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The Role of Green Sukuk in Financing Sustainable Transport and Reducing Emissions

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ABSTRACT:

This study examines how green sukuk, as a sustainable financing tool, can reduce CO2 emissions by financing the sustainable transportation sector in Indonesia. This study uses a qualitative approach and content analysis techniques to investigate the contributions of funds distributed through green sukuk to different green transportation projects. The results show that green sukuk financing for the sustainable transportation sector reached IDR 34 trillion, the largest amount compared to other sectors, such as renewable energy and water management. Financing in this sector has reduced carbon emissions by more than 15 million tonnes from 2018 to 2022. In addition, green sukuk also contributes to achieving SDGs. By offering empirical data on the effects of green sukuk financing in the sustainable transportation sector on lowering CO2 emissions, this study adds to existing literature and emphasises how it helps Indonesia achieve SDGs. This study also identified limitations in data coverage and economic impact that require further exploration. Future research should adopt a more holistic approach and consider external variables that may affect the effectiveness of green sukuk. The government can increase the effectiveness of green sukuk by implementing policies that encourage its development, including providing incentives for investors and integrating smart and green city concepts as strategic steps.

Keywords: Green Sukuk, Sustainable Development Goals, Sustainable Transportation, CO2 Emissions

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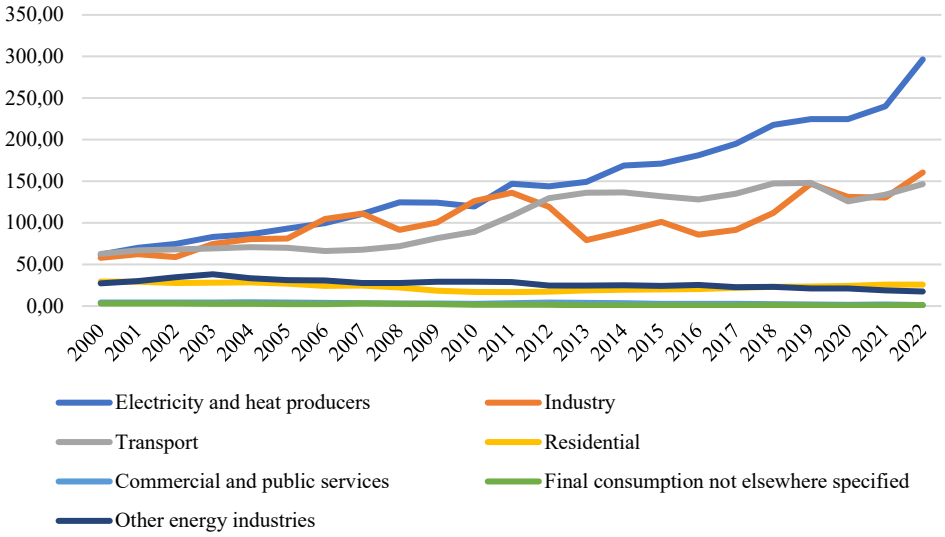
I. INTRODUCTION

2024 is a watershed moment for the world, as it must choose between succumbing to environmental crises and inequality and seizing the opportunity to achieve sustainability, global peace, and human well-being through digital technologies (Sachs, Lafortune, & Fuller, 2024). According to several studies, rising greenhouse gas emissions are the primary cause of global warming, which harms public health. These emissions increase mortality from cardiovascular and respiratory diseases (Aminzadegan, Shahriari, Mehranfar, & Abramović, 2022; Matthias et al., 2020). According to data from the International Energy Agency (2024), CO2 emissions in Indonesia increased significantly between 2000 and 2022, reaching 649.22 metric tonnes. The transport sector is one of the main contributors to CO2 emissions and has increased significantly during this period. By 2022, emissions from this sector will total 146.61 metric tonnes, making it Indonesia's third-largest source of CO2 emissions (see Figure 1). This increase in emissions reflects the prevalence of fossil fuel vehicles and a lack of environmentally friendly public transport infrastructure, posing a challenge to Indonesia's transition to clean energy (Fahamsyah et al., 2023).

Many countries today promote green or sustainable transportation as a mobility solution that meets current needs without harming future generations (Singh, Gurtu, & Singh, 2021; Xu, Wang, & Zhao, 2021). Providing and improving public transportation is one way to achieve a more sustainable future by lowering greenhouse gas emissions, fuel consumption, and air pollution (Dirgahayani & Sutanto, 2020; Qayyum, Jamil, & Ali, 2024). Furthermore, traffic congestion poses a significant environmental challenge by increasing vehicle carbon emissions, contributing to climate change and air pollution. As a result, developing a sustainable transportation system is critical to addressing these concerns (Afrin & Yodo, 2020). The Government of the Republic of Indonesia has implemented various policies and programs to develop environmentally friendly transportation infrastructure, such as efficient public transportation (Biro Komunikasi dan Informasi Publik, 2024). Expanding sustainable individual transport options and strengthening the public transport system are important steps towards realising a

sustainable transport system, both in the medium and long term (Eisenmann, Nobis, Kolarova, Lenz, & Winkler, 2021).



Source: International Energy Agency (2024)
Figure 1. CO2 Emissions by Sector in Indonesia (Metric Tonnes CO2 Equivalent)

One of the efforts to improve sustainable transportation is financing through green sukuk, an effective Islamic financial instrument to address climate change and reduce emissions (Jumat, Khateeb, & Ali, 2023). Green sukuk are Islamic bonds that finance environmentally sustainable development projects, meeting Climate Bonds Initiative criteria and aligning with the Paris Agreement's goals to limit global temperature rise (Mohd Ma'Sum Billah, Hassan, Haron, Rosman, & Billah, 2024). Since 2018, Indonesia has pioneered the global issuance of green sukuk. In 2022, it raised USD 6.9 billion, marking the largest and first 10-year issuance (Ministry of Finance Republic of Indonesia, 2023). In contrast, the Indonesian government demonstrates its commitment to sustainable finance and climate resilience (Sisdianto, Dakun, Robiansyah, Bin Ahmad Razimi, & Afifah, 2024). However, financing green projects presents several difficulties, including small project sizes, high transaction costs, limited investor knowledge, and insufficient financial mechanisms (Yadav, Samadhiya, Kumar, Luthra, & Pandey, 2024).

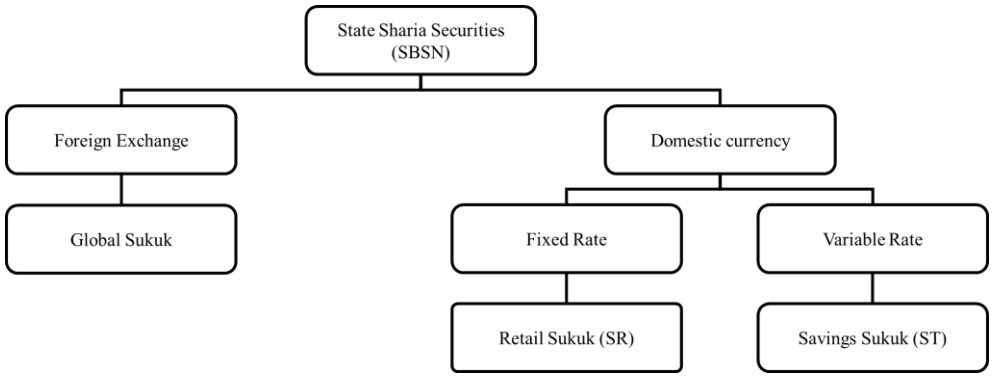
The application of green sukuk as a sustainable financing instrument aligns effectively with the global efforts outlined in the SDGs. These goals offer a comprehensive framework to tackle social, economic, and environmental challenges. They also serve as a strategic guide for achieving sustainable development until 2030 (Diallo & Gundogdu, 2021; Furqon, 2024; Khan & Haneef, 2022). Sustainable development comprises three main pillars: environmental, economic, and social. These pillars must work together harmoniously to meet both current and future needs (Al-Jayyousi, 2012; Elliott, 2006). This research aims to analyse how effective green sukuk can be in reducing CO2 emissions by financing sustainable transportation projects in Indonesia. Furthermore, it will investigate how the allocation of green sukuk funds can support environmentally friendly transportation initiatives. The study will assess the actual contributions of this financing instrument to achieving the SDGs, particularly in terms of climate change mitigation and sustainable infrastructure development. Thus, this research seeks to provide valuable recommendations for policymakers to enhance the use of green sukuk in fulfilling the SDGs.

II. LITERATURE REVIEW

Green Sukuk

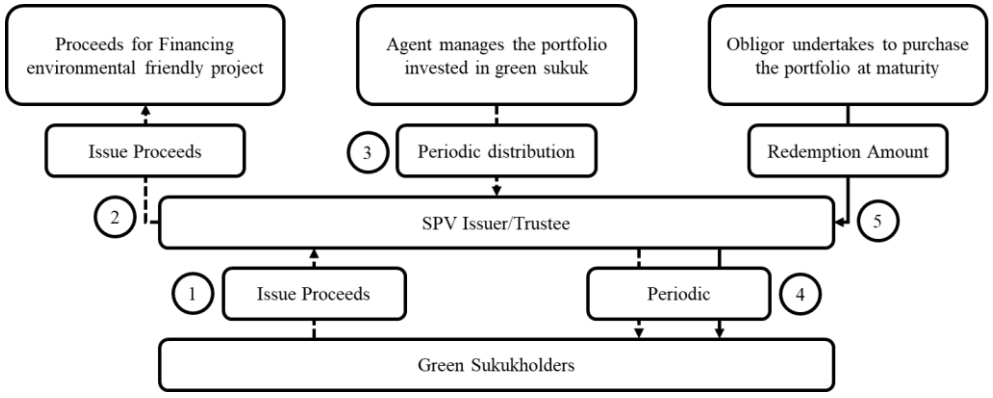
As Islamic bonds, sukuk are financial instruments fully compliant with Shariah law. In contrast to conventional bonds, the sukuk structures are closer to equity-based instruments. This is because, under Shariah norms, there is a prohibition against fixed income or risk-free returns (Hassan, AlMaghaireh, & Islam, 2022). The Islamic Development Bank (IDB) is a pioneer in developing global markets. Sukuk issued by IDB are often oversubscribed, making them one of the most sought-after instruments in the

market. IDB. This success has attracted the attention of the international financial market, especially after IDB shifted from being a mere sukuk issuer to an incubator that develops important research and ideas to advance the Islamic capital market (Usman & Sa'ad, 2023). Sukuk in Indonesia is included in the State Sharia Securities (SBSN) category, which is differentiated based on currency: rupiah-denominated government bonds and foreign currencies. There are two types of rupiah-denominated SBSNs based on their interest rates: variable and fixed. Savings Sukuk is an example of an SBSN with a variable rate. At the same time, Retail Sukuk is an example of an SBSN that uses a fixed rate (see Figure 2) (Ministry of Finance of the Republic of Indonesia, 2024a).



Source: Ministry of Finance of the Republic of Indonesia (2024a)
Figure 2. Types of State Sharia Securities (SBSN)

Green sukuk are Shariah-compliant financial instruments designed to fund sustainable projects that adhere to environmental, social, and governance principles. Growing global demand, particularly from Western investors, demonstrates the potential of green sukuk in filling the green investment supply gap (Mohd Ma'Sum Billah et al., 2024). In Arab and Southeast Asian countries, the use of green sukuk continues to increase, which aligns with the global energy transformation. The surge in green sukuk issuance since 2020 reflects the potential for increasingly competitive fees (Jumat et al., 2023). Based on the underlying assets' risk, collateral, and stability, investors can achieve yields of 1% to 5%. Green sukuk plays an important role as the issuer commits to using the proceeds to fund climate-friendly projects (Naifar & Elsayed, 2023). The Financial Services Authority Regulation Number 18 of 2023 regulates green sukuk regulations in Indonesia. This regulation ensures that the issuance and use of green sukuk funds follow sustainability principles (Financial Services Authority of the Republic of Indonesia, 2023). El Amri (2021) describes the general mechanism of green sukuk as presented in Figure 3 below.



Source: El-Amri et al. (2021)
Figure 3. Generic Structure for Green Sukuk

Green sukuk play an important role in accelerating the transition to a circular economy by funding projects that focus on conserving the environment and natural resources. Ali and Jumat (2021) explained that the objectives of green sukuk include: (1) preserving environmental sustainability and natural resources, (2) saving energy, (3) promoting the use of renewable energy, (4) reducing greenhouse gas

emissions, and (5) improving people's quality of life. The structure of green sukuk relies on the securitisation of cash flows from future income generated by assets or projects that meet certain criteria, with the funds raised primarily used for Shariah-compliant projects. After operating costs are deducted, profits from the portfolio will be distributed to sukuk holders. At maturity, the obligor is obliged to repurchase the portfolio at a price determined based on the nominal amount of the certificate and any unpaid distributions (Dorsman, Arslan-Ayaydin, & Karan, 2016). The projects financed by green sukuk include flood management, drainage management, coastal area conservation, and the development and use of renewable energy (Cadman & Sarker, 2022).

Sustainable Transportation

Sustainable development is understood through two main perspectives. First, the focus on the balance between the environment, society, and profit. Second, the emphasis on environmentally friendly economic growth, which requires that economic development does not damage the environment and is sustainable in the long term (Kaltenborn, Krajewski, & Kuhn, 2020). The United Nations (in Department of Economic and Social Affairs, 2023) emphasised that the SDGs play a crucial role in improving human well-being and preserving the Earth and are recognised as an essential step in better global governance (Ramutsindela & Mickler, 2020). Sustainability is defined as meeting the needs of the present generation without compromising future generations, which is a crucial principle of the UN 2030 Agenda (Bsoul, Omer, Kucukalic, & Archbold, 2022). The sustainable development model integrates ecological, social, and economic dimensions to ensure equity and inclusiveness (Baker, 2006). Achieving this goal requires compromises and decisions considering time and scale, as development can incur costs for particular groups (Elliott, 2006; Servaes, 2017).

Sustainable transportation is one form of implementing sustainable development in the transportation sector. Key publications such as Our Common Future, government policies, and international agreements actively reflect efforts to reduce the negative impacts of transport, including in discussions on the post-2015 agenda (Gudmundsson, Hall, Marsden, & Zietsman, 2016). Zhao and Yuan (2023) define sustainable transportation through four main aspects: accessibility, safety and comfort, efficiency and reliability, and sustainability, which includes green and resilient elements. Various studies have shown that people are important in achieving sustainable development. Joshi et al. (2018) explain that sustainable transportation refers to the use of renewable energy without dependence on non-renewable resources, which includes (1) walking, (2) cycling, (3) public transportation, and (4) electric, solar, or hybrid vehicles. Authorities actively encourage the use of public transportation over private transportation. The shift toward sustainable transportation also requires active support from local governments (Werland & Rudolph, 2023).

Abastante et al. (2014) explain that infrastructure in the transportation sector provides significant social benefits, creating new opportunities for trade, mobility, production, settlement placement, and tourism. The long-term impacts of this infrastructure include changes in income, job creation, and productivity, as well as broader connections between regional and national levels. Various sustainable transportation solutions will be necessary, and each country and region will select a portfolio of solutions based on factors such as cost, energy security, infrastructure, demographics, job creation, and consumer behaviour (Gainsborough, 2012). Investment in sustainable transportation can lead to fuel savings and lower operational costs, as well as reduce congestion and air pollution (Santos, de Abreu, de Assis, Ribeiro, & Ribeiro, 2021). It is estimated that efforts to promote sustainable transportation could save up to USD 70 trillion by 2050. Promoting public transportation, both in terms of quantity and quality, is considered a key strategy in achieving sustainable transportation in line with the concept of smart city growth (Shakibamanesh, Ghorbanian, & Moghadam, 2020).

III. RESEARCH METHODS

Data and Materials

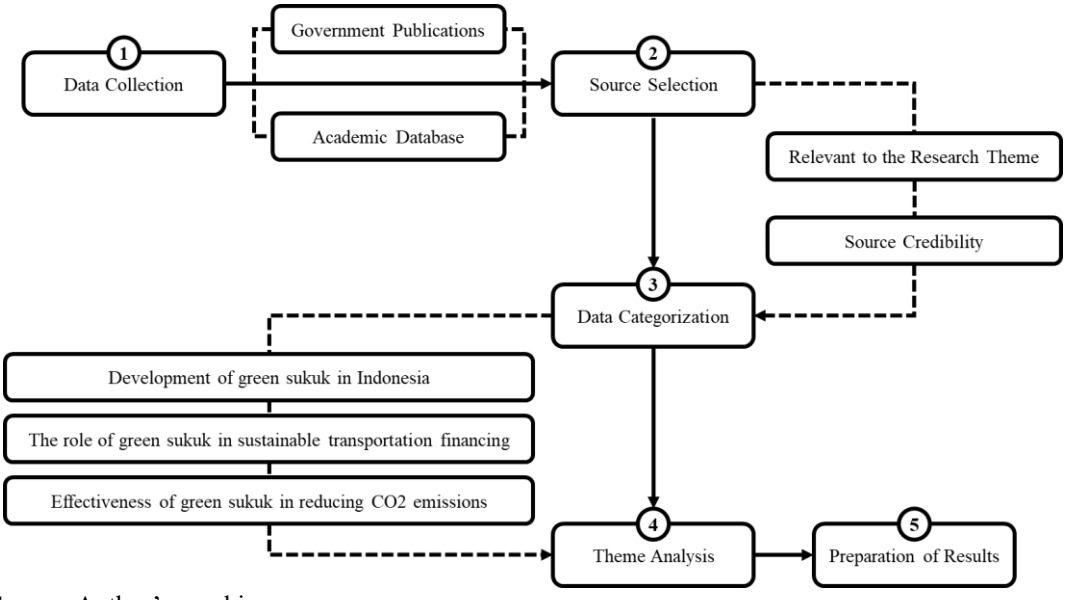
The materials and data used in this study included green sukuk reports issued by the Ministry of Finance of the Republic of Indonesia, government publications related to green sukuk and sustainable transportation, and scientific articles relevant to this theme. Green Sukuk reports provide a comprehensive overview of the allocation and use of funds generated through this financial instrument and its impact on environmentally friendly projects in Indonesia. Furthermore, government publications

provide context for policies and initiatives that promote the development of sustainable transport, which is one of the primary goals for using this instrument. This study will examine the role of green sukuk in reducing CO2 emissions and achieving sustainable development goals, particularly in the transport sector, by combining data from official reports and scientific articles.

Data Analysis Technique

This study uses a qualitative approach with content analysis techniques to examine the contribution of green sukuk to reducing CO2 emissions through the development of sustainable transportation in Indonesia. Content analysis is an empirical and exploratory research method that aims to provide valid predictions and conclusions regarding the phenomenon under study (Krippendorff, 2019). This method was chosen to deeply understand the patterns, themes, and relationships that emerge from various data sources. Thus, this method is able to provide a clear and comprehensive picture of the role of green sukuk in advancing environmentally friendly transportation (Ahmed, Islam, Ariffin, & Amran, 2022). This analysis includes not only visible content but also hidden meanings, nuances, and contexts that require in-depth investigation. Categorisation was undertaken to code material relevant to the research questions, using categories developed through deductive, inductive, or a combination of both approaches (Kuckartz & Rädiker, 2023). The steps in the content analysis are shown in Figure 4.

The author systematically conducted steps in the content analysis of this study to ensure the validity and accuracy of the findings. Data collection began with a search for articles from various sources, including government publications and academic databases, such as Google Scholar, Scopus, and Emerald. The keywords used by the authors in this search were “green sukuk” and “sustainable transport.” The author then selected relevant and high-quality sources. The selection criteria included relevance to the research theme and source credibility. The collected data was then categorised based on recurring themes or issues, such as development of green sukuk in Indonesia, the role of green sukuk in sustainable transportation financing, and effectiveness of green sukuk in reducing CO2 emissions. The author then conducted analyses to extract key themes and understand the context, nuances, and implications of each finding. The analysis results were then compiled into a systematic narrative to illustrate the effectiveness of green sukuk in supporting CO2 emission reduction through sustainable transport financing.



Source: Author’s graphics

Figure 4. Diagram of the Content Analysis Stage

IV. RESULTS AND DISCUSSION

Development of Green Sukuk in Indonesia

In 2018, the Indonesian Government issued the world’s first green sukuk, raising USD 1.25 billion to fund environmentally friendly projects following the established Green Framework. The sukuk issuance attracted global investors, making it the first international green sukuk issued by the

government. This initiative demonstrates Indonesia's commitment to reducing greenhouse gas emissions and supporting environmental sustainability efforts (Ministry of Environment and Forestry of the Republic of Indonesia, 2018). Then, in November 2019, the Indonesian Government began offering Green Sukuk Retail Series ST006, the first instrument issuance. This step reflects the government's commitment to developing the Islamic financial market and supporting efforts to address climate change. Green Sukuk Retail Series ST006 funds will finance environmentally friendly projects in five primary sectors: clean and affordable energy, job creation and economic growth, innovation and industrial infrastructure, sustainable city and community development, and climate change mitigation (Abdurrochim, 2019).

Table 1. Green Sukuk Issued by the Government of Indonesia

Product Name	Publication Year	Allocation (IDR)
Global Green Sukuk	March 2018	19,077,307,282,455
Global Green Sukuk	February 2019	6,481,283,217,398
Retail Green Sukuk (ST-006)	November 2019	5,561,280,630,246
Global Green Sukuk	June 2020	10,863,234,866,036
Retail Green Sukuk (ST-007)	November 2020	5,466,733,076,970
Global Green Sukuk	June 2021	10,961,966,069,613
Retail Green Sukuk (ST-008)	November 2021	5,058,167,934,612
Global Green Sukuk	September 2022	22,809,419,950,547
Retail Green Sukuk (ST-009)	November 2022	15,459,386,588,838

Source: Ministry of Finance of the Republic of Indonesia (Author's Process) (2023)

Based on the data in Table 1, the Indonesian Government's green Sukuk issuance trend from 2018 to 2022 indicates an increase in fund allocation and product diversification. In March 2018, Indonesia launched its first Green Sukuk Global of IDR19,077 trillion, followed by a second issuance in February 2019 of IDR6,481 trillion. In November 2019, the government introduced the Green Sukuk Retail (ST-006) with an allocation of IDR5,561 trillion, which provides an opportunity for retail investors to contribute to financing environmentally friendly projects. The government issued Green Sukuk Global worth IDR10,863 trillion in June 2020 and Green Sukuk Retail (ST-007) worth IDR5,466 trillion in November 2020, despite facing the challenges of the pandemic. In 2021, the government continued demonstrating consistency through the Green Sukuk Global Offering worth IDR10,961 trillion in June and Green Sukuk Retail (ST-008) worth IDR5,058 trillion in November. In 2022, the government issued Green Sukuk Global worth IDR22.809 trillion in September, which was the highest amount since its initial publication, and Green Sukuk Retail (ST-009) worth IDR15.459 trillion in November.

In May 2023, the government issued Sukuk Tabungan ST010 with a 4-year tenure (green sukuk), which was successfully sold for IDR 3.3 trillion. Green sukuk offers the advantage of allowing holders to withdraw funds before maturity through an early redemption facility (Malik, 2023). In December 2023, the Indonesian Government issued the green sukuk series ST011T4 to deepen the domestic financial market and expand the investor base, especially among the retail community. According to the Ministry of Finance of the Republic of Indonesia, the issuance of this retail SBN also aims to encourage a shift from savings to investment patterns (Priyanti, 2023). Then, in November 2023, the Government of Indonesia issued a global green sukuk worth USD 1 billion with a tenure of 10 years, backed by significant state-owned green assets. This issuance demonstrates the government's long-term commitment to supporting sustainable financing and addressing climate change. This is the sixth issuance of global green sukuk, reflecting the government's continued efforts to support green initiatives at the global level (Fitri, 2023).

Then, in May 2024, the Indonesian Government launched Sukuk Tabungan ST012T4 (green sukuk) with a 4-year tenure. By issuing this Retail Green Sukuk, the government shows its commitment to developing the Sharia financial market and contributing to handling climate change (Malik, 2024). Furthermore, in June 2024, the Indonesian Government issued a global green sukuk worth USD 600 million with a 30-year tenure, supported by green assets as underlying (Ministry of Finance of the Republic of Indonesia, 2024b). Indonesia continues to innovate in optimising green sukuk as a sustainable market instrument in the Islamic financial sector. Indonesia's success as the largest green sukuk issuer in the world has received recognition from member countries of the Islamic Development Bank (IsDB). This award was presented at the 50th IsDB Annual Meeting, which raised the theme "Accelerating Climate Finance through Green and Sustainable Sukuk." This initiative shows

Indonesia's commitment to supporting sustainable financing and strengthens the country's position in the international arena in developing environmentally friendly financial instruments (Department of Communications of the Bank Indonesia, 2024).

The Role of Green Sukuk in Sustainable Transportation Financing in Indonesia

Green sukuk allows investors to contribute to sustainable development while adhering to Sharia finance principles (Raimi, Abdur-Rauf, & Ashafa, 2024). In addition to impacting environmental sustainability, green sukuk can improve social welfare (S. M. Billah & Adnan, 2024). The implementation of green sukuk offers a promising solution to address challenges in green financing, combining interconnected economic, environmental, and Islamic principles with unique structural prerequisites (Riaz, Selamat, Nor, & Hassan, 2024). The growth of the green sukuk market has the potential to support environmentally friendly projects, improve public welfare, and help achieve the moral objectives of Islamic finance (Saeed, 2021). As an innovative Shariah-based financial product, green sukuk has become an important component of sustainable finance, providing a positive impact following the principles of Shariah law (Masood, Rahim, & Lee, 2024).

Indonesia's green sukuk is an example of national collaboration in addressing climate change, channelling investment into green sectors through a climate budget tagging mechanism. The green sukuk framework ensures investors channel funds to sectors that have significant climate impacts, such as renewable energy, water management, and sustainable transport (Musari & Hidayat, 2023). This instrument funds various sectors that support sustainability, such as sustainable transportation, climate change resilience, water and wastewater management, renewable energy, energy efficiency, waste-to-energy management, green buildings, and natural resource management (Ministry of Finance Republic of Indonesia, 2023). Between 2018 and 2022, the allocation of green sukuk funds in Indonesia reached IDR 34 trillion, reflecting a significant commitment to projects focused on environmental sustainability (for more details, see Table 2). This green sukuk allocation follows Shariah principles that prioritise benefits and avoid mudharat (Udzma & Faiz, 2024).

Table 2. Allocation of Green Sukuk by Sector (in Billion Rupiah)

Renewable Energy	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**
Renewable Energy	1.526,01	618,93	1.246,74	2.504,91	37,43	5.934,02
Resilience to Climate Change	4.237,15	1.933,23	10.566,0	1.933,23	6.150,43	24.820,1
Energy Efficiency	1.541,39	3.040,80	33,45	-	-	4.615,63
Sustainable Transportation	10.531,9	5.407,21	3.320,02	5.644,67	9.688,32	34.592,1
Waste to Energy Management	1.240,82	1.042,39	1.163,69	913,56	32,70	4.393,16
Sustainable Water and Wastewater	-	-	-	1.698,28	22.256,1	23.954,4
Green Building	-	-	-	109,59	97,49	207,08
Sustainable Natural Resources Management	-	-	-	-	6,30	6,30

Source: Ministry of Finance of the Republic of Indonesia (Author's Process) (2023)

Based on the data in Table 2, the sustainable transportation sector received the largest allocation of funds from green sukuk between 2018 and 2022, with total investment reaching IDR 34,592.17 billion. This makes it one of the sectors with the largest allocations compared to others. The consistent increase in funds, particularly in 2018 and 2022, reflects Indonesia's commitment to supporting the development of environmentally friendly transportation through green sukuk instruments. Green sukuk was developed as an innovative funding instrument to support climate change-related financing and as a key strategy in achieving the Nationally Determined Contribution (NDC) target. With large funding needs, green sukuk is crucial in supporting programs to achieve NDC targets. This mechanism enables Indonesia to reach its NDC target of 29%. Green sukuk is expected to encourage climate finance in Indonesia, reduce dependence on the public sector, and reduce allocations from the state budget (Suroso, Setiawan, Pradono, Iskandar, & Hastari, 2022).

The transformation towards a sustainable transport system includes reducing capacity redundancy and competition between public transport modes, as well as increasing efficiency and connectivity in the transport network (Gautam, De, Dhar, Gupta, & Pandey, 2018). Sustainable transportation plays an important role in sustainable development, as it provides safe and healthy mobility for people, reduces environmental impacts, and conserves non-renewable resources (Chirieleison, Montrone, & Scrucca, 2020). Realising this system requires planning that includes monitoring, evaluation, and assessment of the system and proposed changes (Tomej & Liburd, 2020). In this context, green sukuk play an

important role as a financing instrument that supports the implementation of sustainable transportation projects, including initiatives to reduce carbon emissions and improve energy efficiency. Key interventions needed to improve sustainable transport include improving accessibility and developing pedestrian and cyclist-friendly road networks. Additionally, reducing the distance to public transportation and encouraging the use of active modes such as walking and cycling can create a healthier and more sustainable environment (Nieuwenhuijsen, 2020).

Effectiveness of Green Sukuk in Reducing CO2 Emissions in the Transportation Sector

Over the past few years, the sukuk market has made significant progress in supporting sustainable development by aligning investment policies and practices that not only promote social development but are also environmentally friendly (Boukhatem, 2022). The development of green sukuk emerged in response to growing concerns regarding the environmental and social impacts of business activities, as well as a growing demand for governance and ethics (Liu & Lai, 2021). The effectiveness of green sukuk in supporting sustainable transport in Indonesia is highly visible through the budget allocations directed towards various strategic transport projects over the period 2018-2022 (Table 3). Green sukuk projects in Indonesia focus on the provision, improvement, and maintenance of public transport. These include the construction of dual railway lines, the development of urban rail networks, and land- and sea-based transport initiatives in various regions, including Java, Sumatra, Greater Jakarta, Kalimantan, Sulawesi, Maluku, and Papua. As such, green sukuk can serve as a financial instrument that supports the funding of such projects, thereby accelerating economic development and contributing to the reduction of carbon emissions.

Table 3. Mitigation of Sustainable Transportation Projects 2018-2022 Period

Project	Allocation (IDR)	Mitigation (Tons CO2)	Sosial/ SDGs
Year 2018			
Operation of dual railways in northern Java	1.528.495.127.708	613.434	8, 9, 11, 13
Construction of trans Sumatra railway line	1.344.898.942.236	235.458	8, 9, 11, 13
Development of Greater Jakarta urban train	1.075.441.700.098	856.828	8, 9, 11, 13
Procurement of BRT (Bus Rapid Transit) in all provinces of Indonesia	255.966.202.700	165.704	8, 9, 11, 13
Procurement and installation of ICT-based traffic control system in Kediri and Yogyakarta	10.762.305.000	203.116	9, 11, 13
Development of pioneering sea transportation in DK Jakarta	1.500.012.910.000	5.868	7, 9, 11, 13
Development and management of railway infrastructure in Sumatera	274.377.549.000	206.470	-
Development and management of Railway Infrastructure in Greater Jakarta	4.541.992.313.000	169.004	-
Total	**10.531.947.049.742**	**2.455.882**	**7, 8, 9, 11, 13**
Year 2019			
Railway infrastructure development and management in Sumatra	155.006.799.295	572.324	8, 9, 11, 13
Development and management of railway infrastructure on the Java Line	4.082.935.380.746	179.160	8, 9, 11, 13
Development and management of railway infrastructure in Sumatra	1.014.879.772.000	235.438	8, 9, 11, 13
Development and management of double railway line in northern Java	112.081.354.000	613.434	8, 9, 11, 13
Development of Greater Jakarta Urban Railway	42.307.547.000	856.828	8, 9, 11, 13
Total	**5.407.210.853.041**	**2.457.184**	**8, 9, 11, 13**
Year 2020			
Railway infrastructure development in South Sumatra and West Java	2.532.893.416.136	1.105.492	8, 9, 11, 13
Improvement of railway infrastructure in Jakarta and Central Java	8.952.704.665	851.373	8, 9, 11, 13
Railway network enhancement in Central and East Java	593.748.602.651	-	8, 9, 11, 13
Improvement of railroad network in Java Island	184.422.350.664	564.345	8, 9, 11, 13
Total	**3.320.017.074.116**	**2.521.210**	**8, 9, 11, 13**
Year 2021			
Railway service connectivity in West Sumatra, DK Jakarta, Central Java, and East Java	2.341.211.922.031	1.887.953	8, 9, 11, 13
Development and management of railway infrastructure in Sumatra and Java	651.382.448.487	-	7, 8, 9, 11, 13
Railway transportation infrastructure connectivity in South Sumatra	689.951.315.000	-	7, 8, 9, 11, 13
Development and management of railway infrastructure and supporting facilities in DK Jakarta	1.962.126.674.298	197.565	7, 8, 9, 11, 13
Total	**5.644.672.359.816**	**2.085.518**	**7, 8, 9, 11, 13**
Year 2022			
Railroad infrastructure connectivity in Sumatra, Java, Kalimantan, Sulawesi, Maluku, and Papua	563.661.284.186	-	8, 9, 11, 13
Greater Jakarta transportation infrastructure connectivity	14.352.594.000	242.689	8, 9, 11, 13

Project	Allocation (IDR)	Mitigation (Tons CO2)	Sosial/ SDGs
Railway transportation infrastructure connectivity and development across Java	2.504.452.649.556	710.596	8, 9, 11, 13
Railway transportation infrastructure and service connectivity in West Sumatra and North Sumatra	845.432.416.172	29.455	8, 9, 11, 13
Railway transportation infrastructure connectivity in South Sulawesi	18.074.040.913	-	8, 9, 11, 13
DK Jakarta and Central Java transportation infrastructure connectivity and development	38.244.100.593	1.887.953	8, 9, 11, 13
Railway transportation infrastructure connectivity in South Sulawesi	2.283.483.000	-	8, 9, 11, 13
Improvement of rail transportation services in Central Java	859.234.070	1.790.882	8, 9, 11, 13
Railway transportation infrastructure connectivity in East Java	326.477.356.932	1.293.690	8, 9, 11, 13
Railway infrastructure development and management in Sumatra, DI Yogyakarta, and South Sulawesi	5.374.487.427.244	1.293.690	8, 9, 11, 13
Total	**9.688.324.586.666**	**7.248.955**	**8, 9, 11, 13**

Source: Ministry of Finance of the Republic of Indonesia (Author's Process) (2023)

Based on Table 3, in 2018, the budget allocation for transport projects reached more than IDR10.5 trillion, which contributed to the mitigation of about 2.45 million metric tonnes of CO2. These projects include the operation of a dual railway line in North Java, the development of urban transport in Greater Jakarta, as well as the procurement of bus rapid transit (BRT) across the province. However, in 2019, the government reduced the total budget to IDR5.4 trillion; despite this, the green sukuk still managed to achieve a significant CO2 mitigation impact of approximately 2.45 million metric tonnes of CO2. In 2020, the funding allocation increased again to Rp3.3 trillion, with CO2 mitigation reaching 2.52 million metric tonnes. This year, railway infrastructure development projects in South Sumatra and West Java received attention, highlighting the importance of both regions in a long-term national transportation strategy. Furthermore, in 2021, a budget of IDR5.6 trillion supports transport projects in various regions, with CO2 mitigation reaching 2.08 million metric tonnes. The year 2022 marks the peak of green sukuk's contribution to sustainable transport development, with a budget of IDR9.68 trillion and carbon emission mitigation of 7.24 million metric tonnes of CO2. Funded projects include railway connectivity across Indonesia.

Green sukuk is important in supporting sustainable transport development in Indonesia, particularly in the railway sector. Based on fund allocation and CO2 emission mitigation for sustainable transportation projects between 2018 and 2022, green sukuk has significantly reduced carbon emissions through various railway infrastructure projects. Projects such as the dual railway line in Java, Greater Jakarta urban rail development, and rail network upgrades in Sumatra reduced emissions by 7.2 million metric tonnes of CO2 by 2022. In addition, the Trans Sulawesi railway line and the installation of solar panels at the Pondok Cabe bus terminal were also funded by green sukuk (Perwitasari & Sutana, 2024). This shows that green sukuk support the achievement of SDG 7 and SDG 13 by helping to reduce carbon emissions through sustainable transport projects, which focus on clean energy efficiency and climate change mitigation (Mohd Ma'Sum Billah, 2021; Hasan, 2022; Hori, Takamura, Fujita, & Kanie, 2020). These projects not only support renewable energy but also provide clean mobility solutions, helping policymakers protect the environment (Guarnieri & Lee-Davies, 2023; Olszewski-Strzyżowski, 2022; Palit, Bari, & Karmaker, 2022; Sergi, Popkova, Ostrovskaya, Chursin, & Ragulina, 2024).

The procurement of BRT (Bus Rapid Transit) systems in all Indonesian provinces is an important step toward creating an efficient and sustainable mass transportation system. Additionally, the installation of ICT-based traffic control systems demonstrates the government's commitment to modernizing transportation and minimizing its negative impacts on the environment. These projects have the potential to help reduce congestion and vehicle overcrowding, thereby improving energy efficiency. Beyond their positive impact on efficiency, these projects also have a social impact by improving community accessibility. In line with this, the Ministry of Transportation of the Republic of Indonesia (in Biro Komunikasi dan Informasi Publik, 2021) states that mobility policies in Indonesia are directed toward the concepts of Smart City, Green City, and Sustainable City, which are based on the 2045 Sustainable Development Goals and the 2020-2024 Medium-Term Development Plan (RPJMN). Sustainable transportation includes safety, affordable fares, high accessibility, and low pollution. The application of technologies such as automated vehicles, IoT, machine learning, and big data can improve safety, mobility, and efficiency while reducing congestion and fuel emissions.

These projects also support SDG 9 and SDG 11, which focus on building high-quality and climate-resilient infrastructure and fostering industry and innovation (Costa, 2024; Mantlana & Maoela, 2020;

Umar, Ji, Kirikkaleli, Shahbaz, & Zhou, 2020; Van Zanten & Van Tulder, 2021). Projects such as Indonesia's dual railway lines and urban transport are examples of efforts to improve transport infrastructure. This infrastructure not only improves mobility efficiency but also supports technological innovation. Mass transport projects such as urban railways in Greater Jakarta and Bus Rapid Transit (BRT) in various provinces are important in creating more environmentally friendly cities. In addition, ICT-based traffic control systems can also play a role in reducing congestion and improving energy efficiency (Chung, Wang, & Lin, 2023; Department of Economic and Social Affairs, 2023). In addition, green sukuk issuance supports SDG 8 through sustainable transport infrastructure development projects that can improve connectivity between regions, promoting inclusive economic growth. Investments in public transport provide significant economic benefits by strengthening social connectivity, which is important for people's well-being (Mittal, Yabe, Ukkusuri, & Arroyo, 2023; Ramutsindela & Mickler, 2020).

V. CONCLUSION

Green sukuk has proven to be an effective financial instrument to fund sustainable transportation projects in Indonesia. From 2018 to 2022, funds allocated through green sukuk have made a significant contribution to reducing CO2 emissions and developing environmentally friendly transportation infrastructure. Projects such as the operation of dual railway lines and the development of urban trains in Greater Jakarta have reduced carbon emissions by millions of tons. Additionally, green sukuk supports SDGs, such as increasing accessibility, creating jobs, and encouraging local economic growth. Government support for the Smart City and Green City concepts further strengthens the potential of green sukuk in creating a more sustainable transportation system. Moreover, green sukuk not only focuses on environmental aspects but also pays attention to the social welfare of the community. With the right financing, funded transportation projects can improve mobility and reduce congestion in urban areas. The existence of green sukuk also creates attractive investment opportunities for various parties, including local and international investors who care about sustainability.

Using green sukuk as a funding instrument for sustainable transportation projects in Indonesia has significant policy implications. First, the government needs to support the development and issuing of green sukuk by strengthening regulations and incentivising investors. For example, tax incentives can encourage greater participation from the private sector. Furthermore, integrating Smart City and Green City concepts in project planning should be a priority. Policies should also focus on social sustainability to ensure that projects benefit the community. Efforts to raise awareness about green sukuk among local and international investors are also needed. Collaboration between the government, private sector, and civil society can strengthen the implementation of projects funded by green sukuk. In addition, continuous monitoring and evaluation should be conducted to assess the environmental and social impacts of the projects. Increased transparency in using Sukuk funds is also critical to building public trust in managing these funds. With a comprehensive approach, green sukuk can effectively achieve SDGs and improve transportation infrastructure in Indonesia.

This study has several limitations that need to be noted. First, the data used in the analysis may not include all transportation projects financed by green sukuk, so the results may not fully reflect the overall impact of this instrument. Second, this study focuses more on the environmental and social aspects, while the economic impact of these projects still needs to be explored in greater depth. Additionally, this study is limited to 2018 to 2022, so the dynamics cannot be analysed after that period. Finally, other external factors, such as government policies and market conditions, influence the results obtained but were not analysed in depth in this study. For future research, conducting a more comprehensive analysis by covering more projects and a longer time frame is recommended. Researchers should also explore the economic impact of projects funded by green sukuk to provide a more complete picture of the benefits. Furthermore, it is important to consider external factors that may affect the effectiveness of green sukuk, such as government policies and global economic conditions.

AUTHOR CONTRIBUTIONS

Conceptualization, H.Z.M. and A.W.; methodology, H.Z.M. and A.W.; software, H.Z.M.; validation, H.Z.M.; formal analysis, H.Z.M.; investigation, H.Z.M.; resources, H.Z.M.; data curation, H.Z.M.;

writing – original draft preparation, H.Z.M.; writing – review and editing, H.Z.M.; visualization, H.Z.M.; supervision, A.W.

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INFORMED CONSENT STATEMENT

Not applicable.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author, [M.Z.H].

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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