

Implementation of Green Finance based on Blue-Green Infrastructure

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ABSTRACT

The global development agenda driven by the United Nations Sustainable Development Goals (SDGs)—specifically Goal 11 (Sustainable Cities and Communities) and Goal 12 (Responsible Consumption and Production)—prioritizes waste management in the pursuit of sustainable cities. At the local level, Metro City faces rising waste generation driven by population growth and economic activity, yet its management system remains dominated by the conventional "collect-transport-dispose" model. While initiatives such as waste banks and TPS3R (Reduce, Reuse, Recycle at Source) facilities have been implemented, challenges persist regarding infrastructure, institutional capacity, spatial planning integration, and funding limitations. This study aims to analyze and formulate a "blue-green development" policy model by integrating blue-green infrastructure (BGI) and optimizing green finance for waste management in Metro City. A qualitative research approach was employed, utilizing data collection methods such as in-depth interviews, field observations, and document analysis. The findings indicate that Metro City has not yet fully implemented BGI, as waste management efforts lack integration across the various managing units. Nevertheless, the city possesses existing policies that could serve as a foundation for future BGI implementation. Furthermore, Metro City is equipped with waste management infrastructure, including a final disposal site (TPA), TPS3R facilities, wastewater treatment plants (IPAL), and waste processing units (PDU). However, the development of green finance mechanisms for waste management has not progressed effectively; the government remains heavily reliant on the local budget (APBD) and has yet to maximize collaboration with the private sector.

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1. INTRODUCTION

The global development agenda outlined in the Sustainable Development

Goals (SDGs)—specifically Goal 11 (Sustainable Cities and Communities) and Goal 12 (Responsible Consumption and

Production)—positions environmental issues as a top priority for achieving sustainable development [1]. In an era of massive urbanization, waste management is no longer viewed merely as a technical matter but as a strategic issue intertwined with community quality of life, environmental resilience, public health, and regional development governance. To address the challenges of environmental degradation and climate change at the local level, it is increasingly crucial to integrate environmentally conscious development approaches—such as "blue and green development"—into the urban landscape through the provision of adaptive infrastructure [2].

However, in Indonesia, the realization of sustainable urban development continues to be hindered by complex waste-related issues [3]. Population growth, shifting consumption patterns, and the rapid expansion of residential areas and economic activities have caused waste volumes to surge year after year [4]. Current management systems remain dominated by the conventional urban paradigm: the "collect-transport-dispose" model, which sends waste to Final Disposal Sites (TPA). This linear system has proven inadequate and, in fact, generates severe negative externalities, such as soil and water pollution, greenhouse gas (GHG) emissions from waste piles, and a decline in sanitation standards for residents. Breaking this cycle requires a radical transformation toward a system that is integrative, sustainability-oriented, and supported by a robust financing ecosystem [5].

This dilemma is clearly evident in Metro City, Lampung Province. As a satellite city reliant on the education, trade, and service sectors, the dynamics of community activity in Metro City directly contribute to high daily waste generation. The Metro City Government has initiated various progressive measures—ranging from developing waste banks at the sub-district level and strengthening community roles through environmental volunteers to optimizing waste management facilities [6], [7]. However, these efforts still encounter complex

structural challenges [8]. The increasingly critical capacity limits of the Karangrejo landfill [9], fluctuating public participation, and constraints on the Regional Budget (APBD) pose significant obstacles to achieving national targets: a 30% reduction in waste generation and 70% in waste handling.

To bridge the gap between local fiscal limitations and the massive need for environmental infrastructure, adopting the blue-green infrastructure (BGI) concept—complemented by green finance schemes—offers a promising alternative solution. Blue-green infrastructure can transform waste management from a linear system into an environmentally friendly circular one [10]. Yet, the physical implementation of BGI requires substantial capital that cannot be sustained by the conventional regional budget alone [11]. This is where green finance—whether through green bonds, green investments, or Public-Private Partnerships (PPP)—serves as a crucial lever for funding the modernization of urban waste management [12].

Although the potential of green finance has been widely discussed at the macro level or regarding national strategic projects, studies specifically examining its implementation and role in supporting circular infrastructure at the level of small cities like Metro remain very limited [13]. Most prior research has focused on the technical aspects of waste recycling or the institutional mechanics of waste banks, while overlooking the aspect of long-term financial sustainability driven by green investment [14]. Therefore, this study aims to analyze the role of green finance in addressing challenges related to waste management based on blue-green infrastructure in Metro City, Lampung. This study seeks to formulate innovative financing strategies capable of overcoming local structural barriers while accelerating the realization of a resilient and sustainable city.

2. LITERATURE REVIEW

2.1 *Sustainable Development and the Sustainable Development Goals (SDGs)*

The concept of sustainable development was first popularized

through the *Our Common Future* report by the World Commission on Environment and Development (WCED) in 1987, which defined it as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs [15]. This concept emphasizes a balance between three main pillars: economic, social, and environmental [16]. Two SDGs are relevant to this study: SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production).

2.2 *The Blue–Green Infrastructure Concept*

The blue–green infrastructure (BGI) concept is an urban planning approach that integrates elements of green infrastructure (green open spaces, city parks, urban vegetation) and blue infrastructure (water management systems, sustainable drainage, protection of water bodies) [10]. This approach aims to enhance urban resilience to climate change, reduce pollution, and improve the quality of urban ecosystems [17]. [18] introduced the "water-sensitive city" concept, which emphasizes integrating water systems into urban design as part of environmental sustainability. Meanwhile, the [19] explains that green and blue infrastructure can provide ecosystem services such as flood control, improved air quality, and natural waste management.

2.3 *Green Finance Theory and Concepts*

Green finance refers to all forms of financing that support economic activities yielding environmental benefits and fostering sustainable development [20]. Green finance instruments include green bonds, green loans, sustainable investments, and financing schemes based on Environmental, Social, and Governance (ESG) principles [21].

3. METHODS

This study employs a qualitative approach with a case study design. The

research was conducted in Metro City, Lampung Province. Informants included the Environmental Agency, the Public Works and Spatial Planning Agency (PUTR), and community members involved in waste management. Data collection methods included in-depth interviews, observation, and document analysis. Data validity is established using source triangulation.

4. RESULTS AND DISCUSSION

According to Law Number 8 of 2008 concerning Waste Management, waste is defined as the residue of daily human activities or natural processes—whether solid or semi-solid, organic or inorganic, and biodegradable or non-biodegradable—that is deemed no longer useful and is discarded into the environment [22]. This definition highlights the diverse nature of waste—ranging from organic to inorganic and solid to liquid—all of which is ultimately discharged into the environment. Consequently, effective waste management is essential to prevent environmental degradation. One approach to achieving this is through the concept of "blue-green development," which entails the implementation of blue-green infrastructure and green finance.

This study examines the application of green finance in the context of blue-green infrastructure for waste management in Metro City, Lampung. It focuses on integrating green open spaces and water management systems to mitigate environmental pollution caused by domestic waste and leachate. The research was conducted between June and July 2026, involving the Public Works and Spatial Planning Agency (PUTR) and the Environmental Agency (LH). Data collection was carried out through in-depth interviews with relevant officials from these agencies, specifically the Waste Management Sub-coordinator (PUTR), the Environmental Agency Sub-coordinator, the Environmental Sanitation Officer (PUTR), and the PDU (Waste Processing Unit) Manager.

Table 1. Data Triangulation

Questions	Informan 1, 2 dan 3	Observation and documentation	Data Obtained
How is the government integrating the concept of Blue-Green Infrastructure (BGI) into current urban waste and wastewater management strategies?	The concept of blue-green infrastructure (BGI) is not yet widely familiar to city governments. In practice, however, municipal governments have already implemented BGI elements in waste and wastewater management—such as providing green open spaces equipped with waste management facilities and creating open spaces around final waste disposal sites. Nevertheless, policies and implementation remain fragmented rather than integrated into a unified system.	The Metro City government has a waste management policy in place; however, it is not yet based on Blue-Green Infrastructure (BGI) principles. This is evident in the lack of integrated governance, which has prevented the creation of an ecosystem aligned with the BGI concept. Waste is effectively managed in accordance with 3R principles, and a waste recycling center is in operation.	1. Metro City has an environmentally-based waste management strategy in place. 2. Blue-Green Development (BGD) initiatives are already underway in Metro City, with policies addressing green environments and clean water. 3. However, BGD principles have not yet been applied to infrastructure development, nor has Blue-Green Infrastructure (BGI) been implemented in an integrated manner; the "blue" and "green" components are still executed separately, even within the same area. 4. Metro City is equipped with TPS3R facilities for waste management.
What regulations or incentives has the government put in place to encourage the private sector to fund eco-friendly BGI projects?	BGI, which implements the BGD concept, has been incorporated into mayoral regulations. These regulations encompass Law No. 26 of 2007 on Spatial Planning; Metro City Regional Regulation No. 5 of 2022 on the Metro City Spatial Plan (RTRW) for 2022–2042; Metro City Mayoral Regulation No. 11 of 2024 on the Metro City Detailed Spatial Plan (RDTR) for 2024–2044; Law No. 18 of 2008 on Waste Management; technical regulations regarding waste management in Metro City; and Metro City Regional Regulation No. 1 of 2025 on the Metro City Medium-Term Development Plan	Metro City has established regulations to support the implementation of Green Infrastructure (BGI), namely Law No. 26 of 2007 on Spatial Planning; Metro City Regional Regulation No. 5 of 2022 on the Metro City Spatial Plan (RTRW) for 2022–2042; Metro City Mayoral Regulation No. 11 of 2024 on the Metro City Detailed Spatial Plan (RDTR) for 2024–2044; Law No. 18 of 2008 on Waste Management; technical regulations regarding waste management in Metro City; and Metro City Regional Regulation No.	1. Metro City has established the necessary legislative acts, government regulations, and technical guidelines regarding the implementation of blue-green infrastructure 2. Metro City has received environmental-related grants from the central government 3. Metro City is equipped with a recycling center and waste banks, established through partnerships between the city

Questions	Informan 1, 2 dan 3	Observation and documentation	Data Obtained
	(RPJMD) for 2025–2029. Although BGI implementation is currently fragmented, the RPJMD serves as a starting point for implementing BGI in an integrated manner. The RPJMD addresses waste management, flood and inundation control, green open spaces (RTH), sustainable drainage, water resource conservation, wastewater management, emission reduction, and climate change adaptation. External parties have provided assistance on several occasions, with the relevant government agency acting solely as a liaison and facilitator between these external parties and the community.	1 of 2025 on the Metro City Medium-Term Development Plan (RPJMD) for 2025–2029. Metro also collaborates with external parties on waste management, such as waste banks and Waste Recycling Centers (PDU).	government and external parties
What is the biggest obstacle to implementing green finance policies for nature-based waste management projects?	The first obstacle is the limited fiscal capacity of local governments. The second obstacle is the lack of clarity regarding the direct financial benefits of BGI projects. The third obstacle is the absence of a pipeline (long-term achievement timeline) of green finance projects ready to be offered to the private sector. The fourth obstacle is the limited availability of data and ecological performance indicators that can serve as a basis for green financing. The fifth obstacle is the lack of integration between waste management and the management of water resources and green spaces.	The obstacles facing Metro City include the absence of a policy on blue-green development to serve as a basis for formulating green finance, a limited city budget, and low levels of stakeholder engagement, with parties still prioritizing their own respective interests.	Obstacles to implementing green finance policies: 1. absence of explicit green finance policies 2. limited state budget (APBN) funds 3. low levels of private sector collaboration in environmental financing
Could you describe how the BGI systems (such as constructed wetlands or biorefineries) at your site help address waste	Metro City already possesses several components that could serve as a foundation for Blue-Green Infrastructure (BGI); however, integrating waste, wastewater, leachate, drainage, green space, and water conservation management is essential to	Metro City does not yet possess infrastructure that qualifies strictly as Blue-Green Infrastructure (BGI). However, the city is equipped with green open spaces, as well as infrastructure for solid	1. Metro City has not yet implemented Green Infrastructure (BGI) in a structured manner. 2. Metro City already possesses the foundational

Questions	Informan 1, 2 dan 3	Observation and documentation	Data Obtained
issues in a tangible way?	optimize ecological, social, and economic benefits. Processing organic waste into compost offers the potential to create an ecological cycle by utilizing the resulting product for greening initiatives and soil quality improvement. In the wastewater sector, existing communal wastewater treatment plants (IPAL) and septage treatment plants (IPLT) can provide a basis for developing nature-based technologies—such as constructed wetlands—for advanced treatment processes. Meanwhile, leachate management at the Karangrejo landfill involves channeling leachate to the treatment plant, constructing leachate control chambers, and separating rainwater runoff from the leachate stream.	waste, wastewater, and clean water management. The city's green open spaces feature waste bins that distinguish between organic and non-organic waste. Additionally, there are adequate drainage channels to prevent water pooling during periods of heavy rainfall. Regarding solid waste management, Metro City operates TPS3R facilities, where waste is sorted and processed according to type. For wastewater management, the city is equipped with an IPLT (Sludge Treatment Plant). Here, nature-based technologies—such as constructed wetlands—are used to treat and clarify liquid waste, allowing the water to be discharged in an environmentally friendly state.	elements for BGI implementation including Green Open Spaces (RTH), 3R-based Waste Processing Sites (TPS3R), Communal Wastewater Treatment Plants (IPAL Komunal), Septage Treatment Plants (IPLT), and Waste Processing Units (PDU)
What has been your experience in accessing capital or green finance to build and maintain that infrastructure? Was the process difficult?	Securing green finance from external sources remains relatively difficult. Currently, there is still a heavy reliance on limited regional budgets (APBD). The primary challenge lies in transforming environmental initiatives into bankable projects that are ready to be presented to financial institutions and the private sector.	Currently, green financing sources still rely heavily on regional government budgets (APBD). The government has not yet maximized collaboration with the banking sector and private sector CSR initiatives.	Environmental financing still relies heavily on regional budgets (APBD).
How does this BGI project generate revenue streams to ensure long-term operations? (e.g., waste processing fees, sales of compost/energy, or subsidies).	Metro City's revenue for the implementation of the Green Infrastructure (BGI) initiative comprises a mix of commercial income, service fees, government support, CSR contributions, and green finance. This approach fosters a circular financing system, wherein a portion of the revenue generated from waste management is reinvested to cover the	If implemented in a structured manner, BGI could potentially generate revenue streams for Metro City. For instance, if the PDU (Waste Processing Unit) is well-managed and secures additional private-sector funding, it could evolve into a city-owned enterprise capable of boosting Metro City's	The BGI project will be a long-term initiative that generates a revenue stream for Metro City.

Questions	Informan 1, 2 dan 3	Observation and documentation	Data Obtained
	operation and maintenance of green infrastructure, thereby ensuring that the project's sustainability does not rely solely on the local government budget (APBD).	locally-generated revenue through the sale of compost, recycled handicrafts, and other products.	

Source: Data processed from interviews and observations

The blue-green infrastructure (BGI) concept is an urban planning approach that integrates elements of green infrastructure (green open spaces, city parks, urban vegetation) and blue infrastructure (water management systems, sustainable drainage, and the protection of water bodies) [23] This approach aims to enhance urban resilience to climate change, reduce pollution, and improve the quality of urban ecosystems [2]. Through BGI, it is expected that an area will possess a healthy ecosystem and minimize risks associated with climate change and environmental pollution.

Regarding its implementation, the Metro City Government does not currently employ Blue-Green Infrastructure (BGI) as a standalone policy with a specific designation. Nevertheless, a number of implemented policies and development programs demonstrate the presence of BGI elements that could be further developed and integrated in a more cohesive manner. These principles are evident in waste management, wastewater management, the development of green open spaces, drainage management, and water resource conservation efforts [24]. Integrating these various sectors is crucial because urban environmental issues cannot be addressed in a fragmented, sectoral manner; rather, they require an approach that links water systems, land, vegetation, waste management, and community activities [25].

Currently, the implementation of Blue-Green Infrastructure (BGI) for waste and wastewater management in Metro City does not yet function as a fully integrated system; however, some infrastructure is already in place and holds potential for development through nature-based approaches [26]. The Rejomulyo Recycling Center (PDU) serves as a tangible example of waste management at

the source, involving the sorting and processing of organic and inorganic waste. Processing organic waste into compost offers the potential to create an ecological cycle by utilizing the end product for greening initiatives and soil quality improvement. In the wastewater sector, existing communal wastewater treatment plants (IPAL) and septage treatment plants (IPLT) can serve as a foundation for developing nature-based technologies—such as constructed wetlands—for advanced treatment processes. Meanwhile, leachate management at the Karangrejo Landfill (TPAS)—involving diversion to the treatment plant, construction of leachate control chambers, and the separation of rainwater runoff from leachate—represents a strengthening of blue infrastructure to prevent environmental pollution. Thus, while Metro City possesses components that could form the foundation of BGI, integration across waste, wastewater, leachate, drainage, green space, and water conservation management is required to optimize ecological, social, and economic benefits.

The application of green finance to waste management in Metro City, Lampung, focuses on optimizing "waste banks" as instruments of the circular economy. The Metro City Government is collaborating with the Financial Services Authority (OJK) to integrate financial literacy education and encourage waste banks to act as drivers of the green economy, including through innovations such as waste-based savings schemes.

Green finance refers to all forms of financing that support economic activities yielding environmental benefits and fostering sustainable development (OECD, 2020). Regarding environmental infrastructure

development, the City of Metro has utilized various financing sources—both within and outside the regional budget (APBD)—including central government grants, development partnership programs, and private sector Corporate Social Responsibility (CSR) initiatives. The construction of the Rejomulyo Recycling Center (PDU) exemplifies central government support through asset grants, while the ARSETI (*Arisan Sedot Tinja* or rotating savings-based septic tank emptying) program demonstrates a collaborative approach to sanitation financing involving the government, the community, and development partners. Meanwhile, private sector involvement via CSR is also being leveraged to support waste management facilities. However, these experiences have not yet fully evolved into structured green finance mechanisms—such as green loans, green bonds, or blended finance—specifically for Blue-Green Infrastructure projects. The application of green finance in Metro City's waste management is being driven by synergies between the city government, the Financial Services Authority (OJK), and the banking sector; these efforts aim to optimize

dozens of waste bank units through financial literacy, cashless transaction systems, and economically valuable savings innovations, such as the "Waste-to-Umrah" [27]–[29].

5. CONCLUSION

Based on the results and discussion, the conclusions of this study are as follows: Blue-green infrastructure-based waste management has not yet been fully implemented in Metro City; the management of green open spaces, waste, and water remains fragmented and independent of one another. Green finance in the city remains limited to the local government budget (APBD), central government grants, and private sector CSR initiatives; the banking sector has not yet been involved, although the OJK (Financial Services Authority) does provide education on green financial literacy.

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