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Municipal Green Sukuk as an Alternative Financing Instrument for Urban Waste Management: A SWOT-TOWS Analysis in Jakarta

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ABSTRACT
Urban waste management requires substantial and long-term financing to support sustainable infrastructure and the transition toward a circular economy. This study aims to assess the potential implementation of municipal green sukuk as an alternative financing instrument for waste management infrastructure in Jakarta. A qualitative case study approach was employed using document analysis of regional planning and financial documents, relevant regulations, green finance frameworks, and scientific literature. Data were analyzed using SWOT through the Internal Factor Analysis Summary (IFAS) and External Factor Analysis Summary (EFAS), followed by TOWS analysis to formulate implementation strategies. The results show that Jakarta is positioned in Quadrant I, with internal and external score differences of +0.40 and +0.56, respectively. The main internal strengths are strong fiscal capacity and own-source revenue, while the key external opportunities include the growth of the global ESG market and international demand for Sharia-compliant investments. However, implementation is constrained by the absence of a regional green sukuk regulatory framework, limited institutional capacity, an underdeveloped monitoring, reporting, and verification (MRV) system, and an insufficiently documented project pipeline. The SO strategy is identified as the priority, supported by strategies addressing regulatory, institutional, governance, and project readiness. The study concludes that municipal green sukuk has potential as an alternative financing instrument, provided that implementation is pursued gradually with adequate regulatory and institutional preparation.

Keywords: Municipal Green Sukuk, Green Finance, Urban Waste Management, Sustainable Infrastructure, SWOT-TOWS.
JEL Code: H54, Q53, G23

I. Introduction

Rapid urbanization has placed increasing pressure on waste management systems in metropolitan cities worldwide. Population growth, expanding economic activity, and changing consumption patterns have contributed to rising volumes of municipal solid waste. As a result, waste management has become an important challenge for achieving sustainable urban development (Kaza et al., 2018; Wilson, 2007). The What a Waste 2.0 report estimates that global municipal solid waste generation will increase from 2.01 billion tonnes in 2016 to 3.40 billion tonnes by 2050 if there are no significant changes in waste management systems and consumption patterns (Kaza et al., 2018). This increase not only places greater pressure on the environment

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but also creates economic, social, and public health consequences and contributes to greenhouse gas emissions (OECD, 2019).

In response to these challenges, waste management practices have increasingly shifted from the conventional collect-transport-dispose approach toward a more circular economy-oriented model. Under this approach, waste is not viewed merely as material to be discarded, but as a resource that retains economic value and can be recovered and reintegrated into production and consumption systems through the principles of reduce, reuse, recycle, and recover (Geissdoerfer et al., 2017; Kirchherr et al., 2017). This shift is consistent with the broader sustainable development agenda, which emphasizes resource efficiency, reduced environmental impacts, and more sustainable patterns of production and consumption. In the context of the Sustainable Development Goals (SDGs), sustainable waste management is closely linked to Goal 11 (Sustainable Cities and Communities), Goal 12 (Responsible Consumption and Production), and Goal 13 (Climate Action) (United Nations, 2015).

As the center of national government and economic activity, Jakarta faces increasingly complex challenges in managing urban waste. According to the Regional Medium-Term Development Plan (RPJMD) of Jakarta for 2025–2029, waste generation in Jakarta reaches 3.17 million tonnes per year, or approximately 7,735 tonnes per day. A substantial proportion of this waste is still managed through final disposal at the Bantargebang Integrated Waste Management Facility (TPST Bantargebang) (Provincial Government of Jakarta, 2025c). This condition indicates that Jakarta's waste management system remains highly dependent on end-of-pipe infrastructure and has not yet fully adopted circular economy principles. At the same time, population growth, urbanization, the expansion of residential areas, and increasing economic activity are expected to continue driving waste generation in the future (BPS-Statistics Indonesia, 2025).

The Provincial Government of Jakarta has identified the transformation of its waste management system as one of its development priorities. The planned measures include the development of intermediate waste processing facilities, refuse-derived fuel (RDF), the strengthening of the Jakarta Recycle Center, the optimization of waste-to-energy technologies, and the development of a circular economy integrated with the low-carbon development agenda (Provincial Government of Jakarta, 2025b). These efforts are also supported by Jakarta Governor Regulation No. 108 of 2019 concerning the Regional Policy and Strategy for Waste Management (Jakstrada), which sets targets of 30% waste reduction and 70% waste handling. However, the development and expansion of waste management infrastructure require substantial investment and long-term financing, given the capital-intensive nature of such infrastructure (Asian Development Bank, 2021). At the same time, the Regional Budget (Anggaran Pendapatan dan Belanja Daerah/APBD) must accommodate various other development and public service needs. This situation highlights the importance of diversifying financing sources for waste management infrastructure, including the use of financing instruments beyond the regional budget (OECD, 2017).

Green sukuk is one financing instrument that can be used to support projects generating environmental benefits, including renewable energy and waste management projects (Ministry of Finance of the Republic of Indonesia, 2025). Indonesia has issued sovereign green sukuk since 2018 as part of its efforts to develop financing for environmentally beneficial projects (Ministry of Finance of the Republic of Indonesia, 2025; Svatikova et al., 2025). This experience provides an important foundation for the development of green sukuk at the national government level. However, a similar instrument at the subnational level, commonly referred to as municipal green sukuk, has not yet been implemented in Indonesia. Its adoption at the local government level would face several challenges, particularly those related to regulatory arrangements, local fiscal and institutional capacity, and the readiness of projects that meet green eligibility criteria (Climate Bonds Initiative, 2024). Local governments would also need to establish adequate governance and reporting mechanisms to ensure that the funds raised are used in accordance with their intended environmental purposes. For green bonds and green sukuk, these requirements include Monitoring, Reporting, and Verification (MRV), allocation reporting, and impact reporting (International Capital Market Association, 2024).

Previous studies on green sukuk have largely focused on its issuance and development at the sovereign and corporate levels. (Keshminder et al., 2019, 2022) examined the development of the SRI Sukuk

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ecosystem in Malaysia. In Indonesia, Santoso (2020) and Supriyadi et al. (2023) examined the legal aspects and implementation of sovereign green sukuk. At the corporate level, (Endri et al., 2022) found that green sukuk issuance continues to face challenges, including limited market understanding and the relatively high costs of green verification. Meanwhile, Hariyani & Kusuma (2020) examined the potential use of green sukuk to support sustainable waste management. These studies explain why green sukuk works for national and corporate issuers and why it is relevant to waste financing. However, they cannot explain three conditions that determine whether a local government can issue the instrument: (1) how subnational fiscal capacity supports or limits issuance, (2) whether local institutional and MRV arrangements exist, and (3) whether waste infrastructure needs have been translated into a documented, green-eligible project pipeline. Research that examines these conditions together with external market and policy conditions for an Indonesian local government remains limited. This study addresses this gap by assessing the potential of municipal green sukuk for waste management infrastructure in Jakarta across these four dimensions, formulating implementation strategies from the assessment, and distinguishing strategic potential from immediate issuance readiness.

Against this background, this study aims to assess the potential implementation of municipal green sukuk as an alternative financing instrument for waste management infrastructure in Jakarta. The study addresses two research questions:

RQ1. What internal and external factors influence the potential implementation of municipal green sukuk for waste management infrastructure in Jakarta?
RQ2. What strategies can be formulated to support its implementation?

This study contributes both theoretically and practically. Theoretically, it adds to the literature on green sukuk by examining its potential at the local-government level, which has received limited attention compared with sovereign and corporate issuers, and by identifying the internal and external factors that shape its implementation. Practically, the findings provide a basis for local governments, regulators, and other stakeholders in formulating implementation strategies and policy recommendations for developing sustainable financing for urban waste management.

II. Literature Review

2.1. Sustainable Waste Management and Its Eligibility as a Green Project

Population growth, urbanization, and changing consumption patterns have contributed to rising waste generation, making waste management an increasingly important issue in urban development (Kaza et al., 2018). Conventional end-of-pipe approaches, which rely on collection, transportation, and final disposal, face growing limitations in reducing waste and recovering resources. Integrated Sustainable Waste Management (ISWM) therefore views waste management as a system encompassing technical, institutional, financial, social, and environmental dimensions (Wilson et al., 2015). ISWM is closely aligned with the circular economy, which treats waste as a resource to be recovered through the principles of reduce, reuse, recycle, and recover (Ellen MacArthur Foundation, 2015; Kirchherr et al., 2017). These principles encourage infrastructure such as recycling facilities, refuse-derived fuel (RDF), waste-to-energy, and landfill mining, and in Indonesia a similar emphasis on waste reduction and resource recovery is reflected in Law No. 18 of 2008 on Waste Management. The Climate Bonds Standard lists waste sorting, reuse and recycling, composting, anaerobic treatment, and energy recovery among activities that may qualify for green financing (Climate Bonds Initiative, 2023). Waste management projects that meet such criteria therefore have the potential to obtain financing through green instruments, including green sukuk.

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2.2. Green Sukuk as a Sustainable Financing Instrument

The need to finance low-carbon development has contributed to the growth of green finance. Green finance directs funding toward projects that generate environmental benefits, supported by mechanisms to ensure appropriate use of proceeds and reporting on environmental outcomes (OECD, 2017; Utermarck et al., 2024). More broadly, sustainable finance integrates environmental, social, and governance (ESG) considerations into capital allocation to advance sustainable development, with strategic funding of environmentally sustainable projects and sound governance driving the transition toward a low-carbon economy (Junaedi, 2024). Green sukuk combines Islamic finance principles with this use-of-proceeds logic: like green bonds, funds are allocated to projects meeting defined environmental criteria, but the structure must also comply with sharia principles (Lee et al., 2025; World Bank, 2020). It can be structured using contracts such as Murabahah, Istisna', and Wakalah (Ali et al., 2025), allowing the structure to be adapted to the asset being financed, which is relevant for waste management infrastructure. As a use-of-proceeds instrument, it also requires mechanisms for project eligibility, monitoring and verification, and allocation and impact reporting (Utermarck et al., 2024; World Bank, 2020).

From a market perspective, Faisal et al. (2023) found that Indonesian investors' intention to purchase green sukuk is influenced by functional, social, emotional, religious, and knowledge values, while Riaz et al. (2024) found that green sukuk announcements generated a positive and significant stock market response, slightly stronger than that for green bonds. However, the evidence is not uniformly favorable. Ali et al. (2025) and Endri et al. (2022a) point to constraints from limited taxonomy standardization, secondary market liquidity, verification and compliance costs, and market understanding. The favorable evidence also comes mainly from investor intentions and corporate announcement effects, and may not carry over to local governments. Municipal green bond studies point in the same direction: González-Ruiz et al. (2023), studying renewable energy green bonds in Latin America and the Caribbean, identify municipal debt ceilings, low credit ratings, and limited capacity to prepare bankable projects as barriers to issuance by local governments, and Alhowaish (2025) links municipal green bond adoption in Saudi Arabia to regulatory capacity, risk perceptions, and stakeholder alignment. Market interest alone therefore does not ensure feasible issuance, which also depends on the issuer's governance and reporting capacity. In Indonesia, green sukuk has also been linked to the sustainable development goals El Amri et al. (2021) and to the maqasid al-shariah principle of environmental protection (hifz al-bi'ah) (Musari & Hidayat, 2023).

2.3. Development and Potential of Green Sukuk for Local Governments

Indonesia has issued sovereign green sukuk since 2018 to finance projects with environmental benefits (Ministry of Finance of the Republic of Indonesia, 2025; Santoso, 2020). This experience provides a basis for considering green financing at lower levels of government, but local governments face different considerations in fiscal capacity, institutional arrangements, legal authority, and development priorities. This national experience may serve as a reference for regional governments, although it does not transfer directly to the subnational level, where fiscal capacity, institutional arrangements, and legal authority differ. Municipal green sukuk may be relevant for local governments with substantial environmental infrastructure needs. Hariyani & Kusuma (2020) indicate that green sukuk can be an alternative instrument for sustainable waste management in Indonesia, consistent with Islamic finance and circular economy principles (Ibrahim & Shirazi, 2020), and applications in other sectors such as forestry show its wider applicability (Wibowo et al., 2026). Yet use at the local level depends on more than financing needs. Malaysia's SRI Sukuk experience shows the role of regulatory and institutional frameworks (Keshminder et al., 2019; Noordin et al., 2018; Securities Commission Malaysia, 2019), Indonesia's sustainable finance policies provide a broader enabling environment (OECD, 2021), and corporate experience shows remaining challenges in market understanding and verification costs (Endri et al., 2022). In the Indonesian regional bond context, Hutahayan et al. (2024) point to inconsistent regulation as a barrier and recommend a revenue bond model, while Milewska (2022) identifies

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public tasks of local authorities in Poland that could be financed through green bonds. Project readiness is equally important. Waste infrastructure such as recycling, RDF, and waste-to-energy has different investment requirements, so needs must be translated into a documented project pipeline linked to clear eligibility, use-of-proceeds, and governance arrangements (Climate Bonds Initiative, 2023, 2024; World Bank, 2020). Evidence from South African metropolitan municipalities likewise links institutional fragmentation, constrained fiscal capacity, and weak project appraisal to difficulties in financing urban greening (Mokgopha & Klingelhöfer, 2026); these considerations are developed in Section II.4.

2.4. Theoretical Perspective: Sustainable Finance and Institutional Readiness

This study is anchored in a sustainable finance perspective, in which financing contributes to environmental objectives when funds are directed to projects with environmental benefits and this link is credible and verifiable (OECD, 2017; Utermarck et al., 2024). For green bonds and green sukuk, credibility rests on clear eligibility criteria (Climate Bonds Initiative, 2023, 2024), management of proceeds, external review, and reporting on allocation and impact (Utermarck et al., 2024; World Bank, 2020). A green label can then signal commitment to sustainability (Faisal et al., 2023; Riaz et al., 2024), but only as strongly as the mechanisms behind it. Ghaemi Asl et al. (2025) find that some green bond types, including municipal green bonds, may be susceptible to greenwashing because they lack a permanent causal link with a sustainable economy. For green sukuk, credibility also depends on sharia governance (Ali et al., 2025; Lee et al., 2025). Applied to a local government, issuance is therefore not only a question of financing need but of whether the issuer can meet these credibility requirements. An institutional readiness perspective adds that the adoption of a new instrument depends on regulatory and institutional support (Keshminder et al., 2019, 2022; Noordin et al., 2018), which is consistent with the barriers reported for municipal green bonds (Alhowaish, 2025; González-Ruiz et al., 2023). The framework therefore leads to examining the internal and external factors that shape the potential implementation of municipal green sukuk, which is the purpose of the SWOT-TOWS analysis. SWOT-TOWS is used here as the analytical procedure that classifies the documented evidence and derives strategies, rather than as a theory; the theoretical perspective above informs how the factors are interpreted.

III. Research Method

This study employs a qualitative approach with a case study design focusing on Jakarta. The case study design was selected to provide an in-depth understanding of the potential implementation of municipal green sukuk within the local policy, fiscal, institutional, and waste management contexts. This approach is appropriate for examining contemporary phenomena that cannot be clearly separated from the institutional and policy contexts in which they occur (Yin, 2018). Jakarta was purposively selected as the case because of its relatively strong fiscal capacity, substantial own-source revenue, high waste generation, and development policies that support the strengthening of the circular economy, as reflected in the Jakarta Regional Medium-Term Development Plan (RPJMD) 2025–2029. These characteristics make Jakarta a relevant case for assessing the initial potential of municipal green sukuk as an alternative financing instrument for waste management infrastructure in Indonesia. SWOT-TOWS was chosen because the perspective in Section 2.4 implies that implementation potential depends on both internal and external conditions, which SWOT classifies directly, and because TOWS translates documented conditions into prioritized strategies. As municipal green sukuk has not yet been issued by a local government in Indonesia, market data such as pricing and investor orders are unavailable, so a qualitative assessment based on documentary evidence is the feasible approach; multi-criteria or pricing analyses are more suitable for later research stages.

The study uses secondary data collected through document analysis (Bowen, 2009). The documents fall into five categories, listed in Table 1, and were selected purposively: they were issued by an authoritative institution, were relevant to municipal green sukuk, local government financing, or waste management in

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Jakarta, and were in force or the latest available version at the time of analysis. Opinion pieces and media articles without verifiable primary sources were excluded. Scientific literature on green sukuk and sustainable finance for local governments, published between 2018 and 2026 as cited in the reference list, was identified through Scopus and SINTA. Using multiple documentary sources facilitates source triangulation and enhances the credibility of the analysis (Bowen, 2009).

Table 1. Documents Analyzed

Category	Documents Analyzed
Planning and policy	Jakarta RPJMD 2025–2029 (Provincial Government of Jakarta, 2025c); Performance Report of the Jakarta Environmental Agency 2025 (2025b).
Fiscal data	LKPD of Jakarta 2025 (Provincial Government of Jakarta, 2025a); Statistical Yearbook of Indonesia 2025 (BPS-Statistics Indonesia, 2025).
Regulations and frameworks	Green sukuk allocation and impact report 2025 (Ministry of Finance, 2025); SRI Sukuk Framework (Securities Commission Malaysia, 2019).
Academic literature	Scopus-indexed international journals, accredited national journals, and scientific books (see References).
International reports and standards	World Bank (2020); OECD (2017, 2019, 2021); Asian Development Bank (2021); Climate Bonds Initiative (2023, 2024); ICMA (2024); ICMA–IsDB guidance (Utermarck et al., 2024).

The data were analyzed in stages, namely a descriptive analysis of waste management conditions and investment needs, benchmarking of international practice, an analysis of Jakarta's fiscal capacity, and an assessment of project eligibility against green finance standards. These stages, together with the planning and regulatory documents, were the basis for identifying the SWOT factors, which were coded as internal (strengths and weaknesses) or external (opportunities and threats) conditions and retained when supported by documentary evidence. The study does not address the design of sharia contracts, pricing, or valuation. The factors were organized into the Internal and External Factor Analysis Summaries (IFAS and EFAS) with reference to Rangkuti (2015) and David & David (2017). Each factor was assigned a weight, representing its relative importance (total weight per group = 1.00), and a rating from 1 to 4, representing its influence on implementation feasibility (Table 2). The authors assigned weights and ratings on the basis of the strength of the empirical evidence for each factor, not from respondents. The weighted scores were used to calculate the S–W and O–T differences, which determine the strategic position in the SWOT quadrant. A TOWS matrix was then used to formulate SO, WO, ST, and WT strategies based on substantive linkages among factors, and the strategies in the prioritized quadrant were used as the basis for recommendations for municipal green sukuk implementation for waste management infrastructure in Jakarta.

Table 2. Rating Rubric

Rating	Definition
4	Decisive influence, supported by direct quantitative or regulatory evidence from primary documents
3	Substantial influence, supported by documentary evidence
2	Moderate influence, or evidence is indirect or partial
1	Limited influence

This design has limitations. Document analysis cannot establish causal relationships, and because no primary data were collected from investors, regulators, or municipal stakeholders, the results indicate strategic potential rather than actual investor demand or issuance feasibility. Weights and ratings reflect the authors' judgment and are partly subjective; the rubric and evidence sources aim to make this transparent.

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IV. Result and Discussion

4.1. Identification of Internal and External Factors

The document analysis examined Jakarta's waste management conditions, fiscal capacity, regulations governing local government financing, developments in green sukuk across different countries, and relevant academic literature. Based on this assessment, a set of internal and external factors was identified as relevant to the potential implementation of municipal green sukuk. Internal factors were classified into strengths and weaknesses, while external factors were categorized as opportunities and threats. These factors subsequently formed the basis for constructing the IFAS and EFAS matrices.

Table 3. Identification of Internal Factors (Strengths and Weaknesses)

Code	Factor	Empirical Basis
S1	Relatively strong fiscal capacity	The regional financial independence ratio was 64.00%, while fiscal space reached 62.57%, based on the 2025 Regional Government Financial Report (LKPD) of Jakarta (Provincial Government of Jakarta, 2025a).
S2	Strong own-source revenue base	The effectiveness ratio of own-source revenue (PAD) was 94.66%. Major revenue sources include motor vehicle tax, motor vehicle ownership transfer fees, land and building tax, certain goods and services tax, cigarette tax, local user charges, and returns from separately managed regional assets (Provincial Government of Jakarta, 2025a).
S3	Commitment to green development	The transition toward a circular economy is incorporated into the Jakarta RPJMD 2025–2029 and supported by the regional waste management policy under Governor Regulation No. 108 of 2019.
S4	National experience with sovereign green sukuk issuance	Indonesia has issued sovereign green sukuk since 2018 and has accumulated experience in developing green sukuk frameworks and reporting mechanisms.
S5	Substantial potential waste management project pipeline	The need to develop RDF, Material Recovery Facilities (MRFs), integrated waste management facilities (TPST), and waste-to-energy facilities is consistent with the high volume of waste generated in Jakarta.
W1	Absence of a specific regulatory framework for local government green sukuk	A review of Law No. 1 of 2022 on Financial Relations between the Central Government and Regional Governments (HKPD) and Financial Services Authority Regulation No. 18 of 2023 indicates that specific provisions governing green sukuk issuance by local governments have not been identified.
W2	No dedicated regional Green Sukuk Framework	Jakarta does not yet have a specific framework covering green project eligibility, project selection and evaluation, use of proceeds, and reporting mechanisms for green sukuk issuance.
W3	Institutional readiness requires further strengthening	No dedicated local government unit or institutional arrangement has yet been identified with specific responsibility for developing and managing green financing.
W4	MRV system is not yet integrated	Allocation and impact reporting mechanisms applied in sovereign green sukuk issuance have not yet been specifically established at the local government level.
W5	Project pipeline is not yet fully documented	RDF, TPST, and waste-to-energy projects require further development of technical and financial documentation, including feasibility studies and assessments of project bankability.

Table 3 indicates that Jakarta has several internal conditions that support the potential development of municipal green sukuk. The principal strengths relate to fiscal capacity and the local revenue base, policy commitment to sustainable development, Indonesia's experience with sovereign green sukuk, and the substantial need for additional waste management infrastructure. Collectively, these conditions provide a basis for considering the diversification of financing sources for waste management infrastructure.

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However, several internal constraints also need to be addressed. These constraints relate to the regulatory framework, the absence of a dedicated Green Sukuk Framework, institutional capacity, reporting mechanisms, and project preparedness. The findings indicate that the challenges of implementing municipal green sukuk extend beyond fiscal capacity to the institutional and governance arrangements required to ensure compliance, accountability, and transparency in green financing. Most of the identified weaknesses concern implementation readiness and may be addressed through regulatory development, institutional strengthening, establishment of an appropriate framework, and systematic project preparation. Therefore, these weaknesses are better understood as areas requiring further institutional and operational preparation rather than as fundamental constraints on Jakarta's capacity to develop municipal green sukuk.

Table 4. Identification of External Factors (Opportunities and Threats)

Code	Factor	Empirical Basis
O1	Growth of the sustainable finance and ESG market	The continued growth of global sustainable bond and sukuk issuance indicates increasing market attention to financing instruments that incorporate environmental and sustainability considerations.
O2	Support from the Net Zero Emission agenda	Indonesia's target to achieve Net Zero Emission by 2060 encourages the development of financing and investment for low-carbon projects, including waste management.
O3	Potential investor base with Islamic and ESG orientations	Indonesia's sovereign green sukuk issuances have received strong market responses, including high levels of oversubscription in several issuances.
O4	Support from national policies and frameworks	The government has established the Green Bond and Green Sukuk Framework and Financial Services Authority Regulation No. 18 of 2023, which can serve as references for developing sustainable financing frameworks.
O5	Advances in waste management technology	Technologies such as RDF, waste-to-energy, and MRF have been developed and implemented in various countries, providing relevant experience for the development of waste management infrastructure.
T1	Regulatory framework uncertainty	Existing arrangements for local government financing through Islamic capital market instruments do not specifically regulate the issuance mechanism for municipal green sukuk, leaving aspects of issuance procedures and oversight requiring further clarification.
T2	Financial market volatility	Changes in interest rates and financial market conditions may affect financing costs and the conditions under which financing instruments are issued.
T3	Competition for green financing	Waste management projects may compete with other green projects for investor attention and allocation of financing from the same pool of investors.
T4	Project implementation risks	Variations in waste characteristics and composition, together with the readiness of technologies and operators, may affect the technical and operational risks of waste management projects.
T5	Changes in national fiscal policy	Changes in intergovernmental transfers and regulations governing local government financing or borrowing may affect the fiscal space available to local governments.

The opportunities identified in Table 4 primarily arise from the expansion of sustainable finance and ESG markets, the transition toward a low-carbon economy, Indonesia's experience with sovereign green sukuk, national policy support, and advances in waste management technology. These factors create external conditions that may facilitate the development of alternative green financing mechanisms at the local government level. However, the potential implementation of municipal green sukuk is also subject to several external factors that are largely beyond the direct control of the local government, including regulatory uncertainty, financial market volatility, competition for green financing, project implementation risks, and changes in national fiscal policy. Such factors may affect regulatory certainty, financing conditions, investor interest, and the risks associated with implementing the proposed instrument.

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Unlike internal weaknesses, which can be addressed through measures within the local government's institutional and policy domain, most external threats cannot be directly eliminated by the Provincial Government of Jakarta. The appropriate strategic response is therefore to anticipate and mitigate their potential effects through regulatory and institutional strengthening, project risk management, appropriate issuance timing, and diversification of financing sources. The identified internal and external factors subsequently serve as the basis for assigning weights and ratings in the IFAS and EFAS matrices and for formulating strategic alternatives through the TOWS matrix.

4.2. IFAS and EFAS Analysis Results

The identified internal and external factors presented in Tables 3 and 4 were subsequently assigned weights and ratings in accordance with the analytical procedure described in the Research Method section. The weight reflects the relative importance of a factor to the implementation of municipal green sukuk, while the rating represents the degree of its influence on implementation feasibility. The weighted score was obtained by multiplying the weight by the corresponding rating. The results of the IFAS and EFAS calculations are presented in Tables 5 and 6.

Table 5. Internal Factor Analysis Summary (IFAS) Scoring

Code	Rating	Weight	Score (Rating x Weight)
S1	4	0.15	0.60
S2	4	0.10	0.40
S3	3	0.08	0.24
S4	3	0.09	0.27
S5	3	0.08	0.24
Subtotal Strengths (S)		**0.50**	**1.75**
W1	4	0.12	0.48
W2	3	0.11	0.33
W3	2	0.09	0.18
W4	2	0.09	0.18
W5	2	0.09	0.18
Subtotal Weaknesses (W)		**0.50**	**1.35**
Total IFAS		**1.00**	**3.10**
Internal Difference (S - W)			**+0.40**

Table 6. External Factor Analysis Summary (EFAS) Scoring

Code	Rating	Weight	Score (Rating x Weight)
O1	4	0.12	0.48
O2	3	0.09	0.27
O3	4	0.12	0.48
O4	3	0.10	0.30
O5	3	0.08	0.24
Subtotal Opportunities (O)		**0.51**	**1.77**
T1	3	0.12	0.36
T2	2	0.08	0.16
T3	2	0.08	0.16
T4	3	0.11	0.33
T5	2	0.10	0.20
Subtotal Threats (T)		**0.49**	**1.21**
Total EFAS		**1.00**	**2.98**
External Difference (O - T)			**+0.56**

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The total IFAS and EFAS scores are 3.10 and 2.98, respectively. Under the rating scale applied in this study, these scores indicate that the identified internal and external factors have relatively high levels of importance and influence in determining the feasibility of municipal green sukuk implementation in Jakarta. The internal analysis yields a strength subtotal of 1.75 and a weakness subtotal of 1.35, resulting in an internal difference (S – W) of +0.40. The external analysis produces an opportunity subtotal of 1.77 and a threat subtotal of 1.21, resulting in an external difference (O – T) of +0.56. The highest-scoring internal factors are S1 and S2, representing regional fiscal capacity and the strength of the own-source revenue base, respectively. On the external side, O1 and O3 obtain the highest scores, reflecting the growth of the global ESG market and potential demand from Islamic and ESG-oriented investors. The positive values of both differences provide the basis for determining the strategic position of municipal green sukuk implementation in the SWOT quadrant analysis.

4.3. Strategic Position of Municipal Green Sukuk Implementation

The strategic position of municipal green sukuk implementation was determined using the coordinates (Internal Difference, External Difference) = (S – W, O – T) = (+0.40, +0.56), as presented in Figure 1. The positive values for both dimensions place the potential implementation of municipal green sukuk in Jakarta in Quadrant I of the SWOT framework. Based on the framework proposed by Rangkuti (2015), this position indicates that the Strengths–Opportunities (SO) strategy may be prioritized by leveraging internal strengths to capitalize on available external opportunities.

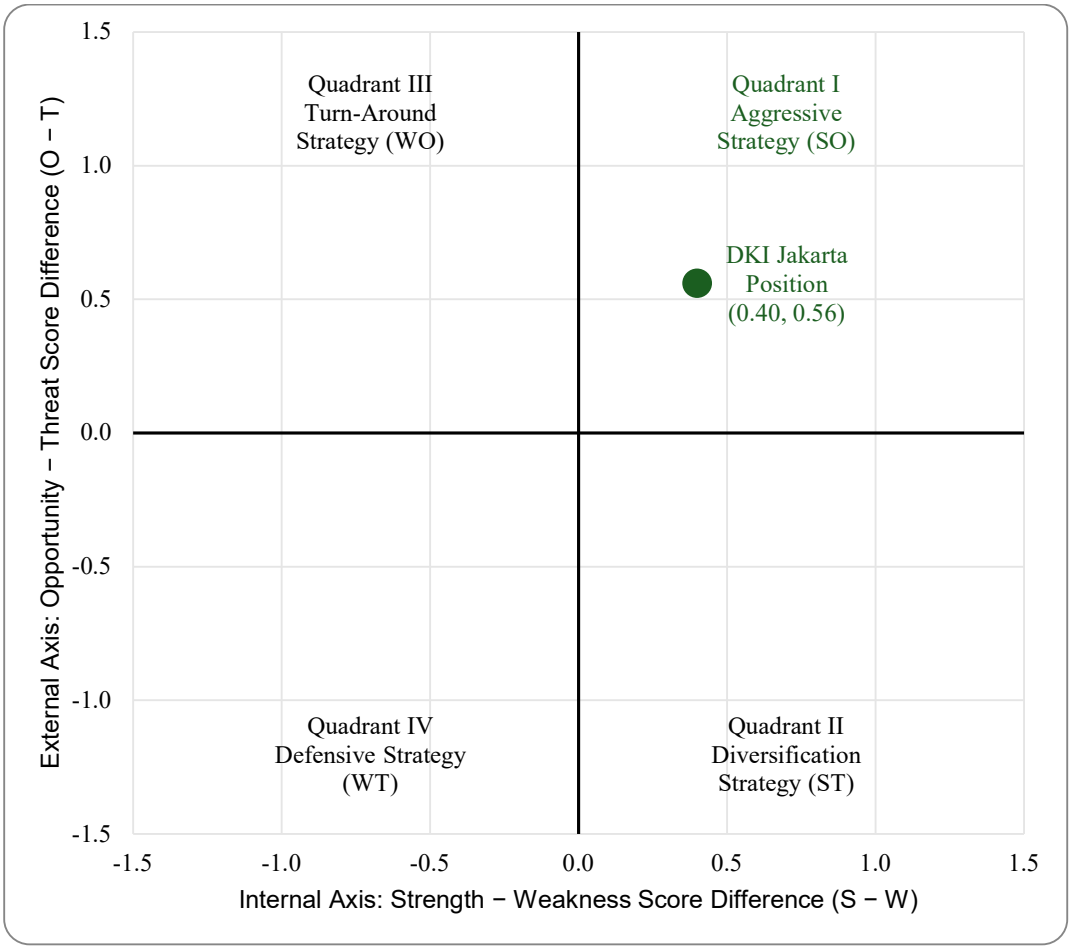


Figure 1. SWOT Quadrant Diagram of Municipal Green Sukuk Implementation in Jakarta

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The Quadrant I position indicates that the identified internal strengths are relatively greater than the weaknesses, while the identified external opportunities are relatively greater than the threats. This position is primarily supported by Jakarta's fiscal capacity and substantial own-source revenue, its policy commitment to green development, and Indonesia's experience with sovereign green sukuk issuance at the national level. From the external perspective, the principal opportunities arise from the expansion of the global ESG market, increasing interest from Islamic and ESG-oriented investors, national policy support, and advances in waste management technologies. Nevertheless, a Quadrant I position does not imply that municipal green sukuk can be issued immediately. Rather, it indicates the presence of strategic conditions that support the preparation and further development of such a financing scheme. Its implementation would still require an adequate regulatory framework, strengthened institutional capacity, a sufficiently prepared project pipeline, and appropriate Monitoring, Reporting, and Verification (MRV) and governance mechanisms. Accordingly, the SO strategy is prioritized in the subsequent strategy formulation, while the identified weaknesses and threats remain important considerations in addressing implementation requirements and potential risks.

4.4. Formulation of Municipal Green Sukuk Implementation Strategies through TOWS Analysis

Based on the IFAS and EFAS results, the strategic position of municipal green sukuk implementation in Jakarta is located in Quadrant I, with coordinates of (+0.40, +0.56). This position indicates that the identified internal strengths are relatively greater than the weaknesses, while the external opportunities are relatively greater than the threats. The resulting position provides a strategic basis for developing strategies that leverage internal strengths to capitalize on external opportunities. A TOWS analysis was subsequently conducted to formulate strategic alternatives by examining the relationships between the internal and external factors identified through the IFAS and EFAS analyses. The TOWS framework comprises four strategic combinations: Strengths–Opportunities (SO), Strengths–Threats (ST), Weaknesses–Opportunities (WO), and Weaknesses–Threats (WT). The selection of factor combinations was based on substantive linkages and strategic relationships among the identified factors, while also considering their relative importance as reflected in the weighted IFAS and EFAS scores. Thus, factors were not paired mechanically; rather, the combinations were selected according to their relevance to supporting, anticipating, or addressing conditions that may affect the implementation of municipal green sukuk.

Table 7. TOWS Matrix for Municipal Green Sukuk Implementation in Jakarta

Internal / External Factor	Opportunities (O)	Threats (T)
Strengths (S)	**SO Strategies** **SO1**. Leverage strong regional fiscal capacity (S1) and a substantial own-source revenue base (S2) to strengthen issuer credibility and capitalize on the growth of the global ESG market (O1) and international interest in Sharia-compliant investments (O3). **SO2**. Leverage the regional commitment to green development (S3) and Indonesia's experience with sovereign green sukuk issuance (S4) to develop a municipal green sukuk scheme aligned with the Net Zero Emission agenda (O2) and national green sukuk policies (O4).	**ST Strategies** **ST1**. Leverage strong regional fiscal capacity and own-source revenue (S1, S2) to strengthen the credibility and competitiveness of local government financing in addressing financial market volatility (T2) and competition for green financing (T3). **ST2**. Leverage Indonesia's experience with sovereign green sukuk issuance (S4) and the regional commitment to green development (S3) as a basis for policy learning and coordination to address regulatory uncertainty (T1) and changes in national fiscal policy (T5).

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	SO3. Leverage the substantial potential of waste management projects (S5) and the regional commitment to green development (S3) to develop a green-eligible project pipeline by utilizing advances in waste management technology (O5).	
Weaknesses (W)	**WO Strategies** **WO1**. Utilize national policy support and Indonesia's Green Sukuk Framework (O4) as references for developing local regulatory arrangements and a regional Green Sukuk Framework to address the absence of a specific local regulatory framework and framework for issuance (W1, W2). **WO2**. Utilize developments in sustainable finance policy and waste management technology (O4, O5) to strengthen institutional capacity, MRV systems, and documentation of the regional project pipeline (W3, W4, W5).	**WT Strategies** **WT1**. Strengthen the regulatory framework and coordination with the central government to mitigate regulatory uncertainty and risks associated with changes in national fiscal policy (W1, W2, T1, T5). **WT2**. Strengthen institutional capacity, MRV systems, and project pipeline readiness to mitigate technological and operational risks associated with waste management projects (W3, W4, W5, T4).

The TOWS analysis produces four groups of strategic alternatives: SO, ST, WO, and WT. Given the Quadrant I position, the SO strategies are prioritized, while the ST, WO, and WT strategies serve as complementary and risk-mitigation strategies. The SO strategies focus on leveraging fiscal capacity, commitment to green development, and the potential waste management project pipeline to capitalize on opportunities in ESG markets and among Islamic and ESG-oriented investors. The WO and WT strategies, in turn, emphasize the strengthening of regulatory arrangements, institutional capacity, MRV systems, and project pipeline readiness as essential supporting conditions for the implementation of municipal green sukuk.

4.5. Discussion

The IFAS and EFAS results suggest that the potential implementation of municipal green sukuk in Jakarta is supported by relatively stronger internal conditions and external opportunities than by the identified weaknesses and threats. The highest-scoring internal factors are fiscal capacity (S1) and the strength of the own-source revenue base (S2), while the most prominent external factors are the growth of the global ESG market (O1) and international interest in Sharia-compliant investment (O3). This configuration suggests a strategic alignment between Jakarta's financing capacity as a potential subnational issuer and the expanding market for sustainable and Sharia-compliant financial instruments. These findings appear particularly relevant given the capital-intensive and long-term nature of urban waste management infrastructure, which may place considerable pressure on conventional public financing sources. Diversifying financing sources can therefore become an important component of sustainable infrastructure financing, particularly where investment requirements extend beyond the capacity of annual regional budgets (Asian Development Bank, 2021; OECD, 2017).

The external opportunities identified in the analysis appear to further support the potential market relevance of municipal green sukuk. The expansion of ESG-oriented investment creates a market environment in which financial instruments linked explicitly to environmental outcomes may attract increasing investor attention. At the same time, the Sharia-compliant structure of sukuk may provide access to a broader investor base, particularly investors whose investment decisions incorporate both sustainability and Islamic finance

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considerations. This potential is supported by Faisal et al. (2023), who found that Indonesian investors' intentions to purchase green sukuk are influenced by functional, social, emotional, religious, and knowledge-related values. Riaz et al. (2024) likewise found a positive market response to corporate green sukuk issuance announcements, indicating that the environmental characteristics of the instrument may generate additional market value. These findings appear to provide support for the market opportunity identified in this study. In the Indonesian context, Idris (2026) similarly finds that the adoption of green finance strategies by financial institutions is shaped by regulatory frameworks, environmental awareness, management support, fintech innovation, and market pressure, while gaps in green financial literacy and the limited standardization of sustainability metrics persist as obstacles. This reinforces the view that a supportive market environment is accompanied by institutional conditions that still require strengthening, consistent with the readiness gaps identified for Jakarta. However, because the present study relies on secondary documentary evidence, these findings should not be interpreted as direct evidence of investor perceptions or as a guarantee of demand for a future municipal issuance. Actual market acceptance would remain dependent on factors such as the credibility of the issuer, project quality, instrument structure, pricing, risk profile, and disclosure quality.

The potential relevance of green sukuk is also associated with the flexibility of its Sharia-compliant structures. Various contracts, including Murabahah, Istisna', and Wakalah, can be employed depending on the characteristics of the underlying transaction and assets (Ali et al., 2025). In the context of waste management, such flexibility provides a basis for considering financing structures that correspond to different types of infrastructure, including recycling facilities, refuse-derived fuel (RDF), and other waste treatment facilities. Nevertheless, structural flexibility alone is insufficient to ensure successful issuance. The credibility of a green sukuk depends on the clear identification of eligible projects, the appropriate allocation and use of proceeds, external review, and transparent reporting of environmental outcomes (International Capital Market Association, 2024; World Bank, 2020). Climate Bonds Initiative (2023, 2024) similarly emphasizes the importance of clearly defined green eligibility criteria for waste-related activities. Where such mechanisms are weak, the green label may be questioned, and Ghaemi Asl et al. (2025) point to greenwashing concerns for some green bond types, including municipal green bonds. Consequently, the potential financing success of municipal green sukuk may depend not only on the availability of funding and suitable projects but also on the institutional mechanisms that would be required to demonstrate that the proceeds generate the intended environmental benefits.

This requirement is particularly important in Jakarta because the SWOT analysis identifies several weaknesses related to implementation readiness. These include the absence of a specific local regulatory framework, the lack of a dedicated Green Sukuk Framework, limited institutional capacity, an underdeveloped integrated Monitoring, Reporting, and Verification (MRV) system, and an insufficiently documented project pipeline. The Quadrant I position should therefore not be interpreted as evidence that Jakarta is immediately ready to issue municipal green sukuk. Rather, it indicates that the strategic conditions for developing such an instrument are relatively favorable, while several institutional and operational foundations still require strengthening. This distinction is important because fiscal capacity represents only one dimension of issuer readiness. A credible green financing instrument also requires governance arrangements capable of establishing project eligibility, managing proceeds, monitoring implementation, and reporting environmental impacts.

The importance of regulatory and institutional readiness appears consistent with evidence from the development of the SRI Sukuk ecosystem in Malaysia. Keshminder et al. (2019) emphasize the role of regulatory and institutional support in establishing a functioning sustainable sukuk market, while Keshminder et al. (2022) identify challenges associated with green taxonomy, the identification of eligible green assets, issuance costs, and the risk characteristics of underlying projects. These findings reinforce the argument that the development of municipal green sukuk requires an enabling ecosystem rather than merely a decision to introduce a new financing instrument. Indonesia's experience with sovereign green sukuk since 2018 provides an important institutional and technical reference, particularly in relation to green project selection, framework development, reporting, and verification (Ministry of Finance of the Republic of Indonesia, 2025).

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However, national-level experience cannot be transferred directly to the subnational level because local governments operate within different legal authorities, fiscal arrangements, institutional capacities, and accountability structures.

The project-readiness dimension also appears to be important. Jakarta's substantial waste generation indicates a significant need for additional waste management infrastructure, but the existence of infrastructure needs does not automatically constitute a bankable green project pipeline. Projects intended to be financed through green sukuk need to be supported by sufficiently developed technical and financial documentation, clear ownership and implementation arrangements, appropriate green eligibility, and measurable environmental outcomes. Climate Bonds Initiative (2023, 2024) identifies a range of waste management activities that may qualify for green financing, including waste sorting, reuse and recycling, composting, anaerobic treatment, and energy recovery, subject to the applicable environmental criteria. Milewska (2022) similarly identifies public tasks of local authorities in Poland that could be financed through green bonds, which illustrates the need to define which local-government activities are eligible. Accordingly, the development of a documented project pipeline represents an important bridge between Jakarta's waste management needs and its potential access to green capital markets.

This finding appears to be consistent with the broader literature on sustainable waste management, which suggests that effective waste management may require more than technological solutions. Wilson et al. (2015) conceptualize integrated sustainable waste management as encompassing technical, institutional, financial, social, and environmental dimensions. Similarly, Zurbrügg et al. (2012) demonstrate that local waste management outcomes are influenced by institutional arrangements and stakeholder participation in addition to technical considerations. Qualitative evidence from metropolitan municipalities in South Africa likewise links institutional fragmentation, constrained fiscal capacity, and weak project appraisal to difficulties in financing urban greening (Mokgopha & Klingelhöfer, 2026). In this respect, the weaknesses identified in Jakarta should be understood as elements of a broader system-readiness challenge. The implementation of municipal green sukuk would require the financing instrument, institutional arrangements, project development process, and waste management system to operate in an integrated manner.

The nature of these constraints also differs from challenges identified in corporate green sukuk markets. Endri et al. (2022), for example, highlight limited market understanding and the relatively high cost of green verification as challenges at the corporate level. Evidence from municipal green bond markets points in a similar direction: González-Ruiz et al. (2023) identify municipal debt ceilings, low credit ratings, and limited capacity to prepare bankable projects as barriers in Latin America, and Alhowaish (2025) links municipal green bond adoption in Saudi Arabia to regulatory capacity, risk perceptions, and stakeholder alignment. In Jakarta, the more prominent constraints identified through the SWOT analysis concern issuer and system readiness, particularly regulation, institutional capacity, MRV, and project preparation. This difference suggests that the challenges associated with green sukuk are context-dependent and vary according to the characteristics of the issuer. For a local government, the development of an appropriate policy and institutional environment is particularly important because the issuance must be integrated with public-sector governance, local fiscal management, and regulatory authority.

The external threats identified in the analysis further demonstrate the need for an enabling policy environment. Regulatory uncertainty, financial market volatility, competition for green financing, technological and operational risks, and changes in national fiscal policy may affect the feasibility and attractiveness of a municipal issuance, while several of these factors are beyond the direct control of the provincial government. In the Indonesian regional bond context, inconsistent regulation has likewise been identified as a barrier to financing regional development (Hutahayan et al., 2024). Consequently, intergovernmental coordination becomes important to ensure consistency between local financing arrangements, national fiscal policy, capital market regulation, and sustainable finance requirements. The need for such coordination is consistent with the broader green sukuk framework, which emphasizes clear eligibility criteria, governance, external review, allocation reporting, and impact reporting as mechanisms for

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maintaining investor confidence and the environmental integrity of the instrument (International Capital Market Association, 2024; World Bank, 2020).

The TOWS results translate these conditions into a set of strategic alternatives. The SO strategy is prioritized because the Quadrant I position indicates that Jakarta can potentially leverage its internal strengths to capitalize on favorable external opportunities. In practical terms, Jakarta can utilize its relatively strong fiscal capacity, established commitment to green development, Indonesia's experience with sovereign green sukuk, and substantial waste management needs to explore access to the growing ESG and sharia-compliant investment markets. Nevertheless, prioritizing SO strategies does not imply that the identified weaknesses can be disregarded. The WO, ST, and WT strategies provide complementary measures to strengthen the institutional foundations and mitigate risks that could otherwise prevent the identified strengths from being converted into an operational financing scheme. In particular, the WO and WT strategies emphasize regulatory development, establishment of a regional Green Sukuk Framework, institutional strengthening, MRV development, and project pipeline preparation.

Taken together, these findings imply that the development of municipal green sukuk in Jakarta should be approached as a staged institutional process rather than as an immediate issuance decision. The initial stage should focus on establishing the regulatory and institutional foundations, developing a regional Green Sukuk Framework aligned with the relevant national framework, establishing an integrated MRV mechanism, and preparing a credible pipeline of projects that satisfy applicable green criteria. These preparatory measures are important to ensure a clear link between the funds raised, the projects financed, and the environmental outcomes generated. Such an approach is consistent with international green finance practices, which treat project eligibility, governance, monitoring, verification, and impact reporting as integral components of credible green financing rather than as post-issuance administrative requirements (Climate Bonds Initiative, 2023; International Capital Market Association, 2024).

The findings also extend the contribution of Hariyani & Kusuma (2020), who examined the potential of green sukuk to support sustainable waste management in Indonesia. While their study establishes the relevance of green sukuk for financing sustainable waste management, the present study incorporates the subnational issuer perspective by examining the interaction between fiscal capacity, institutional readiness, project preparedness, and external market conditions. This provides a more implementation-oriented perspective on municipal green sukuk, particularly in the context of a local government that must operate within a distinct regulatory and fiscal environment. The results therefore suggest that the potential of municipal green sukuk should not be assessed solely on the basis of financing needs or the availability of environmentally eligible projects. Its practical feasibility depends on whether the local government can establish the regulatory, institutional, governance, MRV, and project-development foundations necessary to access and maintain the credibility of the green capital market.

Taken together, the findings should be interpreted within the scope and limitations of the evidence used in this study. The analysis relies exclusively on secondary documents and therefore does not directly capture the perceptions, preferences, or decision-making considerations of investors, regulators, or municipal stakeholders. Accordingly, the identified regulatory, institutional, MRV, and project-readiness conditions represent evidence-based strategic conditions derived from the available documentary evidence rather than validated measures of stakeholder acceptance or actual issuance readiness. The Quadrant I position should therefore be understood as indicating strategic potential, rather than confirming immediate market readiness or the feasibility of an actual municipal green sukuk issuance. Validation through primary stakeholder and market evidence would be necessary to determine whether these strategic conditions translate into actual issuance readiness and market acceptance.

Overall, Jakarta possesses a combination of fiscal capacity, policy commitment, project demand, and favorable market opportunities that provides a strategic basis for exploring municipal green sukuk as an alternative financing instrument for urban waste management. The principal challenge lies not in the absence of financing needs or market opportunities, but in converting these favorable conditions into sufficient issuer and project readiness. The strategic priority is therefore to build the institutional and regulatory foundations

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required for issuance while progressively developing a credible portfolio of eligible waste management projects. Such a staged approach would allow Jakarta to leverage its existing strengths and emerging market opportunities while addressing the institutional and operational constraints identified through the SWOT-TOWS analysis.

V. Conclusion

This study aimed to assess the potential implementation of municipal green sukuk as an alternative financing instrument for waste management infrastructure in Jakarta using a SWOT-TOWS approach. The findings indicate that Jakarta is positioned in Quadrant I, with an internal factor difference of +0.40 and an external factor difference of +0.56. This position indicates that the identified internal strengths are relatively greater than the weaknesses, while the external opportunities are relatively greater than the threats. Fiscal capacity and the strength of the own-source revenue base constitute the principal internal strengths, whereas the growth of the global ESG market and international interest in Sharia-compliant investment represent the most prominent external opportunities. These findings suggest that Jakarta has strategic conditions that support the exploration of municipal green sukuk as an alternative source of financing for waste management infrastructure. However, the Quadrant I position does not imply that Jakarta is immediately ready to issue municipal green sukuk. The analysis identifies several readiness gaps, particularly concerning the regulatory framework, the availability of a regional Green Sukuk Framework, institutional capacity, the Monitoring, Reporting, and Verification (MRV) system, and the documentation of a viable project pipeline. Therefore, the financing potential supported by fiscal capacity and market opportunities needs to be accompanied by the strengthening of institutional and governance foundations. The implementation of municipal green sukuk should be viewed as a process that requires issuer readiness, project readiness, and mechanisms capable of ensuring the appropriate use of proceeds and the achievement of intended environmental benefits.

Theoretically, this study contributes to the green sukuk literature by placing local government as a unit of analysis that remains relatively underexplored. Existing studies have predominantly examined green sukuk at the sovereign and corporate levels, whereas this study demonstrates that its potential application at the local government level needs to be assessed simultaneously from the perspectives of fiscal capacity, institutional readiness, project readiness, and external conditions. The study also contributes to the literature on sustainable financing for waste management by demonstrating that the existence of environmentally beneficial projects alone does not ensure financing readiness. Regulatory, institutional, governance, MRV, and project pipeline readiness constitute integral components of a green financing ecosystem at the local government level. From a managerial perspective, the Provincial Government of Jakarta should utilize its fiscal capacity and emerging market opportunities as a basis for building municipal green sukuk readiness rather than as grounds for immediate issuance. Key priorities include strengthening the regulatory framework and coordination with the central government, developing a regional Green Sukuk Framework, enhancing institutional capacity, establishing an integrated MRV system, and developing a waste management project pipeline that meets relevant technical, financial, and environmental requirements. The SO strategy should be pursued alongside the WO, ST, and WT strategies so that market opportunities can be effectively utilized while regulatory, market, project, and fiscal policy risks are addressed during the preparation stage. Through such a staged approach, municipal green sukuk can be progressively developed as an instrument for diversifying local government financing while supporting transparency, accountability, and the sustainability of waste management infrastructure development.

Future research could extend these findings by validating the readiness conditions identified in this study through primary and comparative evidence. First, stakeholder interviews and investor surveys could examine whether the regulatory, institutional, MRV, and project-readiness conditions identified from secondary documents correspond to the perceptions and decision-making considerations of relevant market participants and public-sector stakeholders. Second, comparative studies across municipalities could assess whether the identified readiness dimensions are specific to Jakarta or applicable across different subnational

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contexts. Third, quantitative feasibility and pricing analyses could examine whether the identified strategic conditions translate into actual issuance readiness, financing feasibility, and market acceptance. Such approaches would complement the present documentary analysis and provide stronger empirical evidence regarding the conditions under which municipal green sukuk could become a viable financing instrument for sustainable urban infrastructure.

AI Disclosure

The authors used ChatGPT, an artificial intelligence tool developed by OpenAI, to assist with manuscript preparation, including language editing, grammar correction, and the organization and refinement of academic text. The tool was not used as a substitute for the authors' research process, documentary analysis, or independent scholarly judgment. All AI-assisted content was reviewed and verified by the authors, who remain fully responsible for the accuracy, originality, integrity, and validity of the manuscript, including its arguments, interpretations, references, and conclusions. ChatGPT is not listed as an author, and its use complies with the journal's publication ethics and research integrity policies.

Authorship Contribution

Conceptualization: Iis Istiqomah and Mohammad Windu Darmawan; Methodology: Iis Istiqomah and Mohammad Windu Darmawan; Investigation: Iis Istiqomah; Data Curation: Iis Istiqomah; Formal Analysis: Iis Istiqomah and Mohammad Windu Darmawan; Writing – Original Draft Preparation: Iis Istiqomah; Writing – Review and Editing: Mohammad Windu Darmawan and Rinni Rodiah Munajatisari; Supervision: Mohammad Windu Darmawan and Rinni Rodiah Munajatisari. All authors have read and approved the final version of the manuscript and agree to be accountable for their respective contributions.

Conflict of Interest Statement

The authors declare that they have no competing interests related to the research, authorship, or publication of this article.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to applicable ethical, legal, and privacy restrictions.

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