

**CAPITAL UNIVERSITY OF SCIENCE AND  
TECHNOLOGY, ISLAMABAD**



**Decarbonization Through Green Finance:  
Empirical Analysis of the Moderating Role of  
Financial Inclusion & Green Technology in  
Shaping Environmental Sustainability**

by

**Muqadus Naseer**

A thesis submitted in partial fulfillment for the  
degree of Master of Science

in the

**Faculty of Management & Social Sciences**

**Department of Management Sciences**

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*This research thesis is wholeheartedly dedicated to my parents whose support and continued encouragement have been my strength and source of inspiration in all of my endeavors.*



## CERTIFICATE OF APPROVAL

**Decarbonization Through Green Finance: Empirical Analysis of the  
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Shaping Environmental Sustainability**

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## *Abstract*

In the context of Sustainable Development Goals, this study explores the nexus between green finance, financial inclusion, green Technology, and CO2 emissions in developing countries. The study identifies the moderating role of financial inclusion and green technology in the relationship between green finance and CO2 emission, providing a more nuanced understanding of these dynamics. The study uses panel data in a large range from 2004-2021, for 84 developing countries. The econometric technique GMM is used for analysis of the data. The results confirm the overall negative impact of green finance on CO2 emission. The negative results of the interaction term of green finance and green technology toward CO2 emission conclude that green finance with green technology significantly reduces CO2 emission. While results reveal that enhanced green finance with financial inclusion significantly lowers CO2 emissions. The three way interaction of green finance, financial inclusion and green technology leads to a significant reduction in CO2 emission. The study is limited to macro-economic perspectives while ignoring the micro-level factors that may have different influence on different countries. The paper holds significance for policymakers and opens new avenues for future researchers by exploring the complex dynamic relationship of these variables. This paper is a novel contribution to finance literature by exploring the relationship between green finance, financial inclusion, green Technology, and CO2 emission, and using financial inclusion and green technology as moderators in this framework.

**Green Finance, Financial Inclusion, Green Technology, CO2 emission, SDGs**

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# Abbreviations

<b>EI</b>	EFinancial Inclusion
<b>GF</b>	Green Finance
<b>GT</b>	Green Technology
<b>IPCC</b>	Intergovernmental Panel on Climate Change
<b>MDGs</b>	Millennium Development Goals
<b>SDGs</b>	Sustainable Development Goals
<b>UNCDF</b>	United Nations Capital Development Fund
<b>WIPO</b>	World Intellectual Property Organization

# Chapter 1

## Introduction

### 1.1 Background of the Study

With the adoption of 2030 Agenda of sustainable development in 2015, proposed by United Nations, there is a significant shift toward green practices. This Agenda contains 17 Sustainable Development Goals (SDGs) that serve as guidance tools for achieving Sustainable Development around the globe. With increasing global warming, CO<sub>2</sub> emission is a major environmental threat, challenging SDG achievement. IPCC report 2018 reported that, human activities are estimated to cause more or less 1.0° C of global warming above pre industrial levels, with a probability of 0.8° C to 1.2° C. Additionally, by the end of this century, unchecked CO<sub>2</sub> emissions might raise global temperatures by an additional 1 to 3.7°C (IPCC, 2022; Dusenge, Duarte, & Way, 2019).

SDG13 suggest taking climate actions, to mitigate climate change and its impact on the environment. Sharif, Saqib, Dong, and Khan (2022) claim that countries can meet the United Nations' SDG7 and SDG13 if they implement green finance and green technology policies. Green finance is considered as an avenue to fast-track the progress toward SDGs (P. Ozili, 2022). By aligning financial flow with environmental sustainability, green finance plays crucial role by contributing in mitigating of climate changes and lowering CO<sub>2</sub> emissions. Green finance are the financial activities that support projects and initiatives that can positively impact the environment. The investment in renewable energies, energy efficiency,

pollution reduction, and conservation projects are all considered green finances. It encompasses financial products such as green loans, green bonds, and sustainable investments, aimed at supporting environment friendly practices and reducing carbon footprints.

Green finance has emerged as a new monetary phenomenon that combines economic benefits with environmental protection, so, it is the best option for funding environment friendly initiatives and organizations that give priority to environment protection (Y. Wang & Zhi, 2016). Existing studies considered the goal of green finance is to balancing the advancement of monetary events, environmental sustainability and ecological protection to achieve long term development (Zhou, Tang, & Zhang, 2020).

In contrast to conventional and bank finance, green finance play it role on environmental benefits (Lv et al., 2021). Now the financial sector is paying attention to green investments, advancing sustainable growth (Falcone, Morone, & Sica, 2018). Green finance considers both economic profitability and environmental advantages (H. Zhang, Geng, & Wei, 2022). Hence, Green finance act as a tool that enables nations to take long-term benefits from resources by investing in environmentally friendly actions (Garza, 2013). So, we can say that green finance has the potential to balance the economic development and environmental sustainability.

Similarly, the UNs General Assembly has suggested the improve energy efficiency by keeping in view the SDG7 guidelines. The role of technological development is related to SDG9, focused on industry, innovation and infrastructure. Many scholars suggest that Green technology and eco-innovations are imperative to improve efficiency of energies (Sinha & Shahbaz, 2018; D. Zhang, Zhang, & Managi, 2019). Guo, Nowakowska-Grunt, Gorbanyov, and Egorova (2020) claims that Green technologies efficiently adds a lot to sustainable societies along with promoting environmental protection and economic development. Green technology is one of the top 6 priorities of the European Union, in the European Green Deal, a growth strategy to transform the EU into a competitive economy. It is the term that originally came into existence in the report by the UK government in 1989 and has been the focus of researchers since then. According to Keniel and Gleen (2012), green technologies lessen the negative consequences that are caused by

human activities. World Intellectual Property Organization (WIPO), elaborated its take on this matter and give the context for the Green Technology,

1. Currently there is no standard available for green technology.
2. The geopolitical climate regarding green technologies are moving up as it is proved as effective initiative for environment.
3. There is the need of in depth knowledge and understanding of the overall ecosystem, financing schemes and timescale.
4. Investments in green technologies are slow return investments.
5. There is the need of skilled labor to deploy green technology and increase in maintenance cost.

Although there is limited empirical evidence, that supports the claim that Scholars have come to the consensus that technological advancements should be focused on developing green products instead of carbon-intensive ones ([Asongu, 2017](#); [Churchill, 2019](#)). The more climate-related technologies there are, the better equipped we are to combat climate changes ([Barbieri, 2016](#)).

The green technologies especially renewable energies plays significant role in minimizing environmental impact and promoting sustainable development ([Khan, Riaz, Ahmed, & Saeed, 2022](#)). Financial inclusion is another concept that has been studied extensively with green finance to understand the mechanism of financial flow. The concept of financial inclusion surfaces in the first decade of 2000, when a study considered financial exclusion as a major cause of poverty ([Chibba, 2009](#)).

Financial inclusion expands access to finance by bringing more populations and businesses into the financial system, making them eligible for green investment opportunities. Financial inclusion also supports sustainable development by expanding finance for green initiatives, thus amplifying the impact of green finance.

The sustainability of the economy requires all ages and enterprises to have access to equal financial services to meet their basic requirements in a sustainable manner ([World Bank, 2018](#)). Jones et al (2017) claim that financial inclusion is essential to achieving the Sustainable Development Goals (SDGs) of the United Nations

Agenda 2030. Although, financial inclusion is not a formal goal of SDGs, but it is argued that achieving some of the SDGs' more general objectives is directly impacted by financial inclusion ([Klapper, El-Zoghbi, & Hess, 2016](#)).

Financial inclusion is the target of eight of the seventeen Sustainable Development Goals, according to UNCDF. SDG1: eradicating poverty; SDG2: attaining food security; SDG3: advancing sustainable agriculture; SDG5: realizing gender parity and women's economic empowerment; SDG8: fostering economic growth and employment; SDG9: bolstering industry, innovation, and infrastructure; SDG10: lowering inequality; and SDG17: fortifying implementation strategies.

More savings mobilization for consumption and investment that can promote growth is implicitly linked to increased financial inclusion. Ultimately, the culmination of these variables contributes to the overarching objective of Sustainable Development. This raises the debate about whether financial inclusion being highly associated with SDGs, plays a role in mitigating CO2 emissions.

Du et al (2022) suggest that in order to lower pollutions, financial inclusion in economy can ensure technological improvement that can reduce energy emissions. While the other argument is that more financial inclusion increases production as well as many other industrial activities, that results in higher CO2 emissions, thus contributes significantly in global warming. According to [Said and Acheampong \(2024\)](#), there exists the difference in relationship of financial inclusion and CO2 emission across different countries.

Following the Environmental Kuznet Curve hypothesis, named for Simon Kuznets, a U shaped curve that hypothesized that income inequality first rises and then falls as economic development proceeds. Once reaching some point of stability, attention shifts toward the protection of natural resources and achieving sustainable development, green finance represents financial mechanisms geared towards environmentally sustainable projects, and CO2 emission reduction represents the environmental protection.

Financial inclusion facilitates access to green finance options for communities, potentially accelerating sustainable development. Similarly, green technology, when integrated effectively, could enhance the efficiency of sustainable projects financed

through Green finance, contributing to improvement in environmental sustainability. The United Nation's 7th, 8th, 9th, 13th, & 17th Sustainable Development Goals (SDGs) serves as the basis on which the study is relying.

Consequently, the purpose of this study is to look into the relationship between green finance, green technologies, financial inclusion, and CO2 emission in developing economies. Most of the time, developing countries faces the dual challenge of removing poverty and mitigating the environmental impacts.

Also the use of carbon intensive technologies and less availability of resources for fast transition toward renewable energies, make them vulnerable to climate change. So, it is crucial for developing countries to transit toward low carbon-intensive economies to fulfil the climate goals. Thus, this study is lying its focus on the developing countries that whether the availability financial resources, as well as the inclusive financial system and renewable energies can influence environmental outcomes.

In our perspective it is likely that financial inclusion greatly influences the path of green financing in predicting CO2 emission, also the use of green technology reduces CO2 emissions through green finance. Our study is mainly focused on exploring the moderating effect of financial inclusion and green Technology, in the relationship of green finance and CO2. So, there is the use of two moderators in this framework. Using the multiple moderators helps in more complex and realistic analysis.

Sometimes, multiple factors or variables influence the outcome simultaneously, so it become crucial to analyze their combined effect. It will give much deeper and comprehensive understanding of the effects of variables. It is a novel contribution to the literature of finance as our study seeks to unravel imperative but likely unexplored perspectives associated with green finance, CO2 emission, financial inclusion, and green technology. In this analysis, there is the use of fundamental macroeconomic variables because this study addresses the large scale, systematic relationships between green finance, financial inclusion, green technology, and CO2 emission in developing countries. The focus of the research is the entire economies or countries rather than firms or industries, so this research is implying the broader perspective in the literature.

## 1.2 Research Gap

In the existing literature, extensive studies have investigated the individual influence of green finance on CO<sub>2</sub> emission.

Similarly, the role of financial inclusion in promoting income equality and its indirect effect on environmental outcomes has been explored, as has the influence of green technology in mitigating CO<sub>2</sub> emissions.

However, the interaction among these factors, specifically the simultaneous moderating effects of financial inclusion and green technology in the relationship of green finance and CO<sub>2</sub>, remains unexplored. Previous studies examined these variables in isolation or with one or more of these variables, and have yet to consider integration of all these variables to create a more nuanced understanding of their combined impact on the environment.

Also there is very limited use of multiple moderators where analysis can be carried out to explore two or more moderator in one model, in the literature of finance. The studies are mostly exploring the two way interaction rather than three way interaction that is leaving a space for further additions in the literature.

## 1.3 Problem Statement

Despite global efforts to combat climate change, CO<sub>2</sub> emission is continuously rising, making it necessary to build effective strategies to promote environmental sustainability. Green finance has emerged as a mobilizing resource for sustainable development, and yet there is a need to explore the dynamics related to it.

Green technology and financial inclusion have been studied individually to estimate CO<sub>2</sub> emission but their combined influence along with green finance in lowering CO<sub>2</sub> emission is not adequately addressed. This literature gap raises the critical question of how these two factors can jointly influence the performance of green finance in lowering CO<sub>2</sub> emissions.

This paper is filling this gap by exploring the nexus among these variables to create a broad perspective and understanding of the pathway through which green

finance can effectively contribute to CO<sub>2</sub> emission reduction efforts in developing countries.

## 1.4 Theoretical Background

### 1.4.1 Ecological Modernization Theory

The Ecological Modernization Theory was developed by Joseph Huber in 1980, who suggest that modern industrial societies can become environmentally sustainable through technological advancement and economic restructuring. At that time, there was the conflicting opinion about economic growth and environmental protection. There was the idea ‘limit to growth’, which suggest that continuous economic growth will lead to resource depletion and environmental degradation.

EMT suggested that industrial modernization rather than degrading environment can solve the problem. The theory has evolved over the time. Mol and Spaargaren extended the theory in late 1980s-1990, suggesting that economic reform can become the part of economic and political institutions of modern societies.

This included adopting cleaner technologies and integrating environmental policies into economic systems. Martin Janicke also contributed by recognizing the role of government policies and regulations in driving ecological modernization.

In the words of Mol (2002), “Ecological modernization refers to the processes in which the development and application of more sophisticated technologies and the restructuring of economic and institutional systems can lead to environmental improvement.”

The implication of EMT is that industrial societies can decouple economic growth from environmental degradation through technological progress, more efficient resource use, and stronger environmental regulations. The theory proposes that economic growth and environmental protection can coexist. According to EMT, modern societies can grow economically, while minimizing environmental harm by adopting environmental friendly technologies. Green technology like renewable energies reduces CO<sub>2</sub> emissions and play their crucial part in economic development,

this aligns with the EMT. Green finance plays crucial role by allocating resources to the environment friendly projects that support sustainable development.

### 1.4.2 Financial Inclusion and Development Theory

Financial inclusion as part of development theory evolved, by the contributions of key figures like Muhammad Yunus, World Bank and UN, Thorsten Beck and Asli Demirgüç-Kunt, at different time period. The Financial inclusion and development theory argues that expanding access to financial services and promoting inclusive financial systems can have significant positive effects on economic growth and development.

Financial inclusion helps in reducing inequality in income by making everyone able to be a part of economic development. The World Bank promoted financial inclusion through Global Findex Database, which indicates the global access to financial services. The United Nations also contributed by aligning Financial inclusion to Millennium Development Goals (MDGs) and later the Sustainable Development Goals (SDGs), particularly in areas related to poverty reduction, gender equality, and economic growth.

In the context of environmental sustainability, financial inclusion plays an imperative role in supporting green finance initiatives, which are crucial for addressing climate change. Development theory increasingly recognizes the interconnection between economic development and environmental sustainability. By promoting access to financial services, financial inclusion facilitates investments in green technologies and other sustainable practices, aids the shift to a low-carbon economy and assists in the reduction of CO<sub>2</sub> emissions.

This integration of financial inclusion into development theory highlights the multidimensional benefits of financial access, not only in fostering economic development but also in promoting environmental protection and achieving long-term sustainable goals. When Green projects are financed through Green Financing methods and there is financial inclusion in the society and everyone is able to finance or take part in those projects, it will result in environmental protection and economic development, leading to achieve SDGs.

## **1.5 Research Questions**

The study tried to answer these questions:

### **Research Question 1**

How green finance Impacts CO2 emission?

### **Research Question 2**

Does financial inclusion matter in the reduction of CO2 emissions?

### **Research Question 3**

How green technology moderates the relationship between green finance and CO2 emission?

### **Research Question 4**

What is the combined effect of financial inclusion and green technology on the pathway of green finance to reduce CO2 emission?

## **1.6 Research Objectives**

The following are some objectives of this study:

### **Research Objective 1**

To explain the role of green finance in CO2 emission reduction.

### **Research Objective 2**

To analyze the impact of financial inclusion in the relationship of green finance and CO2 emission.

### **Research Objective 3**

To examine how green technology moderates the relationship of green finance and CO2 emission.

### **Research Objective 4**

To explore the combined effect of two moderating variables financial inclusion and green technology along with green finance in determining CO2 emission.

## 1.7 Significance of the Study

The study holds significance in the body of literature as it is contributing uniquely. This research stands out from previous research in following way:

- 1) it is exploring the nexus between Green Finance, Financial Inclusion, Green Technology, and CO2 emission, which is a novel contribution in literature.
- 2) This study explores the impact of Green Finance on CO2 emission.
- 3) The study is mainly focused on the moderating role of Financial Inclusion in the relationship between Green Finance and CO2 emission.
- 4) The study explores the moderating role of Green Technology in the relationship of Green Finance and CO2 emission.
- 5) The study is using two moderators, Financial Inclusion and Green Technology between Green Finance and CO2 emission, and analyzing their collective effect.
- 6) The study uses Multiple Moderators Model- multiplicative approach for the analysis of two moderators' effect, which is a unique contribution in finance, as this model was not extensively used in finance.

# Chapter 2

## Literature Review

This literature review seeks to synthesize the existing literature to induct valuable insight into our variables. The efforts of the past researchers, their findings, and theoretical background related to this study are discussed.

The intersection of Finance and Sustainability has gained considerable attention in recent years in academic discourse. Over the growing concerns of environmental degradation and socio-economic disparities, scholars have turned their focus on understanding the role of green finance for sustainable development. It has long entered the stage of rapid development, according to the Guidance on Building a Green Financial System, 2016. Green finance is also named “sustainable finance”, “environmental finance”, “climate finance” and “green investment” (Akomea-Frimpong, Adeabah, Ofori, & Tenakwah, 2021). Different definitions of green finance are accepted commonly. Green finance, according to Lindenberg (2014), is the investments and policies made by financial institutions to promote a green economy.

Since the United Nations (UN) adopted the Sustainable Development Goals in 2015, the field of economic finance has seen an increase in the use of green finance, which is a series of innovation solutions (Trukhachev & Dzhikiya, 2023). The foundational principle of green finance is to align financial systems with sustainability goals, particularly by funding projects that reduce CO2 emissions. In recent years, studies have highlighted how green finance plays a pivotal role in transitioning toward a low-carbon economy.

UNEP considers that the green finance are the increased the level of financial flows from the different sectors of the economy that make sustainable development priorities. In 2016, the German Development Research Institute (DIE) defined green finance as “all investments or loans that take into account environmental impacts and enhance environmental sustainability”. Subsequently, the International Finance Corporation (IFC) identified that green finance is an investment option that serves as protection for the environment, while ensuring social equity, and promoting economic development (Tian, Liu, & Li, 2019). As per (IFC) report, green finance is the “financing of investments that provide environmental benefits”. Green finance is “all forms of investment or lending that consider environmental effect and enhance environmental sustainability” (Dikau & Volz, 2018).

Green finance serves as an intersection among environment friendly behaviors and the financial world (Scholtens, 2006). According to Li and Jia’s (2017) study, the best strategy for halting environmental degradation is to use sustainable financing, often known as environmental finance.

The theoretical works suggest that green finance is a broad term including a more comprehensive range of financial products shaped to mitigate environmental changes (Dikau & Volz, 2018; D. Zhang et al., 2019; Debrah, Chan, & Darko, 2022; Alonso-Conde & Rojo-Suárez, 2020; “Ee”, n.d.) for measuring Green finance. Some uses renewable energy consumption (Newas et al., 2021), climate mitigation finance (Khan et al., 2022), climate bonds (Fan et al., 2022), International Financial Flow to clean energy (Kirikkaleli & Adebayo, 2021) as the measures of green finance. All these measure are helpful to evaluate Green finance impact on environment quality.

Financial inclusion has gained prominence in the global development agenda in the recent years after it is recognized as a key for inclusive growth. The Global Findex Database 2021 indicates that within the past ten years, there has been a noticeable rise in financial inclusion.

In simple terms, some studies declared financial inclusion a basic necessity (World Bank, 2014; Demirgüç-Kunt, Klapper, & Singer, 2013). World Bank defined “Financial inclusion, or broad access to financial services, as an absence of price or non-price barriers in the use of financial services.” According to Sarma and Pais

(2011), financial inclusion is the process that ensures everyone in the economy has simple access to the official financial system and can use it.

Sarma and Pais (2011) identified few merits of Financial inclusion: productive resources are efficiently allocated that can lowers the cost of capital. Also the management of day to day finances is facilitated and improved by easy access to appropriate financial services. The informal sources of credit can be significantly reduced by inclusive financial system, thus lowering the chances of exploitation. Consequently, an overall inclusive financial system can increase efficiency by making sure to provide safe and secure avenues for saving. Because of the financial inclusion individuals are provided with safe place for saving for the future use, this brings financial stability. According to Han and Melecky (2013), the widespread usage of bank deposits helps banks have a more stable deposit base during difficult times.

Access to right financial sector is another important factor in case of financial inclusion. This encourages to give the access to finance to the communities that is far flung and families that have low income (Aduda & Kalunda, 2019; Machdar, 2020; Moslehpour, Chang, Pham, & Dadvari, 2022; Mitic, Kostic, Petrovic, & Cvetanovic, 2020). Central Banks and authorities of many countries globally have included financial inclusion in their policies because it has pivotal role at both macro and micro level (Ratnawati, 2020). Green technology, especially renewable energy, is the technical mechanism that facilitates the transition to a low-carbon economy. Green technologies can be said as efficient technologies that take consideration of environment. It basically implies that the equipment of green technologies must be easy and efficient to operate and should be safe to use and dispose at the end of their lifecycle (Webber & Wallace, 2009). Deep (2023) identified the pivotal role of green technologies to achieve a sustainable future. Many aspects are considered while implementing and consuming clean energies i.e., present economic performance and growth rate of the country, the amount of FDI available in the form of clean technologies, and the national policies regarding clean energy consumption keeping in view their internal factors. (Amria, 2019; Chen, 2022). Green technologies and their innovations are considered as a devoted aspects to save energy and ensuring sustainable innovations (Deng, 2019).

## 2.1 Green Finance and CO2 Emissions

In the contemporary literature, green finance has been studied with many other green aspects: improvements in environmental and social responsibility (Awawdeh, 2021; Sinha & Shahbaz, 2018; Zhou et al., 2020) renewable energy (Sachs, Woo, Yoshino, & Taghizadeh-Hesary, 2019; D. Zhang et al., 2019; Zhou et al., 2020) and regional sustainable development (Islam et al., 2014; Li et al., 2022). Ferreira, de Carvalho, Amorim, Kimura, and de Moraes Barboza (2016) presented the research where he studied the linkage of finance and sustainability in different themes, about investors, institutional investors, governance against impact investment, SRI, climate change and human rights, non-renewable, and SDGs. All these studies show somehow addressed the green finance in support to sustainable Development. Many researchers have connected green finance with ecology. According to Li and Jia (2017), the most efficient way to lessen the risks associated with climate change is through environmental or sustainable finance. Y. Wang and Zhi (2016) implies investing in solar energies can help in achieving environmental sustainability. Wahyudi, Triansyah, and Acheampong (n.d.), induces that with financial decision making along with the consideration of environment conservation, green finance encourages sustainable practices in businesses and ensure economic stability in long run. Green finance makes it possible to transition towards a competitive low-carbon economy. Green finance play its role in reducing the effects of changing climate by allocating finances to those initiatives that have positive impact of environment, thus preserving ecosystem. Liu et al (2024) has outlined the two primary ways in which green finance can reduce carbon emissions. First, by putting constraint on highly polluting and resource intensive enterprises while simultaneously enhancing the financial capabilities of enterprises that are environment friendly He and Liu (2023). Second, green finance can stimulate the adoption of green innovations and initiative leading the businesses to be socially responsible and fostering there environmental performance, ultimately leading to reduction in carbon emissions He and Liu (2023). According to Kahlenborn, Porst, Voss, Fritsch, and Renner (2021), green finance plays a significant role in financing renewable energy projects, energy efficiency initiatives, and carbon capture technologies, all of which directly contribute to the reduction of CO2 emissions. Similarly, D. Zhang,

Mohsin, Rasheed, Chang, and Taghizadeh-Hesary (2021) find that countries with robust green finance policies tend to experience more significant reductions in carbon intensity, as financial resources are directed toward sustainable development projects. However, a number of factors may affect how efficient green finance is at lowering emissions. According to empirical research, while the availability of green finance encourages investments in low-carbon technologies, other supporting variables including the degree of economic development, legal frameworks, and rates of technological adoption frequently influence the scope and speed of CO<sub>2</sub> reduction (Li, 2019). Analyzing the effect of green finance on CO<sub>2</sub> emissions is essential given its role in keeping global warming below 2°C as per the 2015 Paris Agreement and achieving net zero emissions by 2050 Saha, Maji, and Schram (2024). Prior studies have concluded that financial assistance in environment-friendly projects can reduce environmental degradation (Y. Wang & Zhi, 2016). Green finance lowers the fossil fuels emissions by forming the policies and strategies to deal with it. Many researchers have studied green finance and CO<sub>2</sub> emission to analyze their environmental implications, and majority of them agrees that Green finance reduces CO<sub>2</sub> emissions. Khan et al. (2022) suggest that green finance negatively affects CO<sub>2</sub> emission. Many researchers have studied the country-wise effect of green finance on CO<sub>2</sub> emission. Tran (2021) investigated how Vietnam's green finance system contributes to lower CO<sub>2</sub> emissions. He came to conclusions via multivariate time series analysis. He concluded the negative association between green finance and CO<sub>2</sub> emissions, inducing that green finance imperatively reduces CO<sub>2</sub> emissions. Similarly, many scholars studied the relationship between green finance and CO<sub>2</sub> emission in the agriculture industry, inducing the obvious results of the negative relationship between these two factors. According to Saha et al. (2024), CO<sub>2</sub> is a complicated and multidimensional phenomenon. Don et al (2022) argues that the level of emissions varies in developed and developing countries, as does the relationship with green finance. So generalized opinion cannot be used for green finance and CO<sub>2</sub> emissions linkage based on the industry wise or country wise analysis or only by analyzing developed countries. Table 2.1 gives a look over to the studies related to Green finance and CO<sub>2</sub> emissions.

TABLE 2.1: Latest Studies to explore Green Finance and CO2 emissions

Authors	Year	Countries	Econometric Technique	Findings
Khokhar et al.,	2024	ASEAN countries	PMG	The study explains how green finance helps in adopting green technology and Eco-Innovation for environmental sustainability.
Saha et al.,	2024	Global	Mixed Methods Approach	The study draws the conclusion that green finance effectively reduces CO2 emissions.
Huang et al.,	2024	China	GMM	This study analyze that green Financial efficiency plays crucial role in decreasing emissions.
Lie et al.,	2023	China	Sys-GMM	This study concludes that green finance significantly reduces CO2 intensity in China, impacting emission level through different factors.
Gu, M.	2023	China	Mediation Effect Model	The study suggest that green finances play significant role in reducing CO2 emission with the mediating role of green technology innovations.
Ma, H.	2024	China	Quantile Regression Approach	This study gives the perspective that green finance development initially correlated positively with CO2 emissions but at certain point, it works to significantly reducing CO2 emissions.
Hamurcu, C.	2023	26 countries	FEM	The study examines the relationship between GDP, CO2 emissions, and green finance. According to the analysis, there is a negative correlation between green finance and CO2 emissions in 26 different nations.
Saeed Meo, M. Karim, M. Z. A.	2022	Ten top economic countries	Quantile and Quantile regression	The usefulness of green financing in mitigating climate change is demonstrated by this study. The empirical findings indicate a negative association between CO2 emissions and green finance.
Guo et al.,	2022	China	SDM	The study's conclusions demonstrate that green finance directly and negatively affects carbon emissions, but the spillover effect on neighboring provinces are insignificant.

All these researches give a compiled argument that Green financing contributes significantly to the fight against climate change by lowering CO<sub>2</sub> emissions. These reasons served as the foundation for our work, which validates the negative association between green finance and CO<sub>2</sub> emissions, then to explore their nexus with variables.

## 2.2 Moderation Effect of Financial Inclusion between Green Finance and CO<sub>2</sub> Emissions

There are numerous studies that have explored financial inclusion under several themes. Financial inclusion strategies that are specific to each nation (Fungáčová & Weill, 2015; Mitton, 2008) how to use financial institutions and microfinance to achieve financial inclusion (Ghosh, 2013) how technology and financial innovation can help promote financial inclusion (Donovan, 2012; P. K. Ozili, 2019) and how financial inclusion can help advance development (Sarma & Pais, 2011).

Van Niekerk (2024) claims that green finance is valuable for economic progress based on financial inclusiveness. Financial inclusion plays the role in access to finance for sustainable development. When there is effective implementation of financial inclusion, economic entities can acquire loans and financial assistance at the time of need. This encourages the investment and leads to better economic development. Van Niekerk (2024) claims that financial inclusion attracts investments that can enhance the engagement in green initiatives by marginalized communities. In the literature, there are two conflicting schools of thought about the effect of financial inclusion on CO<sub>2</sub> emission.

According to the first school of thinking, financial inclusion can lower CO<sub>2</sub> emissions by encouraging improvements in energy supply technology that will minimize pollution (Du et al., 2022). The other school of thought induces that financial inclusion because of increased industrial activities, can cause more pollution by contributing to the level of CO<sub>2</sub> emission, thus increasing global warming (Jensen, 1996). In Asia, Europe, and the nations of the Belt and Road project, financial inclusion contributes to environmental degradation (Ozturk & Salah Uddin,

2012). In contrast, (J. Wang & Ma, 2022) conclude that in growing economies like China, financial inclusion reduces environmental pollution. According to a different study, financial inclusion raises the carbon footprint and improves access to financial services, nevertheless, it may result in ecologically conscious actions that reduce CO<sub>2</sub> emissions and promote the financial sector's long-term growth (Le, Le, & Taghizadeh-Hesary, 2020).

The studies mentioned above indicate the positive association between Green finance and financial inclusion but the inconsistent arguments and results by the number of scholars on financial inclusion's effect on environmental Sustainability, leads us to explore the nexus of green finance, financial inclusion and CO<sub>2</sub> emission. Due to a differences of information and disparities in methodology, the effects of financial inclusion on carbon emissions are a difficult to evaluate and also they are far from being concluded into comprehensive understanding.

The relationship between green finance and financial inclusion is also being impacted by the financial sector's digital revolution. More access to green financial services has been made possible by the emergence of fintech platforms, even in isolated and rural locations (P. Ozili, 2022). People living in low-income areas are increasingly able to invest in green technologies like solar panels and energy-efficient appliances thanks to mobile banking, microfinance, and other technological advancements. These developments imply that the moderating effect of financial inclusion on the CO<sub>2</sub> emissions of green finance can be further enhanced by digital financial inclusion. The study implies that economies can accelerate their progress through the EKC curve by combining financial inclusion with green finance. The availability of green financial products to a broader population can help more people and businesses adopt sustainable practices more quickly, leading to a fast transition from high to low emissions, thereby reducing CO<sub>2</sub> emissions sooner. In simpler terms, financial inclusion helps more access to financial tools and when the availability of these tools combines with the financial investment in environmental friendly practices, will collectively leads to the point where economic growth results in lower environmental impact. As a moderator, financial inclusion ensures that environmental investments reach a wider segment of society, which may increase the effects of green financing. For example, if traditional

banking systems are weak, financial inclusion can boost the uptake of green investments in rural or impoverished areas. According to Khan et al (2022), this increased access to financing can encourage the adoption of energy-efficient practices and clean technology, which will increase the overall effect of green finance on carbon reductions. The research is still split, nevertheless, with some academics contending that financial inclusion can unintentionally raise consumption-driven emissions in the absence of adequate regulatory control if it is not in line with sustainable practices (Han & Melecky, 2013). These studies have explored the dynamic interplay of these variables to some extent. The contradictory findings exist among studies about the influence of financial inclusion on CO<sub>2</sub> emission. Also the existing literature about the relationship of green finance and financial inclusion has different findings. If growth is not focused on sustainable practices, increasing access to financing may also result in increased energy and consumption, which could raise CO<sub>2</sub> emissions. By ensuring that greater financial inclusion is linked to green investments, the relationship between green finance and financial inclusion can reduce these emissions by increasing the accessibility of eco-friendly technologies and energy solutions. Together, these strategies advance a low-carbon, inclusive economic growth model in which financial inclusion fosters environmental sustainability and social justice.

In the end, by focusing economic growth on sustainable practices and green innovations, Financial Inclusion initiatives that are in line with Green Finance can lower CO<sub>2</sub> emissions. In simpler terms, financial inclusion helps more access to financial tools, and when the availability of these tools combines with financial investment in environmentally friendly practices, it collectively leads to the point where economic growth results in lower environmental impact. As a moderator, financial inclusion ensures that environmental investments reach a wider segment of society, which may increase the effects of green financing. For example, if traditional banking systems are weak, financial inclusion can boost the uptake of green investments in rural or impoverished areas. According to Khan et al. (2022), this increased access to financing can encourage the adoption of energy-efficient practices and clean technology, which will increase the overall effect of green finance on carbon reductions.

TABLE 2.2: Latest Studies to Explore Financial Inclusion in Relation to Green Finance and CO2 Emission.

<b>Authors</b>	<b>Year</b>	<b>Countries</b>	<b>Econometric Technique</b>	<b>Findings</b>
Li et al.,	2024	China	Engle-Granger Technique	The paper suggest that enhanced financial inclusion and green finance reduces CO2 emission in China.
Said & Acheampong	2024	Latin America and MENA countries	GMM, GLS	The study analyze the financial inclusion positively impact CO2 emission in Latin America and has no impact in CO2 emission in MENA.
Hu et al.,	2024	China	FEM, MMA, 2LSL	Green finance reduces the CO2 emission while digital financial inclusion increases the CO2 emission in China. However, digital financial inclusion negatively moderates the association between green finance and CO2 emission.
Ogede, J. S.	2023	Sub-Saharan Africa	PARDL	According to the study's analysis of the relationship between financial inclusion and CO2 emissions, more financial inclusion can lower CO2 emissions in Sub Saharan Africa by connecting it with environmental policies.
Yong et al.,	2024	China	Review analysis	Inclusive finance reduces household CO2 emission in Chinese household in rural areas.

## 2.3 Moderating Role of Green Technology between Green Finance and CO2 Emissions

Existing literature claims that combining cutting-edge technology like Fintech, Blockchain, Artificial Intelligence (AI), and Smart Systems with green Finance is becoming a vital way to improve sustainability initiatives (Trukhachev & Dzhikiya, 2023). In this wake, green technology is another phenomenon that support green practices. Different Scholars have studied green technology with different aspects: green technology and innovation (Bartlett & Trifilova, 2010); green technology and environment (Billatos, 1997; Bonds & Downey, 2012).

In the not too distant future, there's a likelihood that consumers will be motivated to spend more money on environment friendly products and services if the economy's targets for renewable energy sources are met (Liaqat, Gao, Rehman, Lakner, & Olah, 2022; Mikelsone, Spilbergs, Volkova, & Liela, 2020; Wu et al., 2015). Some scholars argue that technological progress can alleviate the constraint of finite resources, enhance environmental conditions, and promote sustainable economic expansion (Tian et al., 2019). Resource consumption, environmental pollution, and economic growth are significantly correlated, even though technological innovation and financial development are significant determinants driving economic growth (Ahmed & Huo, 2020). Anser et al. (2020).

Globally, the importance of research and development projects has increased as renewable energy technology advances (Raghutla, Sampath, & Vadivel, 2019). The consumption of fossil fuels is believed to be a major part of economic growth such as oils, Coal, and natural gases. However, countries are now more focused on the use of alternative sources such as renewable energy due to the realization that fossil fuel emissions due to the use of traditional technologies lead to the worst environmental effects. Renewable energy sources, such as hydropower, biomass, wind, Sun, and geothermal energy have the potential to meet the energy requirement without compromising the environmental effects. The International Energy Agency proposes bringing world temperatures down to within 2°C of pre-industrial levels through the use of nuclear power, renewable energy, and energy efficiency improvements. Green technologies that attempt to lessen their influence on the

environment immediately result in renewable energies like solar, wind, and hydro. Measuring the consumption of these energy sources shows the degree to which these technologies are practically implementing. Mei et al (2018) and Huang and Xie (2021) argue that The generation and utilization of renewable energy sources can reduce the need for fossil fuels for economic growth and encourage businesses to adopt clean production technology, which will increase productivity. The efficient use of renewable energies can restore ecological balance and combat climate changes (Maitey et al., 2023). Ma and Fie (2024) explored that by promoting green technology innovations, CSR disclosure, and social investments, green finance can reduce CO2 emissions. This helps us to understand that green technologies can potentially perform their role in strengthening the impact of green finance in reducing CO2 emissions.

According to Chitimiea et al (2021), adopting green technologies and making green investments are now prerequisites that businesses must fulfil in order to have a competitive edge in the marketplace. Green technologies contribute significantly to a sustainable society while fostering economic growth and environmental preservation, according to Guo et al (2020). According to Ghisetti and Quatraro (2017), green technology is what drives sustainable development, which entails finding new environmentally friendly sectors, creating jobs, and developing environmentally friendly technologies. According to Wahyudi et al (2023), green finance promotes the creation and application of clean transportation systems, energy-efficient technology, renewable energy sources, and sustainable agricultural methods. This occurs as a result of the concern among consumers over the environmental effects of the goods and services they purchase. Because it provides the funding required for research, development, and large-scale deployment, green finance frequently serves as a catalyst for the advancement and spread of these technologies. Green finance's effect on emissions, however, depends on how quickly green technology are embraced.

Huang et al (2021) claim that the intended decrease in emissions may be postponed due to the time lag between financial investment in environmentally friendly initiatives and the actual application of technology. Since faster adoption can lead to faster reductions in CO2 emissions, this shows that green technology is crucial

in moderating the effectiveness of green funding. By directing funds exclusively towards initiatives and innovations that lessen the negative effects on the environment, such as investments in sustainable infrastructure, renewable energy, and pollution control techniques, green finance plays a crucial role. By funding these projects, Green Finance promotes the advancement and use of green technology, which encompasses energy-efficient inventions and renewable energy sources including solar, wind, and hydropower. Green technology provides cleaner, more sustainable alternatives to carbon-intensive energy sources, which in turn immediately lowers CO<sub>2</sub> emissions. This relationship is particularly crucial in underdeveloped nations, where financial resources can greatly hasten the transition to renewable energy sources. When combined, green finance and green technology produce a positive feedback loop whereby financial inputs fuel technological development, which in turn reduces emissions and opens the door to a low-carbon economy. Green financial institutions are in charge of making direct investments in green technologies for the sole purpose of helping people switching to green products by delivering a green solution. Therefore, it is justified to predict that green technology can help in achieving a significant reduction in CO<sub>2</sub> emissions through green finance. Huang et al. (2021) claim that the intended decrease in emissions may be postponed due to the time lag between financial investment in environmentally friendly initiatives and the actual application of technology. Since faster adoption can lead to faster reductions in CO<sub>2</sub> emissions, this shows that green technology is crucial in moderating the effectiveness of green funding. The time lag, however, can be mitigated by strategic planning and policy interventions that prioritize the rapid implementation of green technologies, ensuring that the anticipated environmental benefits are realized more swiftly. For instance, governments and financial institutions can work together to accelerate the adoption of clean technologies by offering subsidies, tax incentives, or low-interest loans specifically targeted at green projects, thus bridging the gap between investment and tangible emissions reductions. By directing funds exclusively towards initiatives and innovations that lessen the negative effects on the environment, such as investments in sustainable infrastructure, renewable energy, and pollution control techniques, green finance plays a crucial role.

TABLE 2.3: Latest Studies to Explore Green Technology in Relation to Green Finance and CO2 Emissions

Authors	Year	Countries	Econometric Technique	Findings
Khokhar et al.,	2024	ASEAN countries	PMG	The study explains how green finance helps in adopting green technology and eco-Innovation for environmental sustainability.
Huang et al.,	2024	China	GMM	This study analyze how green finance reduces CO2 emission by fostering green technology in China
Hu et al.,	2023	China	Multiple techniques	The study used technological innovation as mediator in the relationship of green finance and CO2 emissions. The results show that Green finance directly reduces CO2 emission and indirectly through promoting technological innovation.
Rajuru & Kautish	2023	Asia	Review Paper	This paper suggest that green finance support green technology to reduce CO2 emissions. This research evaluates the strategies for sustainable growth by integrating technology and green financing into parallel models.
Bilgili et al.,	2024	EU countries	PVAR	The paper concludes that renewable energies and technology adoptions can reduce CO2 emissions significantly.
Tang & Cao	2023	G7 & BRICS	Endogenous tests	The paper finds that green technology significantly reduces CO2 emissions.
Wang et al.,	2023	OECD	Quantile Regression Method	The study suggest that green Innovations, including renewable energies and eco innovations, significantly reduces CO2 emissions.
Dam et al.,	2024	E-7 countries	PMG-ARDL	The study concludes that the technological innovation and renewable energy consumption significantly reduces ecological footprints.

## 2.4 Moderation Role of Financial Inclusion and Green Technology in the Relationship of Green Finance and CO2 Emission

The two moderators in one framework are used when there is a need to understand the effect of two moderators jointly on the direct relationship. Extensions to multiple moderator models are essential because researchers often do subgroup analysis or independently test several single moderator models (Blanco et al., 2015; Buunk et al., 2001).

There is very limited literature available because of the lack of use of multiple moderators in one model. Testing all moderators at once is more parsimonious and yields a more complete picture of how the moderators interact with the focal predictor and among themselves to predict the results (Montaya, 2024).

The relationship between green technology and financial inclusion has a big impact on how effective green finance is. By giving underprivileged markets access to capital that would otherwise prevent them from affording technical advancements, financial inclusion helps accelerate the spread of green technologies. Synergies may result from this connection, such as increased environmental benefits when green technologies are more widely available due to financial inclusion.

This study claims that financial inclusion and green technology jointly influence the path of reduced CO2 emission achieved through green finance. There is three way interaction in which we are evaluating the combined effect of green finance, financial inclusion, and green technology in predicting CO2 emission.

The concept here is that financial inclusion enables SMEs and individuals to access financial products at affordable cost, because of which the investments on clean technologies is possible. Green technologies promote both economic and sustainable development and financial inclusiveness can contribute to CO2 reduction through this channel.

This means that when investors of green projects have access to finance they have opportunity to avail green financing that can help employ renewable energy

that ultimately results in lower emissions. But in this study, we assume that both financial inclusion and green technology being moderating factors, enhance the effectiveness of green finance in driving reduced CO<sub>2</sub> emission, ultimately contributing to the Sustainable Development Goals.

## 2.5 Theories of Sustainable Finance

Ozili (2023) formulated six theories of sustainable finance. The theory are explained as follow:

### 2.5.1 Priority Theory of Sustainable Finance

According to Wilson (2010), the priority theory of sustainable finance contends that the speed at which economic actors in a nation or area exert every effort to meet sustainable finance targets is an accurate indicator of the importance placed on the agenda for sustainable finance.

Priority can be assessed by the efforts that are coordinated, independent and collaborative for achieving sustainable goals, how much time will be taken for consensus, and how quickly the sustainable goals can be achieved. The theory implies that if the sustainable finance agenda is one of the priority of economic agents, then they will take it very seriously and put effort to achieving SDGs (Kuhn, 2020).

There are two merits of this theory. Firstly, among the multiple sustainable financing becomes much more important in terms of economic considerations. Second, economic agents have the chance to fully comprehend the significance assigned to the sustainable goals. The theory also has two demerits, one demerit is that only by making them the priority, sustainable objectives cannot be achieved. Other demerit is even if the sustainable objectives are not the priority they can still be achieved.

In the context of our study, this theory is relevant in sense that our research focuses on how green finance can be leveraged to reduce CO<sub>2</sub> emissions, with

financial inclusion and Green technology serving as moderators in this relationship. The study gives an insight that developing countries should make the green finance a priority to start green projects so that environment quality can get better. The theory emphasizes the importance of prioritizing investments that have the greatest potential to reduce CO2 emissions that helps in achieving environmental sustainability.

### **2.5.2 Peer Emulation Theory of Sustainable Finance**

According to the peer emulation theory of sustainable finance, economic agents imitate the policies and strategies of their peers in order to achieve sustainable finance objectives. This theory suggests when no policy can be used to guide the actions for sustainable finance, the key entities within the economy adopt same policies or action that are used by their peers.

In simple terms it means that once a country or organization implements sustainable finance practices successfully, others will also pursue the same, because their peers are doing so. Cowett (2008) implies that it make sense when the economic agents have similar perspective of sustainability. In context of our study, if a country or institution successfully implements Green finance initiatives and demonstrates significant reductions in CO2 emissions, it sets a precedent that others are likely to emulate.

There are five merits of this theory. First, it provides the economic entities the opportunity to share the same vision of the sustainable finance with the emulating peers. Second, only few adjustments are need in the policies and actions that are already implemented by peers. Third, it is cheaper way as there is no need to spent resources on framing new policies and actions.

Fourth, significant improvements can be made in the policies while adopting. Fifth, economic entities does not consider the peers as competitors. There are also two demerits. First, peer miss the opportunity to implement creativity and valuable insight in the process to building policies because of following their peer and just implementing their policies. Second, the financial markets are different as well as the financial regulation, they could experience different results from peers.

In context of our study, if a country successfully implants the green finance initiatives, and yield the desired results of reduced CO<sub>2</sub> emission, the other countries are likely to emulate. This will leads to a broader adoption of green practices in different regions and countries, enhancing the efforts to combat climate changes. This emulation effect can play crucial role in scaling global efforts to achieve sustainability.

### **2.5.3 Life Span Theory of Sustainable Finance**

The Vernon's product cycle hypothesis is the basis for this idea (Vernon, 1979). According to the hypothesis, the duration of sustainable finance instruments, schemes, programs, products, services, or activities influences the interest of economic agents in sustainable finance.

The theory argues that there is the life cycle of sustainable finance, which include introduction, growth maturity and decline. The knowledge of this cycle by the economic entities help them to independently predict the expected life span of the sustainable finance products and they are able to decide based on this prediction whether to support sustainable finance by making long commitment on short commitment.

This theory has two merits. One, they can explain well the reason of more or less demand and supply of green instruments. The second merit is that they can identify the expectations about the lifespan of these instruments. There are two demerits of the lifespan theory of sustainable finance. First, the expectation of the life span of these green products can be subjective or biased. Second, the prediction of the lifespan of specific sustainable finance product can be inaccurate.

In the context of this study, green finance initiatives can be seen as evolving over time- from initiation and growth to maturity and eventual renewal or decline. Initially, these initiatives might focus on establishing projects and raising awareness. Moving forward, they enter a growth stage, where investment in clean energy and technology take place, leading to significant reductions in CO<sub>2</sub> emissions.

Over time, green finance matures, there may be a transition toward more innovative projects that further amplify sustainability efforts. Investments in green

projects may require time to develop infrastructure, technology, and capacity before they can reduce emissions. Over time, as these investments mature, their impact on reducing CO2 emissions is likely to increase, aligning with the life cycle of green finance investments.

#### **2.5.4 System Disruption Theory of Sustainable Finance**

This theory of sustainable finance suggest that expected disruptions in the existing financial system (mainstream finance) due to the shift toward sustainable financial system can result in economic entities to decide, between supporting or joining this transition. The decisions are based on the fact that perceived benefits of sustainable finance should be more than the costs associated with it.

There are two merits of this theory. First, the theory acknowledges that transitions can disrupt the existing traditional financial system. Second, the full information on how the transition take place and it help economic entities to evaluate the reason of transitions, this will reduce their resistance to transition.

The major demerit of this theory is that making the shift doesn't necessarily need a total overhaul of the current financial system. Instead, sustainable finance can coexist in the blended financial system or as a sub-sector of the traditional financial system (Gutterman, 2020; Meyer et al., 2016), in which economic entities can decide whether they want financing that takes into account ESG factors or not (Ozili, 2021).

This theory can relate our study as the green finance can play disruptive role in traditional financial system by redirecting capital from conventional investments to sustainable projects. The shift is essential to ensure environmental sustainability. As the economies are aware of the environmental hazards, their impact on the climate and the need to save the environment, this information give them the reason to transition from traditional financial system to green financial system, there are almost no chances of them to resist this transition.

### **2.5.5 Positive Signaling Theory of Sustainable Finance**

The theory implies that economic entities can communicate to external parties that they are committed to pursuing one or more sustainable financial goals. This is a constructive way for them to get support for their aims (Quatrini, 2021; Park, 2018).

This positive information can be disclosed by public announcements in the media or in annual reports. These announcements serves as the positive signals to outside world, that not only increase the country's reputation in terms of sustainability but also signals that the country is ready to receive foreign technical support to implement sustainable finance policies, this will attract Foreign Direct Investment to clean energies.

The merit of the theory is that it considerably reduces the information asymmetry among firms and investors. The demerit is that disclosing information does not necessarily means that economic agents will follow along. Second, disclosing the positive information about sustainable finance can be used as a tactic to divert attention from bad news or actions, or to suppress them.

In relation to our study, the allocation of funds to green finance projects act as strong positive signal, indicating a commitment to sustainability and environmental responsibility. This signaling effect can attract international financial flow in clean energies or green projects that have potential to reduce CO<sub>2</sub> emission and reduce dependence of fossil fuels. It not only enhances the reputation of the country but also encourages other financial institutions to follow, thus amplify the global efforts to achieve sustainability by reducing CO<sub>2</sub> emissions or emissions of other pollutants.

### **2.5.6 Resource Theory of Sustainable Finance**

According to the theory, certain countries have a comparative advantage over others because they have access to human-made resources that enable them to transition from traditional finance to sustainable finance and help them meet their targets. The theory implies that some countries where the availability of resources

are extensive, an extensive amount of investors willingly invest in sustainable financial products.

Because of the abundance of human made resources these countries are able to achieve sustainable finance goals quickly as compare to the countries who have not these resources. This can also enhance countries' ability to quickly transit from tradition to sustainable finance, also less institutional investor will get attracted to invest in their sustainable finance products because of limited human made resource availability. The theory only suggests that, in comparison to nations with limited resources, economic entities in countries with an abundance of human generated resources are able to rapidly accomplish the aim of sustainable financing.

The first merit of the theory is that it is acknowledged that there is difference in resource abundance in different countries, it explains the reason for them to quickly achieve the goals. Second, because of this difference, the theory determines the different level of development between countries.

The demerit of the theory is that the disparities in human resources can be used to discriminate against nations that fall short of sustainable finance targets. Second, building human made resources require long period of time, which is overlooked by the theory. Some countries with less resources can use this as excuse to not achieve sustainable finance goals.

Based on our study, the resource theory emphasizes to use the financial resources to achieve environmental sustainability. The green finance should be utilized effectively to support sustainable practices, such as investments in clean energy or renewable energies. In the developing countries where human made resources are not very abundant, there should be a policy that effectively allocate the resources to the project that potentially reduces carbon intensity.

## **2.6 Hypothesis Statement**

H1: Green finance significantly reduces CO2 emissions.

H2: Financial inclusion moderates the relationship between green finance and CO2 emissions.

H3: Green technology moderates the relationship between green finance and CO<sub>2</sub> emissions.

H4: Green finance, financial inclusion, and green technology jointly reduce CO<sub>2</sub> emissions.

## 2.7 Theoretical Framework

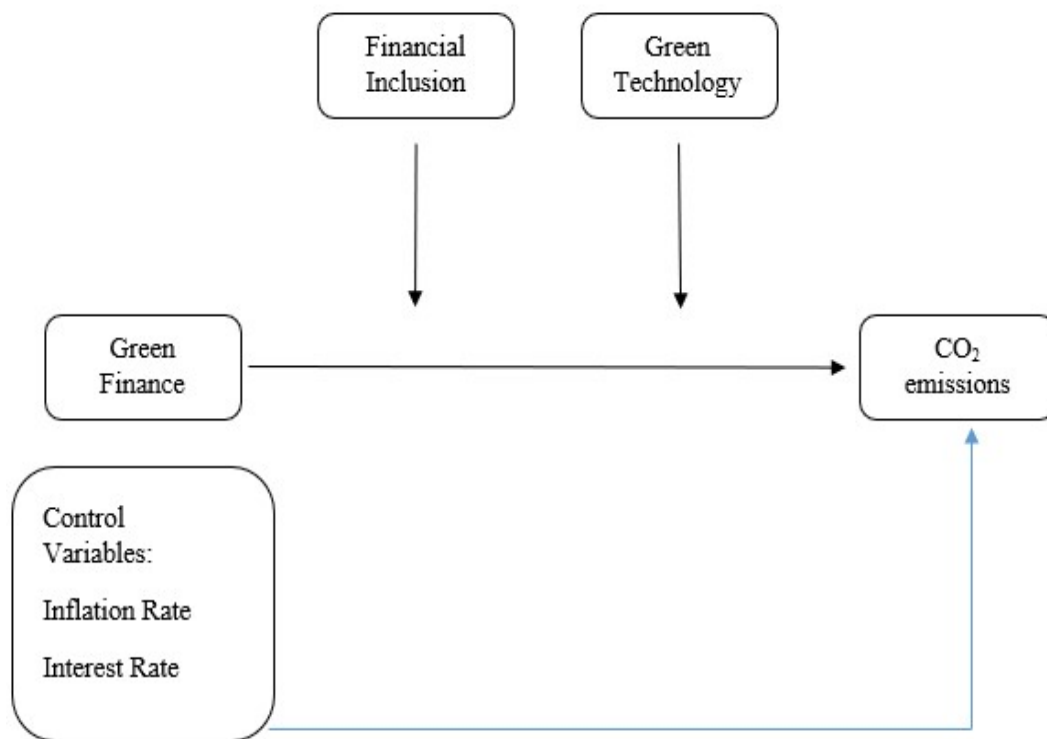


FIGURE 2.1: Framework of Research

This theoretical framework shows that this study is analyzing the direct effect of green finance on CO<sub>2</sub>. The direct effect of financial inclusion on CO<sub>2</sub> emissions and moderating role of financial inclusion is considered. The direct effect of green technology on CO<sub>2</sub> emissions and moderating role of green technology in the relationship of green finance and CO<sub>2</sub> emissions is considered. Then the combined effect of green finance, financial inclusion, and green technology is considered in predicting CO<sub>2</sub> emissions. So, this theoretical framework is exploring the nexus between green finance, financial inclusion, green technology and CO<sub>2</sub> emissions.

# Chapter 3

## Research Methodology

This section of the study is based on the data collection and methodology incorporated. The data type, data source, and data range are discussed in this part. Also, this section presents the measures/proxies of variables, econometric techniques used in the study, and data modeling. The variables in this study are green finance (IV), Sustainable Development (DV), financial inclusion (moderator), and green technology (moderator). The control variables are Inflation Rate, and Interest Rate.

### 3.1 Data Description and Methodology

This section of the study is based on the data collection and methodology incorporated. The data type, data source, and data range are discussed in this part. Also, this section presents the measures/proxies of variables, econometric techniques used in the study, and data modeling. The variables in this study are green finance (IV), CO2 emissions (DV), financial inclusion (moderator), and green technology (moderator). The control variables are Inflation Rate, and Interest Rate.

#### 3.1.1 Population

The population of this study is consist of 84 developing countries.

### **3.1.2 Sample**

Initially, the data was extracted for 160 developing countries for year 2000 to 2021. Then the data was sorted according to the number of countries that have accurate data available for each of the variables, for the desired years. Due to the data availability, we opt for a data range of 2004 to 2021, for 84 countries. The reason for choosing that range was that the data for financial inclusion was available only for 2004-2021. In order to maintain consistency, the overall data range for all variables is 2004-2021.

### **3.1.3 Sources of Data**

This study used the panel data collected from 2 sources; our worldindata.org and World Bank Indicator (WDI).

## **3.2 Variable Measurement**

### **3.2.1 Dependent Variable**

The dependent variable is CO2 emission. To measure CO2 emission, we used CO2 emissions (kg per 2017 US\$ of GDP) as the proxies, extracted for years 2004-2021. The data source is WDI. CO2 emission is indicated as CO2, throughout the whole study. These indicator shows how much CO2 is emitted for every dollar of real economic output in terms of 2017. It is a strong indicator as it shows how efficiently a country is performing in terms of GDP relative to the CO2 emission. By using 2017 as a base year, the effects of inflation is removed. It standardize the economic output measurement so it allows for more accurate comparisons over time and between different countries.

### **3.2.2 Independent Variable**

Green finance is an independent variable. International Financial flows to developing countries in support of clean energy research and development and renewable

energy production, including in hybrid system (millions of constant 2020 United States dollars), is used to measure green finance (Kirikkaleli & Adebayo, 2021) from 2004 to 2021. The data source of this proxy is ourworldindata.org. Green finance is indicated as GF.

### 3.2.3 Moderating Variables

#### 3.2.3.1 Financial Inclusion

Our first moderator named financial inclusion is measured by the Commercial bank branches (per 100,000 adults), Depositors with commercial banks (per 1,000 adults) & Borrowers from commercial banks (per 1,000 adults) (Chien, 2023). This measure indicates the access to finance among developing countries. The data source is WDI. The data is extracted for the period of 2004-2021. Due to the lack of data availability of 2nd and 3rd proxy for year 2004-2021 for 84 countries, we are only using one proxy, Commercial bank branches (per 100,000 adults), instead of 3, unlike Chien (2023) whose study was only limited to China. Financial inclusion is indicated as FI.

#### 3.2.3.2 Green Technology

Green technology is the second moderator in our study. The proxy for this variable is Renewable energy consumption (% of total final energy consumption) as used by the Milindi and Inglesi Lotz (2021). The data source for this proxy is WDI and ranges from 2004-2021. Green technology is indicated as GT.

Renewable energies are the means of energy production from unlimited sources or the energies that are derived from natural resources or processes that are constantly replenished over time. Unlike fossil fuels which are finite and contribute to environmental degradation through carbon emissions, renewable energy sources are sustainable and environmentally friendly. The exploitation of renewable energies can generate few pollutants. So, renewable energies are considered as a privileged vector in fight against global warming Milindi and Inglesi Lotz (2021). This is the reason we have used renewable energy consumption as the indicator of

green Technology, as it indicates the practical outcome of the green technology in reducing CO2 emission.

### 3.2.4 Control Variables

This research is based on macro-economic perspective so we included those variables as controlled that have great influence on macro-economic performance of the economy. Inflation Rate and Interest Rate are the factors that highly contribute in shaping economy at macro level. These factor influence the availability of financial products to a great extent.

#### 3.2.4.1 Inflation Rate

The first control variable is inflation rate. Inflation rate is the increase in the prices over the period of time. Inflation rate has impact on economy as it may results in slower economic growth. The measure of the inflation rate is consumer price based (annual %) as used by Abu Bakar and Adeel-Farooq. The data is sourced from WDI. Existing studies has considered INF as crucial factor for determining number of investments in an economy, that's why there is need to control the rise in price level (Shim et al., 1995) so that better analysis can be done. It is labeled as INF.

#### 3.2.4.2 Interest Rate

Interest rate has effect on the economy because it influence the volume and productivity of the investments. So, Interest rate is second control variable in this study. The measure used for this control variable is real interest rate (%) as used by [Abu Bakar and Adeel-Farooq \(2019\)](#). The data source is WDI. Interest Rate is symbolized as RIR. Interest rate has effect on the economy because it influence the volume and productivity of the investments. So, Interest rate is second control variable in this study. The measure used for this control variable is real interest rate (%) as used by [Abu Bakar and Adeel-Farooq \(2019\)](#). The data source is WDI. Interest Rate is symbolized as RIR.

TABLE 3.1: List of Variables

Variable Type/ Name	Measured of the variable	Label	Source	Reference
Dependent: CO2 Emissions	CO2 emissions (kg per 2017 US\$ of GDP)	CO2	WDI	Fu, X. (2023)
Independent: Green finance	International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid system (millions of constant 2020 United States dollars)	GF	Our World In Data	Kirikaleli, D., Adebayo, T.S. (2021)
Moderator: Financial inclusion	Commercial bank branches (per 100,000 adults)	FI	WDI	Chien, F.S. (2023)
Moderator: Green Technology	Renewable energy consumption (% of total final energy consumption)	GT	WDI	Milindi, C. B., Inglesi-Lotz, R. (2022)
Control: Inflation Rate	Inflation, consumer price (annual %)	INF	WDI	Abu Bakar, N.A., Adeel-Farooq, R.M. (2019)
Control: Interest Rate	Real interest rate (%)	RIR	WDI	Abu Bakar, N.A., Adeel-Farooq, R.M. (2019)

### 3.3 Data Analysis

#### 3.3.1 Descriptive Statistics

Descriptive statistics is used to capture the statistics behavior of the data. It is the technique used to summarize, organize, and simplify data. Descriptive statistics include mean, which gives the average of the data, median, which divides the data set into two equal segments. In a dataset, the mode denotes the value that occurs the most frequently, and the median is the midpoint value when the values are ordered in either ascending or descending order.

Standard deviation, the square root of the variance, indicates how dispersed the values are around the mean.

The mean and standard deviation must be used in tandem; otherwise, they have no value. A measure of the data distribution's asymmetry is called skewness. It records both the positive and negative data spread. High and low kurtosis indicate whether the distribution curve is flat or not. Kurtosis is a measure of the "tailedness" of the distribution curve.

It focuses on the extremes or outliers in a distribution, indicating how sharp or flat the peak is and how heavy or light the tails are compared to a normal distribution. If the distribution is greater than 3 ( $kurtosis > 3$ ), it is called leptokurtic distribution curve, which means there are many outliers or extreme values in the data.

If the distribution is equal to 3 (*kurtosis* = 3), it refers as mesokurtic, which indicates normal distribution. And the distribution that is less than 3 (*kurtosis* < 3), it is called platykurtic, which means there are fewer outliers.

### 3.3.1.1 Correlation Analysis

Correlation analysis is a statistical measure that describes the strength and direction among variables. It indicates how the change in one variable is associated with the change in another variable. Correlation analysis among variables demonstrates positive and negative connections among distinct variables. Its range is between -1 and +1. The value that is close to the -1 means that the connection between the variable is perfectly negative.

The values that are close to the +1 means that the connection between the variable is perfectly positive. The value that is 0 or close to 0 are showing that the connection between the variable is weak or no connection between them. The likelihood of multicollinearity is lower when there is low correlation between two variables and higher when there is significant correlation between two variables.

### 3.3.1.2 Panel Unit Root Test

It is likely to have unit root in the panel data as there are large number of observations in the data set. It can cause the results to be biased and can results in spurious regression so Panel Unit Root tests are conducted to check the stationarity of the variable.

To measure the unit root in the data set, this study employs a variety of unit root measurements. Levin, Lin, and Chu (2002) and Im, Pesran, and Shin (2003) have been utilized. The two factors used by the approach to make its judgement are the p value and the t statistics.

### 3.3.1.3 Econometric Models

The relationship between green finance, CO2 emissions, and financial inclusion and green technology is the main focus of this study. In order to look deep at the link between the variables, the following model has been created.

The original model for dynamic panel is:

$$Y_{it} = \beta_1 Y_{i(t-1)} + \beta_2 X_{it} + \epsilon_{it} \quad (3.1)$$

This model include lagged dependent variable to estimate the current value of dependent variable.

### **Model 1: Impact of GF on CO2**

The model explains the direct effect of GF on CO2 emission. Lag of CO2 emission is used as regressor in this model to analyze the current CO2 emissions from the past CO2 emissions.

$$CO2_{it} = \beta_1 CO2_{i(t-1)} + \beta_2 GF_{it} + \beta_3 INF_{it} + \beta_4 RIR_{it} + \epsilon_{it} \quad (3.2)$$

### **Model 2: Moderating Role of FI in the Relationship of GF and CO2**

The model explains the moderating role of FI in the relationship of GF and CO2. The direct effect of FI on CO2 emissions is analyzed and interaction of GF and FI is used to analyze their effect on CO2 emissions.

$$CO2_{it} = \beta_1 CO2_{i(t-1)} + \beta_2 GF_{it} + \beta_3 FI_{it} + \beta_4 (GF \times FI)_{it} + \beta_5 INF_{it} + \beta_6 RIR_{it} + \epsilon_{it} \quad (3.3)$$

### **Moderating Role of GT in the Relationship of GF and CO2**

This model includes the analysis of direct effect of GF and GT and then the interaction of GF and GT to predict their impact on CO2 emissions. This model explains moderating role of GT in the relationship of GF and CO2 emissions.

$$CO2_{it} = \beta_1 CO2_{i(t-1)} + \beta_2 GF_{it} + \beta_3 GT_{it} + \beta_4 (GF \times GT)_{it} + \beta_5 INF_{it} + \beta_6 RIR_{it} + \epsilon_{it} \quad (3.4)$$

### **Model 4: Moderating effect of FI and GT in the Relationship of GF and CO2**

According to Laselin et al (2016), the degree to which a treatment's efficacy is reliant on inflammation may vary depending on the participants' receipt of either AR or ACT (a three-way interaction). Montoya (2024) thus examines the multiple moderation model's multiplicative approach.

He proposed including moderator interactions in multiplicative moderation. According to Hayes (2018), all two-way interactions and the three-way interaction between X, W1, and W2 would be included when there are two moderators. Following model is used for analyses of three way interaction of green finance, financial inclusion and green technology to predict CO2 emissions.

$$\begin{aligned} \text{CO2}_{it} = & \beta_1 \text{CO2}_{i(t-1)} + \beta_2 \text{GF}_{it} + \beta_3 \text{FI}_{it} + \beta_4 \text{GT}_{it} + \beta_5 (\text{GF}_{it} \times \text{FI}_{it}) \\ & + \beta_6 (\text{GF}_{it} \times \text{GT}_{it}) + \beta_7 (\text{GF} \times \text{FI} \times \text{GT})_{it} + \beta_8 \text{INF}_{it} + \beta_9 \text{RIR}_{it} + \epsilon_{it} \end{aligned} \quad (3.5)$$

Where,

$\text{CO2}_{it}$  = CO2 emissions for ith countries at time t.

$\beta$  = Coefficient of variables.

$\text{CO2}_{i(t-1)}$  = Lag of dependent variable

$\text{GF}_{it}$  = Green finance for ith countries at time t.

$\text{FI}_{it}$  = Financial inclusion for ith countries a

$\text{GT}_{it}$  = Green technology for ith countries at time t.

INF = Inflation Rate

RIR = Interest Rate

$\epsilon_{it}$  = *ErrorTerms*

### 3.3.1.4 Dynamic Panel Analysis

The panel data set includes both cross-sectional and time-varying data. A balancing panel is one in which each cross-section of a variable has the same series of time observations. A dynamic panel model is an econometric model used to

analyze data that varies across both time and cross-sections. The dynamic panel model uses the lagged dependent variables as a regressor.

It means that previous values of the dependent variable are used to predict the current values. These models can capture the dynamic nature of the relationships being studied. In our study, the dynamic panel model is used as we are trying to capture how previous levels of CO2 emissions, with, affect current CO2 emissions over time. Also we are analyzing the effect of green finance, financial inclusion, and green technology on CO2 emission.

### **Wald Test**

Wald test is a statistical test used to determine the endogeneity. It determine the significance of the variable. It examine if the model's independent variable has a statistically significant effect on the dependent variable. A crucial value from the chi-square distribution with degrees of freedom equal to the number of limitations being tested is compared to the test statistic.

In our study, the Wald test is used to determine whether the coefficients of the variables of our study are statistically significant. For Wald test, first there is the use of FEM. In order to check the endogeneity the f-stat value is observed. When the f-stat value of the Wald test is less than 0.05 or (typically  $p < 0.05$ ), it means that problem of endogeneity is present. If there is endogeneity in one variable, it means that it will affect the whole model. So, GMM will be used to solve this problem.

### **Generalized Method of Moments (GMM)**

A key challenge in the dynamic panel model is endogeneity, which arises when lagged dependent variables correlate with error terms. This correlation can bias the results of estimations. This issue can be resolved by using Generalized Method of Moments (GMM) which uses instruments to provide consistent results. These instruments are those variables that have a correlation with the endogenous regressor but not with the error term.

# Chapter 4

## Result and Analysis

### 4.1 Descriptive Statistics

The study's variables' descriptive statistics were presented in Table 4.1. The GF's standard deviation is  $1.97\text{E}+08$ , and its mean value is  $1.04\text{E}+08$ . Its median is 18800000. The maximum and minimum are  $1.46\text{E}+09$  and 10000 respectively. The skewed value of GF is 3.402 and positive, which means it is positively skewed, while the Kurtosis value is 17.841, which is higher than 3. It means that GF curve is leptokurtic.

FI has a standard deviation of 11.143, mean value of 12.819 and median is 10.230. It has maximum value is 56.23 and minimum is 0.65. It has a positive skew of 1.544. The kurtosis of the FI curve is 5.687, which is likewise more than 3, indicating a leptokurtic curve.

The mean value of GT is 51.695. Its standard deviation is 26.775. Its median is 10.230. The maximum is 97.03 and the minimum is 2.75. The skewness of GT is 0.133, means it is positively skewed. Its kurtosis value is 1.875, which means that curve is platykurtic.

The mean value of CO<sub>2</sub> emission is 0.170, its median is 0.124 and its standard deviation is 0.133. Its maximum and minimum value is 0.679 and 0.028. The skewness value of CO<sub>2</sub> emissions is 1.764, which means the CO<sub>2</sub> emission is positively skewed. The kurtosis value of CO<sub>2</sub> emissions is 5.660, which higher than 3. It means the curve of CO<sub>2</sub> emission distribution is leptokurtic.

The mean value of the first control variable INF is 5.813, its median is 5.036 and its standard deviation is 4.696. The maximum and minimum are 24.406 and 16.859. The skewness of INF is 0.555336, positively skewed. While the kurtosis value of INF is 6.681210, higher than 3. So the curve of INF is leptokurtic.

The control variable, RIR has a mean value 9.107, median is 7.153 and its standard deviation is 8.554 while its maximum and minimum values are 41.713 and 12.711 respectively. RIR is positively skewed. Its skewness value is 1.416 while its kurtosis value is 5.495, higher than 3, which means the curve of RIR is leptokurtic.

TABLE 4.1: Descriptive Statistics

	<b>GF</b>	<b>FI1</b>	<b>GT</b>	<b>CO2</b>	<b>INF</b>	<b>RIR</b>
Mean	1.04E+08	12.819	51.695	0.170	5.813	9.107
Median	18800000	10.230	10.230	0.124	5.036	7.153
Maximum	1.46E+09	56.230	97.030	0.679	24.406	41.713
Minimum	10000.00	0.650	2.750	0.028	16.859	12.714
Std. Dev.	1.97E+08	11.1430	26.775	0.133	4.696	8.554
Skewness	3.402	1.544	0.133	1.764	0.555	1.416
Kurtosis	17.841	5.687	1.875	5.660	6.681	5.495
Jarque-Bera	2366.007	148.830	11.856	173.310	131.215	126.477
Probability	0.000	0.000	0.002	0.000	0.000	0.000
Sum	2.22E+10	2730.480	11011.04	36.33394	1238.248	1939.902
Sum Sq. Dev.	8.19E+18	26323.44	151994.1	3.760583	4676.460	15512.70
Observations	1512	1512	1512	1512	1512	1512

## 4.2 Correlation Matrix Analysis

The table 4.2 shows the relationships among variables. The correlation between GF and FI is perfectly negative. -0.0555 is far from 0, so there is strong relationship between GF and FI. The results show the positive relationship between GF and GT. 0.0557, so the correlation among them is perfectly positive. GF has negative and strong correlation with CO2 emissions. -0.0652 is far from 0, so the correlation between GF and CO2 emission is perfectly negative.

The control variables INF shows negative and very weak correlation with GF, that is -0.006 far from -1 while RIR has moderate correlation with GF at 0.188. The GT has correlation with FI at 0.482 that is negative but moderate relationship with FI. FI has perfectly positive correlation with CO2 emission at 0.085, which is near 1. FI has moderate relationship with INF which is 0.228. FI has very negative and weak correlation with RIR at -0.0003 Similarly, GT has negative but moderate correlation with CO2 emissions at -0.554. GT is positively but moderately associated with control variables at 0.397.

There is negative but moderate correlation between INF and CO2 emission at 0.139. INF is -0.3137 in relation to CO2 emission, which means it is negatively and moderately correlated with CO2 emissions. -0.2755 shows that RIR has a negative and moderate correlation with CO2 emissions. INF has perfectly negative correlation with RIR at -0.081

TABLE 4.2: Correlation Matrix

	<b>GF</b>	<b>FI</b>	<b>GT</b>	<b>CO2</b>	<b>INF</b>	<b>RIR</b>
GF	1.0000					
FI	-0.0555	1.0000				
GT	0.0557	-0.4821	1.0000			
CO2	-0.0652	0.0850	-0.5547	1.0000		
INF	-0.0068	-0.2281	0.3979	-0.3137	1.0000	
RIR	0.1887	-0.0003	0.1390	-0.2755	-0.0814	1.0000

### 4.3 Panel Unit Root Test

Table 4.3 reported the results of unit root test on series. The results indicates that Green finance is Stationary at level and FI is stationary as per Levin, lin & chu but non stationary as per Im, Perasan & Shin at level. The insignificant p-value of the Im, Peresan & Shin test indicates that there may be non-stationarity in some of the individual series. GT is also stationary according to Levin, lin & chu but non stationary as per Im, Perasan & Shin at level. CO2 emission is also stationary. INF and RIR are also stationary.

TABLE 4.3: Panel Unit Root Test @ level

Variables	Levin, Lin & Chu		Im, Pesaran & Shin W-stats	
	Statistic	Prob.	Statistic	Prob.
GF	-1131.33	0.000	-93.415	0.000
FI	-7.818	0.000	-1.003	0.157
GT	-2.912	0.001	1.048	0.852
CO2	-5.345	0.000	-1.863	0.0312
INF	-9.922	0.000	-8.538	0.000
RIR	-12.227	0.000	-9.559	0.000

All the series that are non-stationary at level become stationary at 1st difference. The scale of Green finance is different from all other variables in USD amount, we take the log difference of GF data to align its scale with other variables, ensuring a consistent and accurate analysis. In order to ensure consistency among all variables of study, we have used log difference transformation for all variables. The results after log difference transformation are in table 4.4.

TABLE 4.4: Panel Unit Root Test at 1st difference

Variables	Levin, Lin & Chu		Im, Pesaran & Shin W-stats	
	Statistic	Prob.	Statistic	Prob.
DLGF	-12.125	0.000	-13.308	0.000
DIFI	-6.024	0.000	-5.193	0.000
DLGT	-8.598	0.000	-10.922	0.000
DICO2	-12.289	0.000	-13.034	0.000
DINF	-22.424	0.000	-18.780	0.000
DLRIR	-24.784	0.000	-15.387	0.000

## 4.4 Wald Test

When there is dynamic panel model, the problem of endogeneity exist. In order to check the endogeneity, we have run the Wald test after FEM analysis, the results of the test show that the f-stats value is less than 0.05, which means the problem of

endogeneity exists. The results of this test are in table 4.6. To solve this problem, we used GMM estimations on our data.

TABLE 4.5: Wald Test

Test Statistics	Value	df	Prob.
t-statistics	-2.0729	542	0.0386
f-statistics	4.2972	(1, 542)	0.0386
Chi-square	4.2972	1	0.0382

## 4.5 Results of GMM Estimation

The study uses Green finance as a key variable to explain CO<sub>2</sub> emission along with the moderators. The estimated results of the constructed model 1 to 4 employing GMM estimations are reported in the table.

### 4.5.1 Effect of Green Finance on CO<sub>2</sub> Emission

The base model of our study considered influence of green finance on CO<sub>2</sub> emission. The econometric results of GMM of model 1 suggest that green finance has a negative but significant impact on CO<sub>2</sub> emission. The negative sign indicates the inverse relationship between these two variables. There is a 0.0036% reduction in CO<sub>2</sub> emissions for every 1% rise in green finance. The results are significant. It means that the increase of International flow for clean energy to developing countries significantly reduces CO<sub>2</sub> emissions.

Although the effect is relatively small but it has statistical significance. The finding of this model is supported by several studies. The association between green finance and CO<sub>2</sub> emissions in 44 industrialized and developing nations has been investigated by [Saha et al. \(2024\)](#). The results of this study demonstrate that green finance significantly reduces global CO<sub>2</sub> emissions. Similarly, [Saeed Meo and Karim \(2022\)](#) apply QQR regression to evaluate the association between green finance and CO<sub>2</sub> emissions in the top ten economies. The results reported the negative impact of green finance on CO<sub>2</sub> emissions. Also, [Xu, Li, Zhou, Shahzad,](#)

and Zhao (2022) support the findings that with the developed green finance, CO2 emission decreases.

Similarly, Liu et al (2024) draw the same findings. As the CO2 emissions measure involve the relative association with GDP, we can say that green finance significantly reduces CO2 emission reduces with every dollar of GDP.

The findings of our study induce that the efforts and financing to environment protection initiatives can contribute in lowering CO2 emissions. This shows that if developing countries put long efforts and investments in clean energies, the cumulative effect of all these efforts will eventually lead them to be in the list of sustainable economies. Table 4.7 shows the results of the findings.

TABLE 4.6: Impact of GF on CO2 Emissions

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLCO2(-1)	-0.091458	0.011609	-7.878408	0.0000
DLGF	-0.003662	0.000184	-19.85268	0.0000
DLINF	0.002170	0.000742	2.924644	0.0036
DLRIR	0.008310	0.003566	2.330260	0.0203
Mean dependent var	0.004207	S.D. dependent var		0.067158
S.E. of regression	0.113759	Sum squared resid		5.072921
J-statistic	63.43431	Instrument rank		67
Prob(J-statistic)	0.460964			

#### 4.5.2 The Moderating Effect of Financial Inclusion between Green Finance and CO2 Emission

Table 4.8 shows the results of 2nd model. The positive coefficient of the individual moderating variable, financial inclusion indicates that financial inclusion increases the CO2 emission. The results show a 1% increase in financial inclusion leads to a 0.0813% increase in CO2 emission. This means financial inclusion increases CO2 emissions. This finding is supported by Ogede and Tihamiyu (2022) who explored the relationship between financial inclusion and CO2 emission along with many

other variables in Sub-Saharan Africa (SSA) countries, by using PARDL. The direct effect of Financial inclusion in the long run significantly increases CO2 emission while in the short run, has no significant effect on CO2 emission.

Also, the findings of Said and Acheampong (2024) somehow support our finding as some of the developing countries from MENA showed a positive association with CO2 emission while others showed a negative association with CO2 emission, implying that the effect varies in countries. It can be due to the shift in Consumption patterns as when more people get access to financial services. It makes it possible for households to buy items that run on fuel and energy, such gadgets, cars, and appliances.

This may increase the need for energy, especially in areas with inadequate infrastructure for renewable energy sources, and increase CO2 emissions. However, the interaction term of green finance and financial inclusion has a negative coefficient indicating that when there is interaction of both green finance and financial inclusion, it significantly reduces CO2 emission. A 1% increase in the interaction term causes the CO2 emission to decrease by 0.0086%.

These results help us to understand that individually, financial inclusion has positive or next to no significant effect on CO2 emission. In contrast, along with green finance, it can help mitigate climate change by reducing CO2 emission. As this nexus is a novel contribution to the literature, its empirical results and findings are not essentially backed by literature.

However, [Hu, Jiang, and Cao \(2024\)](#) have examined the moderating influence of digital financial inclusion between green finance and agricultural CO2 emission in China.

The results show that digital financial inclusion negatively moderates the effect of green finance in reducing CO2 emissions. As the purpose of green finance is to finance the environment friendly initiatives.

It suggests that people and small businesses that previously lacked access to credit and other financial services can now engage in green practices and contribute to environmental sustainability when financial inclusion and green finance are combined.

TABLE 4.7: The Moderating Effect of FI between GF and CO2 Emissions

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLCO2(-1)	-0.106036	0.007434	-14.26324	0.0000
DLGF	-0.002670	0.000245	-10.87634	0.0000
DLEFI	0.081348	0.005127	15.86594	0.0000
DLGF*DLEFI	-0.008634	0.002337	-3.693890	0.0003
DLINF	0.004423	0.001061	4.168151	0.0000
DLRIR	0.009120	0.001537	5.934523	0.0000
Mean dependent var	0.004378	S.D. dependent var		0.067314
S.E. of regression	0.116091	Sum squared resid		5.202174
J-statistic	58.90615	Instrument rank		66
Prob(J-statistic)	0.515742			

### 4.5.3 The Moderating Effect of Green Technology between Green Finance and CO2 Emissions

The role of green technology as a moderator in the relationship between green finance and CO2 emission is examined in this section. The table 4.9 shows the result of the analysis. Green technology is negatively associated with CO2 emissions. A 1% increase in green technology leads to 0.6448% decrease in CO2 emission. The findings align with the Rahman et al (2024) who implies that renewable energy consumption has proactive role in reducing CO2 emissions. These results are also backed by many other studies (Billatos, 1997).

The results reveal that the relationship between green finance and CO2 emissions strengthens by incorporating green technologies. The negative coefficient shows that enhanced green technology and green finance significantly reduces CO2 emission. A 1% increase in interaction term leads to a 0.0457% decrease in CO2 emission. The results are somewhat supported by Ma and Fei's (2024) investigation on how green finance affects CO2 levels in China. He conclude that by promoting green technology innovations, CSR disclosure and social investments, green finance reduces CO2 emissions. This means when the developing economies opt for investments in clean energy production and R&D, and ensures the consumptions of renewable energy, the environment quality improves.

TABLE 4.8: The Moderating Effect of GT between GF and CO2 Emissions

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLCO2(-1)	-0.115446	0.006700	-17.22999	0.0000
DLGF	-0.002423	0.000213	-11.34779	0.0000
DLGT	-0.644863	0.014475	-44.54916	0.0000
DLGF*DLGT	-0.045735	0.004128	-11.08036	0.0000
DLINF	-0.010569	0.001582	-6.682806	0.0000
DLRIR	0.001072	0.000872	1.228616	0.2200
Mean dependent var	0.004207	S.D. dependent var		0.067158
S.E. of regression	0.103644	Sum squared resid		4.189406
J-statistic	58.65548	Instrument rank		67
Prob(J-statistic)	0.561371			

#### 4.5.4 The Moderating Effect of Financial Inclusion and Green Technology between Green Finance and CO2 Emission

The model 4 estimated the effect of two moderators' financial inclusion and green Technology, jointly on the relationship of green finance and CO2 emission. This is the complex model based on the multiplicative moderation or three way interaction. The results are reported in table 4.10. The negative sign of the interaction term shows that green finance, financial inclusion, and Green technology jointly reduce CO2 emission. A 1% increase in green finance, financial inclusion, and green technology leads to a significant 0.7126% decrease in CO2 emission. These findings help us to induce that in developing economies, implementation of inclusive financial system and investment in clean energies along with renewable energy consumption, lower CO2 emission for every dollar of GDP. The higher negative coefficient value in these results show that the relationship between green finance and CO2 emissions strengthens by incorporating financial inclusion and green Technology. The findings drawn by Ababio et al (2023), who explored the link between financial inclusion and renewable energy consumption, states that

financial inclusion positively effects renewable energy consumption and environmental sustainability. This shows that financial inclusion has positive association with renewable energy consumption, thus their combined effect is also positive on environmental sustainability. Sarangi et al. (2020) found that in regions where financial inclusion is high, green technology adoption rates increase, leading to greater reductions in carbon emissions. This finding resonate with our study as we have explored the combined effect of financial inclusion and renewable energy consumption as an indicator of green technology, in addition we have combined them with green finance, to analyze the effect of CO2 emissions. The results of our analysis helps us to draw an imperative finding that in developing countries these three variables have significant effect on environmental protection in the past years. It means that if these factors get incorporated with proper strategy and policies, they can make crucial difference in the environmental performance of developing countries. The interaction between financial inclusion and green technology creates a promising avenue for enhancing the impact of green finance on CO2 emissions. Scholars argue that financial inclusion not only facilitates access to financial resources but also plays a crucial role in disseminating green technologies, particularly in low-income and rural areas.

TABLE 4.9: The moderating effect of FI & GT between GF and CO2 Emissions

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLCO2(-1)	-0.123291	0.007979	-15.45197	0.0000
DLGF	-0.001986	0.000243	-8.159610	0.0000
DLFI	0.069540	0.006964	9.985872	0.0000
DLGT	-0.653826	0.012761	-51.23468	0.0000
DLGF*DLFI	-0.009637	0.003958	-2.434819	0.0154
DLGF*DLGT	-0.034299	0.004746	-7.227290	0.0000
DLGF*DLFI*DLGT	-0.712654	0.027618	-25.80403	0.0000
DLINF	-0.009042	0.001579	-5.724773	0.0000
DLRIR	0.001480	0.000857	1.727548	0.0849
Mean dependent var	0.004378	S.D. dependent var		0.067314
S.E. of regression	0.106416	Sum squared resid		4.337255
J-statistic	55.40474	Instrument rank		66
Prob(J-statistic)	0.535137			

# Chapter 5

## Conclusions

### 5.1 Conclusion

Based on balance panel data from 2004-2021, this research explored the nexus between Green finance, financial inclusion, green technology and CO2 emission. This study capture the effect of two moderators in one framework. The three way interaction is employed to understand the multiplicative effect of the two moderators on the outcome variable. The data analysis is done using GMM estimation.

First, the study explores the effect of green finance on CO2 emissions. This serves as a base model of our study. The results shows that green finance negatively affect CO2 emissions. The results support our hypothesis that green finance plays significant role in reducing CO2 emission in developing countries. Then, the study explored the moderating role of our first moderator, financial inclusion on base model.

The results shows that financial inclusion, individually, has positive association with CO2 emission while by interacting with green finance, it significantly reduces CO2 emission. Third, we have explored the moderating effect of green technology in the relationship of green finance and CO2 emissions. The results indicate that green technology individually as well as interactively with green finance significantly lowers CO2 emission. At last, we have explored the combined moderating effect of financial inclusion and green technology on CO2 by using multiplicative approach or three way interaction. The findings show that green finance, green

technology, and financial inclusion all greatly lower CO<sub>2</sub> emissions. The synergistic role of financial inclusion and green technology amplifies the environmental quality by reducing CO<sub>2</sub> emission, leading to the sustainable development.

The combined effect of green finance and financial inclusion not only broadens the economic benefits but also ensures that the resources are directed towards low carbon activities. This approach is highly beneficial for developing economies as the emphasis is placed on achieving sustainable results. The study highlight the critical roles that financial mechanisms and technological advancements play in mitigating environmental impacts, particularly in developing economies that may gradually and eventually lead to the achievement of SDGs. The study was able to answer all research questions and achieve all objectives that we have identified initially.

Q1: The study underscores that green finance is the driving force to transition toward low carbon economy by providing the necessary capital to support clean energies and less fossil fuels dependency. The developing countries who have less resources, can opt for international financial flow and make sure to allocate those resources for the project that are environment friendly.

Q2: Financial inclusion do matters in reducing CO<sub>2</sub> emission. Although financial inclusion does not reduces CO<sub>2</sub> emission alone, but when decoupled with green finance, it lowers CO<sub>2</sub> emission. This study reveals the link of financial inclusion with sustainable aspects. This help us to determine the importance of an inclusive financial system to ensure sustainable development. So, we can say that financial inclusion is not just about economic development but also about supporting the transition toward greener economy.

Q3: Green technology act as catalyst in transition toward green economy and achieving SDGs. Green technology ensures the higher adaption and consumption of renewable energy technologies. Since the consumptions of renewable energy is a practical outcome of green technology, it is used as a green technology indicator. The green technology strengthens the relationship of green finance and CO<sub>2</sub> emission reduction, playing a significant moderating role between them. So, the investment as well as the consumption of clean or renewable energies reduces CO<sub>2</sub> emission, thus leading to more sustainable environment.

Q4: Green finance when complemented with the financial inclusion and green technology, it become the powerful tool to combat the climate changes by reducing CO<sub>2</sub> emissions. The integration of investment, financial access and technological advancement, can slowly and steadily leads to achieve sustainable growth in developing countries.

The use of two moderators enriches the analysis by capturing the multidimensional effects of the variables. The Multiple Moderators provides a comprehensive understanding of how green finance can achieve CO<sub>2</sub> emission reduction by reflecting the complex interplay of investment, financial access and technology advancement. It make it possible to analyze the unexplored combinations and their effect on the path of environmental sustainability.

The study provides clear, concise and contextually grounded understanding of the importance of green finance, financial inclusion and green technology in environmental sustainability in developing countries, and the rationale of including both moderators in this framework.

## **5.2 Policy Implication**

The paper provides policy makers with some policy considerations based on the empirical analysis. Green finance, financial inclusion and green technology plays crucial role in lowering CO<sub>2</sub> emissions in developing nations. These findings are critical in planning green growth policies. The findings encourage the nations to swiftly move toward green financing tools in order to achieve SDGs. The central bank and regulatory authorities should introduce green finance instruments for renewable investments to lower CO<sub>2</sub> emissions.

Increased financial flow toward clean energy and R&D is a great strategy to reduce CO<sub>2</sub> emission in developing countries. The government should prioritize to allocate these resources to the green initiatives where there is maximum potential to reduce emissions. As the findings gives the insight of the role of financial inclusion in green economy it encourages the authorities to focus on inclusive growth and implement policies that ensure inclusive financial systems. It will allow marginalized population in developing countries to participate in environmental protection

initiatives. It is important for policymakers to understand that if financial inclusion is not combined with sustainable practices, it may result in higher CO<sub>2</sub> emissions as per our findings. Policies ought to be designed to direct funding towards environment friendly or low-carbon initiatives.

It is imperative to incorporate sustainability into financial inclusion programs to ensure that environment quality is not compromised by economic growth. The availability of green finance is often concentrated in developed economies, leaving developing nations with limited access to the financial resources needed to implement green projects. This inequality raises important questions about the global distribution of green finance and the importance of cross-border cooperation to address climate change collectively.

Also the findings greatly supports the use of green Technologies to achieve SDGs. Authorities should focus on implementing the strategies that support the adoption of renewable energies and promote efficiency. The authorities should focus on encouraging the organizations and population to opt for renewable energies and use them for the betterment of environment. The encouragement and awareness is also an important factor that can help motivate people to adopt the Green practices in developing countries.

The green finance holds substantial potential for reducing CO<sub>2</sub> emissions, and the level of financial inclusion and the adoption of green technology are also few factors that influence this path. Policymakers must consider these factors when designing frameworks to promote sustainable finance and achieve climate goals.

Although these factors alone cannot lead to net zero carbon target of Paris Agreement in developing countries but these factors together can make the huge difference in environment sustainability. The policy makers in these countries need to find the right balance among these variables to achieve SDGs. Furthermore, international organizations, such as the United Nations and the European Union, have developed frameworks that promote the use of green finance to achieve climate goals. For instance, the European Green Deal includes measures to support green finance as a tool for driving the continent's transition to a low-carbon economy. Nevertheless, there are still gaps in policy implementation, particularly in developing countries, where regulatory systems may not be as advanced or well-enforced.

### **5.3 Limitations of the Study**

Although this study contribute uniquely in the literature, there are still some limitations. The study has limited time period from 2004 to 2021. The reason to use this time period is the limited availability of data for most of the countries. The study focused on the macro perspectives while ignoring the micro level aspect, to ensure proper focus on specific perspectives. The study is only limited to developing countries, thus ignoring the cross country analysis to make generalized perspective.

### **5.4 Future Direction**

Because of the limitation mentioned above, this study opens new avenue for the future researchers to explore. The comparative analysis based on regions, in context of these variables, can help to dive further in this study. Also there should be focus on micro level perspective in further studies. The use of multiple moderators model in finance is next to no, so future researchers can use this model in many possible ways to analyze the complex models in the field of finance. Different methodologies can also be used to further validate the findings of the study.

Future studies can introduce the right balance of these variable to implement in economies. Future research should explore the long-term effects of green finance on CO2 emissions and investigate the conditions under which financial inclusion and green technology serve as the most effective moderators. Understanding the interplay between these variables in different economic contexts can provide valuable insights into how policy frameworks can be tailored to maximize the environmental impact of green finance.

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# Appendix A

TABLE 1: Appendix

S.no	Name	S.no	Name	S.no	Name	S.no	Name
1.	Afghanistan	23.	Congo	45.	Liberia	67.	Paraguay
2.	Algeria	24.	Dominican Republic	46.	Madagascar	68.	Peru
3.	Angola	25.	Egypt	47.	Malawi	69.	Philippine
4.	Armenia	26.	Fiji	48.	Malaysia	70.	Rwanda
5.	Azerbaijan	27.	Georgia	49.	Maldives	71.	Sao Tome
Principe							
6.	Bangladesh	28.	Ghana	50.	Mauritania	72.	Senegal
7.	Belarus	29.	Guatemala	51.	Mexico	73.	Solomon Islands
8.	Benin	30.	Guinea	52.	Micronesia	74.	South Africa
9.	Bhutan	31.	Guinea- Bissau	53.	Moldova	75.	Sri Lanka
10.	Bolivia	32.	Guyana	54.	Mongolia	76.	Tajikistan
11.	Botswana	33.	Haiti	55.	Montenegro	77.	Thailand
12.	Brazil	34.	Honduras	56.	Morocco	78.	Togo
13.	Burkina Faso	35.	India	57.	Mozambique	79.	Tunisia
14.	Burundi	36.	Indonesia	58.	Myanmar	80.	Uganda
15.	Cameroon	37.	Iran	59.	Namibia	81.	Ukraine
16.	Cape Verde	38.	Iraq	60.	Nicaragua	82.	Uruguay
17.	Chile	39.	Jamaica	61.	Niger	83.	Vietnam
18.	China	40.	Jordan	62.	Nigeria	84.	Zambia
19.	Colombia	41.	Kenya	63.	North Macedonia		
20.	Comoros	42.	Kyrgyzstan	64.	Pakistan		
21.	Costa Rica	43.	Lebanon	65.	Panama		
22.	Cote d'Ivoire	44.	Lesotho	66.	Papua New Guinea		