



Fintech Market Engagement in Financing Net-Zero Transitions: The Mediating Role of Digital Inclusion

Dr. P. Sahaya Princy*

Senior lecturer, Department of Business and Commerce, DMI. St. Eugene University, Zambia.

*Corresponding author(s):

DoI: <https://doi.org/10.5281/zenodo.21939677>

Dr. P. Sahaya Princy, Senior lecturer, Department of Business and Commerce, DMI. St. Eugene University, Zambia.

Email: sahayaprincy30@gmail.com

Citation:

Dr. P. Sahaya Princy, (2026). Senior lecturer, Fintech Market Engagement in Financing Net-Zero Transitions: The Mediating Role of Digital Inclusion, International Journal of Multidisciplinary Research Transactions, 8(8), 108–129. <https://doi.org/10.5281/zenodo.21939677>

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Accepted: 13 August 2026

Available online: 15 August 2026

Abstract

This chapter discusses how capital markets (CMs) can be used to distribute the required financial resources to achieve the goals of net-zero emissions and digital inclusion (DI) in the Republic of Africa. It evaluates the ability of such markets to activate the kind of investment that both facilitates the shift in the environment towards sustainability and increases access to digital finance (DF), thus contributing to community growth. It, in particular, explores the primary mechanisms through which the existence of efficient CMs can be utilised to support the green finance (GF) programmes and provide crucial digital infrastructure, among other important ingredients of the sustainable development pathway of Africa. This will involve a discussion of how well green bonds and other international financial instruments will bring capital to renewable energy projects and an assessment of the role played by financial technologies.

Keywords: Capital Market, Finance, Net Zero Transitions, Digital Inclusion, Green Finance, Digital Finance.

1. Introduction

As it is a well-known fact, the worldwide need to switch to a low-carbon economy requires colossal financial mobilisation, which is reported to trigger investments in the trillions of dollars a year (Miled, 2025). Capital Markets (CMs) are the key to directing such funds to climate-resilient infrastructure, renewable energy development, and clean technologies, and

contributing to innovation and economic development (Olanrewaju et al., 2024; Guo & Yin, 2024). This critical position is further soured in the developing nations of the world such as Africa, with specific emphasis on achieving the need for policy targeting and innovative financial tools to drive economically developed countries in line with climate action, especially regarding digital Inclusion (DI) (Rao & Kumar, 2025). Specifically, the convergence of strong CMs and sophisticated digital platforms can enable unprecedented opportunities to finance the net-zero transition (NZT) in Africa, and innovative financial services can bridge any existing gaps in the inclusivity.

This Chapter examines the complex ways in which CMs can also contribute to the financing of NZTs, alongside supporting delivery of DI in Africa. In this, this paper will explore the key aspect of how digital financial technologies have the capability to curb the environmental related risks, foster financial flow for sustainable finance and enhance energy justice (Volz et al., 2025). Digital finance (DF) in particular has transformative potential in terms of both financial inclusion and energy justice that are fundamental to a successful sustainable transition. This is so because DF, which includes FinTech innovations, blockchain, and AI, has the ability to promote efficiency and transparency in financial services, which can enable them to be more accessible and effective for sustainable development efforts (Ahmad et al., 2025).

Indeed, integration of these digital technologies such as blockchain can also tremendously contribute to the energy transition through innovative solutions for green financing through, for example, green bonds. These types of digital innovations make it easier to develop new financial instruments such as carbon credits and crowdfunding platforms that are playing a prominent role in raising capital for clean energy projects and speeding the adoption of sustainable technologies (Xiangling & Qamruzzaman, 2024). As well as, the massive investment needs to meet global sustainability goals, estimated at \$5 trillion to \$7 trillion per annum, reinforce the need for CMs and the private sector to close the gap in funding that can only be addressed by public funds. This large financial investment therefore requires innovative financing and deployment strategies in which digital financial services (DFS) and integrated policy strategies become instrumental in mimicking the roll-out of on-grid in energy access, particularly among underserved communities (Chukwuma-Eke et al., 2025).

Thus, this chapter shares the views on the requirement of CMs in bringing about the needed finance to implement the objectives of net zero emissions and DI in the Republic of Africa. It

assesses the capacity of these markets to unleash the type of investment that helps to transition the environment towards sustainability, as well as expand access to DFS and support community development. It in particular discusses the key mechanisms by which the presence of efficient CMs can be leveraged to support the GF) programmes and offer vital digital infrastructure among other important ingredients of Africa's sustainable development pathway. This will involve a discussion of how well green bonds and other international financial instruments will bring capital to renewable energy projects and an assessment of the role played by financial technologies.

2. Background of Study

Background delves into the conceptual framework of financial inclusion and outlines how DF is a crucial enabler for sustainable development, which is almost synonymously the same with the SDGs. Digital comprehensive finance, spurred by the development of information technology, big data and cloud computing, dramatically reduces the barriers of financial facilities, extending their reach and depth to the household sector. This foster in access to finance through FinTech has enormous potential to help promote inclusive finance, economic development, tackle inequality and combat climate change through savings on transaction costs and advanced access to banking. FinTech, an interdisciplinary field between finance and technology, is a crucial element in wider access to green financing and funding of energy projects to achieve eco-innovation and energy efficiency, thereby reducing carbon emissions and promoting environmental sustainability (Dao et al., 2025; Ersin & Bildirici, 2024). The growing fintech interest in global money is due to the demand of environmental-friendly and easy-to-use offerings which allows financial institutions to accelerate service recovery through technological breakthroughs. This progression in technology enables the mobilization of green finance (GF) through facilitating access to new funds along with investments, which is crucial in achieving the UN SDG in relation to climate change (Tidjani & Madouri, 2024).

FinTech's ability to bring big data and AI together is further driving the shift to a green economy to ensure GF with better access in efficiency. Indeed, the innovative financial solutions made possible through FinTech ranging from mobile payment systems to platform-based blockchain technologies have become an important driving force in the easier shift towards decreased carbon and greenhouse gas emissions. By fostering access to financial services via digital platforms, digital financial inclusion is showcased as a possible enabler for sustainable

development, making it possible to invest in green technologies and convenience resource-efficient innovation (Kumari et al., 2025; Gupta, 2025; Miled, 2025).

3. Problem Statement

Despite the known potential of FinTech in the GF along with sustainable development agenda, there are major challenges in terms of operationalizing in developing economies, such as Africa. Specifically, regulatory barriers, infrastructure constraints, and a lack of understanding around green financial instruments can be key obstacles which prevent the widespread adoption and successful deployment of Green FinTech offerings within the industry, and thus creates barriers in their efforts to deliver full value to NZTs and promotion of efforts toward DI (Mhlanga, 2022).

This chapter, therefore, explores the particular mechanisms in which CMs can use FinTech innovations to support both Net Zero Transitions (NZT) to climate neutrality along with DI in Africa with policy, technology and market dynamics interactions. It further explores how FinTech can bring democratic access to green investments that will foster the transparency of the NZT reporting of these burgeoning markets (Hasan et al., 2024). This analysis will identify critical development pathways for aiding Africa's unique socioeconomic development to accelerate sustainable development and reduce the impact of climate change through the use of innovative financial technologies to reduce (Dao et al., 2025). It further goes into the opportunities and challenges presented vis-a-vis the intersection of FinTech, GF along with DI, especially regarding regulatory frameworks, technological infrastructure and human capital development. The goal is to create an overall structure setting out the strategic integration of FinTech in the CMs to scale an impact of Africa's mission towards net zero emission driving scenarios and equitable access to digital solutions. This framework will ultimately focus on providing a way for policymakers and financial institutions to write accessible policies to harness the FinTech transformation power to achieve sustainable development in the region (Tidjani & Madouri, 2024).

In addition, the impact of FinTech in lowering transaction costs and boosting the efficiency of capital allocation in sustainable development projects in Africa will also be assessed in this chapter. In extension to it, it will explore the potential of blockchain technology in furthering the goal of improving transparency and traceability in GF to foster investor confidence and reduce the risk of greenwashing in the African CM. It further explores the role of FinTech in

bringing about structural transformation and resources diversification, promoting environmental quality hence green financing.

4. Theoretical Base

4.1. Sustainable Finance Theory

Page | 112

This theory stresses on integrating NZT social and governance aspects into the financial decision processes for attaining long-term economic growth with ecological integrity and social equity. Specifically, it assumes that financial institutions and CMs have a critical role to play in providing capital to sustainable economic activities and away from those that create negative externalities. In light of FinTech, the theory proposes that digital financial innovations can play a major role in promoting the efficiency and accessibility of sustainable finance by supporting green investments and financial inclusion (Okere et al., 2025). As well as, the ability of FinTech to simplify green financing sources and make transactions transparent can effectively address the situation of financial exclusion to promote wider inclusion in the sphere of sustainable development of the economy. This approach is in line with the larger goal of achieving SDG by chaneling capital to projects that help in environmental sustainability, energy efficiency, and social equity. The theory even states that the transformation FinTech has brought in lowering the cost of transactions and deepening access to financial services tends to offer a link between the conventional financial system along with SDG, especially in emerging economies where financial exclusion is rampant (Tidjani & Madouri, 2024).

4.2. Finance intermediation theory

This theory holds that the role of financial intermediaries such as banks and financial tech is pivotal to reducing information asymmetry and transaction costs between savers and investors in order to optimize capital allocation. In the context of GF as well as fintech, this theory emphasizes the usage of digital platforms to foster the efficiency of capital flows to environmentally sustainable projects through better due diligence processes and fostering access to a broader pool of investors and green financial offerings. This approach is especially applicable in terms of facilitating the development of green FinTech which has been demonstrated to mitigate information asymmetry along with financing issues for green innovation (Thanapongporn et al., 2024). The integration of FinTech with financial intermediation also helps to expand access to financial services, especially for those who are underserved, promoting financial inclusion and overall access to financial services, and supporting SDG. By reducing the barriers to entry for small investors and highlighting the

financial needs that remain unmet, applications of FinTech support inclusion in CMs and therefore including more people in green investment initiatives. In extension to it, the effective use of resources by such intermediaries, especially in digital innovations, can have the potential to reduce carbon emissions and advance environmentally sustainable solutions.

4.3. Financial Inclusion Theory

This theory approves that the availability of affordable and useful financial offerings and services can go a long way in furthering economic welfare and attaining sustainable development especially amongst the vulnerable population. The inclusion of Fin-tech with this framework is important as it uses technology to reach the unbanked and underbanked population and boost the pace of economic development. FinTech's contribution to the fostering of financial inclusion is further demonstrated by its potential to contribute to green economic growth via several channels such as facilitating green investments and improving allocation of resources to sustainable projects. This widened access to financial services stemming from FinTech has a direct effect on reducing information asymmetry and transaction costs which act as significant barriers to green innovation along with investment (Yu & Zhao, 2025).

4.4. Modern Portfolio Theory (MPT)

This theory, which optimizes investment portfolios by balancing risk along with return, can be extended to GF through making NZT social and governance factors part of investment decisions. As an approach it helps investors benefit from the rising demand for socially conscious investment opportunities while simultaneously improving the market valuation of companies invested in environmental care (Najaf et al., 2024). As well as, Modern Portfolio Theory concept applied in GF helps to spot investment opportunities in entities that are at the forefront of developing sustainable technologies and practices thereby promoting innovation in the green economy. This theory forms a strong basis for understanding how CMs, via the catalytic role of FinTech, can contribute to both financing the NZTs, as well as the cause of DI in emerging economies.

Keeping in mind the far-reaching character of interventions to promote NZTs along with DI, a combination of various theoretical frameworks provides the best understanding. Specifically, Financial Inclusion Theory, promoted through FinTech innovations, addresses the challenge of access and affordability of financial services for underserved populations directly, as underpinning the engagement of the large population in green financing initiatives. Integration

of these theories offers a holistic view of how the CMs can be used to overcome environmental challenges and the DI, which will go a long way into contributing to the carbon neutrality along with SDG.

5. Empirical Literature Review

5.1. CMs and Financing NZT

A new line of empirical analyses has emerged to quantify the role of CMs in facilitating the pathway to net-zero economies (especially focusing on the effectiveness of different financial instruments and policy interventions in channelling capital to sustainable initiatives) (Trabelsi & Fhima, 2024). Specifically, there have been studies that highlight the role of environmental community instruments such as green bonds, sustainability-linked loans (and carbon markets) mobilizing private capital towards renewable energy projects, energy efficiency upgrades and various other decarbonisation efforts (Han & Gao, 2024). However, the efficacy of these instruments can widely differ depending on the economic context and how well they are focused on the goals to be achieved, as there are special problems for a developing economy, as its citizens might be slightly most worried by the shift of capital while still being perceived as areas for higher risk investments and less developed regulations. Nonetheless, the creation of advanced financial markets and establishments, foreign direct investments and use of renewable sources of energy have demonstrably positive effects on environmental quality, although they may vary with income levels (Nabil, 2024). As well as the role of financial markets in energy transition is fostering being influenced by innovative solutions like Blockchain as well as fintech which will contribute to the development of global financial networks and asset management. In extension to it, the literature emphasises the critical role of financial markets in strengthening the implementation of renewable energy technologies through giving businesses and governments access to needed capital (Fu et al., 2023).

5.2. CMs and DI

This impact is important for bridging the digital divide, particularly in developing economies where traditional infrastructure development might be a challenge which is essential for facilitating broader involvement in the digital economy and for facilitating access to essential services (Yang et al, 2024). By the firm's ability to draw high levels of capital flows, these markets spur the development of broadband infrastructure, which is known to be a crucial element in the promotion of enhanced industrial competition and widespread internet access (Nauman et al., 2023). In extension to it, the emergence of strong CMs makes the growth of

FinTech companies providing new kinds of DFS more accessible, such as mobile banking along with digital payments, essential to fostering financial inclusion among otherwise unbanked or underbanked people. The interaction between FinTech along with sustainable finance is further important to highlight its potential to support the transition towards a lower carbon economy, making it an instrumental element in helping not only meet net-zero but also in supporting digital equity (Kashif et al., 2023). This growth of digital infrastructure and services not only helps develop the economy but enhances the ability to conduct sustainable financial practices such as fostering desired accessibility to data and carrying out financial transactions more efficiently. These improvements in DI driven by CM investments are thus intrinsically coupled with the greater aims of sustainable development through more efficient allocation of resources along with financing of climate-smart innovation. As well as, digital financial technologies, open ICT innovations, and GF solutions are more noted for their ability to speed up the progress on SDG (Mavlutova et al., 2025).

5.3. DI and NZT Financing

The synergistic nature of DI along with financing NZTs can be demonstrated by the ways that fostered digital access along with digital literacy can facilitate the flow of GF initiatives, such as their implementation and effectiveness (Chen & Volz, 2021). Specifically, digital platforms enable fostered levels of transparency, efficiency and access to green investment opportunities, enabling a wider range of investors to connect with sustainable projects (Bank, 2021). For instance, digital payment platform models can play a significant role in acting as financing givers for sustainable projects such as renewable energy projects and environmental agriculture as they ease financing of environmentally responsible projects (Dudu et al., 2024). These platforms are also making it possible to better monitor and verify environmental impacts and fostering accountability along with investment in the green economy. The digitalization of financial services and more specifically FinTech progressions is also an important factor in the process of channeling capital into efforts to achieve sustainable development targets by lowering costs and enhancing the transparency and security of transactions (Treu, 2023). This enhanced transparency has been backed with data-driven strategies that enable investors to better access the NZT performance of potential investments (known as finances flows) together with their net-zero goals (Olanrewaju et al., 2024). In extension to it, thanks to digitalization, supply chain optimization and smart energy management and offering automation, a substantial contribution can be made to lower carbon footprints (energy efficiency) when it comes to the utilization of resources and energy use. These technological enhancements, as well as fintech

development in particular, is key to facilitating green energy investments to be accessible and transparent and thereby enabling the foster of investment in enterprises exhibiting a strong ESG performance. This meeting of creative finance along with digital transformation (DT) holds a key for overcoming the problems of climate action and adaptation to green energy across the world (Murtaza et al., 2024; Parveen et al., 2025).

5.4. CMs, Financing NZT, DI Mediation

The convergence of CMs, digital inclusiveness, and green finance (GF) presents a powerful convergence for accelerating NZTs, due to some of the most profound changes that digital technologies have incurred in how financial systems operate, as well as sustainable investment. Digital inclusive finance is a direct contributor to the fight against climate change, both through energy consumption and carbon emissions reduction as well as the expansion of financial service access for vulnerable people in remote locations (Lu & Xia, 2024; Tan et al., 2024; Addy et al., 2024). In extension to it, the progression of financial technology along with DF solutions can significantly reduce the transaction costs and foster traceability in the domain of GF and thus attract more investments to greener initiatives (Zaid et al., 2025). This synergy of DT and GF is further strengthened by its ability to drive financial inclusion which could give a broader demographic access to green financial offerings and engage in sustainable economic activities. This helps in better capital allocation for environmental friendly projects through digital platforms in identifying, evaluating and funding green projects. These progressions are especially important to developing economies that are trying to reach their SDG (Miled, 2025). Consequently, CMs, with their ability to mobilize and allocate large financial resources, gain a key role in scaling up the DI initiatives supporting the premise and assessment of GF, ultimately supporting the transition towards net-zero economies through facilitating investments in sustainable technologies and sustainability of infrastructure (Liu et al., 2025; Wu, 2023). This includes promoting green technological innovations which have a significant limiting bearing in terms of the consumption of fossil fuel energy and carbon emission that helps to transform industrial structures towards environmental sustainability. The strategic use of digital financial inclusion can therefore contribute towards corporate green innovation as a vital pathway to making both environmental and economic sustainability goals through investments into environment friendly technologies. This fusion between the digital financial inclusion and the CMs are especially relevant to address the historical financing challenges that come with green innovation project, thus enabling a more healthy ecosystem in sustainable development. Such initiatives are not only to improve the accessibility of credit to green ventures but also encourage

the innovation of green technologies, which would be in line with global efforts to achieve the dual carbon goals (Liu & Zhang, 2023). DF in terms of reducing the amount of information asymmetry and the operational cost is effective in identifying viable environmental protection projects and green offerings, and as such can also help the cities reduce their emissions and drive a green transformation process (Wu & Cai, 2024). This helps to allocate resources more effectively to environmental protection projects and green industries so as to help to improve the overall efficiency of green economy development in the urban areas. This paradigm change, supported by a digital financial inclusion, provides the means for the transition to a green economy by improving the financial efficiency and accessibility needed for broad-based green-related innovation along with sustainable development. The development of GF, with the support of digital infrastructure is therefore an important policy route to promote sustainable economic development and bridge the substantial financial investment gap needed for green economic expansion. The strategic execution of digital inclusive finance can foster further impetus to regional green technology innovation especially by strengthening information infrastructure and boosting investment in research and development especially in underserved areas (Sun et al., 2024). This strategy takes advantage of the fact that digital platforms can effectively direct capital to environmentally conscious projects and thus promote the large-scale adoption of greener technologies and practices (Lei et al., 2025).

6. Study Model

Founded on literature reviewed as well as theories studied figure 1 proposed the model for testing.

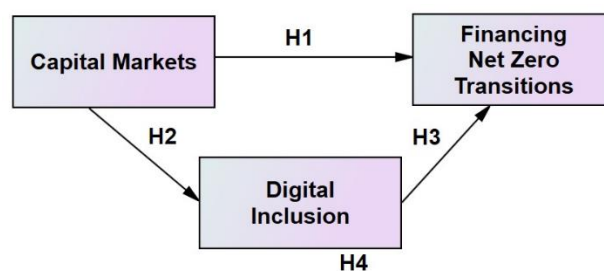


Figure.1. Study model

7. Methodology

This study employed quantitative design of research in order to investigate the role of CMs in promoting financing for NZTs through DI in Africa. The research was based on cross-sectional survey approach which enabled the gathering of primary information from respondents at a single point of time. The target population were stakeholders in financial market, fintech institutions, banking sector, investment institutions and policy related

organizations in Africa. A purposive method of sampling was implemented to select the respondents who have knowledge and experience regarding CMs, DI along with sustainable investment. A total of 360 questionnaires were distributed as well as made valid responses for empirical analysis.

The study involved the use of structured questionnaire based on 16 items of measurement on three constructs (CMs, DI along with financing NZT). Items were all assessed on a scale of one (strongly disagree) to five (strongly agree) using a five-point Likert scale. The data collected were analyzed with the Structural Modeling (SEM) to explore the relationship between variables and test mediating effects of DI.

Before the hypothesis testing, reliability and validity tests were performed. KMO results reached (0.803-0.846) showed that the sampling suitability was adequate and Cronbach (Alpha) values were found to be 0.872-0.901 showing high internal consistency. Discriminant validity was validated with the help of Fornell-Larcker criterion and HTMT ratios and the constructs were confirmed statistically different and appropriate to continue the analysis with a structural model. The results for the SEM were then used to assess the direct and indirect association between CMs, DI, along with financing the NZTs.

8. Results

Table.1. Data suitability

Construct	Number of Items	KMO Value	Cronbach's Alpha
CMs	5	0.821	0.884
DI	6	0.846	0.901
Financing NZT	5	0.803	0.872
Overall Model	16	0.835	0.886

Source: AMOS, 2026

The results in Table 1 indicate that the data are suitable for data analysis. The KMO values for all constructs range from 0.803 to 0.846, which are above the recommended level of 0.70, showing an adequate level of sampling. Cronbach's Alpha values ranged from 0.872 to 0.901 indicating high reliability of measurement items and high internal consistency.

The overall model KMO value (0.835) and Cronbach's Alpha (0.886) also confirm that the data are proper for further factors and SEM analysis.

Table.2. Discriminant Validity

Construct	CMs	DI	Financing NZT
CMs	0.818		
DI	0.62	0.845	
Financing NZT	0.67	0.71	0.810

Page | 119

Source: AMOS, 2026

The results of the discriminant validity utilised both the Fornell-Larcker criteria and HTMT ratios are presented in table 2. According to the Fornell-Larcker criterion, square root of AVE for each construct (CMs = 0.818, DI = 0.845, Financing NZT = 0.810) are higher than the correlation between constructs and each construct, thus indicates good discriminant validity. Additionally, the HTMT values, i.e. 0.62, 0.67, and 0.71 are lower than the recommended threshold of 0.85, confirming that constructs are statistically distinct. Therefore, the measurement model has adequate discriminant and the constructs measure different concepts in the study.

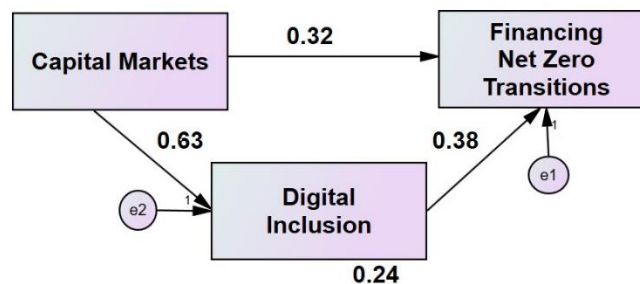


Figure.2. Structure equation model

Table.3. Mediation

Path	Direct Effect (β)	Indirect Effect (β)	Total Effect (β)
CMs $\rightarrow$ DI	0.63	—	0.63
DI $\rightarrow$ Financing NZT	0.38	—	0.38
CMs $\rightarrow$ Financing NZT	0.32	0.24	0.56

Source: AMOS, 2026

These results show in table 3 with figure 2 the significant direct effect of CMs on DI that in turn influences positively on financing of NZT. This means that a strong CM infrastructure is

essential to the growth of digital access, which in turn becomes an accelerator of sustainable finance programs, especially in emerging economies. As well as, the indirect effect summarizes the importance of DI as an intermediary factor, which amplifies the total effect of CMs in the promotion of SDGs. This multifaceted relationship highlights the need for a combined and integrated approach of policies that can promote deepening of financial markets along with DT, to deliver sustainability of the environment.

Table.4. Sobel Mediation Test

Mediation Path	Path a (β)	Path b (β)	Indirect Effect ($a \times b$)	SE (a)	SE (b)	Sobel Z- value	p- value
CMs $\rightarrow$ DI $\rightarrow$ Financing NZT	0.63	0.38	0.239	0.05	0.05	6.50	< 0.001

The results in Table 4 give strong statistical support to the mediation role of DI between CMs and financing the NZT. The large Sobel Z-value ($Z = 6.50$, $p < 0.001$) reinforces the validity of the indirect pathway through the DI, and its substantive relevance within the structural model. This is because it suggests that without supportive digital financial systems, CMs can only play a direct role in sustainable financing outcomes. To this end, the success of CMs in emerging markets like Africa relies heavily on the degree of financial technology integration into the financial system and digital platforms.

Theoretically, the findings presented in Table 4 are an important support for the propositions of Financial Inclusion Theory and Finance Intermediation Theory, as the DI serves as the crucial channel that links financial resources to environmentally-friendly investments in an efficient manner. The mediation effect highlights the role of lowering the transaction cost, making financial services more accessible and breaking through the information asymmetry, which are important mechanisms that enable digital finance to promote green investment flows.

Furthermore, the high moderating role implies that policy makers must not consider expansion of the CM and digitalization as policy spheres working in isolation. Rather, a coordinated approach is needed, in which the policy framework, digital infrastructure and financial innovation policies are aligned to maximize the indirect impact of CMs on sustainability outcomes. Mobile banking, the growth of fintech systems and the introduction of blockchain financial services, for example, can have a powerful impact on the role that CMs can play in green financing projects.

In a management context, the findings from Table 4 suggest that DT as a management tool is an important factor to consider to improve the contribution of financial institutions and investment firms in the implementation of sustainability goals. Firms using digital platforms to increase financial access are more likely to efficiently allocate resources towards green projects, leading to better financial outcomes and environmental benefits. This also highlights the importance of digital financial literacy in the access to wider markets for sustainable investment opportunities.

Table.5. Effect f^2 Size

Path	R ² Included	R ² Excluded	f^2 Effect Size	Effect Magnitude
CMs → DI	0.40	0.00	0.67	Large
DI → Financing NZT	0.52	0.32	0.42	Large
CMs → Financing NZT	0.56	0.52	0.09	Small

Effect size (f^2) analysis of the results reported in Table 5 is helpful in determining the relative importance and magnitude of the relationships in the structural model. The high effect size of the path between CMs and DI ($f^2 = 0.67$) suggests that the development of the CM is a predominant factor in digital financial expansion. This indicates that greater efficiency, more liquid and accessible CMs significantly boost the development of DFS, especially in emerging markets where traditional banking systems are less developed.

Likewise, the large effect size of DI on financing NZTs ($f^2 = 0.42$) demonstrates the significant impact digital financial systems can have on sustainable investment flows. This discovery suggests that DI is not just a facilitator but a key enabler for GF, helping access funds for renewable energy initiatives, climate-proof infrastructure and environmentally-friendly innovations. This impact is significant, highlighting the potential of fintech to drive progress toward sustainability goals.

When DI is not taken into account, the direct contribution of CMs to sustainability outcomes is limited in general but with an effect size of $f^2 = 0.09$. This result is especially significant since it substantively confirms the mediation variables from Table 4, as the digital financial channels play a significant role in the process of green financing, and the real effect of CMs on green financing is of a greater indirect nature.

Policy implications from Table 5 highlight the importance of specific interventions to enhance digital financial infrastructure and build up the CM. The governments should prioritize improving internet connectivity, fostering innovation in the fintech sector, and creating enabling regulatory frameworks to support DFS. These can enhance the role of CMs in fulfilling sustainability goals.

The results indicate that, from a strategic and managerial perspective, investments in digital capabilities are crucial for leveraging its potential contribution to sustainable finance. Companies that embed digital financial solutions within their operations stand to gain greater access to financing, lower financing limitations, and greater backing of green innovation projects. Moreover, the different effect sizes emphasize the need to focus on DI as a significant tool to improve economic and environmental performance. Table 5 gives a nuanced idea of the structural relations, as it quantifies the relative strength of these relations; this is valuable for theory development, for the formulation of policies, and for strategic decisions with respect to sustainable finance and DT.

9. Discussion

The empirical findings reported in the table show that there is a significant direct impact of CM on DI, which shows that the development of robust CMs directly supports the development of broader access to DFS. This strong positive correlation implies that an advanced CM infrastructure plays an instrumental role in lowering the entry barriers to digital financial service providers, which helps to foster the reach of financial services and adoption of the service across a population. Additionally, the results show a strong direct effect of DI on financing NZT, showing how greater access to DFS helps people and businesses get access to and capitalize in green investment opportunities. This mediation effect suggests that improving the digital financial inclusion can provide a pathway for effective capital channelling to sustainable projects thereby facilitating the green development objectives of a country. In extension to it, the synergy of financial development along with digital innovation is pertinent for fostering the quality of the environment because both have been developing together in order to implement green financing mechanisms and foster the efficiency of investments in sustainable projects. The extensive indirect impact observed validates energy transition as an important intermediary mechanism for green DF policies and industrial upgrading, and exposures the interrelatedness of these facets in promoting sustainable development (Xiao et al., 2024). Specifically, for poor nations like Africa, policy responses need to focus on advancing DI (Bogari, 2025).

Such interventions are of great importance in less financially developed countries, where strengthening of the technological infrastructure can greatly amplify the sustainability gains arising from the financial systems. Such measures include incentive programs for the use of renewable energy sources, as well as enabling the development of GF funds that will channel investments to environmentally sustainable projects. This involves creating policies that support the introduction of green financial offerings as well as supporting the scaling of low carbon technologies, key to mitigate the impacts of ecological degradation and support sustainable development. As well as, a concerted attempt to maximize the benefits of DF especially by fostering informatization and digitization in the financial sector can lead to advanced financial efficiency and channelling of internet-based funding to small and medium enterprises to drive green entrepreneurship. These initiatives are working collectively towards a more environmentally friendly financial landscape where priority is put on sustainable finance rather than investments in industries with less environmental impact efficiency. In extension to it, an effort to promote green innovation using DF can enhance sustainable development to a great extent especially in the economies that have new green technology sectors (Hossain et al., 2024).

10. Conclusion

By promoting financial instruments and innovative practices that catalyse sustainability transitions is especially important in developing economies, in which the positive correlation between GF, green innovation along with sustainable economic development is not as strong. To further strengthen these efforts, governments should also enact separate innovation incentive schemes to promote technological investment by industrial and private businesses, in addition to policies with green innovation as a priority with environmental investment and with tax incentives to those who use GF. This includes setting elaborate strategies for medium to long-term development of the digital economy, coordinating for optimal strategic development at different levels of government and strategizing to improve the high level blueprints for digital economy growth, and ensuring that digital financial institutions proactively explore and innovate in terms of service scope, funding channel, and financial offerings to optimize spreading effects of DF. Besides, the government should work towards mitigating systemic risk associated with the financing of new organizations by encouraging international alternative financing operations of industrial offerings and private industries, through measures such as government-led equity investment. In extension to it, there is a critical need for better financial and environmental policy coordination to generate regional green innovation and create and

deal with the information asymmetry of green financing activities. To achieve this, an active use of emerging digital technologies is paramount to supplement the capacity of financial institutions in supporting the green development, particularly in developing countries where lagging financial development in terms of supporting green development is a common dilemma. Addressing this, financial institutions, enterprises and research institutes should work together to pool resources, and cooperatively research on green technologies, promote the introduction of green digital financial offerings, and carry out demonstration projects to optimize the allocation of resources and promote cooperative innovation.

11. Theoretical Implications

This mechanism, in which DF enables the conduit of optimal financial resources allocation, in driving inclusive green innovation, by mitigating financial constraints and reducing costs associated with such innovation, affecting the time curve of user engagement in green innovation. This kind of dynamic interplay underlines the concept of "quantitative change before qualitative change" in the development of green innovation caused by the DF. The impact of DF is not confined to financial facilitation but also actively covers the change of the green technological development landscape which breaks the information asymmetry and promotes the collaborative innovation among various performers. This further hints on a positive cross-multiplier association between digital financial inclusion and urban technological innovation wherein positive innovation environment enhances the usefulness of DF for sustainable economic growth. In extension to it, DF, which is combined with digital technology and financial services, greatly improves the efficiency of green financial services, which greatly alleviates the information asymmetry of innovation decision-making in enterprises, which is bound to improve the innovation efficiency.

12. Managerial Implications

For managers, the strategic implementation of digital financial technologies is therefore of key importance for closing the gap of the financial financing of green initiatives, especially for small and medium sized enterprises, by exploiting the better information matching functions in order to correct for the under allocation of resources. This is important to speed up the transition to a green economy by supporting access to capital for environmentally-friendly technologies and creating an innovation ecosystem where just in time fintech know-how in line with sustainability. In this aspect, DF plays an important role in terms of helping enterprise to improve financial constraint & curbing associated costs thus propelling green innovation. DF

specific also get heterogeneous impact on the green technology innovation, the impact on growing and mature enterprises are more obvious than on young enterprises, it indicates that DF can play a significant role in facilitating financial guarantee for the breakthrough innovation activities. This means that managers of developing and mature enterprises should strategically use digital financial tools in order to maximize the impact of their endeavors upon green technology innovation strategies while taking into consideration targeted support mechanisms for developing enterprises.

As well as, the strategic use of DF can be used to reduce financial constraints and enhance R&D investments, which can eventually result in green transformation and innovation in polluting industries. However, it is very important that financial institutions take proactive steps to innovate the scope of their services offered, funding options and financial offerings to maximise the spreading impacts of DF to ease financing pressure faced by firms and bring about continuous enhancements in efficiency of green innovation. In extension to it, considering the heterogeneity of the impact of DF, managers should carry out specific strategies taking into account the heterogeneity of regional and financial development, recognising that the local conditions have a great influence on the effectiveness of the DFS. This calls for a fine management that is sensitive to the particular context and characteristics of their enterprise to realize in full the potential of the DF to their sustainable development. This strategic integration requires an overall understanding of how DF can boost green innovation in a variety of industrial settings and specifically with regards to the peculiarities of the emerging economies.

13. Limitations

Further research on the effects of DFs on the respective functions of B-end industrial chain companies from other corporate structure would create useful knowledge on how to optimize the circulation of capital and ultimately the efficiency of the entire industrial chain. In addition, the study of digital nature of traditional finance as part of comprehensive indices can offer a more precise insight on the full extent of DF in green innovation, especially outside of publicly-listed companies. As well as, to create an inclusive digital financial service system and to develop diversified financial formats is the key to creating an orderly market environment conducive to green innovation; and to strengthen the recognition ability of DFS to reasonably allocate resources to enterprises with high innovation vitality. This would ensure that financial resources are properly allocated to factories, new startups, small and medium sized innovative

enterprises, non-state owned enterprises rather than excessive concentration in leading enterprises.

14. Recommendations

To optimise the effectiveness of DF in driving green innovation and NZTs, policy-makers should pay special attention to the development of targeted digital financial offerings and tailored services for different-sized and different-industry enterprises so as to stimulate both green consumption and enterprise level's green innovation. This proactive policy should also involve the establishment of industrial DF for better circulation of capital within industrial chain, in order to reduce cost and foster overall efficiency for the development of the industry. In extension to it, regulatory frameworks should be continuously adapted in recognition of changing landscape of DF to ensure that the policy interventions to be taken are responsive to variation in development of DF and responsive to local conditions especially in the regions where the development of DF is most consequential. Finally, encouraging digital financial platforms to help guide the consumer to accepting and learning the concept of green consumption and low-carbon consumption patterns through smart recommendations and incentives for green consumption will help accelerate the green innovation by also creating market demand for sustainable offerings and services. These measures, in total, have the goals to bring digital financial solutions to the core of green economic transformation and equitable and efficient allocation of the resources to achieve net-zero targets. In extension to it, the policy-makers should prioritize this process of marketization, which will allow the market mechanisms to facilitate the process of allocation of resources, hence refining the provision of high-quality DFS to support green innovation and development.

Acknowledgement

The authors have no acknowledgements to declare.

Funding

This study has not received any funding from any institution/agency.

Conflict of Interest/Competing Interests

No conflict of interest.

Data Availability

The raw data supporting the findings of this research paper will be made available by the authors upon a reasonable request.

REFERENCES

- [1]. Addy, W. A., Ofodile, O. C., Adeoye, O. B., Oyewole, A. T., Okoye, C. C., Odeyemi, O., & Ololade, Y. J. (2024). DATA-DRIVEN SUSTAINABILITY: HOW FINTECH INNOVATIONS ARE SUPPORTING GREEN FINANCE. *Engineering Science & Technology Journal*, 5(3), 760. <https://doi.org/10.51594/estj.v5i3.871>
- [2]. Ahmad, F., Boumaiza, A., Sanfilippo, A., & Al-Fagih, L. (2025). A Detailed Comprehensive Role of Digital Technologies in Green Finance Initiative for Net-Zero Energy Transition. *Advanced Energy and Sustainability Research*, 6(10). <https://doi.org/10.1002/aesr.202500066>
- [3]. Bank, A. D. (2021). Fintech to Enable Development, Investment, Financial Inclusion, and Sustainability: <https://doi.org/10.22617/tcs210190-2>
- [4]. Bogari, A. (2025). Assessing the impact of digital economy and financial development on environmental quality worldwide. *Discover Sustainability*, 6(1). <https://doi.org/10.1007/s43621-025-01884-5>
- [5]. Chen, Y., & Volz, U. (2021). Scaling Up Sustainable Investment through Blockchain-Based Project Bonds. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3839956>
- [6]. Chukwuma-Eke, E. C., Ogunsola, O. Y., & Isibor, N. J. (2025). Developing Financial Inclusion Strategies through Technology and Policy to Improve Energy Access for Underserved Communities. *International Journal of Scientific Research in Science Engineering and Technology*, 12(2), 324. <https://doi.org/10.32628/ijrsrset25122147>
- [7]. Dao, H., Le, P., & Nguyen, D. K. (2025). Financial inclusion and fintech: a state-of-the-art systematic literature review. *Financial Innovation*, 11(1). <https://doi.org/10.1186/s40854-024-00741-0>
- [8]. Dudu, O. F., Alao, O. B., & Alonge, E. O. (2024). Advancing financial inclusion through digital payment platforms in emerging markets. *Finance & Accounting Research Journal*, 6(11), 2028. <https://doi.org/10.51594/farj.v6i11.1696>
- [9]. Ersin, Ö. Ö., & Bildirici, M. (2024). Are cleaner energy and financial technologies needed? Contagion and causality evidence between global fintech markets, energy consumption, and environmental pollution. *Clean Technologies and Environmental Policy*. <https://doi.org/10.1007/s10098-024-02845-8>
- [10]. Fu, C., Lü, L., & Pirabi, M. (2023). Advancing green finance: A review of sustainable development. *Digital Economy and Sustainable Development*, 1(1), Article 20. <https://doi.org/10.1007/s44265-023-00020-3>
- [11]. Guo, Q., & Yin, C. (2024). Fintech, green imports, technology, and FDI inflow: their role in CO2 emissions reduction and the path to COP26: a comparative analysis of China. *Environmental Science and Pollution Research*, 31(7), 10508. <https://doi.org/10.1007/s11356-023-31732-w>
- [12]. Gupta, S. (2025). Sustainable Digital Banking: Exploring The Role of Fintech in Promoting Green Finance and Sustainable Development Goals. *Journal of Information Systems Engineering & Management*, 10(3), 547. <https://doi.org/10.52783/jisem.v10i3.5674>
- [13]. Han, J., & Gao, H. (2024). Green finance, social inclusion, and sustainable economic growth in OECD member countries. *Humanities and Social Sciences Communications*, 11(1). <https://doi.org/10.1057/s41599-024-02662-w>
- [14]. Hasan, Md. R., Hossain, M. Z., Hasan, L., & Dewan, M. A. (2024). FinTech and Sustainable Finance: How is FinTech Shaping the Future of Sustainable Finance? *European Journal of Management, Economics and Business*, 1(3), 100. [https://doi.org/10.59324/ejmeb.2024.1\(3\).09](https://doi.org/10.59324/ejmeb.2024.1(3).09)
- [15]. Hossain, M. R., Rao, A., Sharma, G. D., Dev, D., & Kharbanda, A. (2024). Empowering energy transition: Green innovation, digital finance, and the path to sustainable prosperity through green finance initiatives. *Energy Economics*, 136, 107736. <https://doi.org/10.1016/j.eneco.2024.107736>
- [16]. Kashif, M., Pinglu, C., Ullah, S., & Zaman, M. (2023). Evaluating the influence of financial technology (FinTech) on sustainable finance: a comprehensive global analysis. *Financial Markets and Portfolio Management*, 38(1), 123. <https://doi.org/10.1007/s11408-023-00439-w>
- [17]. Kumari, D., Giri, A. K., & Malesios, C. (2025). Impact of digital financial inclusion on environmental sustainability in Asian economies. *Discover Sustainability*, 6(1). <https://doi.org/10.1007/s43621-025-01922-2>

- [18]. Lei, Z., Chun-xia, Z., Li, H., Cai, L., & Zhou, Y. (2025). How does digital financial inclusion improve Chinese county-level carbon productivity? *Frontiers in Climate*, 7. <https://doi.org/10.3389/fclim.2025.1644628>
- [19]. Liu, J., Song, R., & Fu, Y. (2025). Digital finance Empowering Corporate ESG Performance: The Dual-Engine Role of Digital Transformation and Green Technological Innovation. *Sustainability*, 17(23), 10743. <https://doi.org/10.3390/su172310743>
- [20]. Liu, Y., & Zhang, X. (2023). Data-Intelligence Empowerment, Digital Inclusive Finance and Green Innovation of Private Enterprises. In *Advances in economics, business and management research/Advances in Economics, Business and Management Research* (p. 631). Atlantis Press. https://doi.org/10.2991/978-94-6463-246-0_76
- [21]. Lu, Y., & Xia, Z. (2024). Digital inclusive finance, green technological innovation, and carbon emissions from a spatial perspective. *Scientific Reports*, 14(1). <https://doi.org/10.1038/s41598-024-59081-9>
- [22]. Mavřutova, I., Spilbergs, A., Romānova, I., Kuzmina, J., Fomins, A., Verdenhofs, A., & Nātrīņš, A. (2025). The role of green digital investments in promoting sustainable development goals and green energy consumption. *Journal of Open Innovation Technology Market and Complexity*, 11(2), 100518. <https://doi.org/10.1016/j.joitmc.2025.100518>
- [23]. Mhlanga, D. (2022). The role of financial inclusion and FinTech in addressing climate-related challenges in the industry 4.0: Lessons for sustainable development goals. *Frontiers in Climate*, 4. <https://doi.org/10.3389/fclim.2022.949178>
- [24]. Miled, K. B. H. (2025). Nexus between fintech, green finance natural resources, economic growth and environment sustainability: evidence from BRICS countries. *Future Business Journal*, 11(1). <https://doi.org/10.1186/s43093-025-00469-y>
- [25]. Murtaza, M. R., Fan, H., Rădulescu, M., Javed, H., & Ileana, S. C. (2024). Nexus of green energy, financial inclusion, militarization, and environmental sustainability: A global perspective. *PLoS ONE*, 19(5). <https://doi.org/10.1371/journal.pone.0301122>
- [26]. Nabil, M. (2024). Assessment of the Relationship among Climate Change, Green Finance and Financial Stability: Evidence from Emerging and Developed Markets. *International Journal of Economics and Finance*, 16(2), 51. <https://doi.org/10.5539/ijef.v16n2p51>
- [27]. Najaf, K., Ali, M., Asiaei, K., & Dhiaf, M. M. (2024). The Impact of carbon emissions on market performance: fintech versus non-fintech. *Electronic Commerce Research*. <https://doi.org/10.1007/s10660-024-09866-x>
- [28]. Okere, K. I., Dimnwobi, S. K., Fasanya, I. O., & Umeajaghaku, O. L. (2025). Advancing environmental sustainability through fintech, structural transformation, and resource diversification in emerging economies. *Environmental Sciences Europe*, 37(1). <https://doi.org/10.1186/s12302-025-01209-3>
- [29]. Olanrewaju, O. I. K., Oduro, P., & Babayeju, O. A. (2024). Exploring capital market innovations for net zero goals: A data-driven investment approach. *Finance & Accounting Research Journal*, 6(6), 1091. <https://doi.org/10.51594/farj.v6i6.1244>
- [30]. Parveen, S., Coccoresse, P., Umer, M., & Tahir, A. H. (2025). Synergizing Financial Inclusion and Green Finance: Advancing Sustainable Development Goals 2030 and 2050 in Alignment With COP 29 Commitments. *Sustainable Development*, 33, 48. <https://doi.org/10.1002/sd.3553>
- [31]. Rao, A., & Kumar, S. (2025). Climate resilience through finance: The divergent roles of institutions and markets. *Finance Research Letters*, 85, 108008. <https://doi.org/10.1016/j.frl.2025.108008>
- [32]. Sun, H., Luo, Y., Liu, J., & Bhuiyan, M. A. (2024). Digital inclusive finance, R&D investment, and green technology innovation nexus. *PLoS ONE*, 19(1). <https://doi.org/10.1371/journal.pone.0297264>
- [33]. Tan, L., Tian, N., Li, X., & Chen, H. (2024). Can digital financial inclusion converge the regional agricultural carbon emissions intensity gap? *PLoS ONE*, 19(7). <https://doi.org/10.1371/journal.pone.0307328>
- [34]. Thanapongporn, A., Saengchote, K., & Gowanit, C. (2024). The new service development process of green FinTech innovation: A multi-case study. *International Journal of Advanced And Applied Sciences*, 11(7), 101. <https://doi.org/10.21833/ijaas.2024.07.012>
- [35]. Tidjani, C., & Madouri, A. (2024). Fintech, financial inclusion, and sustainable development in the African region. *Frontiers in Applied Mathematics and Statistics*, 10. <https://doi.org/10.3389/fams.2024.1276218>

-
- [36]. Trabelsi, E., & Fhima, T. (2024). Financial Inclusion and Environmental Sustainability in Emerging and Developing Countries: Do control of corruption and trade openness matter? *Journal of Economic Analysis*, 4(1), 124. <https://doi.org/10.58567/jea04010007>
 - [37]. Treu, J. (2023). Moving Beyond Silo Thinking: A Deductive Analysis of Financial Literacy, Financial Inclusion, FinTech, and the UN Sustainable Development Goals. *International Journal of Economics and Finance*, 16(2), 1. <https://doi.org/10.5539/ijef.v16n2p1>
 - [38]. Volz, U., Haahr, M., & Dikau, S. (2025). Enhancing Digital Sustainable Finance: Digital Solutions to Mobilise Capital, Assess Environmental Risks and Enhance Financial Inclusion. In *Financial innovation and technology* (p. 141). https://doi.org/10.1007/978-3-032-02983-6_10
 - [39]. Wu, G., & Cai, Y. (2024). A Study on the Impact of Digital finance on the Efficiency of Urban Green Economy Development. *Polish Journal of Environmental Studies*, 33(3), 3431. <https://doi.org/10.15244/pjoes/176046>
 - [40]. Wu, Y. (2023). ESG transformation in the largest emerging capital market of China: A literature review. *Journal of Corporate Finance Research*, 17(4), 132–150. <https://doi.org/10.17323/j.jcfr.2073-0438.17.4.2023.132-150>
 - [41]. Xiangling, L., & Qamruzzaman, Md. (2024). The role of ICT investment, digital financial inclusion, and environmental tax in promoting sustainable energy development in the MENA region: Evidences with Dynamic Common Correlated Effects (DCE) and instrumental variable-adjusted DCE. *PLoS ONE*, 19(5). <https://doi.org/10.1371/journal.pone.0301838>
 - [42]. Xiao, Y., Lin, M., & Wang, L. (2024). Impact of green digital finance on sustainable development: evidence from China's pilot zones. *Financial Innovation*, 10(1). <https://doi.org/10.1186/s40854-023-00552-9>
 - [43]. Yang, S., Luo, Y., Liu, J. H., Hua, Z., & Liu, C. (2024). Development of Financial Instruments in the Green Energy Sector from the Perspective of Digital Empowerment. *Applied Mathematics and Nonlinear Sciences*, 9(1). <https://doi.org/10.2478/amns-2024-0435>
 - [44]. Yu, B., & Zhao, F. (2025). Revealing the impact of fintech on energy saving and carbon reduction innovation. *Frontiers in Environmental Science*, 13. <https://doi.org/10.3389/fenvs.2025.1669416>
 - [45]. Zaid, M. A. K., Khan, M. F., Al-Mekhlafi, A.-W. A.-G. S., Koliby, I. S. A., Saoula, O., Saeed, H. A. E. M., & Mohammad, R. A. (2025). The future of green finance: how digital transformation and FinTech drive sustainability. *Discover Sustainability*, 6(1). <https://doi.org/10.1007/s43621-025-01356-w>