry of Environment and Forestry (KLHK), the Ministry of Energy and Mineral Resources (ESDM), the Meteorology, Climatology, and Geophysics Agency (BMKG), as well as other relevant ministries and institutions. In addition, this research also examines scientific journal articles, international reports, and literature related to low carbon development and climate change. Data analysis was conducted using a policy analysis approach to identify the extent to which LCD principles have been integrated into national and regional planning documents. Furthermore, a gap analysis was employed to examine discrepancies between the conceptual framework and actual implementation.

C. RESULTS AND DISCUSSION

The Low Carbon Development (LCD) Paradigm in Indonesia's Development

Low Carbon Development (LCD) is a development paradigm that emerged in response to increasingly evident climate change and the shifting global demand for sustainable development. This paradigm emphasizes the importance of reducing greenhouse gas (GHG) emissions through a transition to a greener economy, focusing on the use of renewable energy, energy efficiency, and sustainable natural resource management. LCD also aims to create a balance between economic growth, environmental protection, and social well-being. In Indonesia, LCD has become increasingly relevant in light of the climate change impacts experienced by communities and ecosystems, as well as the need to establish more inclusive and sustainable development (Setiawan et al., 2021).

The origins of LCD can be traced back to the late 20th century, when the world began to realize that economic growth based on large-scale natural resource exploitation and fossil fuel consumption posed serious risks to the future of the environment. In 1990, the IPCC released its first report highlighting the link between human activities, global warming, and climate change. Later,

in 1997, the Kyoto Protocol established commitments for developed countries to reduce GHG emissions, further reinforcing the urgency of climate mitigation policies. LCD emerged as a response to this crisis, integrating emission reduction efforts with inclusive and sustainable economic development (Patunru & Yusuf, 2016).

Indonesia, as a country with relatively rapid economic growth, faces major challenges in its transition to a low-carbon economy, particularly in the energy sector, which remains heavily dependent on coal and petroleum. However, the implementation of Low Carbon Development (LCD) also presents significant opportunities, especially in the development of renewable energy, sustainable forest management, and improved energy efficiency. The Indonesian government has demonstrated its commitment to low-carbon development through policies integrated into the National Long-Term Development Plan (RPJPN), which aims to achieve Net Zero Emissions (NZE) by 2060. To achieve this goal, Indonesia must design policies that not only reduce emissions but also safeguard the social and economic resilience of its people (Sambodo et al., 2022).

LCD goes beyond merely reducing greenhouse gas emissions. It is a holistic and systemic approach to designing sustainable development, involving multiple sectors such as energy, transportation, agriculture, and forestry. Scholars such as Setiawan et al. (2021) emphasize that the implementation of LCD must involve technological innovations that enhance resource efficiency and reduce reliance on fossil fuels. Effective LCD policies also require collaboration among government, the private sector, and society to ensure that the transition to a low-carbon economy is achieved in a fair and inclusive manner.

A key characteristic of the LCD paradigm is its close integration of economic, social, and environmental dimensions. While LCD focuses on reducing greenhouse gas emissions, it also creates green jobs, improves air and water quality, and enhances people's quality of life. This approach combines a range of policies and interventions that strengthen economic resilience to the impacts of climate change while encouraging the adoption of environmentally

friendly technologies across various industries and infrastructures. LCD also promotes the development of green economic sectors such as renewable energy, energy efficiency, and environmentally sound waste management (Sambodo et al., 2022).

Implementation of LCD in Indonesia has already begun through policies embedded in the RPJPN and the National Medium-Term Development Plan (RPJMN). In the RPJMN 2025–2029, Indonesia has set a target of reducing greenhouse gas emissions by 29% by 2030 through various policy interventions in the energy, forestry, and agricultural sectors. In addition, Indonesia has committed to increasing the share of renewable energy in its national energy mix to reduce dependence on fossil fuels and lower CO₂ emissions from the energy sector (Sudarwanto & Daryanti, 2025). Despite these clear commitments, the main challenges lie in adequate policy implementation and sufficient funding. Indonesia requires substantial investments to develop renewable energy infrastructure and strengthen institutional capacity for implementing low-carbon policies. More ambitious emission reduction efforts, such as those outlined in the High-PRK Scenario, are estimated to require significant additional investments, encompassing both domestic and international financing. According to Bappenas (2019), Indonesia will need approximately USD 22 billion annually over the next five years to support low-carbon development policies, with the majority of financing expected to come from the private sector and international donors.

Table 1. The Historical Emergence of the Low Carbon Development (LCD) Paradigm

No	Types of Development Paradigms	Year	Description
1	Conventional Economy	1940s	This paradigm emphasizes high economic growth driven by the exploitation of natural resources and fossil fuels, without taking environmental impacts into account.
2	Sustainable Development	1987	Launched by the Brundtland Commission, this paradigm emphasizes the importance of balancing economic growth, environmental protection, and social well-being.
3	Kyoto Protocol	1997	An international agreement that binds developed countries to reduce greenhouse gas emissions as part of global efforts to address climate change.
4	Green Economy	2008	Carrying the principle that economic growth must be pursued in an environmentally friendly manner while enhancing social well-being.
5	Low Carbon Development	2010s	Focus on reducing greenhouse gas emissions through the transition to renewable energy, energy efficiency, and sustainable natural resource management.
6	Low Carbon Development (Indonesia)	2017	In Indonesia, this paradigm began with a government-initiated effort led by Bappenas to integrate climate action into national development planning with emission reduction targets.

The implementation of LCD in Indonesia is expected to create a greener economy, not only by reducing greenhouse gas emissions but also by generating better employment opportunities, improving air and environmental quality, and enhancing people's quality of life. LCD is not merely an option but a necessity to create a better future for the next generations. The High Ambition PRK scenario, which includes various ambitious policies to achieve more than 40% emission reduction by 2030, presents a significant opportunity for Indonesia to become a leader in low-carbon development in the Southeast Asian region (Bappenas, 2019).

Implementation of the LCD Paradigm in National and Regional Development Planning

The formal application of the low-carbon development paradigm in Indonesia's national development planning began with its integration into the

2020–2024 National Medium-Term Development Plan (RPJMN). In this document, low-carbon development is no longer positioned as a supplementary sectoral instrument but as a national development framework integrated with economic growth, job creation, and poverty reduction agendas. Furthermore, the 2025–2045 National Long-Term Development Plan (RPJPN) positions low-carbon development and climate resilience as a mainstream development approach rather than merely a sectoral strategy.

This demonstrates an increased national commitment to the global agenda and serves as a concrete articulation of Indonesia’s Nationally Determined Contribution (NDC) to reduce emissions by 31.89% through domestic efforts and up to 43.20% with international support by 2030 (UNFCC, 2022). In line with this, Bappenas formulated the Low Carbon Development Indonesia (LCDI) as an integrative platform that combines development planning and environmental management to achieve sustainable development goals and fulfill the nation’s climate change mitigation commitments.

In the “Green Economy Index” document (Bappenas, 2022), it is shown that LCD is not only focused on reducing greenhouse gas (GHG) emissions but also emphasizes resource efficiency, economic productivity, and social equity. The study also recommends strengthening inter-agency coordination and involving local governments to ensure the successful comprehensive implementation of LCD. Despite the clear direction of national policy, challenges remain at the regional level. Experiences from various regions show that the integration of low-carbon development indicators and principles into regional planning documents, such as the Regional Medium-Term Development Plan (RPJMD), still faces several obstacles. Some of the inhibiting factors include:

1. Limited spatial and sectoral data to support LCD planning.
2. Insufficient technical understanding among regional planners regarding the concepts and methods for calculating greenhouse gas (GHG) emissions and LCD indicators.
3. Lack of systemic integration between the planning system and the carbon emissions inventory system.

4. Absence of adequate evaluation mechanisms and incentives for local governments that successfully implement low-carbon development principles.

In addition, the LCD approach at the national level also faces challenges in inter-sectoral coordination, particularly in the energy, transportation, agriculture, and forestry sectors. The ideal concept of low-carbon development requires a transition to clean energy, ecosystem conservation, and changes in consumption and production patterns. However, the implementation across these sectors often occurs independently without optimal synergy. Therefore, it is crucial for the central government to develop technical guidelines and an adaptive incentive framework tailored to regional needs and characteristics to ensure that the contextualization of LCD can be carried out more effectively and comprehensively.

Impacts of Climate Change and the Urgency of LCD in Indonesia

Indonesia, as a tropical country located in Southeast Asia, is highly vulnerable to the impacts of climate change. This biodiverse nation has experienced a significant increase in average temperatures over the past decades. Data from the National Development Planning Agency (Bappenas) indicates that Indonesia's annual average temperature has risen by approximately 0.3°C over the last three decades, a clear indication of ongoing global warming. This temperature increase has led to a higher frequency of extreme weather events such as floods, droughts, and forest fires, affecting nearly all sectors of life. The agricultural sector in Indonesia is among the most affected by climate change. Irregular rainfall patterns and rising temperatures threaten crop yields, particularly rice, which is highly dependent on the rainy season. In 2020, Bappenas reported that climate change caused a decline of up to 10% in agricultural yields in several major food-producing regions. Additionally, longer dry seasons and annual extreme droughts have further undermined Indonesia's food security. Climate change disrupts the distribution and quality of agricultural products and increases vulnerability to pests and plant diseases.

Indonesia's forestry sector also plays a significant role in global climate change. Rapid deforestation and frequent annual forest fires contribute substantially to greenhouse gas emissions. According to Bappenas, the forestry sector accounts for more than 80% of Indonesia's total emissions reductions. Forest fires during dry seasons, such as those in 2019 and 2020, caused extensive damage to forest ecosystems, threatened biodiversity, and increased air pollution with negative impacts on public health. Successful peatland restoration and sustainable forest management are therefore key priorities in Indonesia's climate mitigation strategy. Climate change also impacts Indonesia's fisheries and marine sector. Rising sea surface temperatures and increased ocean acidity damage coral reefs and disrupt marine life. These impacts severely affect the fisheries sector, which serves as a livelihood source for millions of coastal communities. Bappenas reports that 30% of Indonesia's total fisheries output is threatened by climate change, with the greatest impacts on small-scale fishers who depend heavily on sustainable marine ecosystems for their livelihoods.

Beyond the direct effects on key sectors, climate change exacerbates water security issues in Indonesia. Some regions experience excessive rainfall causing major floods, while others face prolonged droughts that threaten clean water availability. Data analysis from the Ministry of Environment and Forestry (KLHK) estimates that 60% of Indonesia's regions will face increased drought risk and declining water availability in the coming decade. This threatens food security and the quality of life, especially in areas heavily dependent on agriculture and fisheries.

In the energy sector, although Indonesia has sought to reduce its reliance on fossil fuels by increasing the share of renewable energy, greenhouse gas emissions from energy and transportation sectors remain very high. Indonesia is committed to expanding renewable energy use, but achieving this requires significant investment in infrastructure and technology. According to Bappenas, the energy and transportation sectors contribute more than 30% of Indonesia's total greenhouse gas emissions. Developing more efficient renewable energy and

transitioning to clean energy will be crucial steps in mitigating climate impacts in these sectors.

Climate change also affects public health in Indonesia. Rising temperatures and more frequent heatwaves increase the risk of heat-related illnesses such as dehydration, heat stroke, and respiratory disorders. Irregular rainfall patterns also increase the risk of waterborne diseases, such as diarrhea and cholera, which occur more frequently during the rainy season. Bappenas reports that climate change may increase the burden of weather-related diseases, raising healthcare costs and threatening public productivity.

A major challenge for Indonesia in addressing climate change is the increased risk of natural disasters. Higher rainfall intensity and tropical storms cause flash floods and landslides that damage infrastructure and agricultural land. Coastal areas are increasingly threatened by sea-level rise, leading to coastal erosion and loss of habitats. Data from the Meteorology, Climatology, and Geophysics Agency (BMKG) indicate that Indonesia has experienced an increased frequency of climate-induced natural disasters, directly affecting the economy and community livelihoods.

Moreover, climate change threatens the sustainability of tourism in Indonesia. Tourist destinations such as Bali and Lombok face severe impacts from climate change, including coral reef damage reducing underwater tourism appeal and increased natural disaster risk damaging tourism facilities. Environmental degradation caused by climate change can reduce economic potential in the tourism sector, which is one of the country's largest foreign exchange earners. Detailed data on the impacts of climate change in Indonesia, illustrating trends in temperature changes, rainfall, and natural disaster occurrences based on Bappenas and BMKG data, can be reviewed in the following table:

Table 2. Climate Change Impacts in Indonesia (1990–2020)

No	Impact	1990	2000	2010	2020
1	Average Temperature Increase (°C)	0.2°C	0.3°C	0.4°C	0.5°C
2	Decline in Agricultural Yields (%)	-	-	5%	10%
3	Increase in Natural Disaster Frequency	>50%	>60%	>75%	>80%
4	Coral Reef Damage (%)	20%	30%	40%	60%
5	Impact on Food Security (%)	5%	10%	15%	20%

From this temporal data, it can be seen that the impacts of climate change on temperature, the agricultural sector, and natural disaster occurrences in Indonesia are increasing. With the growing frequency of extreme weather events and climate-induced disasters, Indonesia faces a significant challenge in implementing low-carbon development policies that can mitigate these impacts while maintaining economic growth and social welfare. Overall, climate change has substantial effects on Indonesia, impacting multiple sectors and exacerbating social and economic inequalities. Therefore, it is crucial for Indonesia to integrate climate change mitigation and adaptation efforts into development policies at both national and regional levels. Collaboration among the government, private sector, and society is essential to ensure that Indonesia can reduce climate impacts while achieving inclusive and low-carbon sustainable development.

Challenges and Opportunities for Contextualizing LCD Development in Indonesia

Low-carbon development (LCD) in Indonesia presents significant opportunities to achieve a more sustainable and environmentally friendly economy. As a country with abundant natural resources and a large population, Indonesia has the potential to integrate green technologies and sustainable development practices into national policy. One of the greatest opportunities lies

in diversifying energy sources through the development of renewable energy, such as solar, wind, and biomass. With high solar irradiance and wind potential in certain regions, Indonesia can utilize these resources to reduce dependence on fossil fuels and lower greenhouse gas (GHG) emissions. In addition, the forestry sector, through peatland restoration and forest protection policies, also plays a key role in emission reduction. These programs provide Indonesia with opportunities to improve environmental quality and enhance ecosystem resilience, which serves as a buffer for community welfare (Bappenas, 2019).

However, alongside these significant opportunities, challenges remain in the implementation and contextualization of low-carbon development in Indonesia. One major challenge is the country's dependence on fossil energy. Although Indonesia is committed to increasing renewable energy use, fossil energy sources such as coal, oil, and natural gas still dominate the national energy mix. As of 2024, the share of new and renewable energy (NRE) in the national energy mix reached only 12.06%, far below the annual target. According to the Ministry of Energy and Mineral Resources (ESDM), coal accounted for 68.18% of total electricity production of 408.4 TWh in 2024, followed by natural gas at 16.26%, renewable energy at 12.06%, and petroleum fuels (BBM) at 3.50%.

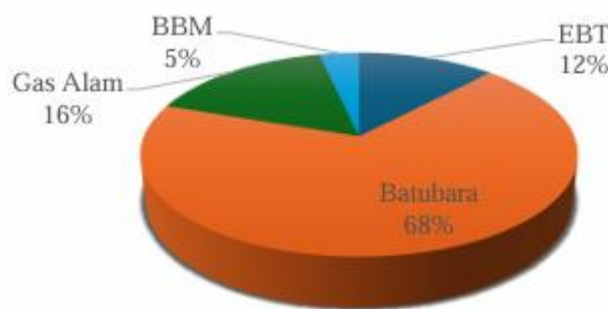


Figure 1. Indonesia's Energy Mix in 2024

The transition to clean energy requires significant investment in infrastructure and technology, which are not yet fully available in Indonesia. In addition, constraints related to fiscal policy, green financing, and incentives for the private sector to invest in renewable energy projects pose barriers to accelerating the energy transition. With rapid population growth and

urbanization, Indonesia's energy demand is expected to continue increasing, necessitating more progressive policies to reduce emissions impacts (Sambodo, 2022).

The Indonesian agricultural sector also faces significant challenges in implementing LCD. Although the sector has great potential to reduce emissions through sustainable agricultural practices, Indonesia still struggles with land management and excessive use of chemical fertilizers. Adapting to environmentally friendly agricultural technologies requires farmer education and financing to support the implementation of sustainable practices, such as agroforestry, organic fertilizer use, and efficient irrigation management. Limited access to technology and knowledge for small-scale farmers, as well as insufficient local government policy support, are major obstacles to achieving sustainable low-carbon agriculture in Indonesia (Yuliana et al., 2022). Nevertheless, the agricultural sector presents significant opportunities through the adoption of more efficient and sustainable technologies. The use of renewable energy in agriculture, such as solar power for irrigation or crop processing, can reduce dependence on fossil fuels. Furthermore, agriculture's role in carbon sequestration through agroforestry and soil conservation is critical in creating an environmentally friendly sector and supporting long-term food security. Training programs and technical assistance for farmers in adopting green technologies, along with incentives for those implementing sustainable practices, can help drive the agricultural sector's transition toward low-carbon development (Setiawan et al., 2021).

The transportation sector in Indonesia also faces challenges in achieving low-carbon development. This sector is the second-largest emitter after the energy sector, with the increasing number of motor vehicles in urban areas. Rapid urbanization and the low quality of public transportation in many major cities exacerbate the problem. Transitioning to environmentally friendly transportation, such as electric vehicles and renewable energy-based public transit, requires substantial investment in infrastructure and supportive policies. Developing greener infrastructure and reducing transportation sector emissions

can decrease reliance on fossil fuels and improve air quality in major cities (Sudarwanto & Daryanti, 2025). However, the transportation sector also offers significant opportunities, particularly with advancements in electric vehicle technology and smart transportation systems. Indonesia has the potential to develop an electric vehicle industry, which can reduce CO₂ emissions and improve air quality. Some major cities, such as Jakarta, have begun introducing electric buses and renewable energy-based transportation systems, which could serve as models for other regions in Indonesia. These opportunities can be leveraged to drive the transformation of the transportation sector toward a greener and more sustainable future (Setiawan et al., 2021).

One of the major opportunities for low-carbon development in Indonesia lies in the forestry and land restoration sectors. Indonesia has approximately 120 million hectares of tropical forests, which are crucial for carbon dioxide absorption and biodiversity protection. Through stronger conservation policies and the implementation of Peatland Ecosystem Restoration (REG) and the Carbon Clean Forest (HBC) Program, Indonesia can reduce carbon emissions from deforestation and land degradation. This sector also presents opportunities for green economic development, such as sustainable timber industries and community-based forest management, which can enhance local livelihoods while maintaining environmental sustainability (Sambodo et al., 2022).

Additional opportunities exist in developing a green economy, involving the industrial sector in transitioning to more environmentally friendly practices. By improving energy efficiency and reducing emissions, the industrial sector can become a major contributor to achieving low-carbon development in Indonesia. Furthermore, this sector can create new sustainable jobs and strengthen Indonesia's economic resilience in an increasingly sustainability-focused global market. The Indonesian government can encourage private sector investment in green technologies by offering fiscal incentives and more supportive regulations (Setiawan et al., 2021). The following table provides a comparative overview of the opportunities and challenges in implementing LCD development in Indonesia:

Table 3. Opportunities and Challenges of LCD Development in Indonesia

No	Opportunities	Challenges
1	Development of renewable energy (solar, wind, biomass)	Dependence on fossil fuels and high investment requirements for renewable energy infrastructure.
2	Advancement of sustainable agriculture (agroforestry, organic fertilizers)	Limited access to technology and knowledge for small-scale farmers
3	Transition toward environmentally friendly transportation (electric vehicles, renewable energy-based public transport)	Inadequate public transport infrastructure and difficulty in reducing dependence on motor vehicles.
4	Forest restoration and peatland management for carbon sequestration	Ongoing issues of deforestation and forest fires
5	Development of green industries and a low-carbon economy	Lack of fiscal policies supporting green investment

Overall, although Indonesia faces significant challenges in implementing low-carbon development (LCD), there are numerous opportunities that can be leveraged to achieve these goals. The success of LCD in Indonesia will heavily depend on appropriate policy support, the strengthening of green infrastructure, and collaboration among the government, private sector, and communities in addressing climate change challenges. Furthermore, green financing and innovative funding schemes will play a key role in driving the transformation toward a sustainable and inclusive low-carbon economy.

Discussion

Contextualizing low-carbon development is a strategic necessity to address disparities in capacity and regional characteristics across Indonesia. Given that Indonesia is an archipelagic country with diverse biophysical, social, economic, and institutional conditions, a one-size-fits-all approach in implementing LCD risks policy failure. Therefore, the proposed contextualization scheme is based on the principles of regional differentiation, system integration, and participatory institutional strengthening. This scheme is structured within a transition

framework from “idea to plan to practice,” with the following five main elements:

1. Reorienting Regional Development Vision and Goals

Regional development should not solely focus on economic growth but also consider environmental carrying capacity and limits. This means that the RPJMD vision must explicitly include the LCD agenda as a pillar of regional development. Performance targets should also include indicators for priority sector emissions, energy efficiency, and sustainable land use. For example, in agrarian regions, LCD efforts may focus on reducing methane emissions from agriculture, using organic fertilizers, and conserving water. In coastal areas, the focus could be on mangrove ecosystem protection and low-emission marine bioeconomy.

2. Differentiating Approaches Based on Regional Typology

Indonesia’s regions can be classified according to biophysical typology (highlands, coastal areas, tropical forests), economic activity (industry, agriculture, tourism), and social status (poverty levels, climate resilience index). LCD programs should be contextualized according to these typology combinations. For instance, regions in Kalimantan and Papua have high carbon sequestration potential, so the LCD scheme could emphasize forest restoration and REDD+ incentives. Conversely, large cities such as Jakarta or Surabaya are more suitable for energy efficiency and low-carbon transport policies.

3. Strengthening Regional Capacity and Institutions

Institutional capacity is crucial for LCD contextualization. This includes enhancing the technical capabilities of regional planners, engaging non-government actors (NGOs, academia, private sector), and establishing emission management units within Bappeda. Instruments such as place-based training, green budgeting, and participatory planning need to be implemented systematically.

4. Sectoral and Spatial Integration

Contextual LCD implementation requires synergy across sectors (energy, agriculture, transportation, forestry) and spatial integration across administrative boundaries. This can be facilitated through the establishment of Regional Low Carbon Forums that connect regions within an ecoregion to share knowledge and resources. Additionally, the use of geographic instruments such as Geographic Information Systems (GIS) and carrying capacity analysis should be strengthened to ensure that LCD is not merely normative but also based on spatial data and scientific calculations.

5. Mobilizing Low-Carbon Financing

Financing must also be contextualized. Regions should be provided with performance-based fiscal incentives for LCD, such as through Green Regional Incentive Funds (DID Hijau) or Climate Budget Tagging schemes. Moreover, innovative financing mechanisms, such as green bonds, carbon pricing, and partnerships with international partners (blended finance), can serve as alternatives to strengthen LCD implementation.

Through this scheme, low-carbon development can move from a normative narrative to transformative practices rooted in the local realities of each region. Contextualization is not merely a technical adaptation but a political and institutional process that requires paradigm shifts, inclusivity of actors, and the courage to restructure development systems toward greater equity and sustainability.

D. CONCLUSION

Low-carbon development (LCD) in Indonesia is a critical strategy to address the impacts of climate change while promoting a sustainable economy. The challenges include the dominance of fossil energy, limited technical capacity at the regional level, weak cross-sectoral coordination, and suboptimal fiscal support and incentives. Nevertheless, significant opportunities exist through the transition to renewable energy, the strengthening of sustainable agriculture, green transportation, and forest restoration. To ensure more contextual and effective implementation, LCD policies should be differentiated

according to regional typologies, supported by institutional capacity building, sectoral-spatial integration, and innovative green financing schemes. With this approach, Indonesia can transform LCD from a policy discourse into tangible actions aligned with regional conditions, while supporting the country's Net Zero Emission targets and sustainable development goals.

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