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Driving factors for the adoption of green finance in green building for sustainable development in developing countries: The case of Ghana

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Abstract

While there are many motivating factors for green finance (GF) implementation, a *comprehensive taxonomy* of these variables is lacking in the literature, especially for green buildings (GBs). This study aims to analyze the criticality and interdependence of GF-in-GB's driving factors. This study develops a valid set of factors to justify the interrelationships among the drivers. The drivers of GF-in-GB are qualitative in nature, and uncertainties exist among them due to linguistic preferences. This study applies the fuzzy Delphi method to validate eight drivers under uncertainties. Fuzzy Decision-Making Trial and Evaluation Laboratory (FDEMATEL) with qualitative information is used to determine the interrelationships among the drivers. The drivers were grouped under two categories: prominent drivers and cause-effect drivers. The findings revealed that "increased awareness of GF models in GB" and "preferential capital requirements for low-carbon assets" are the top two most prominent/important drivers of GF-in-GB. In Ghana, the top three cause group drivers are "climate commitment," "improved access to and lower cost of capital," and "favorable macroeconomic conditions and investment returns." Drivers with the highest prominence values have the potential to affect and/or be affected by other drivers; therefore, managers and policymakers should prioritize promoting or pursuing these drivers in the short term. On the other hand, it is important to pay more than equal attention to the drivers with the highest net cause values because they have the largest long-term impact on the entire system. The theoretical and practical implications of the study are discussed, enhancing understanding and decision-making in GF-in-GB.

KEYWORDS
drivers, fuzzy Delphi method, fuzzy DEMATEL, green building, green finance, sustainable development

1 | INTRODUCTION

The impact of buildings and construction on the climate is critical to the global discourse on climate change and sustainable development. The latest *Global Status Report for Buildings and Construction* (UNEP, 2022) reveals that the industry accounts for the highest share of global energy consumption and carbon emissions. These have negatively contributed to the well-being and health of people in diverse ways (Darko et al., 2023). Other negative impacts of construction include excessive noise and waste generation, leading to environmental pollution (Zhang et al., 2018). Green building (GB) is perhaps the most important current issue in the construction industry, because of its ability to address the negative impacts of buildings and construction on people and the environment.

GB is defined by the World Green Building Council (WorldGBC, 2022) as "a building project that, in its design, construction or operation, reduces or eliminates negative impacts and can create positive impacts on our climate and natural environment. It can preserve precious natural resources and improve our quality of life." Over a decade of research and practice has revealed that GB benefits include lower operating costs, increased comfort, health and productivity, enhanced corporate reputation, increased market value, and positive environmental externalities (Darko et al., 2017; Dwaikat & Ali, 2016; Zhang et al., 2018). Despite these benefits, GB adoption remains low, particularly in developing countries (Darko & Chan, 2017). High investment costs and inadequate capital or green finance (GF) are critical cost barriers that affect GB adoption in the construction industry (Darko & Chan, 2017; Debrah, Chan, & Darko, 2022b; WorldGBC, 2021). However, emerging evidence suggests that GF can address the cost barriers that limit GB development (Debrah et al., 2023; Debrah, Chan, & Darko, 2022a, 2022b; Debrah, Darko, et al., 2022). *The International Capital Market Association* (ICMA) describes GF as a finance mechanism that is "broader than *climate finance* in that it also addresses other environmental objectives such as natural resource conservation, biodiversity conservation, and pollution prevention and control." *Climate finance* refers to "financing that supports the transition to a climate resilient economy by enabling mitigation actions, especially the reduction of greenhouse gas emissions, and adaptation initiatives promoting the climate resilience of infrastructure as well as generally of social and economic assets" (ICMA, 2020).

In the present study, GF-in-GB is therefore defined as "a financial instrument that supports GBs and climate-resilient infrastructure development as a means of protecting the environment through emission reductions, reduced energy use, and reduced material use to create positive impacts on the climate." It includes products such as climate-certified bonds or green bonds linked to GB, green commercial building loans, green construction loans, green insurance, green mortgages, green credit, and green securitization for GB (Gholipour et al., 2022; IFC, 2019; Noh, 2019). According to the Climate Bonds Initiative (CBI, 2022), GF-in-GB represents the second largest use of proceeds after energy investments. However, GF-in-GB is not free of barriers and difficulties. Barriers such as split incentives, inadequate private investment, inadequate management support, and inadequate green projects limits its use (Agyekum et al., 2021; Akomea-Frimpong et al., 2022; Debrah, Chan, & Darko, 2022b; Zhang et al., 2020). In this light, several factors have been identified to influence and drive the adoption and implementation of GF-in-GB in different countries and regions. Emerging research on the drivers of GF-in-GB remains nascent, with limited studies in developing countries. Recent reviews (Akomea-Frimpong et al., 2022; Debrah, Chan, & Darko, 2022b) indicate that very few studies have attempted to analyze the factors driving GF-in-GB, particularly in developing countries. In most cases, available studies identify and rank drivers without considering the interrelationship between them. It is important to note that various drivers of GF-in-GB, albeit, having varying degrees of criticality, do not act in isolation but rather establish complex interrelationships that shape the acceptance and implementation of GF. Without examining the interrelationships between these factors, if not impossible, it will be difficult to zero in on the most crucial ones and devise effective plans for putting GF into action.

Considering the above, the objective of this study is to identify the critical drivers of GF-in-GB and to model the interrelationship between drivers using multi-criteria decision-making (MCDM) techniques with reference to the developing country of Ghana. Although GB development has grown over time, it still accounts for a small portion of the total building stock in both developing and developed countries (UNEP, 2021). Notably, little evidence is available for developing countries, particularly sub-Saharan African countries, amidst affordable housing challenges (Agyekum et al., 2019; Akinwande & Hui, 2023). In Ghana, GB is still viewed as a novel concept and development. Little research has been conducted on this subject. Certified GBs in Ghana represent approximately 1% of all new construction projects by 2020 (IFC EDGE, 2020). Additionally, the construction industry in Ghana is highly informal, with government support available to just the formal sector in the form of subsidized land and tax breaks (UN-Habitat, 2011). The main financing mechanisms for housing facilities in the country are personal savings, windfall gains, and family loans. The lack of bank or financial institution participation in the housing supply process is a major obstacle to housing development in Ghana (UN-Habitat, 2011). The financing avenues and challenges identified in the country do not align with GB goals to achieve sustainability in the built environment sector.

To overcome the financing challenges of sustainable development, GF has emerged and is increasing, especially in developed countries (Dong et al., 2024). However, only a few developing countries are taking advantage of this innovation. For instance, the African Development Bank (2022) estimates an annual climate finance gap of US$1288.20 billion from 2020 to 2030 within African countries. The Government of Ghana estimates that US$3558 million is required to finance its citywide resilient housing development (IFC, 2022). Yet, the government is yet to explore how GF products, such as green bonds, can fund the country's housing and infrastructure deficits. To date, there have been no green bonds, whether sovereign or corporate, in Ghana (FSD Africa, 2021). So far, evidence of GF products, such as green bonds, is seen in a few countries on the continent

(Mutarindwa & Stephan, 2022; Taghizadeh-Hesary et al., 2022). In addition, limited research and development exists on GF in Ghana, particularly in the building sector (Agyekum et al., 2021, 2021). To promote sustainable financing of GBs in developing countries and bridge the gaps outlined above, this study aims to identify and prioritize the critical driving factors of GF-in-GB using Ghana as a case study. The Ghanaian case was selected because it presents some specificities and commonalities with other emerging and developing economies. Hence, MCDM methods are applied to identify the dependence relations between the drivers of GF-in-GB, which are currently lacking in the literature.

The application of MCDM techniques has the capacity to analyze complicated interdependencies among factors. Traditional survey methods often rely on the additive concept and the assumption of independence, but it is not always the case that each criterion is completely independent (Wu, 2008). Several MDCM techniques have been proposed in the literature for addressing the interactions among elements, as these techniques can effectively analyze complex interdependencies that are often overlooked in studies that rely solely on surveys and interviews (Agyekum et al., 2021; Tan, 2019; Zhang et al., 2020). Previous studies have employed MCDM techniques to analyze barriers to blockchain-based lifecycle assessment (Farooque et al., 2020), prioritize key success factors of hospital service quality (Shieh et al., 2010), select management systems (Tsai & Chou, 2009), and evaluate e-learning programs (Tzeng et al., 2007). Common MCDM techniques include DEMATEL, analytical network process (ANP), analytical hierarchy process (AHP), and interpretive structural modeling (ISM) (Farooque et al., 2020;Khoshnava et al., 2018; Tsai & Chou, 2009). These MCDM techniques can effectively handle complex and interrelated problems with uncertainties by converting qualitative assessments into quantitative values (Khoshnava et al., 2018; Tsai & Chou, 2009). Based on a recent comparison of the widely used MCDM methods, DEMATEL outperformed AHP, ANP and ISM in terms of effectiveness (Farooque et al., 2020). The DEMATEL is more advantageous because it provides the degree of influence of the factors and uses heterogeneous factors for analysis (Alam-Tabriz et al., 2014). DEMATEL is proficient in quantifying the strength of direct and indirect linkages between factors and illustrating causal connections through impact-relationship diagrams (Kumar & Dixit, 2018). Therefore, DEMATEL was deemed more appropriate for this study. To overcome biases and fuzziness in man-made decisions, fuzzy set theory was used to extend the DEMATEL approach (Negash et al., 2021). Hence, this study applies the fuzzy Delphi-DEMATEL approach to evaluate the cause-effect relationships among the drivers of GF-in-GB, which are assumed to be interdependent in nature.

Specifically, this study addressed the following research questions:

1. What are the critical drivers of GF-in-GB?
2. What are the cause-and-effect relationships between the drivers of GF-in-GB using MCDM techniques: the fuzzy Delphi method (FDM) and the fuzzy Decision-Making Trial and Evaluation Laboratory (FDEMATEL) method?

This study is important because it is the foremost to evaluate the interrelationship between the drivers of GF-in-GB using MCDM techniques. This study makes novel contributions by identifying important drivers based on the extant literature via expert inputs using FDM. It further applies the FDEMATEL method to prioritize the important and cause-effect drivers. The identification and prioritization of drivers using the hybrid method provides a systematic way to analyze how to promote the most influential drivers. In addition, given the limited number of studies examining GF-in-GB in developing countries, the empirical findings add significantly to the existing GB and GF literature. Moreover, this study improves the understanding of the relevant drivers of GF-in-GB adoption and the interrelationships between them, which is necessary for guiding decision-making regarding GF-in-GB adoption by industrial practitioners and other stakeholders. The findings will also help policymakers and advocates focus on and allocate resources to the most influential drivers that can be widely promoted to encourage the widespread adoption of GF-in-GB to meet targets in nationally determined contributions and ultimately achieve sustainable development goals.

The remainder of this paper is organized as follows: Section 2 reviews the relevant literature and theoretical background of the study. Section 3 explains the research methodology and data collection procedure. Section 4 presents the results, analysis, and findings. Section 5 provides a discussion of the results and findings. The final section concludes the study by highlighting the conclusion, implications and limitations of the research.

2 | THEORETICAL BACKGROUND AND LITERATURE REVIEW

2.1 | The concept and theory of green finance

Previous research has demonstrated that GF is a powerful tool for promoting environmental conservation and economic growth. It is a product of combining the qualities of both "green" and "finance." Unlike conventional finance, GF prioritizes environmental concerns and views environmental protection and resource efficiency as essential indicators of its success (Lv et al., 2021). Consequently, GF has gained increasing recognition globally. GF is not only a market mechanism design but also an institutional arrangement based on medium- and long-term sustainable development (Huang et al., 2022). It supports the policy of green innovation, such as GB, by promoting the implementation of green credit, green bonds, green funds, green insurance and other financial instruments (Debrah, Chan, & Darko, 2022a; Debrah, Chan, & Darko, 2022b). It covers a range of instruments, from private loans to insurance, and includes equity, derivatives, and fiscal and investment funds (Taghizadeh-Hesary et al., 2021). GF, therefore, seeks to promote the integration of environmental sustainability into various aspects of financial decision-making, including private sector investments and market-driven initiatives, rather than relying solely on public funding and interventions. Hence, it actively broadens the financing channels of green industry funds, develops a diversified structure of investments with joint participation of private capital, pension funds, financial institutions, foreign capital, and government funds, and creates suitable incentive mechanisms for the development of green funds (Huang et al., 2022).

Using *stakeholder and institutional theories*, this study visualizes the role of GF in stimulating GB development within the context of developing countries. These theories have been adopted in previous studies to explain the role in GF in promoting sustainable development across sectors (Christensen et al., 2021; Kawabata, 2019). *Stakeholder theory* suggests that "managers of firms have obligations to some set of stakeholders" (Freeman, 2015). Stakeholders are groups or individuals that affect or are affected by an organization. Generally, they include *primary stakeholders* (customers, financiers—stockholders and creditors—, suppliers, employees and local communities) and *secondary stakeholders* (political groups, governments, media, competitors, consumer advocate groups, and special interest groups). The theory suggests that organizations must be managed in the interest of all stakeholders to maximize shareholder wealth (Freeman, 2015; UNEP, 2015). Organizations are now more concerned about the negative impacts of their activities on the environment and society. More intentional efforts have been devised to address and/or correct such unintended implications by adopting a sustainability mindset in operations and activities. This has led to redefining, re-describing, and reinterpreting stakeholder interests to satisfy or create more value for both primary and secondary stakeholders through sustainability principles. Schaltegger et al. (2019) describe this as "stakeholder business cases for sustainability." The purpose of a stakeholder business case for sustainability is to create value (not only economic value) for a larger group of stakeholders by solving sustainability problems such as the GHG effect, housing affordability, land degradation, and so on. Therefore, companies in the GB sector, for example, contribute to the solution of a sustainability-related problem (climate change) and consequently create manifold benefits for their stakeholders. GF firms supporting GB firms act as agents to support climate change mitigation and adaptation actions in the buildings and construction industry. The benefits created include orders for their green suppliers, long- and short-term profits for investors, creating greener jobs, thereby reducing unemployment, reducing the negative impacts of buildings and construction on the environment and society, creating taxes for the state, and perhaps most obviously, providing an option for customers who are willing to pay for GBs. Ultimately, GB and GF firms solve environmental and social problems simultaneously. Additionally, employee awareness and management-level engagement in climate-change-related decision-making are associated with higher levels of GF engagement (Kawabata, 2019). This indicates the importance of stakeholder engagement in climate change-related issues and financing.

On the other hand, *institutional theory* considers how various groups and organizations better secure their positions and legitimacy by conforming to the rules (such as regulatory structures, governmental agencies, laws, courts, professions, scripts, and other societal and cultural practices that exert conformance and pressures) and norms of their institutional environment (DiMaggio & Powell, 1983; Scott, 2008). It is concerned with regulatory, social, and cultural influences that promote the survival and legitimacy of an organization, rather than solely on efficiency-seeking behavior (Roy, 1999). *Institutions*, in this context, refers to the formal rule sets, ex ante agreements, less formal shared interaction sequences, and taken-for-granted assumptions that organizations and individuals are expected to follow (Bruton et al., 2010). Here, *legitimacy* refers to the adoption of proper and acceptable sustainable practices as perceived by stakeholders (DiMaggio & Powell, 1983). Institutional theory has been used to explain how changes in social values, technological advancements, and regulations affect decisions regarding "green" sustainable activities (Ball & Craig, 2010).

Hence, this study adapted the *stakeholder and institutional theories* to explain the drivers of GF-in-GB.

2.2 | Literature review and methodological gaps

An increasing body of literature and influential works exist on GF. However, research on GF-in-GB is limited (Debrah, Chan, & Darko, 2022b). Yet, the severity of buildings and construction carbon emissions presents a strong background for continuous research on financing decarbonization within the built environment sector. Hence, conceptualizing previous studies, especially within developing countries, related to GF and GB is critical to advance scholarship in the field. The current section aims to enhance understanding of GF-in-GB through a comprehensive literature review and to identify the existing literature and methodological gaps undergirding this study.

Studies from the United Kingdom, United States, Canada Hong Kong, and Denmark reveals that GF is the best financial approach for reducing carbon emissions (Saeed Meo & Karim, 2022). This reveals that GF is a potent mechanism to decarbonize buildings and construction. Gholipour et al. (2022) argue that GB finance is key to achieving the sustainable development goals and the Paris Agreement Accord related to the buildings and construction sector. In addition, there is evidence that GF has a significant promotion effect on GB development (Debrah, Chan, & Darko, 2022b; He et al., 2022). Hence, it is important to study the factors driving GF-in-GB. This is because for GF-in-GB to be effective, what is required are country-specific government policies and instruments (Rocca et al., 2012). Besides, knowledge of the critical country-specific drivers necessary to drive GF growth in the buildings and construction sector is key. Such insights will enhance the understanding of stakeholders such as GB developers, green banks, GF issuers, and investors on the key determinants of GF-in-GB for further development and growth.

The researchers conducted a comprehensive literature review of the works at the intersection of the "drivers" of "green *finance*" and "green building." A literature review is useful for identifying and evaluating the current understanding and gaps in knowledge of specific topics within a particular field in order to expand the body of knowledge. Unlike traditional reviews, comprehensive literature reviews follow a replicable, scientific, and transparent process to minimize bias during searching, identification, appraisal, synthesis, analysis, and summary of studies. It uses unambiguous and systematic procedures to provide reliable findings and conclusions (Adabre & Chan, 2018; Darko & Chan, 2017). A query was made in the Scopus and Web of Science databases using the keywords: "green building," "sustainable building," "green construction," "sustainable construction," "green finance," "climate finance," "sustainable finance," "carbon finance," "green bonds," "drivers," and "motivations." With document type "article or review" and under the "title/abstract/keyword" section of Scopus, an initial search was conducted with no time limitations on articles published. The initial search resulted in the identification of a total of 46 articles (searched on 4 January 2023). A similar search conducted in the Web of Science returned 27 articles. However, not all the initially identified articles presented studies on drivers of GF-in-GB. Some just happen to have some of the search keywords in their title or abstract, or keywords. Hence, a brief review of the abstracts, and in some cases, where the abstracts do not provide sufficient information, the contents of the initially identified articles, was therefore conducted. After filtering, 15 articles were found to be relevant and considered valid for further analysis. Three more publications were found using Google Scholar and a snowball search of references. However, the above keywords were not intended to be exhaustive but to overcome the challenge of obtaining a workable number of relevant papers for this research (Debrah, Chan, & Darko, 2022b). Further full-text screening revealed that only 12 publications focused on the drivers of GF-in-GB (Agyekum et al., 2021; Akomea-Frimpong et al., 2022; An & Pivo, 2020; Christensen et al., 2021; Debrah, Chan, & Darko, 2022b; He et al., 2022; Kim et al., 2022; MacAskill et al., 2021; Tan, 2019; Wang et al., 2021; Wang & Wen, 2022; Zhang et al., 2020). The few identified papers, both empirical and conceptual, show that the research topic is at a nascent stage. This is evident in recent literature reviews on the subject (Akomea-Frimpong et al., 2022; Debrah, Chan, & Darko, 2022b).

Zhang et al.'s (2020) study focused on barriers to unlocking GF for building energy retrofits in western China based on surveys and interview. Using a similar approach, Agyekum et al. (2021) investigated key drivers for GB project financing in Ghana. Other studies revealed that GF is an influencing factor in GB development in China (He et al., 2022; Wang et al., 2021), Australia (MacAskill et al., 2021), and South Korea (Kim et al., 2022). Other studies focused on the impact of GB loans on default risk and loan terms (An & Pivo, 2020), institutional investor motivation, processes, and expectations for GF-in-GB (Christensen et al., 2021), benefits and risks of GF-in-GB (Wang & Wen, 2022), and quantifying the returns on GF-in-GB (-Tan, 2019). While the identified studies make substantial contributions, it is noteworthy that further research on the interrelationships of the driving factors of GF-in-GB would enhance the understanding of GF development within the built environment sector. Additionally, key studies on drivers of GB finance were surveys and interviews (Agyekum et al., 2021; Christensen et al., 2021; Zhang et al., 2020). Hence, the methodological novelty in evaluating the interrelationships and impacts of the identified drivers is missing in previous studies.

Various MCDM techniques have been used in several studies to assess the interactions between factors. For example, to analyze barriers to blockchain-based life cycle assessment (Farooque et al., 2020), key success factors of hospital service quality (Shieh et al., 2010), selecting management systems (Tsai & Chou, 2009), and evaluating e-learning programs (Tzeng et al., 2007), among others. Commonly used MCDM techniques include DEMATEL, ANP, AHP, and ISM (Farooque et al., 2020; Khoshnava et al., 2018; Tsai & Chou, 2009). They can resolve complicated and interrelated problems under uncertainty by transforming qualitative judgments into quantitative values (Khoshnava et al., 2018; Tsai & Chou, 2009).

Despite the benefits of MCDM techniques, their application in resolving GF issues, particularly in GBs, is low. Previous studies employed surveys, interviews, case studies, and econometric models (Debrah, Chan, & Darko, 2022b; Utomo et al., 2023). Descriptive and statistical analyses of surveys have been used to assess the drivers of GF-in-GB in China (Tan, 2019; Zhang et al., 2020) and Ghana (Agyekum et al., 2021). Other studies applied an artificial intelligence method to determine the influencing factors of China's GB development (Wang et al., 2021). Evolutionary game analysis has been applied to evaluate the factors affecting the application of green loans to green retrofits in South Korea (Kim et al., 2022). Some studies involve content analysis of interviews (Christensen et al., 2021) and time-series econometric models (An & Pivo, 2020; He et al., 2022; MacAskill et al., 2021).

While different methods have been used to identify factors that drive GF-in-GB, the interrelationships between drivers have not been considered in previous studies. As noted, MCDM techniques can analyze complicated interdependencies among factors. A comparative analysis of the widely used MCDM techniques revealed that DEMATEL is superior to ISM and AHP (Farooque et al., 2020). To overcome biases and fuzziness in man-made decisions, fuzzy set theory was used to extend the DEMATEL approach (Negash et al., 2021). Hence, this study applies the fuzzy Delphi-DEMATEL approach to evaluate the cause-effect relationships among the drivers of GF-in-GB, which are assumed to be interdependent in nature. This incorporates pairwise comparison datasets and calculates the degree of influence of the driving factors.

The following literature review focuses on the drivers of GF-in-GB.

2.2.1 | Drivers of green finance

Recent literature reviews identified 10 (Debrah, Chan, & Darko, 2022b) and 27 (Akomea-Frimpong et al., 2022) generic drivers influencing GF-in-GB projects. Based on this list, the researchers shortlisted the 20 most relevant drivers for adopting GF-in-GB in Ghana.

In the process of shortlisting the drivers, the researchers conducted interviews with two experts with at least 10 years of work or academic experience in GB finance. They were asked to comment on the suitability of the drivers, in addition to suggesting other relevant drivers. It was found that, while some drivers were dependent on others, it was necessary to combine others that appeared ambiguous

TABLE 1 Drivers of GF-in-GB.

Category	Criteria (drivers)		Description	References
Regulatory drivers	DC1	Government participation and support for GF	Credit enhancement available from multilaterals or government-related entities; government-issued bonds	Akomea-Frimpong et al., 2022; Sangiorgi & Schopohl, 2021
	DC2	Regulatory incentives for GF	Tax incentives, subsidies, exemptions, price support	Murovec et al., 2012; Ragosa & Warren, 2019
	DC3	Mandatory legislation, standards and climate-relative financial disclosures	Using or developing mandatory green standards and legislation (e.g., the EU Task Force Climate-related Financial Disclosures [TCFD])	Agyekum et al., 2021; Sangiorgi & Schopohl, 2021
Financial drivers	DC4	Favorable macroeconomic conditions and investment returns	Sound financial system conducive to low interest rates; better financial returns or incentives.	Agliardi & Agliardi, 2021; Agyekum et al., 2021; Keeley & Matsumoto, 2018; Mielke, 2019; Prajapati et al., 2021; Sangiorgi & Schopohl, 2021; Tolliver et al., 2020
	DC5	Improved access to and lower cost of capital	Broadened investor base or attracting more investors.	Eyraud et al., 2013; Falsen & Johansson, 2015; Keeley & Matsumoto, 2018; Prajapati et al., 2021
	DC6	Reduced business and financial risk	Reduces overall portfolio risk	Krueger et al., 2020; Maltais & Nykvist, 2020
	DC7	Reasonable maturity/investment period	Long-term investment opportunity/ maturity period	Akomea-Frimpong et al., 2022; Eccles et al., 2017; Prajapati et al., 2021
	DC8	Preferential capital requirements for low-carbon assets	Penalizing capital requirements for high-carbon assets (e.g., carbon pricing, higher prices for unsustainable energy forms and non-GB)	Sangiorgi & Schopohl, 2021
Organizational drivers	DC9	Improve corporate branding or reputation	Protection of investors' reputation; preventing damage to or improve corporate reputation	Agyekum et al., 2021; Krueger et al., 2020; Maltais & Nykvist, 2020
	DC10	Institutional/peer pressure	External pressure from peers and large (and presumably powerful) institutions or early adopters; pressure from stakeholders or consumers	Contreras et al., 2019; Ming et al., 2015
	DC11	Management commitment	Support and commitment by internal stakeholders or senior management	Abdullah & Keshminder, 2020; Kawabata, 2019
	DC12	Positive fundamentals or green credentials of issuer/developer	Satisfactory credentials or green labels and their impact at issuance and post issuance; external reviews; impact reporting	Barua & Chiesa, 2019; Chiesa & Barua, 2019; Hyun et al., 2020; Mielke, 2019; Sangiorgi & Schopohl, 2021
Environmental and social drivers	DC13	Ecological and corporate social responsibility	Conservation of resources; promoting social good beyond firm's benefits and not mandated by law	Abdullah & Keshminder, 2020; Agyekum et al., 2021
	DC14	Climate commitment	Climate commitments such as the SDGs and Paris Agreement	Tolliver et al., 2019, 2020
	DC15	Promotion of responsible and ethical investment	Incorporating environmental, social and governance (ESG) factors when making investment decisions	Agyekum et al., 2021; Gutsche et al., 2020; Gutsche & Ziegler, 2019; Singh et al., 2020; Zerbib, 2019

(Continues)

TABLE 1 (Continued)

Category	Criteria (drivers)		Description	References
			rather than purely relying financial considerations	
	DC16	Increased awareness of GF models in GB	Awareness creation of/media influence on GF-in-GB	Bae et al., 2021; Gutsche et al., 2021; Gutsche & Ziegler, 2019; Prajapati et al., 2021

and were likely to cause misunderstanding or were less relevant to the Ghanaian context. As a result, minor revisions were made to the identified drivers list (Akomea-Frimpong et al., 2022; Debrah, Chan, & Darko, 2022b) and others were combined to improve clarity and ensure content validity (Farooque et al., 2020). Consequently, a final list of 16 drivers (Table 1) was confirmed to be relevant to GF-in-GB in Ghana. The categorization of the drivers explained below is based on common groups of drivers (Rakhshan et al., 2020) and previous studies (Keeley & Matsumoto, 2018; Maltais & Nykvist, 2020).

2.2.2 | Regulatory drivers

This category focuses on the influence of institutional arrangements, regulations, and government policies on GF growth. Three drivers were included: government participation and support for GF; regulatory incentives for GF; and mandatory legislation, standards and climate-relative financial disclosures. Regulatory incentive policies, such as tax incentives, subsidies, exemptions, and price support, are strong drivers of GF (Murovec et al., 2012; Ragosa & Warren, 2019). These regulatory requirements have been informed by climate commitments, such as the Paris Agreement and the UN-SDGs, which are also unique drivers of GF (Tolliver et al., 2019, 2020). To meet these climate goals, several governments have introduced penalizing capital requirements for high-carbon assets and preferential capital treatment for low-carbon assets (Sangiorgi & Schopohl, 2021). Mandatory climate-relative financial disclosures, bonds included in indices, GF certification, and international credit ratings that integrate environmental risk analysis are known GF drivers (Sangiorgi & Schopohl, 2021). Additionally, the new markets created by GF (Maltais & Nykvist, 2020), together with the availability of full/partial investment guarantees (Sangiorgi & Schopohl, 2021), have also been noted as GF drivers. These guarantees include partial/full credit guarantees, debt repayments to investors, insurance equity to investors, and so on.

2.2.3 | Economic/financial drivers

From the reviewed studies, it was observed that financial motives largely influence GF growth. Five economic drivers are shortlisted: favorable macroeconomic conditions and investment returns, improved access to and lower cost of capital, reduced business and financial risk, reasonable maturity/ investment period, and preferential capital requirement for low-carbon assets. First, macroeconomic drivers behind conventional capital market growth, such as stock market capitalization (Tolliver et al., 2020), exchange rate stability and currency risk (Keeley & Matsumoto, 2018; Sangiorgi & Schopohl, 2021), liquidity/issue size (Barua & Chiesa, 2019; Sangiorgi & Schopohl, 2021), and credit rating constraints (Prajapati et al., 2021; Sangiorgi & Schopohl, 2021), drive GF growth. Again, the literature shows that GF investors are motivated by higher returns on investment (Agyekum et al., 2021; Mielke, 2019). This is because climate considerations improve investment returns (Krueger et al., 2020; Maltais & Nykvist, 2020). For instance, research shows that GF has *a negative premium* or *greenium*, the yield difference between a conventional bond and a green bond with the same characteristics. This is regarded favorably by issuers because it can lower their funding costs, while investors will receive slightly lower yields than existing similar bonds (Agliardi & Agliardi, 2021). Other financial drivers, such as reduced business and financial risks (Krueger et al., 2020; Maltais & Nykvist, 2020), lower interest rate (Eyraud et al., 2013; Prajapati et al., 2021), and market competition (Christensen et al., 2021), also contribute to higher investment returns. This, therefore, broadens the investor base (Maltais & Nykvist, 2020) by improving access to capital for GF (Falsen & Johansson, 2015; Keeley & Matsumoto, 2018). Lastly, the long-term investment or maturity of GF further drives growth. Therefore, GF helps foster a long-term investment mindset (Eccles et al., 2017).

2.2.4 | Organizational drivers

Organizations play a critical role in the global sustainability agenda. Darko and Chan (2017) stressed the importance of understanding the intrinsic organizational drivers that promote sustainability in business. Four drivers were identified under this category: improve corporate branding/reputation; institutional/peer pressure; management commitment; and positive fundamentals or green credentials of issuers/ developers. These drivers are seen as internal organizational actions that promote GF initiatives. Research has shown that institutional/ peer pressure (Contreras et al., 2019; Ming et al., 2015) are more effective in stimulating the implementation of GF initiatives (Hoppmann et al., 2018). Other factors, such as management commitment to GF (Abdullah & Keshminder, 2020; Kawabata, 2019), are critical to improving corporate branding or reputation (Krueger et al., 2020; Maltais & Nykvist, 2020). Moreover, issuer or sector constraints have driven organizations to finance green projects. The viability of green projects/assets (Russo et al., 2021; Sangiorgi & Schopohl, 2021) and the positive fundamentals or green credentials of bond issuers (Barua & Chiesa, 2019; Chiesa & Barua, 2019) play key roles. Such assessments are usually obtained through external reviews (Hyun et al., 2020; Sangiorgi & Schopohl, 2021) or available impact reporting (Mielke, 2019; Sangiorgi & Schopohl, 2021). Hence, an organization's past environmental investments (Murovec et al., 2012) are likely to drive future GF.

2.2.5 | Environmental and social drivers

GF primarily promotes initiatives that protect the environment (Fleming, 2020). Non-pecuniary drivers, such as investors' pro-environmental preferences, have been identified as a major reason behind GF growth (Gutsche et al., 2020; Zerbib, 2019). This is because investors are willing to sacrifice returns for environmental objectives (Gutsche & Ziegler, 2019). Four environmental and social drivers were identified: ecological and corporate social responsibility (CSR); climate commitment; promotion of responsible and ethical investment; and increased awareness of GF. Agyekum et al. (2021) note that investors perceive GF as a CSR activity. Investors recognize this as a sense of social responsibility “to do the right thing” (Abdullah & Keshminder, 2020), which is achieved through collectivism (Singh et al., 2020). Increased awareness of GF (Prajapati et al., 2021) significantly drive GF growth. Increased awareness of GF is facilitated by other drivers, such as social signaling, word-of-mouth learning (Gutsche et al., 2021; Gutsche & Ziegler, 2019) and media visibility (Bae et al., 2021).

3 | RESEARCH METHODOLOGY

DEMATEL was developed by the Battelle Geneva Research Centre to study and resolve complicated and interconnected problems (Gabus & Fontela, 1972). Since then, it has been applied to resolve many situations such as hospital service quality (Shieh et al., 2010), sustainable construction and demolition waste management (Negash et al., 2021), and barriers to smart energy cities (Addae et al., 2019), among others. The literature shows that the DEMATEL method can improve the understanding of a specific problem, the cluster of interconnected problems, and contribute to the identification of workable solutions by a hierarchical structure (Shieh et al., 2010). Moreover, it can convert the relationship between the cause and effect of criteria into a visual structural model (*digraphs*) and handle the inner dependencies within a set of criteria (Wu, 2008). Digraphs are more useful than directionless graphs because they can demonstrate the directed relationships between subsystems. It portrays the basic concept of contextual relations among the elements of the system, in which the strength of influence is represented by a number (Shieh et al., 2010).

Despite its potency, the DEMATEL process depends on human judgment which are often given crisp values. Crisp values are vague and do not fully reflect the real world (Negash et al., 2021; Zadeh, 1965). This is because human judgment regarding preferences is often unclear and difficult to estimate using exact numerical values. Fuzzy logic can handle problems that appear vague and imprecise (Wu & Lee, 2007). As a result, this study used fuzzy logic to improve DEMATEL to make better decisions in fuzzy environments (Addae et al., 2019; Wu & Lee, 2007).

The following steps present the fuzzy Delphi-DEMATEL process based on the literature (Addae et al., 2019; Negash et al., 2021; Shieh et al., 2010) and are summarized in Figure 1.

3.1 | Step 1: Expert selection and qualification requirements

Unlike typical Delphi surveys that require multiple rounds to reach a consensus in order to reduce variance in responses and to improve precision (Hallowell & Gambatese, 2010), FDM does not require multiple investigation. It has therefore become preferred due to its simplicity, requiring only a single investigation, making it a more efficient option compared to the classical Delphi method. The FDM does not mandate that experts modify their extreme opinions like the Delphi method. Moreover, FDM aids experts in distinguishing their optimistic, pessimistic, and realistic opinions by utilizing triangular fuzzy numbers (TFNs) (Hashemi Petrudi et al., 2022). Hence, this study applied the FDM to validate the factors of study for GF-in-GB under uncertainties. The FDM combines the advantages of incorporating the fuzzy set theory and the standard Delphi procedure to validate the criteria gathered from the literature.

Furthermore, the FDEMATEL was employed in the second round of surveys. In the FDEMATEL method, the fuzzy set theory was utilized to resolve the fuzziness in expert judgments, while the DEMATEL was employed to evaluate the cause-effect links between factors. This entailed collecting qualitative evaluations and converting the linguistic terms into equivalent TFNs.

Similar to the Delphi method, the accuracy and effectiveness of the FDM and FDEMATEL method depended on the number of panelists. A minimum of eight panel members is suggested because most studies incorporate between 8 and 16 panelists (Rowe & Wright, 1999). Similarly, Hallowell and Gambatese (2010) recommend that the number of panelists range from 8 to 12. This study conducted a two-round questionnaire survey regarding linguistic evaluation to obtain expert opinions from 12 panelists (out of 30 experts initially identified) with GF-in-GB experience. The relatively large sample of expert panelists considers issues such as some panelists dropping out due to other commitments or disinterest (Hallowell & Gambatese, 2010). Table 2 presents the guidelines used to identify and qualify a panel of experts.

To be selected, panelists must satisfy at least four key requirements. This is key to obtaining a healthy balance between professional

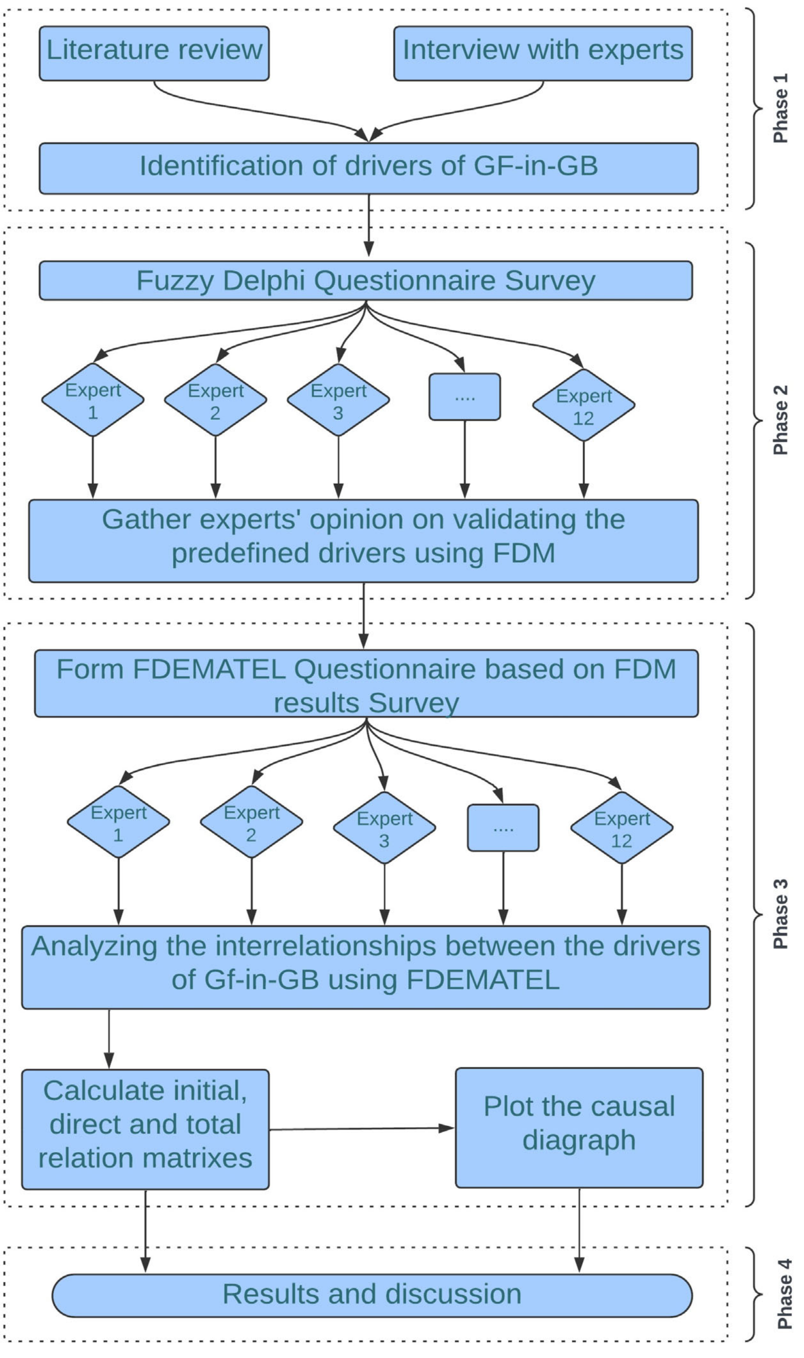

FIGURE 1 Proposed fuzzy Delphi-DEMATEL framework for this study.

and academic experience on the topic. Hallowell and Gambatese (2010) recommended a flexible point system for qualifying panel of experts. It is suggested that panelists score at least one point in four different categories and a minimum of 11 points as a requirement to qualify for participation.

Research has shown that after two rounds (i.e., FDM and FDEMATEL), results become accurate. Additional rounds may reduce the accuracy (Dalkey et al., 1970). Table 3 presents the demographic information of the experts. While the study was based in the Ghanaian context, some of the experts had experiences in other countries such as the United States, Australia, Hong Kong, Kenya, and Nigeria, aside Ghana.

3.2 | Step 2: Determine drivers using fuzzy Delphi method

This study applied FDM to validate the drivers identified in the literature. FDM is a hybrid method comprising the fuzzy set theory and the traditional Delphi technique (Negash et al., 2021). Fuzzy set theory was utilized to resolve fuzziness, uncertainties, and ambiguities in expert judgments. FDM was used to screen-out non-significant criteria from the initial set of drivers. This entailed collecting qualitative evaluations and utilizing Table 4 to convert linguistic terms into equivalent TFNs.

TABLE 2 Guidelines for identifying and qualifying a panel of experts (modified from Hallowell & Gambatese, 2010).

Characteristics	Minimum requirement	Points (each)
Identifying potential experts	Membership in a nationally recognized committee in the focus area of research (e.g., Ghana Green Building Council, Ghana Institute of Surveyors, Ghana Institute of Construction, etc.)	N/A
	Primary author of publication in peer-reviewed journals	N/A
	Invited to present at a conference	N/A
	Recognized participation in similar expert-based studies	N/A
Qualifying panelists as experts	Experts must fulfill at least four of the criteria below in related research topics	
	Primary/secondary author of at least three peer-reviewed journal articles	2
	Invited to present at a conference	0.5
	Member (M) or chair (C) of a nationally recognized committee	M (1), C (3)
	Faculty member at an accredited institution of higher learning	3
	Writer or editor of a book (B) or a book chapter (Ch) on the topic	B (4), Ch (2)
	Advanced degree in the field of construction or civil engineering management and/or finance and/or other related fields (minimum of a bachelor's degree)	BS (4), MS (2), PhD (4)
	Professional registration such as (e.g., Licensed Architect, Certified Finance Expert, Licensed Quantity Surveyor or Estimator, Valuer, etc.)	3

A linguistic variable obtains values defined by linguistic terms that are words or sentences in a natural language (Kiani Mavi & Standing, 2018), where $\tilde{Z} = (l, m, u)$ on X is a TFN if its membership function $\mu_{\tilde{A}}(x): X \to [0,1]$ follows Equation (1):

$$\mu_{\tilde{A}}(x) = \begin{cases} (x-l)/(m-l), & l \le x \le m \\ (u-x)/(u-m), & m \le x \le u \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

In this study, five basic linguistics with respect to a fuzzy-level scale (Table 4) were used to evaluate drivers against each other using the FDM. Based on the above TFNs, the respondent evaluation scores were aggregated using the geometric mean and the fuzzy weight (w_j) of each criterion was determined using Equation (2).

$$w_j = \left\{ a_j = \min(a_{ij}), b_j = \left(\sum_{i=1}^{n} (b_{ij})\right)^{\frac{1}{n}}, c_j = \max(c_{ij}) \right\} \tag{2}$$

where j represents the significance evaluation score of the criteria j; i represents the expert-rated criterion j; n represents the number of experts; and a,b, and c represent the lower, middle, and upper values of the TFNs, respectively. The aggregated weights of each criterion are defined as follows:

$$S_j = \frac{a_j + b_j + C_j}{3} \; j = 1,2,3 \ldots m \tag{3}$$

where m represents the number of criteria.

The threshold (α) was chosen to screen out non-significant criteria. If $S_j \ge \alpha$, the jth criterion is accepted; otherwise, it is rejected. In most cases, α value of 0.5 is utilized. This approach is adopted in similar studies on demolition waste management and sustainable supply chain finance (Negash et al., 2021, 2024) to filter out nonsignificant factors during the FDM stage before administering the second round of questionnaire surveys for the FDEMATEL analysis.

3.3 | Step 3: Fuzzy DEMATEL

To assess the cause-effect of the interrelationships among the criteria, this study applied DEMATEL. As noted, the fuzzy set theory was utilized to address uncertainties in expert decisions. Using Table 5, qualitative expert judgments were gathered using linguistic terms and transformed into the corresponding TFNS.

There are n members in the decision group and $\tilde{z}_{ij}^{f}$ denotes the fuzzy weight of the ith characteristic impacting the fth evaluator. FDEMATEL was implemented using the following approach:

Based on the TFNs, we set $i = 1,2,\ldots,n$; where n is the evaluation factor. Experts were requested to compare the drivers in pairs to develop a fuzzy matrix $(\tilde{Z}_{(1)}, \tilde{Z}_{(2)}, \ldots, \tilde{Z}_{(n)})$. The fuzzy matrix $\tilde{Z}_{(K)}$ is the initial direct relation fuzzy matrix of expert k, following Equation (4).

$$\tilde{Z}^{(k)} = \begin{bmatrix} 0 & \tilde{Z}_{12}^{(k)} & \tilde{Z}_{1n}^{(k)} \\ \tilde{Z}_{21}^{(k)} & 0 & \tilde{Z}_{2n}^{(k)} \\ \vdots & \vdots & \vdots \\ \tilde{Z}_{n1}^{(k)} & \tilde{Z}_{n2}^{(k)} & 0 \end{bmatrix} k = 1,2,\ldots,n \tag{4}$$

$\tilde{Z}_{ij}^{(k)} = \left(l_{ij}^{(k)}, m_{ij}^{(k)}, u_{ij}^{(k)}\right)$ where $1 \le k \le K$ is the fuzzy evaluation of the kth research participant rate based on the degree to which driver i affects driver j. If K is the number of participants who estimated the causality between the identified n drivers, then the inputs given by the participants result in an $n \times n$ matrix, that is, $X^k = x_{ij}^k$; where $k = 1,2,3,4,\ldots n$ (number of research participants).

$$A = a_{ij}^k = \frac{1}{K} \sum_{k=1}^{K} x_{ij}^k \tag{5}$$

Subsequently, the defuzzification process converts the fuzzy numbers to crisp numbers to make it possible to perform matrix operations. Equation (6) was used to de-fuzzify the fuzzy direct-relation matrix.

TABLE 3 Demographic information of experts.

Attribute	Sub-attribute	Frequency ($N = 12$)	Percentage ($N = 100\%$)
Education level	PhD degree	4	33.3
	Master's degree	8	66.7
	Total	12	100.0
Professional background[a]	Chattered accountant	1	8.3
	Investment manager	1	8.3
	Quantity surveyor	5	41.7
	Academic/researcher	8	66.7
	Project/construction manager	8	66.7
	Engineer	2	16.7
Years of experience	1–5 years	6	50.0
	6–10 years	4	33.3
	>10 years	2	16.7
	Total	12	100.0
Area of related expertise	Green finance	3	25.0
	Green building	2	16.7
	Both	7	58.3
	Total	12	100.0
Organization	Academic or research institute	6	50.0
	Green certification firm	1	8.3
	Contractor firm	2	16.7
	Consultant firm	1	8.3
	Development/commercial banks	2	16.7
	Total	12	100.0
Professional membership[a]	Association of Certified Chattered Accountants (ASCE)	1	8.3
	American Society of Civil Engineers (ASCE)	1	8.3
	Australian Institute of Project Managers (AIPM)	1	8.3
	Ghana Institute of Construction (GIOC)	6	50.0
	Ghana Institute of Surveyors (GhIS)	3	25.0
	Project Management Professional (PMP-Ghana)	3	25.0
	Institute of Engineering Technology Ghana (IETG)	1	8.3
	International Finance Corporation Excellence in Design for Greater Efficiencies (IFC EDGE) Expert	3	25.0
Type of GB certification involved in[a]	Green Star South Africa-Ghana	4	33.3
	IFC EDGE	6	50.0
	US LEED	5	41.7
GF certification/standards involved in[a]	Climate Bonds Initiative	3	25.0
	ICMA Green Bond Principles	6	50.0
	GRESB Green Bond Guidelines	1	8.3
Journal or book publications	≥3 publications	8	66.7
Presented in conferences	Yes	4	33.3
Type of GB supply involved in[a]	Commercial, public, and institutional buildings	6	50.0
	Residential buildings or homes	5	41.7
	Healthcare facilities and laboratories	1	8.3
	Green retrofitting of existing buildings	1	8.3
	All the above	2	16.7

TABLE 3 (Continued)

Attribute	Sub-attribute	Frequency ($N = 12$)	Percentage ($N = 100\%$)
Extent GF impact investment decision in GB[b]	Prefer GF such as green bonds where available and where competitively priced	7	58.3
	Mandates or targets	1	8.3
Preferred channels of green fixed income investments for GBs[b]	Development bank green bonds	5	41.7
	Corporate green bonds	8	66.7
	Private placement of green bonds	1	8.3
	Green loans	8	66.7
	Sovereign green bonds	3	25.0

[a]Some experts possess multiple professional backgrounds and memberships; hence percentages may exceed 100%.
[b]Multiple answers were allowed.

TABLE 4 Fuzzy interpretation for lingual expression (*Source*: Negash et al., 2021).

Lingual expression	Corresponding TFNs		
Extreme	0.75	1.00	1.00
Demonstrated	0.50	0.75	1.00
Strong	0.25	0.50	0.75
Moderate	0.00	0.25	0.50
Equal	0.00	0.00	0.25

Abbreviation: TFNs, triangular fuzzy numbers.

TABLE 5 TFNs for FDEMATEL assessment (*Source*: Negash et al., 2021).

Linguistic terms	Corresponding TFNs		
Very high (VH)	0.70	0.90	1.00
High (H)	0.50	0.70	0.90
Medium (M)	0.30	0.50	0.70
Low (L)	0.10	0.30	0.50
Very low (VL)	0.00	0.10	0.30

Abbreviation: TFNs, triangular fuzzy numbers.

$$I_T = \frac{1}{6}(e + 4f + g) \tag{6}$$

3.4 | Step 4: Normalize the direct-relation fuzzy matrix (*D*)

$$m = \min\left[\frac{1}{\max \sum_{j=1}^{n} |a_{ij}|}, \frac{1}{\max \sum_{i=1}^{n} |a_{ij}|}\right] \tag{7}$$

$$D = m \times A \tag{8}$$

3.5 | Step 5: Development of total relation matrix *T*

After normalizing the direct-relation matrix, the total relation matrix (T) can be obtained using Equations (9) and (10).

$$T = D(I - D)^{-1} \tag{9}$$

where I represents the identity matrix and T is the total relation matrix.

$$T = [t_{ij}]_{n \times n} \tag{10}$$

3.6 | Step 6: Derivation of the cause-effect relationship of *R* and *C*

In the total-relation matrix T, the sum of the rows and columns is represented by vectors R and C, as represented by Equations (11) and (12).

$$R = \left[\sum_{j=1}^{n} t_{ij}\right]_{n \times 1} \tag{11}$$

$$C = \left[\sum_{i=1}^{n} t_{ij}\right]_{1 \times n} \tag{12}$$

R denotes the overall impact driver i has on driver j. C represents the overall effect of driver i on driver j. If r_j and c_i are the sum of ith rows and columns in matrix T, respectively. This shows the direct and indirect effects of criterion i on other criteria (drivers). When $j = i$, the sum of $(r_i + c_j)$ is the total effect given and received by criterion i. Thus, $(r_i + c_j)$ indicates the degree of importance that criterion i plays in the entire system. By contrast, the difference $(r_i - c_j)$ depicts the net effect that criterion i contributes to the system. Hence, if $(r_i - c_j)$ is positive, then criterion i is a net cause, whereas criterion i is a net receiver if $(r_i - c_j)$ is negative (Ali et al., 2020; Shieh et al., 2010).

3.7 | Step 6: Produce the causal diagraph

The causal diagraph represents the cause-and-effect relationship between criteria and is constructed using all sets of $(R+C, R-C)$. $(R+C)$ is the horizontal axis that measures the prominence of a driver and indicates its total effects in terms of influenced and influential power. $(R-C)$ is the vertical axis which explains the cause-effect relationship between drivers. A driver falls into the cause group if its $(R-C)$ value is ≥0 (Farooque et al., 2020). Moreover, significant relations between drivers were mapped on the cause-effect diagraph by arrows, highlighting their interdependence. The diagraph shows the complex interrelationship between decision criteria and helps judge which criteria are the most influential and how they affect other criteria (drivers). To obtain this diagraph, a threshold was established using Equation (13).

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}[t_{ij}]}{N} \tag{13}$$

where N is the total number of decision criteria in the total relation matrix T.

4 | RESULTS

Expert opinions were collected in two rounds: the FDM (round one) and FDEMATEL (round two). Following a comprehensive literature review, 16 criteria (Table 1) of the drivers of GF-in-GB were presented for FDM evaluation.

4.1 | Fuzzy Delphi method results

Using Equations (1) and (2), the acceptance threshold is found to be 0.521. The FDM results included the weights of the criteria and their thresholds. As presented in Table 6, all criteria with defuzzied weights below the threshold value were unacceptable and removed.

4.2 | Fuzzy DEMATEL results

The interrelationship between the criteria (drivers) was evaluated by experts using the validated set of drivers from Table 6. The expert responses were defuzzied and normalized according to the following steps. The FDEMATEL process followed for the criteria is explained as follows. First, a 12 8 × 8 non-negative matrices were created, including:

$$E1 = \begin{vmatrix} NE & H & L & VH & A & NE & A \\ NE & H & L & A & VH & A & NE \\ L & NE & A & H & L & H & H \\ H & VH & NE & H & A & L & NE \\ H & L & NE & NE & H & L & H \\ H & VH & A & H & NE & H & VH \\ L & A & H & VH & H & NE & L \\ H & L & A & V & H & L & NE \end{vmatrix}$$

$$E2 = \begin{vmatrix} NE & L & H & VH & H & A & H \\ L & NE & H & VH & H & A & H \\ H & H & NE & H & A & L & VH \\ VH & VH & H & NE & A & H & H \\ H & H & A & A & NE & VH & H \\ A & A & L & H & VH & NE & A \\ H & H & VH & H & H & A & NE \\ H & VH & H & VH & H & H & VH \end{vmatrix}$$

$$E3 = \begin{vmatrix} NE & A & H & H & H & H & A \\ A & NE & VH & H & H & A & H \\ H & VH & NE & H & H & H & H \\ H & H & H & NE & A & A & VH \\ H & H & H & A & NE & H & H \\ H & A & H & A & H & NE & VH \\ A & H & H & VH & H & VH & NE \\ H & H & H & VH & H & H & H \end{vmatrix}$$

$$E4 = \begin{vmatrix} NE & H & L & A & VH & A & NE \\ L & NE & A & H & L & H & H \\ H & VH & NE & H & A & L & NE \\ H & L & NE & NE & H & L & H \\ H & VH & A & H & NE & H & VH \\ L & A & H & VH & H & NE & L \\ H & L & A & V & H & L & NE \\ VH & A & L & H & H & L & H \end{vmatrix}$$

$$E5 = \begin{vmatrix} NE & H & L & A & VH & A & NE \\ L & NE & A & H & L & H & H \\ H & VH & NE & H & A & L & NE \\ H & L & NE & NE & H & L & H \\ H & VH & A & H & NE & H & VH \\ L & A & H & VH & H & NE & L \\ H & L & A & V & H & L & NE \\ VH & A & L & H & H & L & H \end{vmatrix}$$

$$E6 = \begin{vmatrix} NE & H & A & H & A & A & H \\ A & NE & H & H & H & A & H \\ H & H & NE & VH & H & A & H \\ H & H & H & NE & H & H & H \\ A & H & A & A & NE & H & H \\ H & A & H & H & H & NE & A \\ VH & H & H & H & H & H & NE \\ A & A & A & A & A & H & H \end{vmatrix}$$

$$E7 = \begin{vmatrix} NE & H & H & H & H & H & H \\ H & NE & H & H & H & H & H \\ H & H & NE & H & H & H & H \\ H & H & H & NE & H & H & H \\ H & H & H & H & NE & H & H \\ H & H & H & H & H & NE & H \\ H & H & H & H & H & H & NE \\ H & H & H & VH & H & H & H \end{vmatrix}$$

$$E8 = \begin{vmatrix} NE & A & A & A & H & H & VH \\ A & NE & VH & VH & VH & VH & VH \\ A & VH & NE & VH & VH & VH & VH \\ H & H & VH & NE & VH & VH & VH \\ H & H & H & VH & NE & H & VH \\ VH & VH & VH & H & H & NE & VH \\ VH & H & VH & H & H & VH & NE \\ VH & A & VH & H & VH & VH & VH \end{vmatrix}$$

TABLE 6 Drivers screening out—fuzzy Delphi method (round one).

Criteria (drivers)		Weights	Decision
DC1	Government participation and support for GF	0.515	Unaccepted
DC2	Regulatory incentives for GF	0.532	Accepted
DC3	Mandatory legislation, standards and climate-relative financial disclosures	0.514	Unaccepted
DC4	Favorable macroeconomic conditions and investment returns	0.532	Accepted
DC5	Improved access to and lower cost of capital	0.523	Accepted
DC6	Reduced business and financial risk	0.526	Accepted
DC7	Reasonable maturity/investment period	0.510	Unaccepted
DC8	Preferential capital requirements for low-carbon assets	0.524	Accepted
DC9	Improve corporate branding or reputation	0.513	Unaccepted
DC10	Institutional/peer pressure	0.513	Unaccepted
DC11	Management commitment	0.518	Unaccepted
DC12	Positive fundamentals or green credentials of issuer/developer	0.519	Unaccepted
DC13	Ecological and corporate social responsibility	0.505	Unaccepted
DC14	Climate commitment	0.525	Accepted
DC15	Promotion of responsible and ethical investment	0.534	Accepted
DC16	Increased awareness of GF models in GB	0.526	Accepted
	Threshold (α)	0.521	

$$E9=\begin{vmatrix} NE & A & VH & H & A & VH & VH \\ A & NE & VH & VH & A & VH & H \\ H & H & NE & A & A & H & A \\ H & H & H & NE & A & VH & VH \\ A & A & A & A & NE & A & A \\ VH & H & VH & H & H & NE & VH \\ VH & VH & H & VH & A & H & NE \\ H & VH & VH & VH & A & VH & VH \end{vmatrix}$$

$$E10=\begin{vmatrix} NE & VH & H & VH & VH & L & L \\ H & NE & VH & VH & VH & L & H \\ VH & VH & NE & VH & H & H & H \\ VH & VH & VH & NE & H & H & H \\ VH & VH & H & H & NE & VH & H \\ L & L & H & H & VH & NE & H \\ L & H & H & H & H & H & NE \\ VH & H & VH & VH & VH & VH & VH \end{vmatrix}$$

$$E11=\begin{vmatrix} NE & VH & H & H & H & H & H \\ VH & NE & H & H & H & VH & H \\ H & H & NE & H & H & L & H \\ H & VH & H & NE & L & L & L \\ H & L & H & H & NE & H & H \\ L & L & H & L & H & NE & H \\ H & H & L & L & H & H & NE \\ L & L & H & L & L & L & L \end{vmatrix}$$

$$E12=\begin{vmatrix} NE & H & L & A & VH & A & NE \\ L & NE & A & H & L & H & H \\ H & VH & NE & H & A & L & NE \\ H & L & NE & NE & H & L & H \\ H & VH & A & H & NE & H & VH \\ L & A & H & VH & H & NE & L \\ H & L & A & V & H & L & NE \\ VH & A & L & H & H & L & H \end{vmatrix}$$

Second, the average matrix A can be constructed by following the steps outlined in Equation (5):

$$A=\begin{vmatrix} 0.0000 & 0.5257 & 0.4284 & 0.5251 & 0.6219 & 0.4600 & 0.3668 & 0.5446 \\ 0.3630 & 0.0000 & 0.5730 & 0.6393 & 0.4612 & 0.5416 & 0.5924 & 0.6307 \\ 0.5758 & 0.6864 & 0.0000 & 0.6070 & 0.4930 & 0.3797 & 0.3994 & 0.5846 \\ 0.6080 & 0.4933 & 0.4159 & 0.0000 & 0.5098 & 0.4281 & 0.5910 & 0.4859 \\ 0.5592 & 0.6059 & 0.4604 & 0.5260 & 0.0000 & 0.5918 & 0.6386 & 0.5213 \\ 0.3959 & 0.4110 & 0.5758 & 0.5900 & 0.6083 & 0.0000 & 0.4601 & 0.6159 \\ 0.5744 & 0.4620 & 0.5089 & 0.5752 & 0.5602 & 0.4607 & 0.0000 & 0.6642 \\ 0.6216 & 0.4759 & 0.4764 & 0.6056 & 0.5421 & 0.4604 & 0.6067 & 0.0000 \end{vmatrix}$$

Third, the normalized initial direct-relation matrix (D) was calculated using Equations (6)–(8):

$$D=A\times\frac{1}{\max\limits_{1\leq i\leq 8}\sum_{j=1}^{8}a_{ij}}$$

$$\begin{vmatrix} 0.0000 & 0.1347 & 0.1098 & 0.1345 & 0.1593 & 0.1178 & 0.0940 & 0.1395 \\ 0.0930 & 0.0000 & 0.1468 & 0.1638 & 0.1182 & 0.1388 & 0.1518 & 0.1616 \\ 0.1475 & 0.1759 & 0.0000 & 0.1555 & 0.1263 & 0.0973 & 0.1023 & 0.1498 \\ 0.1558 & 0.1264 & 0.1066 & 0.0000 & 0.1306 & 0.1097 & 0.1514 & 0.1245 \\ 0.1433 & 0.1552 & 0.1180 & 0.1348 & 0.0000 & 0.1516 & 0.1636 & 0.1335 \\ 0.1014 & 0.1053 & 0.1475 & 0.1512 & 0.1558 & 0.0000 & 0.1179 & 0.1578 \\ 0.1472 & 0.1184 & 0.1304 & 0.1474 & 0.1435 & 0.1180 & 0.0000 & 0.1702 \\ 0.1593 & 0.1219 & 0.1220 & 0.1552 & 0.1389 & 0.1180 & 0.1554 & 0.0000 \end{vmatrix}$$

Fourth, the total interrelationship matrix (T) is estimated using the following formula:

$$T = D(I-D)^{-1} = \begin{vmatrix} 2.1820 & 2.2662 & 2.1149 & 2.4755 & 2.3560 & 2.0813 & 0.2495 & 2.4734 \\ 2.4499 & 2.3245 & 2.3146 & 2.6942 & 2.5072 & 2.2593 & 2.4732 & 2.6829 \\ 2.4453 & 2.4314 & 2.1432 & 2.6381 & 2.4666 & 2.1862 & 2.3890 & 2.6237 \\ 2.3460 & 2.2871 & 2.1412 & 2.3875 & 2.3633 & 2.0998 & 2.3209 & 2.4904 \\ 2.5415 & 2.5122 & 2.3426 & 2.7301 & 2.4576 & 2.3199 & 2.5353 & 2.7205 \\ 2.3787 & 2.3445 & 2.2420 & 2.5992 & 2.4572 & 2.0672 & 2.3693 & 2.5947 \\ 2.4918 & 2.4303 & 2.2997 & 2.6798 & 2.5270 & 2.2430 & 2.3398 & 2.6879 \\ 2.4888 & 2.4211 & 2.2822 & 2.6727 & 2.5115 & 2.2322 & 2.4622 & 2.5294 \end{vmatrix}$$

Table 7 presents the direct and indirect effects of the eight criteria evaluated. Finally, the threshold value explained in step 6 (Equations 11 and 12) was computed to obtain the average of the elements in matrix T, which was 2.4090. A diagraph of these eight criteria is shown in Figure 2.

From Table 7, the prominence or importance of the eight criteria can be prioritized as DC16 > DC8 > DC6 > DC15 > DC4 > DC2 > DC5 > DC14 based on the $(R+C)$ values, where increased awareness of GF models in GB is the most important criterion with a value of 40.4029. In contrast, climate commitment (DC14), improved access to and lower cost of capital (DC5), favorable macroeconomic conditions and investment returns (DC4), promotion of responsible and ethical investment (DC15), and preferential capital requirements for low-carbon assets (DC8) are net causes, whereas regulatory incentives for GF (DC2), increased awareness of GF models in GB (DC16), and reduced business and financial risks (DC6) are net receivers based on $(R-C)$ values. Table 8 provides a summary of the drivers with the highest prominence and net cause-effect values.

Figure 2 illustrates the causal relations among the eight criteria of GF-in-GB.

It shows that criterion DC5 (improved access to and lower cost of capital) is not affected by others but affects DC8 (preferential capital requirements for low-carbon assets) and DC2 (regulatory incentives for GF). In general, pairs (DC4 and DC8) and (DC2 and DC16) are mutually influenced by each other. It was also observed that DC6 (reduced business and financial risk) receives most impact when most of the drivers are promoted. Finally, while criterion DC14 (climate commitment) has the highest net cause, it possesses medium impact on DC6 and DC16.

5 | DISCUSSION

GB is crucial to achieving the UN-SDGs, yet it still represents a small share of the buildings and construction sector (UNEP, 2021). Lack of green investments is cited as one of the key barriers to global GB advancement, particularly in Ghana (Chan et al., 2018). While GF presents a major source of investment for GB (Debrah, Chan, & Darko, 2022b), it generally accounts for a small portion of the financial market (Taghizadeh-Hesary et al., 2021). Besides, just a few studies can be found in the literature on GF-in-GB (Akomea-Frimpong et al., 2022; Debrah, Chan, & Darko, 2022b). This highlights the need for increased research on GF-in-GB, particularly on driving factors for increased GF-in-GB. To meet the UN-SDGs and the goals of the Paris Agreement in the built environment, it is crucial to investigate drivers and motivations that influence GF-in-GB investments. Therefore, this study identified the critical drivers of GF-in-GB and modeled the interrelationship between drivers using the FDM and FDEMATEL techniques from the perspective of a developing country.

In this study, using the FDM, 12 experts evaluated the 16 driving factors identified from the literature. Based on the FDM results, eight critical drivers were identified by the experts for further evaluation and analysis using the FDEMATEL method. The FDEMATEL method was used to determine the prominent and cause drivers.

TABLE 7 The sum of influence given and received among the eight criteria.

	Criteria	$R+C$	DEMATEL ranking of prominence/importance	$R-C$	Cause-effect ranking
DC14	Climate commitment	36.5418	8	1.5640	1
DC5	Improved access to and lower cost of capital	37.2040	7	1.4432	2
DC4	Favorable macroeconomic conditions and investment returns	38.7230	5	0.6887	3
DC15	Promotion of responsible and ethical investment	38.8386	4	0.5600	4
DC8	Preferential capital requirements for low-carbon assets	39.8058	2	0.5132	5
DC2	Regulatory incentives for GF	37.5227	6	−1.1252	6
DC16	Increased awareness of GF models in GB	40.4029	1	−1.2028	7
DC6	Reduced business and financial risk	39.3134	3	−2.4410	8

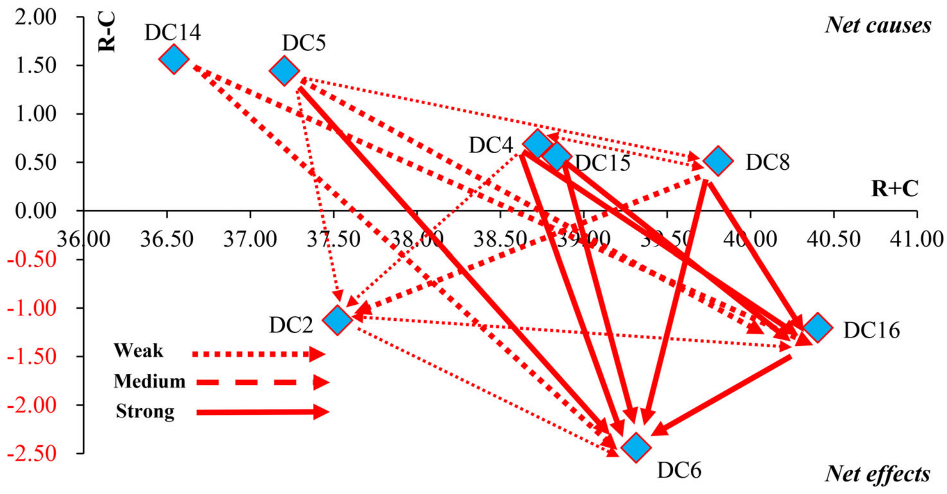

FIGURE 2 The diagraph shows the causal relationships among these eight criteria. All doubled-head arrows show two-way relationships or interdependence among each other. For instance, weak relationships exist between these drivers: DC4 and DC8; DC2 and DC16. This means that they exhibit the same effect on each other, thereby focusing on either of the two will yield the same results.

TABLE 8 Drivers with the highest prominence and net cause-effect values.

	Criteria	Most prominent drivers	Key cause drivers
DC2	Regulatory incentives for GF		
DC4	Favorable macroeconomic conditions and investment returns	✓	✓
DC5	Improved access to and lower cost of capital		✓
DC6	Reduced business and financial risk	✓	
DC8	Preferential capital requirements for low-carbon assets	✓	✓
DC14	Climate commitments		✓
DC15	Promotion of responsible and ethical investment	✓	✓
DC16	Increased awareness of GF models in GB	✓	

Subsequently, the interrelationship between the critical drivers was modeled. The FDEMATEL method thrives on the principle that those drivers found in the "cause groups" (i.e., drivers with positive cause index) has the tendency of affecting the whole system and influence other drivers (Addae et al., 2019; Lin, 2013). Since their impact can affect those drivers in the effect group, they are deemed critical (Negash et al., 2021). Evaluating how these drivers interact with each other is critical to focusing on the most prominent drivers and to understanding how to allocate constrained resources to influential drivers based on the cause-effect matrix using the fuzzy-Delphi-DEMATEL method (Farooque et al., 2020; Negash et al., 2021). From Tables 7 and 8, GF-in-GB drivers can be grouped in two major categories, as discussed below.

The *first category* are those drivers that scored *high prominent indexes*, referred to as "high global important index" in other studies drivers (Addae et al., 2019). These drivers have the potential to affect and/or be affected by other drivers, therefore, managers and policymakers should prioritize promoting or pursuing these drivers in the short term. For "increased awareness of GF models in GB" (DC16) emerging as the driver with the highest prominence could explain the underinvestment of GF to support GB development (Debrah et al., 2023). According to Stoikov et al. (2021), there is a lack of an ideal GF model fit for the GB sector. This is because traditional financing models still dominate the financing of GB projects, even if they are not in line with the core principles of GB (Li et al., 2023). Hence, despite the success stories and positive outlook of GB on the environment and the climate, it does not receive adequate financing (IFC, 2019). With GB categorized as one of the eligible green projects under ICMA's Green Bond Principles (ICMA, 2021), it is critical to create a GF model/system fit for the GB sector. More importantly, there should be increased awareness of GF-in-GB models so that policymakers and professionals become fully cognizant of the sustainability imperatives within buildings and construction for increased investment. It is expected that increased awareness will heighten the green investors willingness to invest in GB (Behera et al., 2024). With this, government can steer the market toward the desired sustainability goals of buildings and construction at relatively low policy costs (Li et al., 2023). In addition, business marketing efforts by banks and financial institutions to raise awareness of GF-in-GB, especially through beneficial GF terms could jump-start the market, build capacity for GB project, thereby increasing the pipeline of GB eligible for GF (IFC, 2019).

The second most prominent driver found was "preferential capital requirements for low-carbon assets." The results demonstrate that preferential capital requirements for low-carbon assets influence other drivers of GF-in-GB. It is noted as a key policy measure to grow the green bond market by Sangiorgi and Schopohl (2021). The preferential capital treatment would encourage financial institutions to provide more financial support to green project, particularly GB through mechanisms such as guarantees and green insurance. In turn, this would attract a lower risk-weight and in turn a lower capital requirement, contributing to GB development. Previous studies (Tolliver et al., 2020) have shown that institutional factors such as regulatory quality promote GF. To meet these climate goals, several governments have introduced penalizing capital requirements for high-carbon assets and preferential capital treatment for low-carbon assets. However, in a similar study, investors favored preferential capital treatments of low-carbon assets, while they indicate a lack of support for penalizing capital treatment of high carbon assets (Sangiorgi & Schopohl, 2021). Mandatory climate-relative financial disclosures, included in GF indices, GF certification, and international credit ratings that integrate environmental risk analysis are known GF drivers (Sangiorgi & Schopohl, 2021). Similarly, due to the increasing investor preference for low-carbon investments amidst a favorable economic situation within a country, more awareness of GF models and products will be created. This indicates that, government policy should focus on creating an environment where both government and financial institutions treat traditional finance separately from GF. With this, investors will become more aligned to GF due to preferential capital treatment for low-carbon assets as against policies that penalize capital treatment of high-carbon assets to avoid resistance. Besides, according to Liu and Wu (2023), GF is favored by capital market participants and consistent with the general sentiment of environmental concerns. In recent times, the general public and investors' view GF and GB as a way to make an impact through investments.

The third most prominent driver was “reduced business and financial risk.” Previous studies have found that both investors and issuers have direct financial incentives and business case for investing in or issuing GF instruments. For the investor, there GF provides lower risk, better returns, and diversification benefits compared to its conventional counterpart (Agyekum et al., 2021; Debrah et al., 2023; Maltais & Nykvist, 2020). Hence, GF is capable of reducing a company's real and perceived risk of environmental violation and the associated financial and reputational costs. In addition, some studies show that GF improves the cash flow of low-carbon firms due to government support such as government procurement, green subsidies, and tax credits. Besides, it has been noted that GF instruments contribute to firm's access to capital and innovation related to environmental efforts (Liu & Wu, 2023). According to Maltais and Nykvist (2020), GF reduces the cost of capital and/or improves their access to capital, thereby reduces capital availability risks. Therefore, investors who intend to reduce their business and financial risks may utilize GF to fund GB projects. Green banks involved in GF-in-GB can reduce non-performing loans and transaction costs, as well as increase their investment portfolio of low-carbon assets and reduce their carbon footprints (Cui et al., 2018; Debrah et al., 2023). Small and medium GB firms that struggle to access finance because of high collateral requirements would be reduced through access to GF (Debrah, Chan, & Darko, 2022b; Zhang et al., 2021).

The *second category* are drivers that belong to the “cause group” and “effect group.” Drivers with positive cause index belong to the cause group and can influence the entire system, leading to the emergence of other drivers (Addae et al., 2019; Negash et al., 2021). Conversely, drivers with a negative cause index are part of the effect group. Since cause drivers can impact effect drivers, they are considered critical (Negash et al., 2021). From Tables 7 and 8, GF-in-GB actors and policymakers should pay more attention to five cause drivers (DC14, DC5, DC4, DC15, and DC8) than effect drivers (DC2, DC16, DC6). GF presents a great business opportunity for GB investors and developers to overcome several cost-related barriers such as inadequate capital and higher investment costs (Debrah, Chan, & Darko, 2022b). This is a way to allocate financial resources to the economy to support sustainable development and fight climate change in the built environment. This could explain why “climate commitment” ranked as the highest cause driver of GF-in-GB. Climate commitment is therefore very influential in the GF-in-GB system. This suggests that climate commitment to achieve the Paris Agreement Goals and sustainable development goals in the built environment should be pursued intensively. Research has shown that if emissions are not rapidly reduced per the Paris Agreement, the world will face much danger. The recent wildfire destruction of forests, homes, and lives has made climate commitments even more urgent (UNEP, 2022). For instance, using the nationally determined contributions of countries, Debrah, Darko, et al. (2022) explained the potential of GF-in-GB to the global economy and available investment opportunities. Thus, GF can support efforts from countries to shift from conventional construction to GB and promote green retrofits, as outlined in nationally determined contributions emerging from the Paris Agreement (Debrah, Darko, et al., 2022). In addition, Tolliver et al. (2019, 2020) demonstrated that nationally determined contributions to the Paris Agreement have the largest impact on the drivers of GF. Therefore, both public and private participation in realizing climate commitments are likely to exert a strong influence on the other driving factors of GF-in-GB. Climate commitment also creates new business opportunities (Agyekum et al., 2021), thereby creating a pipeline of green projects. DC5 (improved access to and lower cost of capital) is a key criterion because it is not affected by other criteria. Improving access to and lower cost of capital or GF promotes other drivers such as DC8 (preferential capital requirements for low-carbon assets), DC2 (regulatory incentives for GF), and DC6 (reduced business and financial risks). However, improved access to and lower cost of capital (DC5) ranks seventh in terms of importance. This may explain the weak impact of driver DC5 on DC8 and DC2 since they rank higher. On the contrary, while DC6 has higher prominence than DC5, DC5 is a stronger cause of driver DC6. Again, Figure 2 shows that if most drivers are promoted, the business and financial risks associated with GF-in-GB will be reduced. It is therefore not a necessity to focus on reducing the business and financial risk of GF-in-GB since it is the major net receiver of the promotional results of majority of the drivers of GF-in-GB. Preferential capital requirements for low-carbon assets (DC8) and favorable macroeconomic conditions and investment returns (DC4) rank second and fifth, respectively, in terms of prominence ($R+C$). Moreover, drivers DC8 and DC4 (preferential capital requirements for low-carbon assets and favorable macroeconomic conditions and investment returns) mutually affect several drivers: regulatory incentives for GF, reduced business and financial risk, and increased awareness of GF models in GB. Tolliver et al. (2020) revealed that macroeconomic factors such as trade openness, size of the economy or gross domestic product and stock market capitalization positively influence GF issuance volumes. It is therefore not surprising that "favorable macroeconomic conditions" are identified as highly prominent and influence other drivers.

6 | CONCLUSIONS, IMPLICATIONS, AND LIMITATIONS

GB is perceived as a potent approach meet for the current sustainability challenges faced by the buildings and construction sector globally. While the tangible and intangible benefits of GB is well-documented in the literature, the global adoption is very low, particularly in developing countries. Inadequate finance and lack of capital are usually cited as critical barriers to GB. The emergence of GF which targets financing green projects to adapt to and mitigate climate change risks, there are now opportunities to sustainably finance GB, and to create more eligible pipeline of GB projects for GF. Given these, developing countries can adopt GF for GB projects to meet targets of reducing carbon emissions in the built environment. Knowledge of the critical drivers of GF-in-GB and their interrelationship could support policy amidst limited resources and the novelty of GF-in-GB in developing countries, particularly in Ghana. In this study, we present the relationship between the critical drivers of GF-in-GB. The identified drivers were validated using the FDM. FDEMATEL was further applied to identify the interdependence of the eight criteria of drivers. The FDEMATEL method was based on the FDM results. The combined and result-oriented method of FDM and FDEMATAL proposed in this study is useful for managers to be resource-efficient in their decision to adopt GF-in-GB. This method is suitable for bridging the challenge identifying important and critical drivers by considering uncertainties and possible interactions established between identified drivers and then prioritized. Ghana like many developing countries faces diverse economic challenges and have limited resources to meet developmental goals, particularly toward meeting climate and sustainable development goals.

The methodology proposed in this study offers practical benefits for managers, investors, issuers, government agencies, and other stakeholders by promoting resource efficiency and aiding strategic decision-making, especially in allocating limited resource toward cause group drivers, which then will influence other drivers in the effect group. The combined fuzzy-Delphi-DEMATEL (i.e., FDM and FDEMATEL) method provides a detailed insight into the factors driving GF-in-GB, highlighting the interactions between the drivers through graphical results, simplifying complexities and facilitating clearer communication. From the results, all stakeholders must pay more attention to the top three drivers with positive cause indexes, climate commitment (DC14), improved access to and lower cost of capital (DC5), and favorable macroeconomic conditions and investment returns (DC4). While the effect group or negative cause drivers identified in this study included regulatory incentives for GF (DC2), increased awareness of GF models in GB (DC16), and reduced business and financial risks (DC6). Interestingly, DC6 and DC16 were categorized among the most prominent drivers of GF-in-GB. This could be that although these two drivers are important, they do not influence or impact other drivers. As a result, drivers DC6 and DC16 should be closely monitored, while promoting the cause group drivers due their level of importance within the GF-in-GB system. Besides, it is quite surprising that experts rated regulatory incentives for GF (DC2) very low in terms of importance and effect on GF-in-GB, despite the growing proliferation in the literature that regulatory incentives are key to the growth of both GF and GB sectors. This could be that experts rate other drivers to be critical than regulatory incentives, which may require more in-depth studies in future. It should be however noted that after the initial screening using the FDM, all the remaining eight drivers presented for FDEMATEL analysis are considered relevant to GF-in-GB system. Hence, these drivers based on their category in terms of "importance" or "effect" should either be monitored or promoted in either the short-term or long-term to promote the development and growth of GF-in-GB. For instance, drivers with the highest prominence values have the potential to affect and/or be affected by other drivers, and therefore managers and policymakers should prioritize promoting or pursuing these in the short term. Similarly, drivers with the highest net cause values have the greatest long-term impact on the entire system, so they should receive more attention than equal attention. Moreover, this study is beneficial for international organizations such as the IFC and World Bank, as well as other advocates of GF-in-GB in Ghana. It aims to facilitate global efforts in environmental sustainability and economic development through increased sustainable financing for green projects.

Theoretically, this study has several implications for research on sustainability. The findings of this study not only contribute to filling the knowledge gap concerning the drivers of GF-in-GB in developing countries, but also provides valuable reference for helping policy makers and practitioners take suitable measure to promote the driving factors of GF-in-GB. As one of the few empirical studies to present the major driving factors and their interrelationship in a developing country, the findings will add significantly to the existing GB and GF literature. Despite the focus of this study being the case of Ghana, the impact of this research may go beyond the selected case. For instance, other developing countries seeking to promote GF-in-GB under uncertainties and limited resources, may find this research useful since the following questions are addressed: how to identify drivers of GF-in-GB, how to organize these drivers, how these drivers interact, and how to prioritize these drivers and how to enhance strategic decision-making using the fuzzy-Delphi-DEMATEL methodologies. This approach provides a systematic way to analyze how to promote the most influential factors within a system. Also, many of the critical drivers of GF-in-GB identified in this study may be similar to other countries, hence this research can be a useful reference for further studies.

Despite the contributions, this study has some limitations. Given the infancy of GF application in GB research and practice, the analysis presented in this study was based on the results of 12 experts with GF and GB experience in Ghana. Hence the data analysis was based on responses within the Ghanaian context thereby limiting its generalizability to other developing countries. However, the lessons of this study are easily adaptive to other developing countries due to the comparability between emerging economies. Future researchers should therefore consider a larger scale in terms of the number of respondents. Additionally, this research may be extended to other developing and developed countries. Future research that incorporates distinct perspectives of the different stakeholders of GF-in-GB, such as issuers, investors, developers, governments, and non-governmental organizations, may provide further understanding of how different stakeholders perceive different drivers. Forecasting the effects of drivers in a GF-in-GB system can be achieved using neural networks and adaptive fuzzy-inference systems. Intelligent models can be applied to explain how the identified influential GF-in-GB drivers can be optimized amidst constraints for maximum impact.

AUTHOR CONTRIBUTIONS

This work represents a collaborative effort by all authors. Below, we detail the contributions made by each member of the team: *Conceptualization*: Caleb Debrah, Albert Ping Chuen Chan, and Amos Darko. *Formal analysis*: Caleb Debrah and Eric Ohene. *Funding acquisition*: Albert Ping Chuen Chan and Amos Darko. *Methodology*: Caleb Debrah, Albert Ping Chuen Chan, and Amos Darko. *Supervision*: Albert Ping Chuen Chan, Amos Darko, and Robert J Ries. *Writing—Original draft preparation*: Caleb Debrah, Albert Ping Chuen Chan, Amos Darko, Robert J Ries, Eric Ohene, and Mershack Opoku Tetteh. *Writing—Review and editing*: Caleb Debrah, Albert Ping Chuen Chan, Amos Darko, Robert J. Ries, Eric Ohene, and Mershack Opoku Tetteh.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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