CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY, ISLAMABAD

The Effects of Natural Resource Rents and Green Environment on Sustainable Development, the Mediating Role of Financial Development, and the Moderating Role of Fintech: Evidence from N11 Countries

by

Nadia Jamil

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This thesis is dedicated to my beloved parents, Mian Mohammad Jamil and Shafquat, my husband Ali Majeed, my precious children Ashar and Abeeha

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This is to certify that the research work presented in the dissertation, entitled "**The Effects of Natural Resource Rents and Green Environment on Sustainable Development, the Mediating Role of Financial Development, and the Moderating Role of Fintech: Evidence from N11 Countries** was conducted under the supervision of **Dr. Jaleel Ahmed Malik**. No part of this dissertation has been submitted anywhere else for any other degree. This dissertation is submitted to the **Department of Management Sciences, Capital University of Science and Technology** in partial fulfillment of the requirements for the degree of Doctor in Philosophy in the field of **Management Sciences.** The open defence of dissertation was conducted on **November 24, 2025**.

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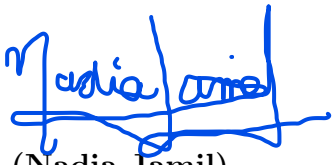

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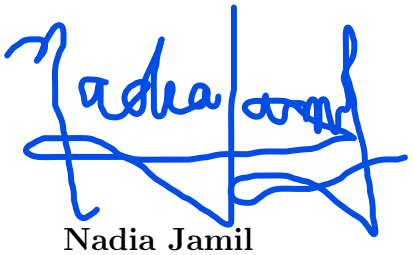
1. Jamil, N., & Ahmed, J. (2025). Natural Resources—Are They a Blessing or Curse? A Systematic Literature Review of Resource-Finance Nexus. *Sustainable Development*, 1-17.



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Abstract

Sustainable development is a holistic notion that emphasizes meeting current demands without risking the capability of next generations to fulfill their own needs. The combustion of fossil fuels increases the atmospheric levels of carbon dioxide and other greenhouse gases, leading to global warming. The primary objective of this study is to analyse how the management of natural resource rents, green finance, and green technology adoption might facilitate sustainable development. Sustainable development necessitates a multifaceted strategy. This study presents a novel idea of linking natural resource rents, green finance, and green technology to sustainable economic growth while addressing environmental deterioration. A notable gap persists in comprehending the indirect impact of these variables on sustainable development via the mediation function of financial development. Structural Equation Modelling (SEM) has been utilised on the data of 16 countries comprising N11 and BRICS to empirically examine the influence of natural resource rents, green finance, and green technology on sustainable development, incorporating the mediating effect of financial development. Structural Equation Modelling (SEM) is a second-generation methodology to evaluate hypotheses and analyse direct and indirect relationships. The results suggest that financial development is essential and partially mediates the relationship between natural resource rents, green finance, green technology, and sustainable development. Natural resource rents are intricately associated with the attainment of Sustainable Development Goal 13 (Climate Action) and Goal 8 (Sustainable Economic Growth). The study confirms that natural resource rents are blessings, and the Fintech adoption significantly strengthens the resource-finance linkage. Natural resource rents assist the economy in capital formation. Financial development effectively utilizes these funds to finance green projects that reduce CO_2 emissions and support economic growth, resulting in sustainable development. Within the framework of sustainable development, the demand-side hypothesis posits that higher consumer demand for sustainable products and services can stimulate investment in green technologies and eco-friendly behaviours. The study emphasizes the significance of the Triple Helix Model, proposing that in contemporary knowledge-driven economies, academia,

business, and government partnerships should be utilized to manage natural resource rents and implement Fintech solutions efficiently, strengthening financial development to attain Sustainable Development Goals. The supply of financial resources towards green initiatives, with the support of the financial sector, can help economies in achieving their sustainable goals. It also offers insights for financial analysts, policymakers, and stakeholders looking to harness green finance, green technologies, and financial development in pursuit of achieving the SDGs.

Keywords: Natural resource rents, Financial development, Systematic literature review, Fintech, Sustainable development, Green technology, Green finance, Structural equation modelling, N-11 and BRICS

Contents

List of Figures

List of Tables

Abbreviations

AI	Artificial Intelligence
CD	Coefficient of determination
CFI	Comparative Fit Index
CO2	Carbon Dioxide
CV	Control Variable
DV	Dependent Variable
EG	Economic Growth
EKC	Environmental Kuznets Curve
FD	Financial Development
FDI	Foreign Direct Investment
FINT	Fintech
GDP	Gross Domestic Product
GF	Green Finance
GT	Green Technology
HC	Human Capital
IND	Industrial Growth
INF	Inflation
IQ	Institutional Quality
IV	Independent Variable
MED	Mediation
MOD	Moderation
N11	Next-11 Countries
NRR	Natural Resource Rents
OECD	Organisation for Economic Co-operation and Development

POP	Population
RMSE	Root Mean Square Error of Approximation
SDGs	Sustainable Development Goals
SEM	Structural Equation Modeling
SLR	Systematic Literature Review
SRMR	Standardized root mean squared residual
TLI	Tucker-Lewis's Index
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change

Chapter 1

Introduction

1.1 Background of the Study

Sustainable development requires the responsible use of available resources that ensure environmental sustainability and safeguard the needs of future generations. Sustainable development encourages innovation, industrialization, preservation of natural resources, reducing climate change, and protecting biodiversity (Han, 2024). Globally, countries face huge economic losses due to severe and uncertain weather conditions and natural disasters. In this regard, countries worldwide agreed in the United Nations Framework Convention on Climate Change (UNFCCC) to reduce carbon emissions by using green energy in manufacturing processes. This transition from conventional to energy-efficient process requires a huge amount of investment. Especially in developing countries, insufficient funds and technical knowledge are a hurdle to adopting green technology (Liang et al., 2024).

Due to rapid urbanization and industrialization, N-11 and BRICS countries rely on natural resources and contribute to carbon emissions (Javed et al., 2025; Yadav et al., 2024). Natural resource rents (NRR), green finance (GF), green technology (GT), financial development (FD), and Fintech can play a significant role in filling the financial gap by facilitating capital allocation toward sustainable initiatives. The financial resources retrieved from them can help to achieve SDG 1, zero poverty; SDG 7, inexpensive and clean energy; SDG 8, sustainable economic growth; and SDG 13, climate action. Mineral resource rent can play a significant

role in economic growth and environmental sustainability by channeling excess revenue produced from natural resource extraction toward sustainable projects like renewable energy adoption, circular economies, and environmental conservation initiatives (Wang and Wang, 2024; Zhu et al., 2024).

Financial sector development is a way of reducing the cost of market transactions, gathering information efficiently, promoting trade-related activities, and mobilizing economic savings within a financial system. It also channelizes money towards international and domestic capital investments, promoting capital accumulation that results in economic growth (Allegret et al., 2014). Financial development is the best approach for boosting the nation's economic and trade activities through natural resources (Badeeb and Lean, 2017). By the best use of natural resources, the financial sector might play a vital role in economic progress. Resource-rich countries are expected to have more developed financial markets, and more bank credits are available for individuals and businesses (Bhattacharyya and Hodler, 2014; Sun et al., 2020). The term "resource-finance nexus" describes how the rents from natural resources (such as oil, gas, minerals, or agricultural products) and financial factors (such as investment, economic growth, stock market effectiveness, and financial institution advancements) interact.

The fact that natural resource rents are a blessing for financial development is supported by the favorable role they play in it (Li et al., 2021; Hussain et al., 2021; Ali et al., 2022). Revenue from natural resources can result in the accumulation of savings. The financial sector serves as a middleman to direct savings to the most effective and productive parts of the domestic and international economies (Atil et al., 2020). A country's transition from "underdevelopment" to "industrial take-off" relies heavily on its natural resources. Some researchers view natural resources as a curse (Naseer et al., 2020; Nassani et al., 2021; Umar et al., 2021). Countries with abundant nonrenewable resources, such as minerals, oil, and natural gas, have low financial development metrics compared to countries with less abundant natural resources. For example, the resource-poor economies of the OECD outperform the resource-rich economies of Sub-Saharan Africa, the Middle East, and North Africa (Nurmakhanova et al., 2023).

Wang et al. (2023c) stated that the resource curse impacts industrialized and developing countries alike. At the same time, high natural resource rents and intensive resource utilization demand more natural resource extraction to match consumer demand. Meeting the rising demand for resources hinders the economic progress of these countries in the short and long term. However, some researchers discovered no connection between the two variables (Haque et al., 2022). Consequently, the literature on this aspect remains inconclusive. Furthermore, the resource-finance-growth nexus is also unclear. Studies that follow the supply-side hypothesis believe that natural resource rents improve business for the financial sector, which leads to increased economic growth (Redmond and Nasir, 2020). Others have stated that NR promotes economic growth that further leads to financial progress, i.e., the demand hypothesis (Shahbaz et al., 2018; Atil et al., 2020; Wang et al., 2021). Prior research on resource-dependent economies has primarily focused on economic expansion rather than financial development. Therefore, it is important to research how financial development works in nations that depend on natural resources (Kurronen, 2015). Although numerous studies have focused on the resource-finance nexus, unanswered questions still necessitate a thorough literature assessment (Shobande and Enemona, 2021; Ibrahim and Alagidede, 2018).

The primary objective of countries as they go towards industrialization is to boost their economic growth. They aim to maximize the use of natural resources to increase economic productivity. Global problems including global warming and environmental pollution have gained attention in recent years. Environmental sustainability is currently a subject of continuous discourse in today's society, and it is widely recognized as a crucial element in development initiatives (Shaheen et al., 2022). At the 21st Conference of the Parties in Paris (COP 21), conducted under the umbrella of the United Nations Framework Convention on Climate Change (UNFCCC), countries agreed to collectively deal with climate change and to increase the financial resources required for a sustainable, low-carbon future, and provide essential assistance to developing countries and focus on the socio-economic wellbeing of current and future generations.

Sustainable development is required to fulfill the needs of current and future generations while preserving Earth's finite resources. Sustainable development can be

accomplished through the efficient utilization of resources, resulting in economic expansion by reducing resource wastage and accomplishing environmental sustainability simultaneously. The rising pace of economic growth and the escalating levels of environmental pollution have led to significant attention on economic efficiency. Therefore, studying economic efficiency is important in assessing sustainable economic performance and measuring environmental performance. Eco-efficiency is valuable for evaluating the sustainability of products and companies. It also evaluates and monitors their environmental performance (Chen et al., 2022). Therefore, the study is using eco-efficiency as a proxy to measure SD.

This study uses financial development as a mediator between the independent variable, NRR, and the dependent variable, sustainable development. Financial development can play a crucial role by diverting the surplus revenues derived from the natural resources towards sustainable projects. A strong financial sector acts as a catalyst by promoting transparency and accountability, so that NRR results in blessings by maintaining the balance between both environmental sustainability and economic growth (Wang and Wang, 2024). Fintech is employed as a moderator between NRR and financial development. It enhances the efficiency and effectiveness of financial development. Fintech supports in maintaining transparency and accountability within the economic system so that NRR can be effectively channelized in the financial sector, contributing indirectly towards achieving sustainable goals, and NRR does not result in Dutch disease. Fintech as a moderator plays a significant role in mobilizing finance for green initiatives that support environmental sustainability (Yang et al., 2021). In resource-rich, extraction-driven economies, it increases economic efficiency and reduces the extraction cost (Zhu et al., 2024).

In recent years, Fintech, or financial technology, has played a significant role in boosting financial development. Fintech has enabled financial institutions to deliver digital financial services, allowing people who are unbanked or underbanked to have access to financial services. This has facilitated the inclusion of a larger number of individuals into the formal financial system, hence increasing economic growth. Financial innovation produces novel business models, apps, procedures, and products that significantly improve financial markets, institutions, and the accessibility of financial products. Fintech companies are mostly emerging businesses using

state-of-the-art technology to offer financial services, including payment processing, fund transfers, lending, insurance, and asset management. Mobile banking, digital wallets, Robo-advisors, peer-to-peer lending, crowdfunding, and Blockchain-based solutions represent prominent Fintech offerings.

Fintech adoption can help economies recover from the Dutch disease that caused the natural resource curse. Dutch disease diverts NRR from the financial sector to offshore foreign businesses and non-financial industries, reducing financial development. In countries with abundant natural resources, Fintech solutions such as Blockchain, artificial intelligence, and crowdfunding can be supportive by enhancing the transparency, accountability, and governance of natural resource rents. Crowdfunding can help ease the process of raising funds for eco-friendly initiatives and promote the adoption of green technology. The rise of financial technologies has facilitated the expansion of the worldwide financial industry. Lisha et al. (2023) suggested that financial technology and environmental sustainability have a close connection. Still, the literature on this relationship is limited. It is pivotal to study the role of the financial sector and Fintech in understanding the concerns related to natural resources, the sustainable environment, and economic growth.

The study used green finance and green technology as green environment. Green technology explains the use of technology to reduce harmful environmental effects and enhance energy efficiency in energy production and consumption. Green technology facilitates the achievement of SDGs and economic competitiveness. Green technological innovation must result in reducing pollution, product stewardship, and sustainable development (Hart and Dowell, 2011). Renewable energy sources are considered a component of green technology. The renewable energy consumption is one of the most effective ways to decrease the growing level of ecological imprint (Usman et al., 2022).

Developed countries are extracting and consuming more natural resources, resulting in more financial development, greater energy consumption, and industrialization. Alternative sources of energy should be emphasized rather than continuing to extract natural resources. Economies must accurately anticipate the supply and demand of natural resources to attain sustainable goals (Shahbaz et al., 2018).

Financial development can play a significant role in sustainable development and reducing the adverse impact of natural resources on the environment by funding the adoption of green technology that further supports efficient energy usage and environmental sustainability. Financial development sponsors R&D projects and technological improvement to assist economies in achieving long-term economic goals while minimizing environmental issues (Xie et al., 2022).

However, inadequate financial resources are a primary hurdle in keeping the balance between sustainable economic growth and ecological sustainability (Mngumi et al., 2022). This is where green finance joins, guiding resources towards sustainable initiatives, thus ensuring that financial systems assist in attaining SDGs (Li and Umair, 2023). Green finance is connected to the United Nations SDG 13 (Climate Action), SDG 7 (Affordable and Clean Energy), and sustainable economic growth (SDG 8). The UNFCCC states that to achieve SDGs by 2030, US$ 1.5 trillion in annual green spending is required (Hunjra et al., 2023).

Green bonds are an important component of green financing. They are growing globally as a means of addressing and resolving the issue of inadequate funding for the development of the green economy (Jian et al., 2022). The terms “sustainable finance” and “environmental finance” are used interchangeably for green finance. Its objective is to reduce environmental hazards and financial industry gaps to restore the environment (Xu et al., 2022). Renewable energy, green buildings, clean transportation, sustainable land use, biodiversity, and clean water are all examples of ecologically or climate-friendly activities that may be financed using green bonds. Green bonds enable the issuer to raise funds for eco-friendly projects for a specified period while providing investors interest payments as revenue. The principal amount is returned upon reaching the maturity date. Green bonds are similar to other corporate bonds, they are named as "green" due to the issuer’s commitment to use the funds for eco-friendly projects in compliance with specified sustainability criteria. Reputation, transparency, and disclosure are also requirements for green bonds (Agliardi and Agliardi, 2019). Green finance is a multidisciplinary area of research. Other components of green finance are green loans, green mortgages, and green insurance.

Green finance is an evolving and important financial instrument for sustainable

development ventures (He et al., 2019). There is currently a dearth of literature explaining the influence of green financing on sustainable development (Wang et al., 2022a). The green market is comparatively complex and small, with a limited investment pool and regulatory concerns. Despite this, its potential is undeniable. Green bonds issued by companies accelerate performance in both the financial and environmental sectors. While green bonds constitute 1.4% of the global debt market, they have tremendous room to expand (Agliardi and Agliardi, 2019). Green finance has a potential for global change if it keeps increasing and aligning financial systems in line with the need for a sustainable future. With the increase in the variety and expansion of green finance products, demand and engagement from investors will be stipulated, resulting in a high level of liquidity in financial markets (Rasoulinezhad and Taghizadeh-Hesary, 2022).

To grasp the full potential of green finance, it must be promoted in developing countries (Chen et al., 2024). In these countries, the role of the financial institution is vital. Commercial banks play the role of intermediaries; they create the linkage between green finance and sustainable ventures by directing the capital flow towards the renewable energy sector (Nguyen et al., 2023). Similarly, Countries with advanced banking sectors have a strong positive linkage between green bonds and renewable energy initiatives (Xiong and Dai, 2023). Though green technology involves a significant initial investment, the long-term benefits offset the cost. Green finance can be useful for covering the early costs of adopting green technology. Green technology contributes to both environmental sustainability and swift economic growth.

The achievement of sustainable development goals effectively depends on a robust financial sector. Strengthening financial development has arisen as a principal goal for economies globally, reflecting its pivotal role in achieving sustainable development. Therefore, it is necessary to study all those factors that encourage financial development (Yang et al., 2024). Green finance and financial development are closely interlinked. Green finance and financial development are closely interlinked. Green finance helps to expand and diversify the financial sector by encouraging the development of innovative financial instruments and promoting sustainable

practices inside financial institutions. Financial development improves environmental quality by delivering the essential support and financial resources required to address different economic, social, and environmental issues, especially in areas where natural resources are more explored. This strategy promotes safeguarding natural resources and helps to preserve them (Han et al., 2022). This study proposes that NRR, GF, and green technology adoption are a source of capital formulation, particularly in N11 and BRICS economies, and indirectly contribute towards environmental well-being and economic growth through the support of the financial sector. Financial development is crucial for natural resource management, clean energy consumption, and sustainable development. It encourages technological innovations via research and development that support the green economy (Zhu et al., 2024).

The N-11 countries constitute 19.5% of the world population and produce a GDP of $6.43 trillion. The high growth rate demands more energy consumption. To manage the energy demands, they depend on the exploitation of natural resources, resulting in carbon emissions. Mostly, the N-11 countries depend on importing non-renewable energy sources, which negatively affect their balance of payments. The high cost of imported fuel raises their cost of production, decreases the purchasing power of individuals, and hampers economic growth. Therefore, the N-11 countries are now focusing more on renewable energy sources to achieve sustainable development (Javed et al., 2025). BRICS countries have large populations and high levels of industrial growth. They contribute 32% GDP to the world's economy. This growth is raising the energy demand and affecting the environment. However, on the other side, for combating environmental concerns, BRICS countries are using 16% of global renewable energy. Through knowledge sharing and joint efforts, BRICS countries can overcome environmental concerns and sustain their economic growth (Yadav et al., 2024).

1.2 Theoretical Background

There is ample literature available on sustainable development, however, there are still many unanswered questions and a scarcity of theorization in the domain of

sustainable finance (Lagoarde-Segot, 2019). This is because there is limited data available on how sustainable finance influences society and the natural environment equally, and financial logic is still broadly applied with a short-term perspective. The sustainable finance literature has a strong emphasis on empirical research, particularly evaluating the financial outcomes for investors and businesses. The important predictors, moderators, and mediators could be used to construct new theories that can explain this mechanism (Cunha et al., 2021).

1.2.1 Theories on Resource-Finance Nexus

The Economist magazine introduced the term "Dutch disease" in 1977 to describe the problems in the Dutch economy. This term highlighted the linkage between natural resource rent, financial development, and economic growth. In the Dutch economy, large gas deposits were found in 1959. Despite a sharp growth in exports, the Dutch economy suffered. Economists recognize that large resource discoveries can harm economies in the long run (Capo et al., 2007). Remittance influx from natural resources is called Dutch disease if it hinders financial growth (Ma et al., 2021). Natural resource rents impede economic and financial development because resource-rich countries excessively rely on the extractive sector while ignoring other critical sectors, such as the tradeable (non-resource) manufacturing sector. (Sandow et al., 2022) suggested that the Dutch disease occurs when there is a risk that the manufacturing sector becomes less competitive, leading to deindustrialization due to a decrease in manufacturing output and jobs.

Since the late 1980s, the term resource curse has been the subject of numerous theories. Auty (1994) coined the term "resource curse hypothesis." The debate over whether hot resources are a curse or a blessing has continued since then. The phrase "resource curse" refers to the trade policies that any government adopts (Wang et al., 2021). The resource curse is the process in which resource-rich economies enjoy fewer favorable development outcomes than resource-poor economies. The resource-finance-growth linkage has received much attention in the context of the natural resource curse. According to the financial resource curse hypothesis, NR revenues do not enter the financial sector but instead go into government coffers and offshore

accounts. In such a situation, reliance on resource revenues negatively affects the efficiency of intermediation within an economy; this ultimately highlights the inverse relationship between natural resources windfall gains and financial sector deepening. According to a modified financial resource curse hypothesis, this relationship is prevalent in countries with weak institutional and regulatory systems. Subsequently, this harms financial development and economic growth (Beck and Poelhekke, 2023).

Kurronen (2015) explained interest group theory in the context of natural resources. In resource-dependence economies, high levels of trade and financial openness weaken the opposition from interest groups, resulting in natural resource blessings. The demand side hypothesis states that economic growth influences financial development in countries with considerable oil rent (Haque et al., 2022). The resources-finance nexus has been the subject of diverse fields. Several theories have been proposed in this regard. The efficient resource extraction model mainly focuses on mineral resource revenues, which are influenced by several essential factors, including ecological footprints, energy efficiency, population growth, economic growth, trade liberalization policies, financial development, and insurance premiums (Nassani et al., 2021). The COVID-19 pandemic not only had a negative financial and health impact on nations but also flora and wildlife worldwide. The healthcare signaling theory is put forth to establish a connection between monetary growth, resource development, environmental degradation, and the COVID-19 pandemic. The theory states that financial development is necessary to revive the sustainability agenda for healthcare by expanding sustainable financing options in the healthcare and commodity markets to strike a balance (Anser et al., 2021).

1.2.2 Institutional Theory

The theoretical framework provided by Institutional theory enables researchers to examine the role of culture, social context, regulatory framework, tradition, history, economic incentives, and significance of resources in ensuring the survival and credibility of organizations (Mariani et al., 2022). As businesses strive to gain acceptance or legitimacy from other stakeholders, Institutional theory posits

that social, political, and economic factors from outside the company impact organizational decision-making and strategy. Changes in social values, technology improvements, and legislation can all have an impact on decisions related to 'green' sustainable activities (Haigh, 2012). Three categories of forces might alter the strategies, structures, and processes of an organization, as outlined by Institutional theory. These forces are coercive, normative, and mimetic.

Companies can be coerced in two ways: first, by the public and private bodies on whose behalf they rely, and second, by the social norms and expectations that govern their operations. Such pressure may be perceived as force or as an encouragement to participate in cooperation. For example, industries use new pollution control technologies to comply with environmental standards as a direct response to government mandates. Coercion results from the influence of individuals in positions of authority. Coercive pressures are essential for environmental management and sustainability. Normative force ensures that firms comply with regulations to be perceived as participating in legal activity. It mostly stems from a commitment to professionalism. Professionalism refers to the collective effort of individuals within an organization to establish the boundaries and strategies for their job, ensuring efficient production and establishing a solid intellectual basis and recognition for their professional autonomy. Hence, businesses are compelled by normative constraints to adopt a more environmentally sensitive approach.

To understand and address emerging societal norms, such as ethical principles and ecological thinking, businesses must engage in institutional research and develop organizational strategies to tackle environmental concerns. Mimetic compels organizations to emulate the habits of successful rivals to reproduce the road to success. Uncertainty serves as a significant driver for replication. Organizations may emulate other organizations when they have a limited understanding of organizational technology, unclear aims, or when the environment creates symbolic ambiguity (Glover et al., 2014; DiMaggio and Powell, 1983). This theory has been used in research for environmental management in organizations, changes in social values, and technological advances connected to sustainable operations.

According to Escobar and Vredenburg (2011), sustainable development is a social concern. Businesses are implementing sustainable practices at a slow pace.

Multinational oil and gas corporations experience institutional pressures during foreign operations. Their strategic approach to these pressures is influenced by sustainable development challenges, including climate change, biodiversity, renewable energy advancement, and social investment. Normative and coercive pressures do not manifest universally, as sustainable development is predominantly driven by stakeholders rather than widespread societal pressure. Mimetic force may arise, but due to its reliance on complex and intangible resources, mimetic processes are gradual, infrequent, and biased.

Institutional theorists suggest that firms subject to the same institutional forces will ultimately implement similar strategies. Consequently, multinational corporations' behaviors are shaped by stakeholders in society (Clarkson, 1995; Freeman, 2010), including governments (by regulations), industry (through standards and norms), competitors (via superior business models), and consumers (through loyalty). For a multinational corporation to be a sustainability-oriented entity, it must either be subject to external pressures from regulators or the industry, or there must be established successful models that include sustainable development required actions with beneficial business practices for the corporation to replicate in pursuit of new competitive advantages.

1.2.3 The Resource Dependence Theory

Following the resource dependence theory of sustainable finance, some nations are better than others at using human-generated resources to achieve their goals and adopt sustainable finance (Mariani et al., 2022). Some nations possess considerable foreign currency reserves, a surplus budget, negligible external borrowing, a robust financial sector, advanced Fintech systems, robust financial oversight and governance, effective climate change monitoring systems, a population that highly prioritizes sustainability, and a considerable number of institutional investors eager to invest in environmentally friendly financial instruments. The resource theory of sustainable finance proposes that nations endowed with ample human-made resources are more likely to achieve sustainable finance objectives at a much faster rate than those with limited human-made resources. Therefore, it is vital to enable

each nation to freely pursue its sustainable financial goals at its own pace, taking into consideration the current human resource constraints (Cunha et al., 2021).

To create intuitive linkages between NRR and financial development, the resource dependence theory states that a steady influx of NRRs diminishes the necessity to save and invest in nations with abundant natural resources. Devoting more resources to rent-seeking and less to human and social capital in resource-rich countries causes a reduction in saving and investment. This further reduces economic and financial development (Billmeier and Massa, 2009). According to the resource absorption hypothesis, surplus income and wealth from windfall gains positively impact financial sector deposits and loans, resulting in financial sector deepening (Beck and Poelhekke, 2023).

The resource-based perspective of an organization claims that unique, valuable, and difficult-to-replicate traits give the basis of competitive advantage. The competition is focused on superior competencies rather than larger markets. Unique, valuable, and difficult-to-replicate competencies are specific to each organization; hence, the broad range of competencies available to a firm is the outcome of the strategic decisions it has undertaken in response to competition (Pettus, 2001). The resource-based view believes that organizations vary in the competencies they possess, and this heterogeneity accounts for the competitive advantage enjoyed by certain corporations.

There are two categories of a corporation's competencies: tangible competencies, including technology and property rights, and intangible competencies, including knowledge and organizational culture. Intangible competencies, such as stakeholder engagement, can only be cultivated internally within the multinational corporation. Intangible competencies are more likely to serve as a sustainable source of competitive advantage compared to tangible competencies. The lowered business cost for corporations depends on a blend of tangible and intangible competencies, including pollution control and prevention, environmental management systems, product stewardship, and life-cycle assessment of products and technology (Hart and Dowell, 2011). Corporations mitigate their risk exposure with intangible competencies, including stakeholder involvement. These competencies may provide a sustained source of competitive advantage.

1.3 Research Gap

The current study intends to fill the gap by proposing that natural resource rents and sustainable development require a multidimensional approach considering technological, financial, economic, and environmental factors. Natural resource rents are closely linked to the UNs Sustainable Development Goals, particularly Goal 13 (Climate Action), Goal 9 (Industry, Innovation, and Infrastructure), and Goal 8 (Sustainable Economic Growth). The convergence of NRRs, Fintech, and FD strengthens economic stability and a sustainable environment. Future studies should concentrate on Fintech's function beyond inclusion and how it may help developing countries achieve financial stability and long-term financial development as it continues to change the global financial environment (Muganyi et al., 2022). The research has not comprehensively examined the effect of Fintech on financial development (Mavlutova et al., 2021; Ha, 2022). Scholars are examining how Fintech might help to explain the resource-finance connection. According to Tan et al. (2023), there is a study vacuum on the relationship between Fintech and natural resource rents.

Financial development as a mediator can channel the surplus rents received from the natural resource extraction toward funding green initiatives like adopting green technologies, circular economies, social development, and environmental conservation. Further study highlights that Fintech solutions enhance transparency and accountability, increase financial inclusion, and create an environment where natural resource rent distribution is directed by careful investment and strategic planning. Robust technologies can turn the negative consequences of natural resource consumption into favorable outcomes and assist green initiatives, thereby aligning the nation's efforts towards attaining the 2030 target efficiently and effectively.

Several studies have recently studied the direct influence of green finance on sustainable development (Xiong and Dai, 2023; Li and Umair, 2023; Behera et al., 2024). A notable gap persists in comprehending its indirect impact on sustainable development via the mediation function of financial development. More research is

needed on how green finance explicitly affects the development and evolution of financial markets and institutions. Green finance seeks to stimulate the progress of innovative financial instruments, including green bonds and climate-aligned funds. Despite this, limited research investigates how the proliferation of these instruments can contribute to enhanced market growth through liquidity, depth, and diversification.

This study addresses the research gap by offering empirical evidence and theoretical insights on the capacity of green finance to promote financial development. It highlights the importance of green financial instruments in improving market liquidity, helping diversity in financial portfolios, and directing funds to sustainable sectors such as renewable energy. This strengthens an in-depth comprehension of the symbiotic linkage between green finance and financial development, which is crucial for policymakers, financial experts, and researchers seeking to foster economic and environmental resilience.

This research adds to the existing body of literature in the following novel ways. Firstly, in the context of N11 and BRICS countries, it is the first study to empirically investigate Fintech as a moderator on the resource-finance nexus. Secondly, many studies on the natural resource rents and sustainable development relationship have taken a limited view, focusing mainly on environmental sustainability or employing separate indicators for social, economic, and environmental development. Chen et al. (2022) have utilized CO_2 emissions as an indicator, some researchers have employed distinct indicators for sustainable development, such as CO_2 emissions and economic development (Manigandan et al., 2023; Arslan et al., 2022), as well as the human development index (Safdar et al., 2022).

This study employs a singular measure of sustainable development, namely economic efficiency, which takes into consideration both economic growth and CO_2 emissions simultaneously. The concept of eco-efficiency has received considerable focus in the scholarly discourse on sustainable development. Economic efficiency pertains to the efficient distribution of resources and the enhancement of factor productivity, resulting in economic expansion via maximizing resource usage and minimal environmental harm. There is limited research work on sustainable development in N11 nations, as no study has specifically addressed this issue. Thirdly,

the study used financial development as a mediator variable to assess the impact of natural resource rents and a green environment on sustainable development. Most research on green technology and green finance focuses on the concept of sustainable development. There is a limited amount of research conducted on the influence of green finance and green technologies on financial development.

Fourthly, financial development is used as a mediator between a green environment (green technology, green finance) and sustainable development. The relationship between Fintech and green finance has not been extensively studied (Yang et al., 2021). This study presents a comprehensive model that examines the effect of Fintech, natural resource abundance, green technology, and green finance on sustainable development. Fifthly, a significant body of research on the resource finance nexus has concentrated on banking institutions. There is a study gap regarding the inclusion of stock markets (Moradbeigi and Law, 2017) or the simultaneous investigation of both stock markets and financial institutions (Ha, 2022; Ali et al., 2022; Zaidi et al., 2019; Hadj and Ghodbane, 2021). This study bridges the research gaps by using inclusive metrics for financial development, covering the development of financial institutions and financial markets. Finally, there is scarce literature available on the resource-finance nexus, sustainable development, Fintech, and green environment in the situation of N11 and BRICS economies.

1.4 Problem Statement

Sustainable development is a broad term incorporating economic growth, sustainable natural resources, social development, sustainable environment and much more. In developing countries, NRRs are the backbone of an economy, but excessive use of natural resources results in the resource curse. Therefore, in developing countries, natural resource management is necessary for sustainable development because high fossil fuel consumption is deteriorating their environment (Zhu et al., 2024). CO_2 emissions are rising globally, intensifying climate change. For the 21st century, this is a threat and a challenge to sustainable development that needs prompt action through collaborative efforts worldwide. Climate change

jeopardizes economic stability and individual welfare. Rising ocean levels, shifting atmospheric conditions, the swift depletion of natural resources, population growth, and industrial development impose escalating pressures on the climate and ecosystem. Formulating a balanced strategy that facilitates the allocation of finance to initiatives aimed at reducing CO_2 emissions while enhancing economic growth presents two significant challenges (Li and Umair, 2023).

NRRs are essential for the economic and financial advancement of nations. These inflows of funds are a key source of revenue for governments, and they are frequently essential for funding public projects, and social programs. Natural resource-rich economies are frequently confronted with economic issues. One of the causes of this dilemma is the mismanagement of resource earnings, as well as the so-called resource curse. Resource-poor economies, on the other hand, may have more consistent and considerable economic growth as a result of a higher emphasis on innovation, manufacturing, and services. The role of financial development is important for obtaining and deploying financial resources. Therefore, it is necessary to study the current developments and innovations occurring within the financial sector. Since the global financial crisis of 2008, there has been a greater emphasis on improving the resilience and transparency of financial systems around the world.

Natural resources create considerable difficulties, largely because they are scarce and they impose negative environmental repercussions during the process of their extraction and consumption (Fu et al., 2023). Concerns about the use of natural resources and sustainable development are widespread. Scientific research indicates that the Earth's surface is seeing an increase in average temperature. This is a result of burning fossil fuels, which increases the atmospheric concentration of CO_2 and other GHGs. Overutilization of natural resources and carbon dioxide emissions cause environmental degradation, intensifying global warming, leading to water shortages, disturbing biodiversity, and causing soil erosion (Yao et al., 2021).

Global warming results from burning fossil fuels, which raises the atmospheric concentration of carbon dioxide and other greenhouse gases. Therefore, it is necessary to restrict the utilization of fossil fuels and advocate for sustainable energy sources (Omer, 2008). Another perspective is to ensure environmental sustainability through natural resource management (Arslan et al., 2022). This

can be achieved by channeling natural resource rents towards investment in green projects for attaining sustainable development (Ulucak et al., 2021; Aladejare, 2022). These projects can enhance energy efficiency, reduce carbon emissions, promote biodiversity, and foster economic growth by creating jobs in the green sector.

As a member of the United Nations' 2030 Agenda for SD, several economies have vowed to actively engage in sustainable development efforts inside their national boundaries. This collective commitment reflects a global commitment towards reducing the negative effects of climate change by pursuing measures that prioritize not only environmental preservation but also the socioeconomic well-being of present and next generations. The primary focus is on efficient natural resource management and energy consumption. Robust technologies can turn the negative consequences of natural resource consumption into favorable outcomes and assist green initiatives, thereby aligning the nation's efforts towards attaining the 2030 target efficiently and effectively. Natural resource management can help address concerns about environmental performance and enable sustainable financial development (Xie et al., 2022).

Is Fintech meant to be used in combination with financial development, or separately? Nevertheless, a more thorough and systematic analysis is necessary to offer a conclusive response to this subject. The empirical research on Fintech is still in its infancy (Muganyi et al., 2022). While several studies have examined the potential of Fintech to promote financial inclusion, there has been limited research on its impact on financial development and sustainable development, despite the strong connection between these areas. The emergence of innovative financial technologies has facilitated the expansion of the worldwide financial industry. Since Fintech's inception, researchers have examined financial development while tackling issues related to energy use, natural resource exploitation, sustainable economic growth, and the environment (Li et al., 2023).

Fintech has an important linkage with NRR and SD, but there is a dearth of literature available on how NRR and Fintech together affect SD (Zhu et al., 2024). It is argued that Fintech causes environmental pollution, such as carbon emissions; so, it is necessary to rebuild such technologies with long-term environmental

aspects. Reduced energy usage in the Fintech sector, notably cryptocurrency mining, might be one answer to this problem. Using renewable energy sources to power Cryptocurrency mining might help reduce reliance on fossil fuels, which could lead to long-term sustainability gains (Lisha et al., 2023).

Conventional financial systems face difficulties in facilitating environmentally friendly advancements, and it remains uncertain how this problem may be addressed (Feng et al., 2022). Green financing is the ideal way to address the green financial gap, which arises from the high demand for green infrastructure investment (Yang et al., 2021). It is important to analyze green finance through the lens of developing nations. This approach would assist regulators and policymakers in harmonizing different policy aims and setting clear policy goals (Zhang et al., 2019). In addition, there have been few investigations into the influence of green financing on the reduction of CO_2 emissions. The majority of studies have mostly examined the connection between economic growth and carbon emissions (Mngumi et al., 2022). The significance of green financing in addressing climate change and reducing excessive greenhouse gas emissions has been increasingly recognized in recent environmental and economic studies (Wu, 2022).

This research aims to offer creative answers to the problems mentioned above. Creative financial models can surmount the obstacles that impede green technology creation. Fintech accelerates the progress of green finance by reducing the information asymmetry between investors, promoting effectiveness, recognizing the worth of natural resources, and endorsing sustainable lifestyles to foster superior economic growth. Moreover, to enhance the accessibility and affordability of capital for environmentally friendly projects, green finance may be integrated with financial technology (Fintech).

Fintech can result in faster decision-making and reduced transaction times, which enables completing commercial transactions whenever and wherever they are possible. In this regard, Fintech might make it easier, quicker, and more economical for environmentally friendly businesses to get the financing and resources they need. While the notion of green finance, green technology, and financial technology is broadly accepted, research in this sector is still in its infancy, with few associated studies. There has been little research into the mechanism of how green

finance, financial technology, and green technology affect financial development and sustainable development, as well as actual evidence supporting their relationship.

1.5 Research Questions

The study intends to find an answer to the following questions:

1. Do natural resources increase or reduce financial development through a systematic literature review?
2. What are the significant themes in natural resource and financial development literature?
3. What future research avenues may support the resource-financial nexus?
4. Do NRR affect the sustainable development of the N11 and BRICS countries?
5. Are natural resource rents blessings or a curse for financial development in N11 and BRICS countries?
6. Does Fintech play a moderating role in the resource-finance nexus in N11 and BRICS countries?
7. Does financial development mediate between NRR and SD in N11 and BRICS countries?
8. Is a green environment beneficial to sustainable development for N11 and BRICS countries?
9. Does green environment progression affect the financial development of N11 and BRICS countries?
10. Does financial development mediate between the green environment and sustainable development in N11 and BRICS countries?
11. Does financial development impact the sustainable development in N11 and BRICS countries?

1.6 Research Objectives

The research seeks to achieve the following research objectives:

1. To discover through SLR whether NRR increase or reduce financial development.
2. To identify significant themes in NR and FD literature.
3. To identify future research avenues that can support the impact of NRRs on financial development and sustainable development.
4. To analyze the impact of NRRs on the sustainable development of N11 and BRICS countries.
5. To examine whether natural resources are a blessing or a curse for the financial development of N11 and BRICS countries.
6. To unveil whether financial development mediates the rents derived from natural resources and sustainable development of N11 and BRICS countries.
7. To examine how Fintech adoption, in the context of N11 and BRICS economies, moderates the relationship between natural resources and financial development.
8. To study the effect of a green environment on the sustainable development of N11 and BRICS countries.
9. To analyze the impact of a green environment on the financial development of the N11 and BRICS countries.
10. To determine if financial development mediates between the green environment and sustainable development in the N11 countries.
11. To study the effect of N11 and BRICS countries' financial development on sustainable development.

1.7 Significance of the Study

The theoretical, contextual, and practical significance of the study is explained below.

1.7.1 Theoretical significance

The study adds to the existing body of knowledge by incorporating the role of financial development as a mediator between natural resource rents, green environment, and sustainable development. Additionally, fintech adoption is used as a moderator between the resource-finance nexus. Previously, the Natural Resource Blessings theory was used to study the impact of natural resource rents on financial development. This study proposes that natural resource rents are a blessing for the economies if they enhance the financial sector, and these resources are further utilized for achieving the SDGs, with the crucial role of financial development. In the light of resource dependence theory, the study presents empirical evidence that the efficient consumption of natural resources can foster economic growth, and the revenue generated from these resources can be used in adopting sustainable technologies for reducing carbon dioxide emissions. The study using institutional theory provided empirical evidence that the role of financial institutions is significant in attaining SDG 2030.

Financial development channels financial resources from natural resource rents and green finance into green initiatives. Fintech adoption improves the transparency, accountability, and governance of resource earnings. It also facilitates the financial sector by serving the unbanked population. Thus, guiding the economies in achieving the SDGs. N11 and BRICS economies are investing in new pollution control technologies to comply with environmental standards as a direct response to the UN Paris Agreement. The demand for finances increases when an industry within an economy adopts green technology. Financial institutions, markets, and regulatory bodies react by developing new financial products to fill the gap, which results in financial sector development. The inflow of funds enables financial

development to offer funds at a low cost to businesses that maximize economic and environmental benefits, resulting in sustainable development.

1.7.2 Contextual significance

This study highlights the factors that can cause the natural resource curse, which will help policymakers and governments in resource-rich emerging economies to make financial policies to overcome weak areas and achieve long-term growth by converting the natural resource curse into a blessing with the help of an efficient financial system. The study's findings will serve as a roadmap for N11 and BRICS countries to achieve the agenda of the United Nations' 2030 SDGs. The growing popularity of Fintech is providing new insights into the field of financial development, which is gaining support among academics, researchers, financial analysts, and government officials on a global scale (Li et al., 2023). The study attempts to demonstrate that financial industries can experience revolutionary changes that will increase financial development after implementing cutting-edge technologies. It can assist in bridging the financial gaps that green initiatives confront. The study will assist authorities in formulating regulations to promote Fintech and financial development in the context of the green environment-sustainable development nexus. Recommendations related to the unexplored future directions will assist academicians in further exploring this domain.

1.7.3 Practical significance

Further, this study will encourage governmental organizations to reassess methods, in the case of environmental disasters, to generate future perspectives on the sustainable use of NRR. The study emphasizes the significance of the Triple Helix Model, proposing that in contemporary knowledge-driven economies, academia, business, and government partnerships should be utilized to manage natural resource rents, more mobilization of green finance to promote green technological innovations, and implement Fintech solutions efficiently, strengthening financial development to attain Sustainable Development Goals. The increase in economic growth causes increased energy demand. Therefore, it is necessary to consider the

role of financial development towards renewable energy projects and the SDGs. This study focuses on the relationship between growth prospects and the environment that will help regulators develop policy for developing innovative financial products and a smooth flow of funds from the financial sector to green initiatives. Promoting green businesses in the economy and achieving the SDGs.

1.8 Organization of the Document

The organization of this study is as follows: Chapter 2, deals with the literature review; Chapter 3 covers data collection and the research methodology; Chapter 4 covers data analysis and discussions; Chapter 5 incorporates the conclusion, recommendations, and limitations of the study.

Chapter 2

Literature Review and Hypothesis Development

2.1 Natural Resource Rents and Sustainable Development

Countries or firms produce natural resource rents through the utilization of resources such as timber, gas, minerals, and oil. These revenues are essential for many developing countries, but they can also be a double-edged sword, causing economic instability, corruption, environmental damage, and social inequality. SD is a holistic notion that emphasizes meeting current demands without risking the capability of next generations to fulfill their own needs. To develop a linkage between NRR and SD, it is necessary to develop a comprehensive strategy comprising economic, social, and environmental factors.

Natural resource rents and economic efficiency are positively associated with each other, according to research by Chen et al. (2022), who studied the 10 most polluted countries. Mostly, the economies in the selected panel have a high or upper-middle-income categorization and utilize natural resources at a high pace. The governments of these nations must manage and control the excessive utilization of natural resources. The consumption patterns of their citizens must be managed, the nation should implement measures such as decreasing fishing and deforestation activities, conserving energy and water resources, and encouraging the use of

energy-efficient products in their daily routines. The mining sector, specifically, must be incentivized to use cutting-edge and energy-efficient technologies in their activities to effectively regulate the utilization of scarce minerals.

Arslan et al. (2022) examined the temporal dynamics of NRR of China, environmental sustainability, and sustainable economic growth from 1970 to 2016. The research used the Generalized Method of Moments (GMM) and Dynamic Ordinary Least Squares (DOLS) multiple regressions to study long-run trends. CO_2 emissions, ecological footprints, and economic growth are employed as indicators to measure SD. In the long run, natural resources support environmental sustainability, but they slow down economic growth in the short term. The article suggests increasing governance for natural resource management.

Ulucak et al. (2020) studied the relationship between natural resource rents, per capita income, disaggregated energy consumption, and environmental degradation in 26 OECD countries from 1980-2016 by developing three models that reflected environmental sustainability using CO_2 emissions, ecological footprints, and carbon footprints. Natural resource extraction raises CO_2 emissions, but they have an insignificant relationship with the ecological footprint and carbon footprint. The study suggested that excessive exploration of natural resources must be controlled and good governance is required for effective resource management. The role of institutional quality is crucial in improving governance, regulatory bodies should prioritize transparency and accountability in the sustainable exploration of natural resources. The study offered policymakers evidence that to attain sustainable development, it is necessary to have sustainable utilization of natural resources, together with a consumption of renewable energy.

Similarly, Lisha et al. (2023) found that natural resource consumption harms environmental sustainability. Due to the rising environmental pressure, economies should execute environmentally friendly initiatives intended to reduce ecological footprints. Human capital with relevant background knowledge and competence can be helpful in cautious natural resource consumption. Aladejare (2022) studied the effects of NRR and globalization on environmental sustainability in the 5 highest-income African countries from 1990-2019. The study used fixed and random effects models, feasible generalized least squares, and augmented mean groups.

The study indicated that natural resource consumption significantly contributes to environmental hazards. Renewable hydrogen energy is a favorable alternative to fossil fuels for transportation, industrial, and domestic usage. To diminish CO_2 emissions, renewable energy consumption, and sustainable economic growth should be prioritized. It is essential to use modern technologies emphasizing the discovery of natural resources, regardless of their purchasing cost, as long as they are ecologically sustainable.

The study by Huang et al. (2021) examined the long- and short-term relations between natural resource rent, financial development, and urbanization on carbon emissions in the United States. The research covered the period from 1995-2015. The study revealed that NRR, FD, and urbanization are causing a significant change in carbon emissions, hindering further economic progress. This state demands considerable planning. The United States must promote all those activities that can contribute to environmental sustainability through financial assistance.

In their study, Wang et al. (2023c) studied the effect of NRR on CO_2 emissions with the help of the Environmental Kuznets Curve. The study used a comprehensive dataset of 208 countries from 1990-2018. The generalized method of moments and the fully modified ordinary least squares estimator were used. The findings confirmed the presence of a curvilinear relationship, an inverted U-shaped curve, between income and CO_2 emissions. Countries consuming natural resources are emitting more CO_2 as compared to countries using renewable energy. Therefore, it is recommended that countries should develop their energy portfolio with reduced dependency on fossil fuels and more addition of renewable energy. An inclusive strategy covering adequate educational programs, proper regulations for renewable energy consumption, and trade policies with a focus on a sustainable future would help to improve environmental quality.

Mngumi et al. (2022) discovered a positive relationship between CO_2 emissions and NRR. The extraction of natural resources increases CO_2 emissions. The rising levels of greenhouse gases in the BRICS countries are due to the misuse of natural resources. Furthermore, the country's dependence on fossil fuels has increased environmental concerns due to greenhouse gas emissions. Safdar et al. (2022) studied how governance and NRR have affected SD in South Asian countries

from 1996-2020. The study developed three parameters for measuring sustainable development: economic sustainability, social sustainability, and environmental sustainability. The first model confirmed that governance has a positive impact, and natural resource rent harms economic growth. The interaction term between governance and natural resource rent positively affects economic growth in South Asian countries. The second model suggests that strong institutions are vital in developing the social sector in South Asia. Moreover, natural resource rents negatively correlate with the human development index. The third model confirms the inverse relationship between governance and its interaction with NRR on GHGs. Renewable energy applies a negative effect on greenhouse gas emissions as they include thermal and solar energy, both of which do not release any carbon dioxide. Governance is recommended to attain SDGs and maximize the benefits resulting from natural resource rent.

Natural resource extraction results in deforestation, pollution, and environmental degradation. Bekun et al. (2019) found that in the long- and short-run CO_2 and natural resource rent have a negative relationship. The empirical results were derived on the basis of balanced panel data from 1996-2014 for specified EU-16 countries and utilizes the PMG-ARDL technique. The European Union (EU) members are reducing carbon emissions and promoting a cleaner environment by increasing the proportion of renewable energy sources in their energy mix. Most of the countries in EU are parties to both the Kyoto Protocol and the Paris Agreement. The study emphasized the need for creative approaches to resolve the intricate issues related to natural resource management and the pursuit of sustainable development.

Fu and Liu (2023) scrutinized the impact of NRR on SD from 1990-2020. The study employed the fully-modified ordinary least square, dynamic ordinary least square, and canonical co-integration regression techniques. Results indicated that natural resources have an asymmetrical effect on sustainable development. Mineral and natural gas resources contribute positively to sustainable development, but the overconsumption of forest resources has a damaging effect. SD is mostly dependent on energy productivity; however, environmental technology development has a small but favorable impact on global sustainable development. Thus, renewable

energy sources have the potential to be utilized as a means of production. The Granger causality test examines the bidirectional causal relationship between economic development (used as a proxy for SD) and variables such as forest rents, mineral rents, natural gas rents, energy productivity, and environmental technology development. Moreover, projects targeted at enhancing energy efficiency should be executed. This will minimize the consumption of energy gained from natural resources, and improve production ratio that will result in sustainable economic growth. Besides, high energy production would diminish industrial expenses, fostering economic expansion.

Awosusi et al. (2022) examined the relationship between globalization, renewable energy, NRR, economic development, and environmental sustainability in Colombia from 1970-2018. The modified ordinary least squares, dynamic ordinary least squares, and autoregressive distributed lag estimators were employed to conduct long-term analysis. The study determined that globalization, NRR, and economic growth results in CO_2 emissions. Renewable energy sources are crucial in addressing this issue. Formulating and executing rigorous legislation to govern Colombia's energy and manufacturing sectors would enhance the long-lasting progress of the country. Transitioning to renewable energy is vital for addressing the issues of energy security and environmental damage. The significance of renewable energy consumption has increased in the outcome of the COVID-19 pandemic.

To attain sustainable development, it is essential to establish regulations and statutes that prevent the environment and encourage the cautious utilization of natural resources. The study by Shen et al. (2021) investigated how China is achieving environmental sustainability goal through technological advancement, green investments, NRR, financial development, and energy consumption studying the period 1995–2017. The research used cross-sectional augmented autoregressive distributed lags (CS-ARD). The results found a positive correlation between the natural resource rent and CO_2. Moreover, green investment showed a negative correlation with CO_2, aiding in the mitigation of adverse impacts stemming from carbon emissions. To address the over-exploitation of natural resources, it is essential to execute the natural resource tax laws in Chinese provinces. These laws must result in promoting green investment.

Balsalobre-Lorente et al. (2023) studied 36 OECD countries from 2000-2018 and discovered how in the long run, per capita income, tourism, natural resource rents, urbanization, and ICT affect environmental sustainability. The study used an Augmented Mean Group and a two-step Generalized Method of Moments technique. The results recommend that urbanization, natural resources, and tourism increase CO_2 emissions, whereas ICT reduces emissions. Some countries have shown an inverted Environmental Kuznets Curve. Governance and effective natural resource management are necessary for decreasing natural resource consumption. Moreover, it is necessary to evaluate natural resource policy to reduce the overutilization of resources and protect the next generation from environmental risks. To achieve SD, it is important to consume resources steadily and efficiently, with an increase in the quantity of renewable energy in the total consumption of energy.

According to Wang et al. (2020), the G7 countries should discontinue consumption of coal mining, and fossil fuel-based energy, due to the substantial increase in CO_2 emissions. The government should increase subsidies for renewable energies while reducing subsidies for the exploration and extraction of fossil fuels. Furthermore, products demonstrating a significant degree of emissions may be subject to increased tariff rates. Due to increased resource extraction from agriculture, deforestation, and mining, environmental difficulties are more likely to arise with economic growth, which is why the government is planning to preserve optimal uses of natural resources. Jahanger et al. (2022) suggested that developing countries should adopt strategies to increase the efficient usage of natural resources. Thus, a single unit of national output would be produced with a comparatively smaller quantity of natural resources.

H_1: In the N11 and BRICS countries, NRR positively impacts sustainable development.

2.2 SLR on Resource-Finance Nexus

First, considering the fact that natural resource depletion is problematic and has far-reaching effects. Second, price volatility in international markets is causing problems

for countries exporting and importing natural resources. This has an impact on trade balances, investments, and economic stability. Third, recent technical developments in the resource management and banking sectors. Future dimensions in this field must be identified by thoroughly examining the existing literature on this topic. Thus, this article has adopted the systematic literature review approach to study the resource-financial nexus.

The systematic literature review approach addresses the most recent advancements, limitations, and potential future directions on a specific issue (Tranfield et al., 2003; Mengist et al., 2020). The literature on the resource-finance nexus remains inconclusive. To understand this relationship, our study thoroughly reviewed the prior literature and suggested uncharted future avenues. According to our understanding, this research is the first to conduct a systematic literature review on the resource-finance nexus. Ali et al. (2022) conducted a bibliometric analysis of the role of economic growth, financial development, and natural resources. They also discovered that there needed to be thorough literature studies on the relationship between resource-finance linkage in Google Scholar, Scopus, and Web of Science (WOS) databases.

Antons et al. (2023) stated that the large volume, ongoing expansion, and resulting intricacy of the scientific literature not only heightens the demand for systematic, reproducible, and rigorous literature review but also emphasizes the inherent constraints of researchers' ability to interpret information. To address this predicament, computational methods are now assisting scholars in consolidating enormous volumes of material. There is a dearth of clear and specific guidelines on how to plan, conduct, and document literature reviews incorporating computational methods. The study intends to find an answer to the following questions: (i). do natural resources increase or reduce financial development? (ii). What are the significant themes in natural resource and financial development literature? (iii). What future research avenues may support the transition of NRRs on financial development? This study highlights the factors that can cause the natural resource curse, which will help policymakers and governments in resource-rich economies to make financial policies to overcome weak areas and achieve long-term growth by converting the natural resource curse into a blessing with the help of an efficient financial system. Recommendations related to the unexplored future directions will assist academicians in further exploring this domain.

2.2.1 Analytical Approach

The key component of research is the literature review. Review research refers to research inquiries that utilize scientific methods to analyze and combine previous research to provide new information for academics, practice, and policy-making. A review study is different from empirical and conceptual studies because it relies on existing literature as a data source for producing new knowledge (Kunisch et al., 2023). The aim of a literature review is to comprehend the particular field of study and find research gaps and unanswered questions that research can tackle. Additionally, after the identification of potential research gaps the field of study should be strengthened. The sequential method is an organized evaluation of the literature for searching appropriate search terms, scanning through the relevant material, and conducting analysis are vital steps while conducting research (Tranfield et al., 2003; Kamble et al., 2018; Kanzari et al., 2022). In this study, the authors have used the same review process.

Step 1: Search Strategy

The relevant data sources were first examined to build the search strategy. The study employed the Scopus database to get access to a wide variety of academic and conference publications. WoS and Scopus articles are increasingly used in academic research. The authors selected papers from the Scopus database for this analysis because of its accessibility. Scopus provides a large number of documents (AlRyalat et al., 2019), a greater variety of subjects, and indexed journals (Singh et al., 2021; Meho and Rogers, 2008) more robust search and analysis tools allowing for sophisticated analyses of the collected data as compared to the WoS database and Google Scholar (Zyoud and Fuchs-Hanusch, 2020).

Further, Zhu and Liu (2020) asserted that the recent entry of Scopus threatens WoS's hegemonic status. To achieve comprehensive literature coverage, umbrella terms were employed as keywords. Keywords were chosen from the published articles based on pilot testing. The following search string was produced by

combining the Boolean operators AND and OR to gather pertinent material from digital databases.

Block A - natural resources ("Natural resource curse" OR "natural resources rent" OR "Resource curse hypothesis" OR "Dutch Disease syndrome" OR "Natural resources" OR "natural resource abundance" OR "Financial Resources Curse" OR "natural resources blessing" OR "Aggregate and disaggregate impact of natural resources") AND

Block B - financial development ("Financialization" OR "Financial sector" OR "financial development" OR "stock market development" OR "banking development" OR "financial sector development" OR "bond market development" OR "financial market development" OR "financial institutions development" OR "Financial deepening").

Step 2: Criteria for Selection

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) are used for the selection criteria (Moher et al., 2015). Ali et al. (2022) verified that there is no comprehensive study on the resource-finance nexus in Google Scholar, Scopus, and WoS. As a result, the scope of this topic allows for open selection without restriction or filtering by subject area, period, and affiliation. The study incorporated all conference proceedings, articles, book chapters, and books. No limitations on scientific fields were applied. To gather the maximum literature, the search was primarily focused on mapping the existing research on natural resource abundance and financial development in all fields. The search was carried out in January 2023, including data from 1980 till date. The month of January 2023 is included to provide a general picture of the paper's trend in the area of resource-finance nexus for the current year.

A total of 8526 records were extracted at this step. The article titles, abstracts, and complete articles (where applicable) were reviewed to determine their relevance. Ali et al. (2022) verified that in Google Scholar, Scopus, and WoS there does not exist a comprehensive study on the resource-finance connection. As a result, the scope of this topic allows for open selection without restriction or filtering by subject area, period, and affiliation. The study incorporated

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Step 3: Quality Assessment

Duplicate items were initially removed by loading data into Zotero. The deduplication procedure removed 603 items. Manual filtering is carried out to conduct a systematic literature review. According to Centobelli et al. (2019), it is a transparent procedure that helps writers avoid biased results. The data is organized using an Excel sheet, which is also used to create charts and tables. Three criteria are used to select papers.

Firstly, articles that are irrelevant to the research topic are discarded by carefully reviewing the research topic.

Secondly, after carefully reviewing the abstracts of the publications.

Thirdly, several were discarded after reading the entire articles. The data filtration procedure ensures that the material included in the review process is authentic and relevant.

Step 4: Data Extraction

This procedure allows for the extraction of a sample of 59 publications, detailed in the supplemental file 'Scopus data.xlsx (v1.0)' for reference, emphasizing the study target (see Fig. 2.1). At each stage, records are included and excluded to retrieve the final record.

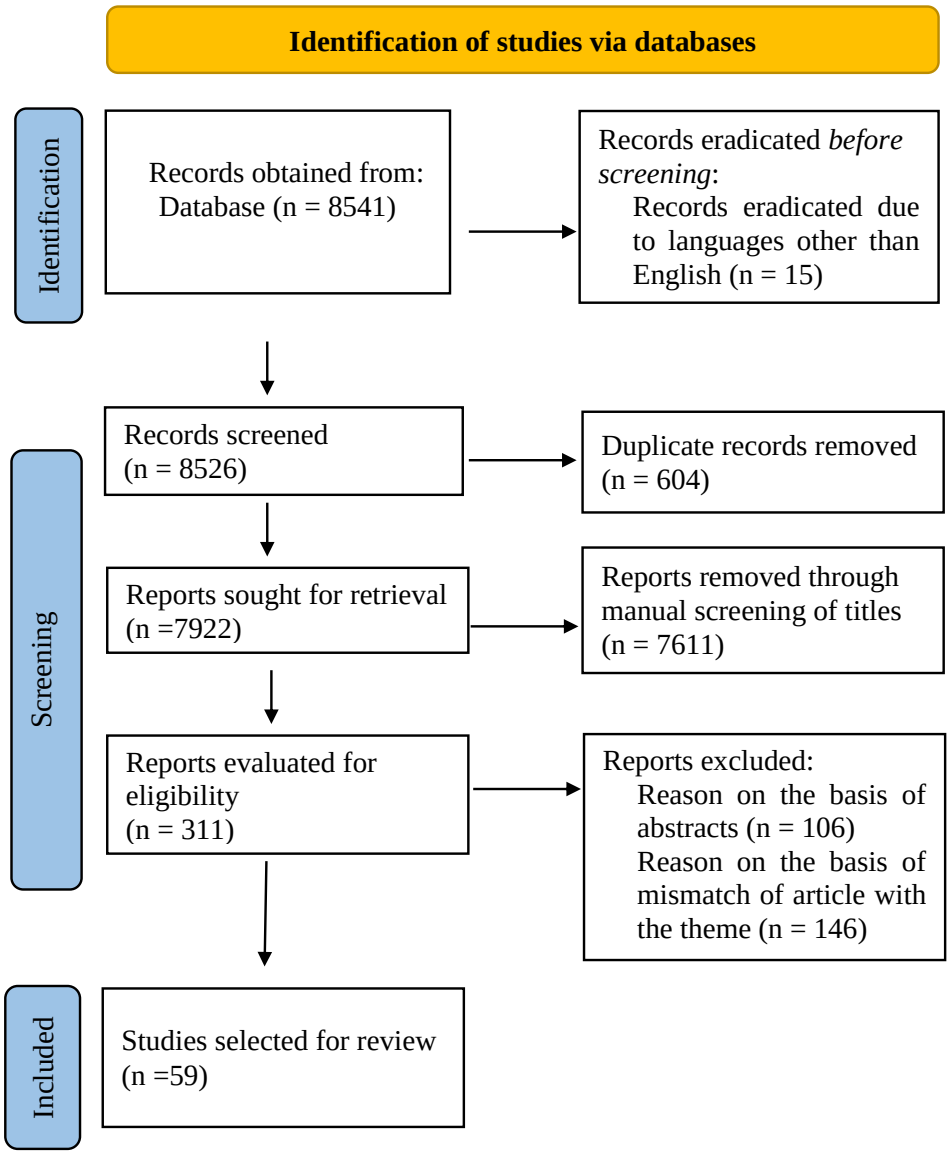

FIGURE 2.1: Procedure for selecting papers

2.2.2 Descriptive Analysis

2.2.2.1 Annual Production Frequency

This information calculates the number of papers published on the resource-finance nexus each year between 1980 and January 2023 (see Fig.2.2). A rising publishing trend is observed. However, the years from 2020 to 2022 show an exceptionally high rise. 8 out of 59 articles were published in 2020, 14 in 2019, and 22 in 2023 (as of January). The significance of natural resource rents and their contribution to

financial development are depicted in this growing trend in publications, especially over the last three years. This pattern implies that researchers are beginning to see NR as a critical component of FD evolution and a means of addressing the financial resource curse. Scholars are looking for novel perspectives or dimensions that can strengthen this relationship.

2.2.2.2 Productive Journals

In this search, 59 publications were retrieved from different journals, books, and conference proceedings. Data consists of 56 journals and 3 books. Whereas the research design for 53 articles is empirical, for 6 articles, a qualitative approach is adopted. The details of the top five publishers are mentioned as shown in Fig. 2.3. Elsevier, which has 34 papers, and Springer, which has 5 papers, are the two publishers with the most publications. Authenticity and fame of journals are two crucial metrics that greatly influence how readers view the publication (Kamble et al., 2018).

Resource Policy Journal by Elsevier publishes most articles (n = 22) on the resources-finance nexus. According to this study, the three most significant journals are Environmental Science and Pollution Research (n = 3), Cogent Economics and Finance (n=2), and the Journal of International Money and Finance (n=2). The volume of articles published in these numerous reputable periodicals highlights the multidisciplinary nature of NR and FD (Ali et al., 2022).

2.2.2.3 Countries

The first author's contribution was used to sort the articles. Fig. 2.4 highlights the knowledge production across countries based on authors' affiliation. Chinese authors published most studies on the resource-finance nexus (n = 19). Malaysian and French authors each wrote five papers to tie for second place.

Authors from the UK and Turkey, then, with four articles each, are in third place. Fourthly, Pakistan, India, Saudi Arabia, and Iran all have two articles. This highlights the global interest and the wide range of arguments presented by researchers from various countries in resource-finance nexus research. Considering

data from the Scopus Database, co-authors were distributed based on their countries of affiliation.

The outcomes diverge slightly from the earlier ones. It was discovered that Chinese researchers hold the top position as primary authors and co-authors, surprisingly followed by Pakistani writers in second place. Malaysia and France were placed third, then Saudi Arabia and the United Kingdom stood fourth. Their contributions emphasize the importance of multiple perspectives and the collaborative effort involved in this field of research (see Fig. 2.5).

2.2.2.4 Research Method Employed in Studies

The analysis of the article revealed that various econometric models were used in the studies.

According to the findings presented in Figure 2.6, co-integration (n=17) was the most prevalent method used by a sizable number of research, followed by panel regression (n=12), ARDL (n=8), QARDL (n=4), CS-ARDL (n=3), GMM (n=3) and VECM (n=2). According to the article review, the 2 SLS model is to be familiarized with the resource-finance nexus.

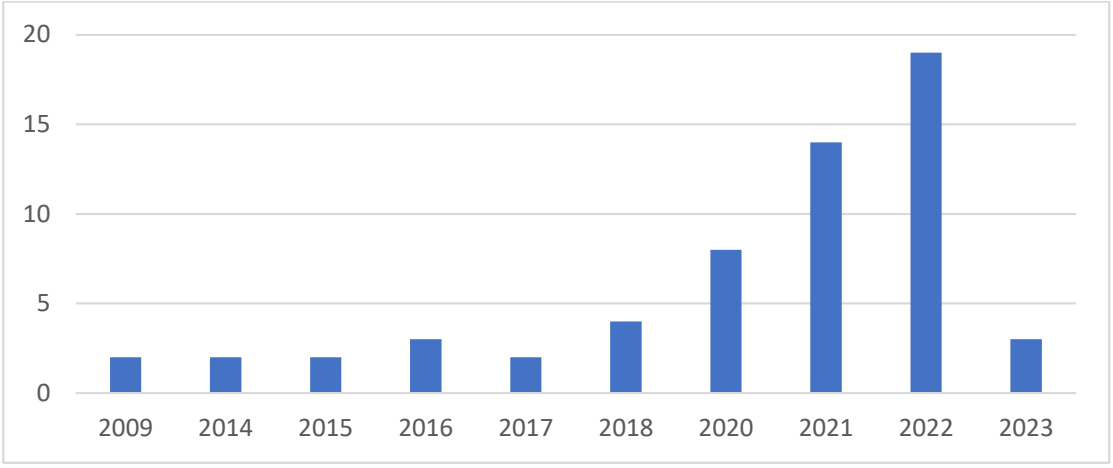

FIGURE 2.2: Natural resource and financial development-related publications trend.

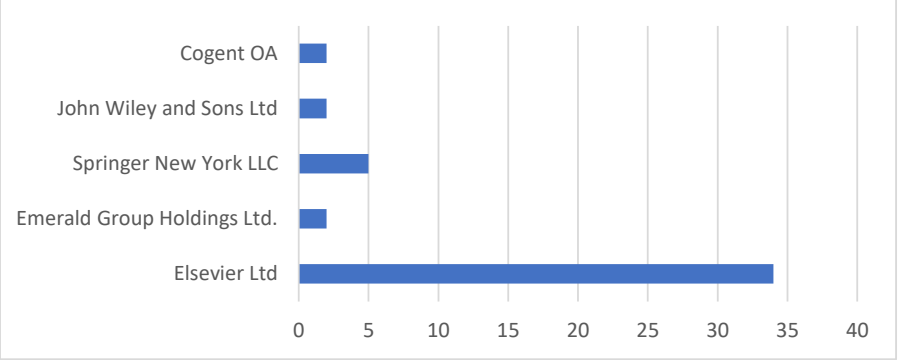

FIGURE 2.3: Publication channels of studies, n $\geq$ 2 (n denotes the number of articles

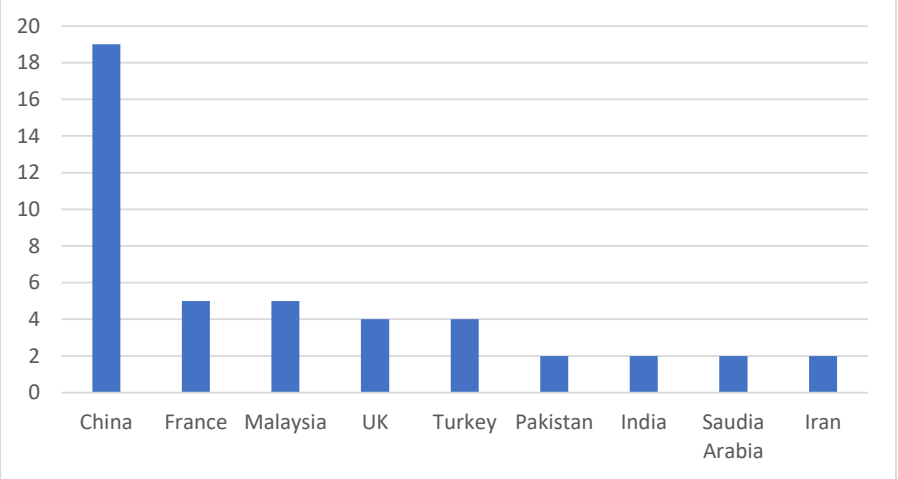

FIGURE 2.4: Knowledge production across countries based on authors' affiliation (n $\geq$ 2)

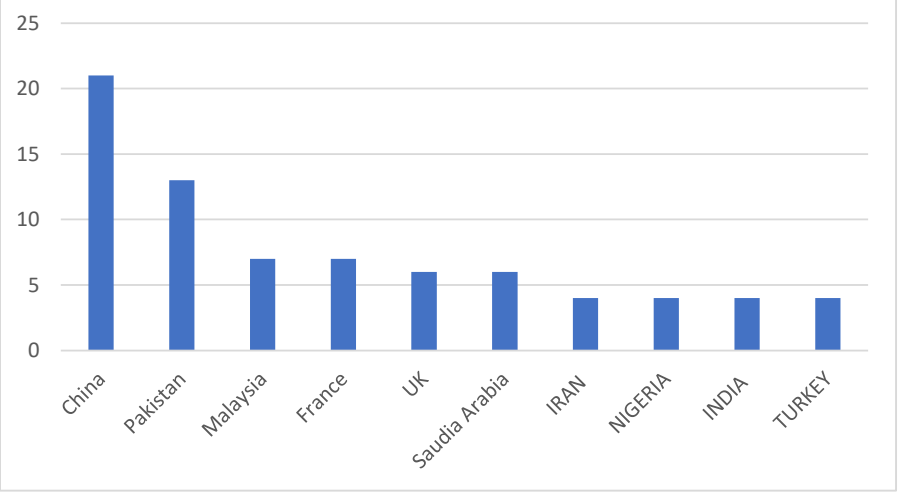

FIGURE 2.5: Co-author publication details country-wise (n $\geq$ 4)

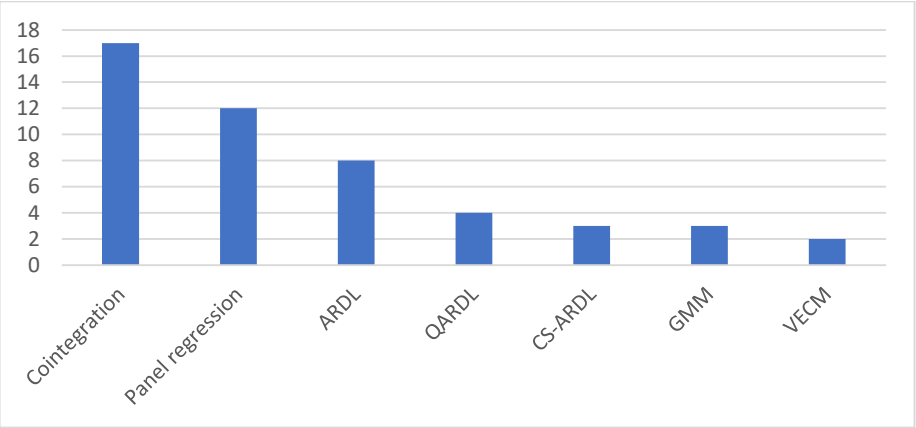

FIGURE 2.6: Research method employed in studies (n $\geq$ 3)

2.2.2.5 Authors

The top ten authors with high citation scores are exhibited in Table 1. The article's central theme, as well as its respective organizations and country affiliations, are highlighted. Van der Ploeg, F. is placed at the top of the table (citation score 245), followed by Bhattacharyya, S. (citation score 155), and then Shahbaz, M. (citation score 124). Based on the number of publications, the prolific authors are Ali, A.; Moradbeigi, M.; and Shahbaz, M., with two articles each. The first author's contribution was used to sort the articles.

TABLE 2.1: The top 10 authors with high citation scores

Author(s) (Year)	Citation score	Journal	Research Themes Investigated	Country	Country Affiliation
Van der Ploeg and Poelhekke (2009)	245	Oxford Economic Papers	investment; economic growth; trade; financial system; human capital; economic development; population growth; income; natural resource	UK	University of Oxford, United Kingdom;
Bhattacharyya and Hodler (2014)	155	World Development	institutional framework; resource management; Financial development; Natural resources; Political institutions	UK	University of Sussex, Brighton, United Kingdom
Shahbaz et al. (2018)	124	Resources Policy	economic growth; Financial development; Natural resources; education	France	Montpellier Business School, Montpellier, France;
Umar et al. (2021)	110	Resources Policy	Financial development; oil production; energy policy; Probability of defaults	China	Department of Management Science and Engineering, School of Business, Qingdao University, China
Asif et al. (2020)	100	Resources Policy	Financial development; Investments; natural resource rents; private sector; capital formation; Broad money supply	Pakistan	Department of Business Administration, Air University, Multan Campus, Pakistan
Billmeier and Massa (2009)	84	Emerging Markets Review	Institutions; Remittances; Stock market capitalization	USA	International Monetary Fund, United States
Atil et al. (2020)	67	Resources Policy	economic growth; globalization; Financial development; Natural resource abundance; globalization	France	Rennes School of Business, France
Moradbeigi and Law (2017)	47	Resources Policy	economic growth; Financial development; Natural resources; oil volatility	Malaysia	Universiti Putra Malaysia
Li et al. (2022)	43	Resources Policy	Financial development; Natural resources; Financial markets; trade; GDP; gross capital formation	China	ChinaUniversity of Technology, Wuchang, Wuhan, Hubei, China
Allegret et al. (2014)	41	Journal of International Money and Finance	Financial development; Oil price; Current account	France	EconomiX-CNRS, University of Paris Ouest, France

2.2.3 Thematic Analysis

The following sections address the elements that influence and improve the NRR and FD relationship is based on a review of previous literature. Table in the Appendix presents the outcomes of empirical research.

2.2.3.1 Price Volatility

Researchers have advocated that to convert the natural resource curse into blessings, economies must adopt strong monetary and fiscal policies and reduce their reliance on NRRs to limit oil price volatility. The price volatility of natural resources, particularly oil, impacts the FD. Allegret et al. (2014) argued that rising oil prices significantly influence less financially developed nations. Umar et al. (2021) demonstrated that high resource prices diminish banking efficiency due to high default rates, resulting in the resource curse. Nations that rely heavily on NRRs usually have underdeveloped financial systems. Further, Badeeb and Lean (2017) investigated the fact that resource-dependent economies experience high volatility in the growth of their gross domestic product (GDP), trade, and real exchange rates, along with the volatility in natural resource prices.

Further, this volatility might hinder the growth of the country's financial sector by gradually and significantly raising the uncertainty level around investment choices, consequently hindering the economy's potential for growth and diversification. The empirical findings demonstrated that a productive finance sector mitigates the adverse effects of falling oil prices by diversifying the economy away from hydrocarbon-related industries (Billmeier and Massa, 2009; Liu et al., 2022). In the situation of Saudi Arabia, Gokmenoglu and Rustamov (2022) suggested that if the government boosts the flow of funds from natural resources to industries, it would increase a country's competitiveness and financial development. The careful credit policy implemented this way will encourage financial system stability by reducing bubbles that appear because of high liquidity in inefficient sectors.

Additionally, Moradbeigi and Law (2016) stated that a robust financial system can overcome the adverse effect of oil price volatility on economic growth volatility.

A more stable financial system reduces household and business uncertainty. It increases public trust in the government, thus strengthening the growth-enhancing effects of oil resources by redirecting incomes to more productive activities. Atil et al. (2020) discovered that natural resources are blessings for Pakistan by empirically testing the data from 1972 to 2017.

The study stated that the financial system would need a set of micro and macro-prudential rules and a regulatory framework for financial stability to deal with the cyclical variations of the natural resource market. Due to financial instability, the banking industry, natural resource management, and earnings are all hampered. The government should work towards maintaining a stable exchange rate and attracting international and domestic investors through effective monetary and fiscal policies. To manage price volatility risk, Khan et al. (2021) proposed that the sustainability and stability of financial markets could be increased by replacing oil with natural gas as asset classes for portfolio diversification.

2.2.3.2 Democracy, Rule of Law, and Accountability

NRRs negatively correlate with FD in nations with subpar political institutions. The financial sector lacks contract enforceability because the ruling elite has less incentive to promote contract enforcement while receiving large natural resource rents. However, if political leaders are held accountable to the public through robust and democratic political institutions, this inclination can be curbed. Democratization might encourage FD in countries with excess natural resources (Bhattacharyya and Hodler, 2014; Ndikumana and Boyce, 2022).

Similarly, Shahbaz et al. (2018) found a bidirectional relationship between the abundance of natural resources and financial development. The resource-finance nexus depends on the governance system. A financial system lowers stakeholder uncertainty, improves public perception of the government, and magnifies the positive impacts of natural resources. Morck and Nakamura (2018) suggested that Japan's post-World War II reconstruction relied less on natural resources and more on bank funding and government guidance. The success of industrialization was due to extensively reformatted political, legal, and economic institutions, democratic

rule of law, laissez-faire economics, low government corruption, and a corporate governance system.

In the emerging and developing oil-exporting nations, Kassouri et al. (2020) demonstrated that strong democratic institutions are likely to counteract the financial sector's curse. Likewise, modern accounting standards, increased investor protection, transparency, and financial sector competition contribute to democratic environments (Sepehrdoust and Shabkhaneh, 2018).

Developing Knowledge-Based components, including social reform, expansion of financial markets, and widespread use of technical equipment, might shift the resource curse status of OPEC nations. Economies with suppressed financial systems and inadequate governance mechanisms are accountable for reduced growth in financial sector deposits and private sector lending (Beck and Poelhekke, 2023). Resource-rich nations with poor institutional integrity may have undeveloped economies because political leaders can quickly advance their political interests through misallocation of natural resource windfalls. If robust democratic institutions guarantee that governing elites are held accountable to their people, this self-interest may be controlled. Moreover, strong institutions may support the protection of property rights and the execution of contracts, enabling the financial industry to function safely (Ali et al., 2022).

2.2.3.3 Institutional Quality

Strong financial institutions maintain institutional influence over the natural resource market to prevent exploitation and rent-seeking of scarce natural resources, which is a common disadvantage in developing countries (Asif et al., 2020; Gu et al., 2021). Similarly, Ali et al. (2022) highlighted that institutional quality must be prioritized to track rent-seeking, corruption, the rule of law, and the enforcement of contracts. It will improve banking and stock market operations as well as the management of resource income.

In the Sub-Saharan countries, Sandow et al. (2022) found a financial resource curse. Findings suggested that NRRs can stimulate economic growth by effectively directing the windfall income through financial institutions and the stock market.

A large pool of cash will be created, which will enhance internal investment, which will lead to the creation of jobs and economic growth, or foreign investment in the form of sovereign welfare funds, which will finance the consumption of future generations.

2.2.3.4 Human Capital and Technological Advancements

Hussain et al. (2021) found that NRRs are blessings after empirically testing the data from 23 high-income resource-abundant economies. Findings indicated that human capital fosters financial development in high-income, resource-abundant economies. These economies use human capital and natural resources effectively to fulfill development goals with the support of technological advancement.

In South Asian countries, Naseer et al. (2020) discovered the resource curse relationship. Adaptation of technology and effective investment polices can support effective utilization of natural resources. To overcome the resource finance curse, emerging countries should focus on technological advancement, human capital, and financial inclusion (Asif et al., 2020; Gu et al., 2021).

In the long run, human capital enhances the financial sector by enabling the effective and efficient utilization of natural resources. Human capital advancement can be raised through investment in R&D, increasing the financial literacy skills of people, and advancement in the sector of science and technology (Oryani et al., 2022).

In Saudia Arab, Gokmenoglu and Rustamov (2022) discovered financial resources. In the long run, strong institutional quality and advancement in human capital can overcome its impact. Çetin et al. (2023) suggested resource-finance nexus can be strengthened by advancement of human capital and a high level of capital formation, technological advancement, and globalization.

2.2.3.5 Sustainable Finance

The financial sector can use natural resource rents to encourage energy-efficient investments. This will, in return, strengthen the resource-finance linkage. In African

countries recently, Nurmakhanova et al. (2023) found a natural resource curse. Revenues from natural resources should be used wisely to improve Africa's financial development. A diversification strategy through which rents from traditional (non-renewable) resources should be directed to the service sector, particularly the financial sector. The study stressed the significance of sustainable finance.

Natural resource revenues can be used to promote green bonds and invest in green cities to make financial development more beneficial to the economy. The literature supports that the financial industry should diversify by directing cash from natural resource rents into sustainable development. Ganda (2022) studied BRICS economies and suggested that financial gains from NRRs (forest, mineral, oil, coal, and natural gas) can be used sustainably to develop an effective green financial sector that promotes economic activity and consumption that employs eco-friendly practices.

Ibrahiem and Sameh (2022) discovered the natural resources curse in Egypt. The study discovered that NRRs are caused by FD. The gradual phase-out of non-renewable energy subsidies in Egypt will generate revenues that the government could use to subsidize energy investments in green capital for SMEs. Shobande and Enemona (2021) verified that the financial resource curse exists in Nigeria and Ghana.

The human development index (economic welfare) has been recognized as the channel via which sustainable finance influences the natural resource curse. The research indicated the necessity for a dynamic, long-term financing plan to support domestic private investors having an interest in natural resource inspection and development while considering macroeconomic sustainability.

2.2.4 Future Research Prospects

Using the data from our content analysis, we developed an extensive conceptual framework that integrates the key findings of this study (see Fig. 2.7). Future research recommendations are outlined below.

2.2.4.1 Fintech

Although there is an emerging amount of research on the effects of NRRs on FD, the precise contribution of Fintech to enhance this link is yet largely unexplored. Previous studies highlighted the difficulties posed by the improper management of natural resource earnings, which have a limited positive impact on financial development. It will be interesting to learn more about how digital platforms and technology might improve the transparency, accountability, and governance of resource earnings by examining the use of Fintech solutions such as blockchain, AI, crowdfunding, etc., and their effects in countries with an abundance of natural resources (Wang et al., 2023a; Tan et al., 2023).

Fintech solutions guide economies in achieving SDGs, like controlling corruption while managing NRR (SDG 16), facilitating economic development (SDG 8), and encouraging innovations (SDG 9). Fintech has transformed financial systems worldwide in the last two decades \citep (Lisha et al., 2023).

2.2.4.2 Digital Financial Inclusion

In natural resource-rich countries, digitalization supports both achieving social objectives by serving the unbanked population and, secondly, financial sector development through financial inclusion. It supports small and medium enterprises by increasing access to banking services, enhancing transparency, and eventually reducing the rent-seeking behavior.

Pang et al. (2022) stated that digital financial inclusion serves underprivileged, promotes business activities, boosts economic empowerment and financial development. Hence, it helps in achieving SDG 1 (poverty reduction), and SDG 5 (promoting gender equality).

2.2.4.3 Sustainable Development

The extraction of natural resources frequently sparks environmental issues, and there is a growing need to incorporate sustainability factors into financial decision-making. In this area, very few studies have been conducted. Research on sustainable

development about the resource-finance nexus still has a lot of untapped potential. It involves efficient utilization of resources, resulting in economic growth and environmental sustainability.

Fintech as a moderator and financial development as a mediator can increase the transparency and facilitate all the activities that focus on social, economic, and environmental protection. Supporting SDG 8 (economic growth) and SDG 13 (handling the consequences of climate change). The availability and effectiveness of capital allocation for sustainable ventures can be further improved via Fintech. In China, Ant Forest is a successful model that supports sustainable development through promoting green financial instruments (Cen and He, 2018).

2.2.4.4 Green Environment

Future studies can highlight new perspectives by examining how the financial sector can contribute to directing the NRR towards green technology adoption. Renewable energy sources, energy-efficient methods, and sustainable resource extraction techniques can give an understanding of how these developments affect the environmental quality of resource-based companies. The green environment comprises the adoption of green technology and green financial instruments.

The rents received from natural resources can be directed towards green technology adoption that supports SDG 7 (clean energy with affordability), SDG 9 (supporting technological innovation), and SDG 13 (mitigating climate change). Whereas NRR can be used to promote green financial instruments with the support of financial development. It will help further in achieving SDG 9 (supporting technological innovation), 12 (ensuring sustainable consumption and production activities), 13 (mitigating climate change), 14 (effective and efficient utilization of marine resources), and 15 (protecting and restoring ecosystem and biodiversity).

2.2.4.5 Research Sample

Most of the resource-rich countries are emerging and developing countries (Hussain et al., 2021). To widen the scope of the resource-finance study, it can be conducted on N-11 countries. Collectively, these countries are not studied as a panel data.

They comprise Pakistan, the Philippines, South Korea, Turkiye, Bangladesh, Egypt, Mexico, Nigeria, Iran, Indonesia, and Vietnam. These economies are rich in natural resources (oil, gas, minerals, and agricultural resources)

2.2.4.6 Proxy Measure

A significant body of research on the resource finance nexus has concentrated on banking institutions. There is a study gap regarding including stock markets (Moradbeigi and Law, 2017) or the simultaneous investigation of both stock markets and financial institutions (Ha, 2022). Using an inclusive or comprehensive proxy for financial development may help scholars in understanding the complex relationship between NRRs and FD. Such a strategy would make it possible to measure the depth, efficiency, and accessibility of a financial system to make a more comprehensive assessment of the FD of a country. Li et al. (2021) stated that natural resources can benefit FD by promoting financial market development.

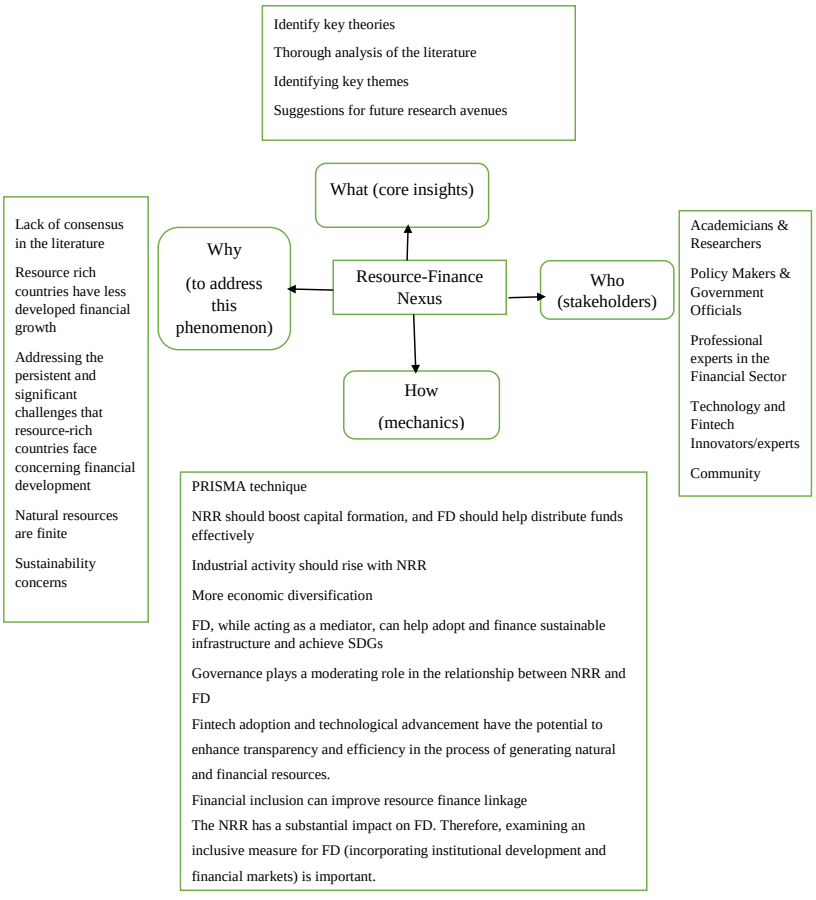

FIGURE 2.7: Conceptual Framework

Natural gas offers significant advantages in terms of affordability and low carbon emissions. It is also an alternative fossil fuel and a replacement for crude oil (Rizvi et al., 2022). Most of the available research on the resource-finance nexus concentrates on oil revenues or conducts a more thorough examination of all natural resources. There is a gap about how natural gas rents directly affect financial development. Moradbeigi and Law (2017) suggested that the resource curse is not exclusive to oil-producing countries.

Further research can examine the function of financial development in reducing the detrimental effects of natural resources other than oil. Natural gas offers significant benefits in terms of cost and low carbon emissions, making it much more than just a substitute for crude oil and an alternative fossil fuel. Therefore, examining how natural gas rents affect financial development can provide insight into macroeconomic indicators, investment trends, fiscal policies, and overall financial development in resource-rich nations.

Numerous studies have been carried out on the connection between natural resource rents and financial development. This research focuses on conducting a systematic literature review by examining the what, how, who, and why of the resource-finance nexus. This will help resource-rich economies attain economic growth, meet the Sustainable Development Goals, and outperform developed economies by leveraging the benefits of their natural resources.

The foundation of problematization is a careful reading of the existing literature, an unconventional way of thinking, and the promotion of creativity. It proposes alternate concepts and perspectives for understanding a phenomenon (Sandberg and Alvesson, 2011). The study uses the same process to examine the resource-finance relationship. It highlights existing trends and identifies future avenues that require more investigation. The study uses the Scopus database to gain access to a wide range of academic literature. The research includes 59 publications that focus primarily on the study's goal. The study employs the PRISMA technique.

The main finding reveals that a resource finance curse exists due to price volatility (Allegret et al., 2014; Moradbeigi and Law, 2016), which would then hinder economic growth and economic diversification (Badeeb and Lean, 2017; Billmeier and Massa,

2009). The green technology usage can provide an understanding of how these developments reduce the negative environmental impact of resource-based countries, which could finally result in sustainable financial development and the attainment of SDGs. In light of the above-mentioned debate, including thematic analysis on the resource-finance nexus, theories are explained, and future research prospects discussed, the study proposes that:

H_2: In the N11 and BRICS countries, NRR positively impacts financial development.

2.3 Financial Development and Sustainable Development

2.3.1 Natural Resource Rents and Sustainable Development

The growth and sophistication of the country's financial system, including its banking sector, stock markets, bond markets, and other financial institutions, is termed as financial development. Financial development with well-functioning financial markets and institutions can offer high access to financial resources for businesses, and individuals. The availability of funds diverts long-term investments in projects such as renewable energy, sustainable technologies, and environmentally friendly infrastructure.

Financial development and economic efficiency have a complex and multidimensional connection. Economic efficiency refers to the best allocation and utilization of resources in an economy to maximize output and total well-being. Financial development can facilitate economic efficiency through capital accumulation, risk management, innovation, and transaction efficiency. Sometimes, high growth in the financial sector or flaws in financial markets can lead to inefficiencies or systemic risks. Excessive risk-taking, or insufficient regulation, can lead to financial crises that undermine economic efficiency.

Xie et al. (2022) investigated the ten most resource-rich economies from 1990-2018. The researchers employed the panel Granger approach to study the relationship between FD, natural resources, and environmental performance. Financial markets

and institutions improve financial services by disseminating loans, assuring the availability of ATMs and bank branches, facilitating the trading of shares, improving stock market valuation, and offering insurance services.

Executing focused strategies to improve financial development through natural resource rents will significantly result in environmental preservation and the accomplishment of sustainable economic growth. Financial markets and institutions are reducing the adverse impacts of natural resources on environmental quality via the adoption of new and sustainable technologies, which promote efficient energy usage and enhance environmental performance. Both ecological modernization and endogenous growth theories support the idea that in the current system technological innovations and institutional reforms can assist countries in attaining long-term economic growth goals while minimizing environmental harm.

In their research, Dogan and Seker (2016) used heterogeneous panel estimate methods that conduct cross-section dependency to examine the influence of real income, renewable energy consumption, non-renewable energy consumption, trade openness, and FD on carbon emissions using the Environmental Kuznets Curve model. The study used countries that rated best in the Renewable Energy Country Attractiveness Index. The study revealed that renewable energy consumption, trade openness, and FD reduce CO_2 emissions. Whereas, consumption of non-renewable energy raises emissions. Lisha et al. (2023) discovered that financial development positively affects SD in BRICS countries.

Moreover, Kirikkaleli and Adebayo (2021) used the Bayer and Hanck co-integration test to find a long-term association between financial development and environmental sustainability. The study examined the global influence of FD and renewable energy consumption on the preservation of the environment. Gradually, the progress in the financial sector has had a reducing effect on CO_2 emissions. Low-interest loans can smooth financial growth and contribute to the achievement of sustainable development goals by encouraging the participation of both corporate and governmental sectors in environmental initiatives.

On the other hand, Manigandan et al. (2023) examined that FD and energy consumption increase annual per capita CO_2 emission rates. However, the technical

innovation moderating role decreases CO_2 emissions. For sustainable economic expansion, the government should introduce new loan schemes with low interest rates and flexible payback periods to encourage private investment inflow. The best way to consume emerging technology would be to digitize the banking system, resulting in more access to loans. Priority must be given to those individuals who are willing to invest in environmentally-friendly initiatives. Comparatively high interest rates should be charged on the Dirty loans.

In addition, the loan payback period for green loans should be greater than that of filthy loans. The financial progress, energy efficiency, anti-corruption efforts, and ecological footprint of the Next 11 countries and the BRICS are studied by Yao et al. (2021) from 1995-2014. The energy efficiency is calculated using the DEA method. According to the results of the System GMM, financial development can increase energy efficiency if corruption is reduced. Additionally, if these economies have transparent processes, environmental quality can be improved by lowering the ecological imprint.

Though financial development can be beneficial to an economy, it can also harm long-term development. Financial progress can increase the exploitation of natural resources and contribute to environmental harm. Chen et al. (2022) studied the 10 most polluted countries between 1990-2019. The Granger panel causality test provided evidence of a bidirectional causal relationship between eco-efficiency and FD. There is a long-term negative correlation between FD and environmental sustainability. The findings suggested that the financial industry has a significant role in causing pollution by providing loans to projects that damage the environment.

To improve eco-efficiency, it is advisable for these countries to gradually increase the adoption of environmentally friendly technological solutions in their financial sectors. Green technology may raise the accessibility of financial resources for eco-conscious businesses. An increase in the effectiveness of the financial sector in these economies can contribute to enhancing eco-efficiency. Abbasi et al. (2022) identified the relationship between FD, technical innovation, and SD in Pakistan from 1990Q1 to 2019Q4 using dynamic ARDL. Financial development significantly affects the increase of both consumption-based emissions (CBE) and territory-based

emissions (TBE). Over time, there is a negative relationship between technical innovation and both CBE and TBE.

Based on the facts, Pakistan experiences environmental deterioration due to the use of conventional energy sources. Policymakers in Pakistan should implement measures to mitigate pollution, since financial growth, economic globalization, economic growth, and technical innovation have a substantial impact on long-term environmental policies.

Financial development frequently prioritizes short-term profit maximization over long-term sustainable solutions. It ignores environmental and social concerns, investments in renewable energy, and the development of sustainable long-term infrastructure. Shen et al. (2021) studied panel data from 30 provinces in China from 1995 to 2017. The study examined the influence of NRRs, green investment, FD, and energy consumption on reducing carbon emissions for sustainable development.

The CS-ARDL results support the positive effect of energy consumption and FD on carbon levels. To promote the total scale of green investment in Chinese provinces, it is necessary to formulate policies that merge financial expansion with green investment. Chinese provinces should increase their percentage consumption of renewable energy to achieve cleaner production and reduce carbon emissions. Xu et al. (2022) revealed that CO_2 emissions are negatively correlated with loan interest rates. Additionally, the study revealed that the disbursement of loans to the private sector raised overall CO_2 emissions. Banks should consider environmental preservation while making loan portfolios.

Banks and credit lending institutions should encourage borrowers to adopt greener practices and charge monetary penalties to those who deviate from the bank's green policy. Financial institutions should incentivize businesses that adopt environmentally sustainable practices by prioritizing giving loans to eco-conscious customers. Consequently, these strategies will facilitate both ecological and economic sustainability.

A high level of financial development boosts productivity by disbursing loans to businesses, but this negatively affects eco-efficiency. Thus, financial growth may foster eco-efficiency by offering credits to firms that focus on clean energy (Yao et al.,

2021). Further, Jahanger et al. (2022) discovered that in Asian countries, financial development reduced ecological footprints, but in African, Latin American, and Caribbean countries, it raised the level of ecological footprints. Green or climate financing is essential, as it raises investment in green projects. They have the potential to counteract the positive influence of financial development on the environment. Further, Arslan et al. (2022) examined sustainable development specifically concerning China's natural resource rents. In the long run, the study found that FD stimulates EG while increasing environmental degradation.

The negative outcome of financial development is not inherent, but rather a result of how financial systems are set up and governed. Proper rules, regulations, and policies can guide in reducing negative outcomes and aligning financial development with long-term development goals. Financial development may play a crucial role in fostering a more sustainable future by combining environmental, economic, and natural resource management into financial decision-making. Taking into consideration the preceding debates, which include thematic analysis of the resource-finance nexus, theories utilized to explain this nexus, and prospective research dimensions. The study proposes the following hypothesis:

H_3: Financial development positively impacts sustainable development in the N11 and BRICS countries.

H_4: Financial development acts as a mediator in the association between natural resource rents and sustainable development in the N11 and BRICS countries.

2.4 Fintech, Natural Resource Rents, Financial Development and Sustainable Development

2.4.1 Fintech and Natural Resource Rents

Fintech can increase and reduce natural resource rents. The effect depends on a diversity of factors, including the technology itself, and the context in which it is implemented. Tan et al. (2023) discovered the association between natural

resource rents and Fintech. Fintech provides strong foundations for natural resource management; hence governments are advised to invest in developing digital technologies that have the potential to support the financial sector. Developments in the economy's financial sector will offer a solid foundation for economic growth and natural resource management. Fintech development can improve individual's quality of life by facilitating their purchasing, investment, and inventory management activities. Additionally, Fintech has made the functioning of the shared economy very convenient and efficient.

According to the study of Ma et al. (2022), the volatility in natural resource taxes significantly impacts the economic performance of Chinese provinces. Volatility in taxes imposed on the mining of natural resources could result in decreasing public investment, disturb consumption behavior, lessen competitiveness, and disrupt economic activity, which could harm the economic development of the country. The digital economy can promote economic growth by promoting human capital and natural resources and increasing the production capacity in the extractive sectors.

Almansour (2023) investigated the use of data-driven algorithms, the advantages of AI, and the effect of AI on the job market. Various studies have analyzed the effects of using disruptive technologies like AI on the internal human resources of the Fintech start-ups, as well as the external natural resources such as minerals and associated industries. The study negated that technology usage may result in technostress and reduce job possibilities. Despite the initial investment cost and change in the standard routines, AI adoption has a beneficial, lasting impact on both organizations and employees. This results in improved well-being, work-life balance, and increased work engagement. Fintech enables investors and traders to make more informed decisions and control price volatility. Additionally, Fintech solutions can provide risk management tools such as hedging products and options, allowing market participants to protect themselves from inevitable price changes.

Cevik et al. (2022) suggested that digital financial instruments have a vital role in determining the price and risk profile of natural resources like crude oil and gold, especially during periods of crisis. The study observed the advantages of portfolio diversification throughout the Covid-19 pandemic. The study proposed that there

are strong negative associations between DeFi tokens (a new type of cryptocurrency asset) and natural resource markets when markets are moving down. This suggests that DeFi tokens can be a good alternative investment choice for gold and crude oil owners to protect their investments.

Fintech can guide natural resource firms in improving their operations and lowering expenses, thus boosting the firm's profitability. Mai et al. (2022) suggested that digital firms are exercising greater influence on coal and gas rents while reducing mineral and forest rents. Digitalization reduces the natural resources consumption (increases resource efficiency). Therefore, persistent investment in digitalization across industries is required to safeguard natural resources.

The rising trend of digital transformation by companies and governments for operations and managerial applications, especially during the COVID-19 crisis, has highlighted its significance. The study of Li and Umair (2023) found that digitalization and Fintech reduce reliance on natural resources. Natural resource consumption and exploration can be made effective by merging digital infrastructure with technological advancements. This will set the whole economy on a trajectory of sustainability where technological advancement will be a key stimulating factor for raising national income and attaining SDGs.

Fintech models like AI-driven Algorithms can monitor drilling operations in real-time and modify settings to maximize resource recovery while minimizing costs. This can result in higher output rates, less wastage, and lesser environmental implications. Adebayo et al. (2022) examined newly industrialized countries (NICs) and found that technological innovation affects the accessibility and consumption of natural resources that further positively influence the environment. Technological innovations are expected to positively impact the discovery of natural resources in the NICs. Newly industrialized countries (NICs) should encourage technical innovation, foster sustainable utilization of natural resources, and expedite economic development rates by implementing sustainable changes in their production and consumption practices.

Further, Miao et al. (2017) proposed that the efficient consumption of natural resources is significantly higher under green technological innovation. Similarly,

Li et al. (2020) said that technological innovation benefits countries by increasing productivity and ensuring efficient utilization of resources that leads to economic development.

In a nutshell, Fintech can influence natural resource rents by improving resource extraction and conservation efficiency, minimizing the negative impact on the environment, and decreasing resource price volatility. Capital is easily available to new entrants. This may result in low profits for natural resource enterprises due to an increase in competition. Thus, the study concludes that Fintech has the potential to increase natural resource rents.

2.4.2 Fintech, Financial Development, and Sustainable Development

Fintech comprises of technological advancements in the financial sector, with the potential to revolutionize financial services through the development of novel or adapted business models, applications, processes, and products. Stankevičienė and Kabulova (2022) proposed that the impact of Fintech varies with market development and the legal framework for Fintech operations. Fintech innovation in developed financial markets reduces stability. Fintech regulations should be aimed at mitigating the financial volatility caused by the Fintech. The sandbox usage by financial institutions operating in emerging economies increases their financial stability. A Fintech sandbox is a virtual environment in which innovators can imitate reactions in real-time. This allows banks and Fintech firms to experiment with novel financial products and services within the boundaries of a controlled and regulated environment. The sandbox involves pilot testing of newly created technology. The Fintech sandbox application is viewed as beneficial for Fintech innovation that can further enhance the stability of financial institutions.

Likewise, Mikhaylov et al. (2023) discovered that innovation and equity market capitalization are highly correlated. AI and machine learning are the key components of Fintech. To improve the operations of capital markets effectively, it is necessary to focus on reducing transaction costs, managing financial institutions,

increasing market transparency, eliminating unethical conduct, and addressing conflicts of interest.

Further, Met et al. (2022) proved how state-of-the-art machine learning systems like AI can enhance the performance of the banking industry. It automatically sets and disseminates annual targets for bank branches and portfolio managers, which is an important step for making decisions and planning a strategy in the banking sector. It becomes simple to measure performance of portfolio managers and bank branches. Automatic machine learning systems operate on massive amounts of data that are impractical to manually process due to constraints on human resources, data sensitivity, and time constraints. Companies can access financial services at a low cost and enhance their efficiency by disseminating information at a low cost, thus resulting in overall lower total costs for economic activities. Digitalization may improve the competitiveness of the products of multinational firms, hereafter increasing the GDP of both the home and host nations.

In China, Khan et al. (2020) found the resource curse. Technological advancements, investment in human capital, and the degree of trade liberalization are the primary drivers of FD. The interaction between human capital and technical innovation can result in financial stability. Technological advancements foster firm growth and enhance competitiveness, thus increasing local output and contributing to financial development. In addition, Ha (2022) studied the correlation between technological advancements and financial development. The measurement of digitalization is based on factors such as digital connection, internet usage, e-business, e-commerce, and e-government. Due to the widespread use of digital transformation, digitalization is anticipated to improve financialization's depth and effectiveness while limiting its accessibility.

Fintech supports competition in the financial sector by introducing new companies and business models. Daud et al. (2022) suggested that digitalization has increased competition that resulted in financial stability. As competition increases more innovative features are produced, portfolios diversify, and efficiency increases, which leads to stability.

Financial innovation fosters growth by encouraging risk-sharing, lowering agency

costs, increasing efficiency, and increasing access for financial transactions. Contrary, the competition-fragility theory states that competition results in reducing market power, profit margins, and franchise worth, and results in higher instability. A higher degree of market power or concentration, on the other hand, is associated with higher risk due to increased loan exposure, default probability, and the problem of moral hazard.

Additional findings of the study conducted by Safiullah and Paramati (2022) said that in the context of Malaysia, Fintech firms have significantly improved the financial stability of banks. The study used data from 26 Malaysian banks, an emerging market, from 2003-2018. Research also shows that Fintech firms have a positive influence on the financial stability of small banks, as compared to the banks with weak corporate governance, and Islamic banks.

Small banks are more responsive than large banks. Big banks must safeguard their clientele by providing competitive and state-of-the-art services that satisfy market demands and increase their financial stability.

Fintech firms have a considerable presence in the financial market, making them competitors for banks. Partnerships between traditional financial institutions and Fintech are mutually beneficial. Mavlutova et al. (2021) proposed that partnerships allow both sides to grow their businesses and access a more significant client base, improving their competitive position and product efficiency.

Fintech firms can be divided into those that provide daily personal financial management services (real-time P2P mobile payments, Mobile wallets, Budgeting, comparison platforms, and foreign exchange), and offer a loan, saving, and investment services (P2P lending or crowdfunding, P2P investments), and third category offers additional financial services, such as data analysis, distributed ledger technologies, cryptocurrencies, and insurance.

Fintech focuses on ease/convenience over cost, for conventional and old-age customers this difference means a lot. Financial institutions should adopt Fintech and take the lead in expanding the Fintech ecosystem. The effect of Fintech on financial stability is enlarged by bank concentration.

On the contrary, the negative side of competition is highlighted by Yuan et al. (2023) Fintech growth drives bank debranching in China. Those banking products and services that overlap with the Fintech firms are at risk and likely to be taken over by Fintech firms, accelerating the macro-level debranching of commercial banks, to minimize operating expenses in running their less profitable branches. The Chinese favor mobile payments over cash payments, fostering a preference for Fintech companies.

Further, Nguyen et al. (2022) found that in developing countries, financial stability declined due to Fintech, however, this problem can be overcome by market discipline. Ownership structure displays a positive role in maintaining the discipline of fintech firms. The presence of asymmetric information might lead to a significant decline in the value of stocks within the banking industry. Big data analysis might make Fintech a viable choice for enhancing transparency, decentralization, ease, and efficiency in financial services. The "competition-stability hypothesis" said that the efficiency of assessing loan requests and the soundness of the loan portfolio are dependent upon the surplus generated by the loan evaluation process. Additionally, when market rivalry increases, the surplus diminishes, leading to a decline in the performance of bank loan portfolios.

Fintech has many advantages, but there are also risks to financial development that should be considered. Jain et al. (2023) highlighted that Fintech has decreased physical crime but increased cybercrime Fintech has given criminals more chances to obtain personal data and utilize it illegally. The lack of strong legislation and the complexity of certain Fintech products increase the chance of illegal action and information asymmetry. Thus, regulatory measures are necessary to create a conducive atmosphere for regulators and Fintech businesses to make policies through collaboration.

Lavrinenko et al. (2023) stated that Fintech influences the depth of the financial market, institutions, and the efficiency of financial markets. Fintech facilitates financial institutions in attracting more deposits and savings from individuals. The Fintech and financial institutions exhibit a negative relationship with each other in areas with limited branches of commercial banks and ATMs per 100,000 individuals. In developing markets with weak financial infrastructure, financial development

can be improved through promoting technological advancements, attracting skilled human capital, and supporting an innovation-friendly environment. Fintech is developing at a fast pace, there is a need for governance in the Fintech sector.

Fintech can be a threat to financial development if it is applied in ways that favor short-term profits above long-term sustainability and social responsibility. These dangers can erode consumers' trust and confidence in Fintech systems, ultimately slowing financial progress. Fintech firms rely significantly on digital platforms and technologies, making them exposed to cyber-attacks and data breaches. Fintech has the potential to disrupt established financial institutions such as banks by providing new methods to access financial services. This can increase competition in the financial sector, resulting in income and market share losses for traditional financial institutions (Safiullah and Paramati, 2022).

Fintech has the potential to worsen existing financial inequities by excluding populations that do not have access to digital platforms or do not fulfill the credit scoring standards utilized by Fintech platforms. Fintech could endanger natural resource management in the following ways: Fintech can encourage natural resource financial speculation, potentially leading to price volatility, market bubbles, and financial instability. Fintech can enable new forms of resource exploitation that are potentially harmful to the environment, such as deep-sea mining, fracking, and tar sand extraction. Fintech can also be used to finance and promote extractive activities in fragile and conflict-affected areas, which can result in human rights violations and environmental destruction.

In China, Muganyi et al. (2022) suggested that fintech promotes financial sector growth by increasing access, and depth of financial services for unserved market segments, and increasing savings of financial institutions. Fintech in the domain of financial regulation (regtech) has the potential to support financial development. Fintech diminishes risks, improves quality, and supports association between conventional financial institutions and fintech firms. Fintech supports stability in financial systems, through AI and Data analytics. Fintech boosts financial development through financial inclusion. It grows its customer base by serving the poor and unbanked segments of the population. Ma et al. (2022) said that a developed financial system diminishes disparity and poverty by supplying financial support

to poor and vulnerable populations, and increases investment and productivity, which further results in increased income.

Fintech supports individuals and institutional investors to take part in green growth and sustainable development, which ultimately benefits financial development. Ignatyuk et al. (2020) narrated that the concern with the green venture is the inability to attract investment due to the inherent high risk of projects and longer payback period. Fintech can support gaining green investments through data analytics. This will make decision-making faster and more cost-effective. Secondly, Fintech reduces the aggregate earnings of banks that they receive from overdraft income, and service costs, raising the risk of liquidity for banks. Therefore, the role of the central bank is vital, for coping with the challenges of the financial sector through administration and policy implementation.

Individual and institutional investors can easily participate in green and sustainable investments because of advancements in Fintech. Croutzet and Dabbous (2021) studied the impact of Fintech on renewable energy. The study used a sample of 21 OECD countries from 2005-2018 using the fixed-effect technique, Driscoll-Kraay standard errors. The results show a positive relationship between Fintech and renewable energy adoption. Fintech has an influence on investments and saving choices used in the sustainable energy industry. Crowdfunding offers financial support for renewable energy projects. The result offers a foundation for governments and policymakers to promote the Fintech adoption in the renewable energy sector. Nenavath (2022) said that India is an emerging economy adopting green finance and Fintech at a fast pace. The study used the semi-parametric difference-in-differences (SDID) model to analyze panel data from 28 Indian states and 8 union territories from 2010-2020.

To alleviate these threats, Fintech must be adopted in accountable and socially responsible manners that encourage equitable and sustainable financial development. As a result, the following hypothesis is suggested:

H_5: In N11 and BRICS economies, the relationship between NRR and financial development is positively moderated by Fintech adoption.

H_6: The indirect effect of NRR through financial development on sustainable development is predicted to be stronger for those with a higher level of Fintech adoption

and weaker for those with a low level of Fintech adoption.

Green Environment

The study uses green finance and green technology as two crucial components of the green environment. Green finance ensures the practical execution of sustainable projects by supplying funds. Green technology fosters sustainable resource utilization and preserves ecosystems.

2.5 Green Finance and Sinancial Development

Green finance encompasses financial products and services that are specifically geared to support ecologically sustainable projects and initiatives. Its primary goal is to direct funds toward activities that benefit the environment while simultaneously providing financial benefits. Green finance encompasses green lending, green insurance, green securities, and green investment. Awawdeh et al. (2021) determined the association between corporate environmental performance and technological innovation among Egyptian energy corporations. The study used SEM based on partial least squares (PLS). According to the findings, technological innovation affected environmental performance and improved company performance. Green financing has a substantial and beneficial role in environmental performance.

Likewise, Mngumi et al. (2022) analyzed the interconnections among green funding, renewable energy, and CO_2 emissions by analyzing data from 2005 to 2019 using a panel quantile regression. The BRICS countries have successfully decreased their CO_2 emissions with greater utilization of renewable energy and progress in the green financing development index. The "green" financial strategies adopted by the BRICS countries had a big effect on declining carbon emissions, but these results are not always consistent. 2.1. Green finance and Sustainable development.

Green financing fosters sustainable development by allocating resources to ecologically friendly projects. Green financing significantly influences sustainable development in China (Udeagha and Muchapondwa, 2023; Xiong and Dai, 2023;

Awawdeh et al., 2021). Further, Hunjra et al. (2023) investigated the influence of green financing and environmental deterioration on sustainable development in 42 developing countries. The research employs a panel dataset from 2000 to 2020, utilizing panel fixed effects and the Generalized Method of Moments technique. The findings indicate that green finance has a positive and statistically significant impact on sustainable development.

Bei and Wang (2023) said that green finance is essential for advancing the renewable energy sector. Policies must be formulated to facilitate the shift from fossil fuels to renewable energy, consequently enhancing numerous elements crucial for an environmentally sustainable future. Wang et al. (2022a) assessed the causative relationship between green financing and global sustainable development via the bootstrap rolling-window Granger causality test. The empirical findings indicate that GF generates advantageous effects on SD throughout multiple sub-periods, corroborating interaction theory. Government and international organizations should prioritize green investment and risk reduction within the systemic framework. Furthermore, Governments in developing countries need to improve and change their CO_2 taxation schemes.

A more robust legislative framework for establishing a green finance system may effectively advance green economic policies. Green bonds must be exempted from or subject to lower taxes as compared to conventional bonds. Making green efforts more transparent will enhance the creditworthiness of the issuer. BRICS and N11 economies are facing challenges in reducing CO_2 emissions.

H_7 Green finance positively impacts the sustainable development in N11 and BRICS countries.

2.6 Green Finance and Financial Development

The public sector is the supreme authority for addressing climate change and SD. Whereas, private commercial banks can supply funds for green projects. In Vietnam, Nguyen et al. (2023) said that foreign banks finance green projects more than local commercial banks. Foreign banks contribute towards developing green

investment policies. They develop partnerships with national and international organizations for the promotion of green financing among the stakeholders. In China, Zhang et al. (2020) identified the primary obstacles to obtaining green funding and proposed effective strategies to overcome them. Chen et al. (2024) highlighted the significant role of the banking sector in supplying capital for energy projects through green bonds.

The study by Udeagha and Muchapondwa (2023) stated that banks offer firms green loans, including project loans and mortgage loans, to facilitate the production of environmentally sustainable products. GF aims to reduce environmental pollution by promoting sustainable economic growth and the modernization of industrial infrastructure. Guang-Wen and Siddik (2023) explained the adoption of Fintech on green financing, green innovation, and environmental sustainability in the financial sector of Bangladesh during the pandemic. The research used SEM to analyze data collected from 302 banking employees. The results confirmed that Fintech adoption improves green financing, green innovation, and environmental performance. The government and central bank of Bangladesh must encourage green finance and green innovation by offering incentive programs for financial institutions that use state-of-the-art technology, including internet, phone banking, Blockchain, and AI. In addition, they can give priority to investment decisions supporting environmentally friendly initiatives, like renewable energy, pollution reduction, and carbon-neutral industries.

Dorfleitner and Braun (2019) stated that Fintech models such as Blockchain, Robo-advisors, and crowdfunding are making investments more environmentally friendly for the masses and improving the efficiency of the financial system. They make it easier to access funds, particularly those supplied by private investors. Fintech offers financial products through a decentralized approach. Blockchain technology increases effective monitoring, reporting, and verification. Fintech models need legal and regulatory frameworks to operate the financial system and green financing effectively.

Further Yang et al. (2021) stated that to improve productivity through green finance, the central government must intervene in the formulation of green financial policy. Regulators must make it compulsory for the entities to disclose information

related to the environment. Due to financial constraints, in China 85% of the monetary support it requires for green development comes from the private sector. As an external intervention strategy, to foster the expansion of green finance, it is necessary to endorse more favorable legislation. Xue et al. (2022) found that Fintech firms support sustainable financial systems. They assist financial institutions in evaluating the risk management, creditworthiness, and potential profit of corporate green innovation projects. It can help green innovation projects in overcoming financial barriers.

Khan et al. (2023) found that green development hinders economic growth in the G-7 countries. This may be because green growth necessitates a higher dependency on sustainable energy sources, resulting in less extraction and use of fossil fuels. Similarly, He et al. (2019) evaluated the investment effectiveness and level of green financial growth of China's 141 listed renewable energy companies. The findings indicate that green financial growth makes it harder for banks to lend money to renewable energy companies and lowers the return on investments in renewable energy.

While talking about the Belt and Road Initiative Jian et al. (2022) conducted empirical research reporting that green bonds reflect a significant positive price effect compared to regular bonds. The fact that China's bond and stock markets reacted favorably to the issuance of green bonds shows that developing nations may use a market-based strategy to address climate challenges and move towards sustainable development.

The role of the banking sector is a crucial element for measuring the effect of GF on investments in renewable energy. Economies with developed banking sectors exhibit a higher positive linkage between green bonds and renewable energy projects. This shows the necessity of a robust financial system for financing green initiatives for promoting environmental sustainability.

H_8: Green finance impacts the financial development in the N11 and BRICS countries.

H_9: Financial development acts as a mediator in the association between green finance and sustainable development in the N11 and BRICS economies.

2.7 Green Technology, and sustainable Development

Green technology, often known as clean technology or eco-technology, encompasses innovative products and processes designed to promote sustainable development. Green innovations promote ecological sustainability. Omer (2008) asserted that energy consumption may be diminished by the reduction of energy demand, the utilization of rational energy practices, and the increased utilization of green energy sources. Implementing environmentally friendly or sustainable practices in societal operations is regarded as a crucial approach to addressing the energy crisis. The increase in pollution stimulates the necessity for environmentally friendly measures such as technological advancement and the increase of nonrenewable energy supplies to achieve long-term economic prosperity. Biomass energy consumption is an emerging form of renewable energy that contributes positively to sustainable development (Wang et al., 2022b).

In addition, Lisha et al. (2023) proposed that the government should promote public-private partnerships to enhance the green technology adoption. However, it is crucial to emphasize that such aid should encompass legal, economic, and physical infrastructure. Kirikkaleli and Adebayo (2021) discovered that renewable energy exhibits a substantial impact and beneficial influence in reducing environmental degradation by changing energy policy, whether in developed or developing nations.

According to Usman et al. (2022), revealed there is a clear connection between the usage of natural resources and non-renewable energy and the increase in ecological footprint levels. The study included natural resources as a moderator in the connection between renewable energy use and ecological footprint. The results indicate that the interplay between the two factors can more effectively control pollution levels. Taking into consideration the negative impacts on environmental sustainability brought on by using non-renewable energy sources and natural resources the one viable solution to this dilemma is an increased utilization of renewable energy sources.

Chen et al. (2022) suggested that eco-efficiency plays a crucial role in driving significant transformations in resource generation and consumption patterns within

societies. It also serves as a metric for evaluating the success of sustainable economic growth. Eco-efficiency is crucial in the sustainable development literature. The study discovered that in the top ten most polluted economies, eco-efficiency was positively affected by GT, NRR, the squared term of economic complexity, and the interaction term of GT with FD over the long run. Conversely, GT, together with the interaction of GT and FD, has a unidirectional positive association with eco-efficiency. Governments should prioritize environmental quality to enhance eco-efficiency. Environmental issues will be solved when green technology legislation increases eco-efficiency.

The above discussions, this study suggests that green technology may assist in the resolution of the energy crisis by saving energy for future consumption. It also helps the environment by reducing CO_2 emissions. Fintech and green finance, according to Guang-Wen and Siddik (2023), help financial institutions remain environmentally sustainable during pandemics by incorporating ecological innovations like digital and mobile banking into their operations and providing funding for various pro-environmental projects. These include waste management, the usage of renewable or alternative energy sources, as well as the advancement of green industries.

Further, Xu et al. (2023a) said Fintech and financial inclusion are combined to create digital inclusive finance, which significantly affects green technologies. The study argues that comprehensive DIF development (including breadth of coverage, depth of use, and degree of digitization) can increase company enthusiasm for green technology R&D. The establishment of regional financial supervision is required. When financial regulation is excessively lax or too rigorous, the growth of DIF will dampen firms' enthusiasm for green technology innovation. Dogan and Seker (2016) proposed that the impact of technology leads to increased productivity by utilizing renewable energy and contemporary technologies. These technologies aid in mitigating the environmental deterioration that may pose a concern.

Fintech through operational efficiency and access to capital has the potential to expedite green innovations. Its unique solutions have the potential to attract investments in environmentally sustainable projects and assist in the fulfillment of sustainability objectives. Further, Fintech and green technologies can work together to enhance financial development. Existing research on the association

between Fintech adoption, green technology, and financial development is at a nascent stage and demands further investigation. The research hypotheses listed below have been proposed in light of the aforementioned.

H_{10}: Green technology exerts a positive and substantial impact on the sustainable development of N11 and BRICS countries.

2.8 Green Technology, and Financial Development

In the 10 most polluted economies, Chen et al. (2022) found a consistent and negative association between financial development and eco-efficiency. The banking sector is a significant contributor to environmental pollution by providing loans to firms in the selected sector that participate in ecologically detrimental activities. The incorporation of sustainable technology into financial development can alleviate the negative impact of FD on ecological efficiency. To improve eco-efficiency, it is advisable for these countries to gradually implement environmentally friendly technological solutions in their financial industries. Green technology can boost economic activity and expand the financial resources available for projects that benefit the environment. Fintech makes it easier for businesses to access capital.

Mirza et al. (2023) examined how the use of Fintech impacts bank profitability and green lending. A panel fixed effects model is used to analyze the sample of data from 319 Eurozone-based banks. Fintech increases bank profitability and fosters green lending. Fintech is playing an essential part in making the financial services industry more environmentally friendly, low-carbon, and time-efficient. A growing number of "green Fintech" products are available with the stated goal of mitigating climate change. They play a vital role for policymakers in their efforts to implement the Paris Agreement and support the achievement of the Sustainable Development Goals (SDGs) highlighted by the UN, especially in emerging and developing nations. The accessibility of big data enables banks to make informed judgments on loan recipients and strategies for promoting sustainability. The customer by using a cell phone to make purchases, invest, and get investment

advice, decreases the need to drive to the bank, eliminates unnecessary transaction costs, improves financial inclusion, and saves time.

Further, Ulucak et al. (2021) discovered that increased financial development results in increased energy usage. Therefore, Pakistan's government and financial institutions should boost investor trust to increase energy efficiency. Companies should raise customer understanding about effective energy use.

Further Feng et al. (2022) stated that financial development is a powerful motivator for fostering green technology innovation. Meanwhile, conventional lending has trouble keeping up with new developments, and it's not clear how to solve this problem.

Green technology innovation is greatly aided by digital financing. Green technology innovation can be more effectively promoted by digital finance development in areas characterized by elevated levels of pollution emissions and more robust governance.

Xue et al. (2022) analyzed the impact of Financial sector development on corporate green technology innovation and its mechanisms in China from 2011 to 2018. Digital finance has a big impact on how businesses innovate in green technologies. The three means through which Fintech promotes growth are by easing financial restraints, recruiting scientific and technological expertise, and improving regulations about the environment.

Similarly, Feng et al. (2022) narrated that an essential factor in driving regional high-quality economic development is digital finance, which has successfully achieved efficient alignment of the demand and supply of money. Innovation in green technologies can be considerably boosted by digital finance. It has a larger favorable impact on the development of green technologies in SMEs.

Further giving local governments more control over environmental governance might improve the capacity of digital finance to support businesses' efforts to innovate in green technologies and increase their access to capital.

Green technology development and adoption may not always be supported by regulatory frameworks and regulations, which might hinder their growth. Manigandan et al. (2023) stated that to meet the SDG by 2030, the BRICS countries are working to maintain their current rates of CO_2 emissions and yearly economic

growth, respectively. Technological innovation acted as a moderator, slowing the growth of emissions, whereas financial development and primary energy usage increased yearly per capita CO_2 emission rates.

The governments of developing countries should focus on cutting down their energy usage and saving energy for later use. Since energy theft frequently results from inadequate institutional quality in developing countries. Moreover, advancement in technology plays a role in the creation of techniques that ensure the enhanced utilization of energy.

Green technologies have greater initial investment costs, making them less accessible to individuals and businesses with financial constraints. Mngumi et al. (2022) found that increased usage of the renewable energy index has helped BRICS countries reduce CO_2 emissions.

The higher unit prices of renewable energy sources compared to non-renewable sources are barriers to the development of renewable energy. The long-term co-integration equation suggests that solar, wind, and nuclear power can all contribute to long-term reductions in carbon emissions. Renewable energy projects need significant investments and longer payback periods.

The following are the solutions suggested by the study: firstly, the growth in renewable energy business can be increased by the provision of loans at lower interest rates, reducing the time for credit approval, and tax freedom.

Secondly, it is imperative to build a substantial quantity of environmentally conscious enterprises that prioritize the consumption of renewable energy sources.

Thirdly, the BRICS countries must reduce the obstacles that hinder the participation of renewable energy companies in their stock markets.

H_{11}: Green technology impacts the financial development in the N11 and BRICS countries.

H_{12}: Financial development acts as a mediator in the association between green technology and sustainable development in the N11 and BRICS economies.

2.9 Theoretical Framework

Considering the preceding discussion, this research introduces the subsequent theoretical frameworks.

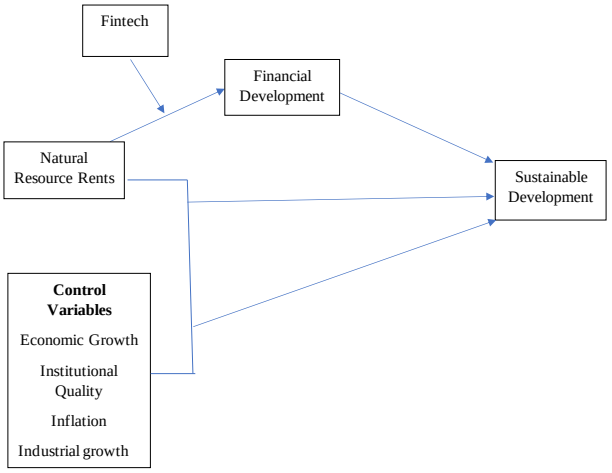

FIGURE 2.8: Theoretical Framework for NRR and SD (Model 1)

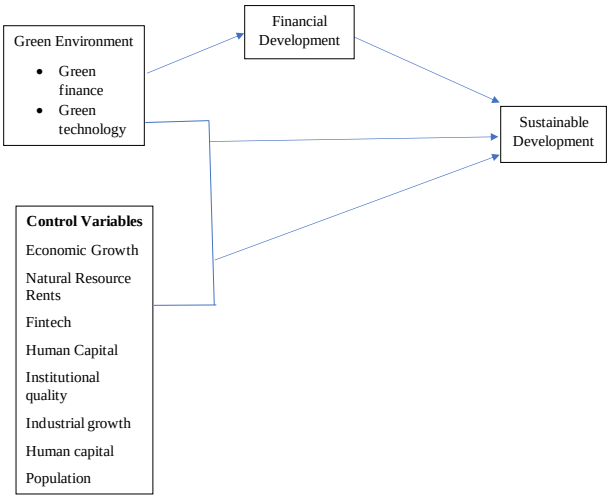

FIGURE 2.9: Theoretical Framework for Green Environment and SD (Model 2)

The study used two models. In model 1 (Fig. 2.8), NRR is used as an independent variable, and its impact is studied on SD. Fintech is used to moderate NRR and FD. Whereas, FD is studied as a mediator between NRR and SD. In model 2 (Fig. 2.9), green finance and green technology are used as two components of the green environment and studied separately to comprehensively analyze their impact on

sustainable development. FD is used as a mediator between GF and SD, then between GT and SD. In model 2, NRR and Fintech are used as control variables, as studies have used them with GF and GT as control variables because of their important role towards SD. NRR, if managed well, can improve economic growth and enhance environmental sustainability (Chen et al., 2022). Fintech supports green initiatives in attaining funds earlier and at a low cost (Yang et al., 2021).

Chapter 3

Data and Methodology

This research explores how sustainable development in the N11 and BRICS countries is influenced by natural resource rents and a green environment. The study is partitioned into two portions. Firstly, the impact of natural resource rents on sustainable development in the N11 and BRICS countries is analyzed. Financial development functions as a mediator between NRR and SD. Furthermore, Fintech's moderating effect is studied on the resource-finance nexus.

Secondly, the study is further divided into two sub-sections. Two elements of a green environment are employed: green finance and green technology. In the first sub-section, the association of green finance with sustainable development is examined in N11 and BRICS countries. Financial development functions as a mediator between green finance and sustainable development. Similarly, the second sub-section employed financial development as a mediator between green technology and sustainable development. This chapter explains the study's data and methodology for testing the hypotheses presented in Chapter 2. Section 3.1 goes into detail about the data. Section 3.2 illustrates the variables; Section 3.3 describes panel data and the model's estimation technique.

3.1 Data Collection and Sample Selection

The study collected annual data of N11 and BRICS countries from the year 2005 to 2020. The data for all the variables is collected from the World Bank, World

in Data and the International Monetary Fund (IMF). The time frame is selected based on the accessibility of data on all the variables. N11 countries contain Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, Philippines, South Korea, Turkiye, and Vietnam. BRICS countries include Brazil, Russia, India, China, and South Africa. For model 2 sub-section 1, Russia and South Korea were omitted due to the unavailability of green finance data. There are various reasons for emphasizing these countries. Next-11 and BRICS countries exhibit common features, such as high population growth rates, which result in a growing number of potential consumers and rising disposable incomes (ALOnaizi and Gadhoum, 2017). These nations represent a diverse spectrum of economic conditions, including developed, emerging, and developing statuses.

Moreover, as emerging markets, the BRICS and N-11 nations shape global economic trends and investment behaviors (Mohanty et al., 2024). They rely heavily on natural resources to meet their consumption demands. These countries exhibited the fastest economic growth over the previous thirty years (Addai et al., 2024). The N-11 countries are rapidly developing nations that Goldman Sachs has identified. The objective was to find countries that can rival the G7, similarly to the BRIC countries. N-11 countries have the potential to become the world's strongest economies in the coming years (Erdoğan et al., 2020).

The N-11 economies can overtake the BRIC nations to become the second-largest rising economies in the world in the upcoming years. Despite their rapid economic expansion, the N-11 economies have more obstacles to surmount than the BRICS nations. Yao et al. (2021) discovered that FD reduces energy efficiency in the N-11 economies. High levels of corruption and a slow pace of technological advancement are obstacles to increasing the N-11's energy efficiency and environmental sustainability. Pakistan has the lowest energy efficiency situation among the N-11 economies. This is an alarming scenario that requires Pakistan's government to seriously explore methods to improve energy efficiency and minimize pollution while pursuing economic growth.

N-11 economies are facing some issues related to economic growth like Nigeria's present concentration on anti-corruption legislation execution. In contrast, Turkeyie

has some geographical concerns with the European Union that must be overcome. Pakistan, on the other hand, is strengthening its banking and taxation legislation. N-11 countries rely heavily on imported nonrenewable energy sources to meet their consumption demands. As a result, they are seen as less energy-efficient and contribute less to mitigating the impact of CO_2 emissions (Shao et al., 2021).

Further, Ulucak et al. (2021) stated that Pakistan's financial industry, particularly the banking sector, has experienced a tremendous expansion in recent years, because of considerable financial reform, therefore, the association between financial development and energy demand is relevant as the country's economic activities expand due to globalization. This study aims to offer solutions to these countries through which they can enhance their energy efficiency, economic growth, and environmental sustainability.

3.2 SEM as an Econometric Model

The study used a second-generation structural equation modelling (SEM) technique for estimations. It enables simultaneous analysis of several relationships among variables, facilitating a more thorough understanding of complex models. SEM incorporates latent variables, addresses measurement error, and captures underlying constructs that are not feasible to measure directly (Wang and Wang, 2024). The regression model is inadequate for addressing situations where variables can be both cause and effect at the same time; for example, in SEM, the mediator functions as both a cause and an effect (Fairchild and MacKinnon, 2009).

SEM concurrently provides covariance analysis, factor analysis, multiple regression analysis, and path modelling analysis. It is a strong model for panel data because it reduces endogeneity (Azimi et al., 2020; Sande and Ghosh, 2018). It is particularly advantageous in small samples, intricate models, or when conventional parametric approaches are unsuitable (Hult et al., 2018). Consequently, SEM is a suitable framework for examining the dynamic relationships among NRR, GT, GF, FD, and SD.

Sobel (1982) introduced a multiplication method to evaluate the statistical significance of mediation effects, including the mediator in the model, which significantly decreases the effect of the independent variable. Baron and Kenny (1986) proposed a series of regression equations to investigate the possibility of mediation between an independent and dependent variable. Preacher and Hayes (2008) made substantial progress in mediation and moderation analysis by proposing more powerful and adaptable statistical approaches for investigating indirect effects through bootstrapping techniques. SEM is widely utilized in business, psychology, and economics (Moyle et al., 2021).

This study has employed Fida and Saeed (2023) procedure for avoiding complexity. The parameters suggesting a strong model fit are also computed for the reliability of tests such as the Comparative fit index (CFI), Tucker-Lewis' Index (TFI), Goodness of fit index (GFI), Root mean square error of approximation (RMSEA), and Coefficient of determination (CD). The study used STATA 14 for conducting the tests. For the cross-confirmation of mediation between the independent variables and the dependent variable, the study has used the Sobel test, Monte Carlo test, and Delta test.

3.3 Variable Explanation

Explanation of the dependent variable, independent variables, mediator, moderator, and control variables is mentioned below. Table 3.1 explains the proxy and data source for all the variables.

3.3.1 Dependent Variables

Sustainable development is a dependent variable. Economic efficiency is used for measuring SD. Sustainable development encompasses the creation of products and services that allow us to fulfill current requirements while also protecting the ability of subsequent generations to meet their respective requirements (Deng et al., 2019; Chen et al., 2022). It recognizes that the environment is a finite resource. Economic efficiency has been used substantially in the literature of sustainable development

(Schaltegger and Synnestvedt, 2002). Economic efficiency refers to the minimum utilization of resources, high economic growth, and environmental sustainability (Moutinho et al., 2017). Rents from natural resources have a detrimental effect on eco-efficiency since they encourage inefficient use of these resources, which in turn increases pollution.

3.3.2 Independent Variables

3.3.2.1 Natural Resource Rents

There are numerous resources, such as opium, gold, stones, diamonds, tin, oil, timber, cocoa, and so on, but there is limited data on these resources from official bodies such as the World Bank (Canh et al., 2020). Therefore, five forms of natural resource rents are selected: coal rentals, oil returns, mineral rents, natural gas rents, and forest rents. The study utilizes the aggregate sum of five distinct categories of natural resource (NR) rents, namely oil, natural gas, coal (both hard and soft), mineral, and forest rents (Chen et al., 2022).

3.3.2.2 Green Environment

A. Green Finance

Green finance refers to any formal or informal financial measures implemented to produce long-term and enhanced environmental results Wu (2022). Green finance incorporates all financial products and services that are designed to facilitate projects and initiatives that result in environmental sustainability. Green finance is a multidisciplinary area of research. Green bonds, green loans, green mortgages, and green offset credit are common examples of green financial securities. Agliardi and Agliardi (2019) stated that corporate green bonds enhance both financial and environmental performance.

B. Green Technology

Green technology refers to the application of technological advancements to enhance energy efficiency and minimize adverse environmental impacts associated with energy consumption and production. It has a crucial role in bringing economic competitiveness and the SDGs together and placing both on the path to green economies (Chen et al., 2022). Renewable energy (RE) refers to the utilization of hydroelectricity, nuclear power, wind power, and solar power. Renewable energy (RE) refers to the utilization of hydroelectricity, nuclear power, wind power, and solar power as sources of energy (Mngumi et al., 2022). The studies have used the terms renewable energy and green technology interchangeably, as the objective is to achieve energy efficiency.

3.3.3 Financial Development as a Mediating Variable

In this study, FD is a mediating variable between endogenous variables (sustainable development) and exogenous variables (natural resources, green environment). Previous studies have mainly ignored the various aspects of FD by characterizing it with a single measure usually, stock market capitalization or bank credit failing to understand FD (Ha, 2022). For measuring financial development this study used an index. It is an inclusive measure covering financial institutional development and financial markets development.

FBI represents the banking sector development index, and FMI is the financial market development index. FDO represents the overall financial development index developed by combining the FBI and FMI. Financial development refers to enhancing banking, stock market, and other financial services in terms of their number, quality, and efficiency. FDI is a comprehensive measure that covers the financial sector's efficiency, depth, and accessibility in any economy. Depth measures the market size and market liquidity. Access measures the capability of individuals and companies to make best use of the financial services offered by the financial institutions. Efficiency measures the capability of financial institutions to offer financial products at a low rate and earn profits.

3.3.4 Fintech as a Moderating Variable

The emergence of financial technology has enabled financial institutions to attract a greater number of customer deposits and savings. In recent years, Fintech, or financial technology, has played an important role in assisting financial development. Fintech has enabled financial institutions to deliver digital financial services, allowing people who are unbanked or underbanked to have access to financial services. This has facilitated the inclusion of a larger number of individuals into the formal financial system, hence having the capacity to enhance economic growth and development.

The Financial Stability Board (2017) described Fintech as "financial innovation that is facilitated by technologies and can produce novel business models, apps, procedures, and products that substantially affect financial markets, institutions, and the availability of financial products." Fintech companies are predominantly emerging businesses that leverage state-of-the-art technology to offer financial services, including payment processing, fund transfers, lending, insurance, and asset management. Mobile banking, digital wallets, Robo-advisors, peer-to-peer lending, crowdfunding, and blockchain-based solutions represent prominent Fintech offerings. The Fintech index is constructed based on the following studies using the principal component analysis (PCA) Emara (2022), Emara and Mohieldin (2022), Tan et al. (2023). All Fintech metrics are on a logarithmic scale.

3.3.5 Control Variables

The study used the following control variables.

3.3.5.1 Economic Growth

All economic variables that affect economic growth are also associated with FD. Therefore, economic growth is used as a control variable. The demand-side hypothesis suggests that strong EG leads to FD. Research has revealed a reciprocal bidirectional association between financial development and economic growth

(Kandil et al., 2015; Çetin et al., 2023). Further, Mirza et al. (2023) suggested that economic expansion contributes to a more sustainable economy. Green funding is influenced favorably by a country's strong economic condition, therefore, stable and growing nations have a higher chance of developing a sustainable economy than those with slow economic expansion.

3.3.5.2 Human Capital

Reaping the benefits of natural resources is impossible without skilled labor. In developing countries, human capital minimizes the ecological imprint (Jahanger et al., 2022). Similarly, Li et al. (2020) suggested that in developed countries, human capital facilitates sustainable and fast growth. Human capital has a favorable impact on green financing. To achieve sustainable goals, it is encouraged that human resources with the necessary training, experience, and background knowledge be given priority.

Economies can overcome the resource curse by investing in their human capital. This is likely because banks are better able to make credit decisions on green finance due to people's high levels of skills, knowledge, and competence (Mirza et al., 2023). This further contributes to a sustainable economy. Lisha et al. (2023) advocated for the integration of human capital into effective procedures for the natural resource extraction and exploitation

3.3.5.3 Institutional Quality

Institutional quality helps lessen the adverse impact of energy consumption on the environment. Yao et al. (2021) said that developing nations like Pakistan and India have more political control over their regulators. Emerging economies should prevent themselves from corruption and rent-seeking behavior. Additionally, the government must forcefully enforce its anti-corruption efforts. Legislators should execute corruption laws and educate the people about the need to curb corruption at the public level.

For Model 1 control for corruption is used as a proxy for institutional quality. Studies have used this parameter only as a proxy to assess institutional quality.

For green environment Models a composite index is constructed incorporating six parameters of a country's governance. Principal Component Analysis (PCA) is used to develop the IQ index. The details are in Table 3.1. These indicators were recently employed in several studies (Gerelmaa and Kotani, 2016; Dogan et al., 2020; Henri, 2019).

3.3.5.4 Foreign Direct Investment

FDI flow boosts economic and financial development by supplying financial resources as well as modern technology that aids in boosting production quality and lowering production costs, thereby increasing the competitiveness of local products in foreign markets (Ibrahiem and Sameh, 2022). Foreign direct investment (FDI) contributes to the development of superior management, specialized technical skills, and innovative practices in the manufacturing process. This can occur through both backward and forward linkages, and there is potential for the transfer of these technologies to local enterprises (Wang et al., 2022b). Foreign direct investment (FDI) also has a detrimental influence on CO_2 emissions (Mngumi et al., 2022).

3.3.5.5 Inflation

Inflation rates harm natural resource rents. High inflation decreases profitability and revenues in the extraction and utilization of coal, oil, mineral, and natural gas resources (Yu et al., 2024). Therefore, it is vital for economic planning and sustainable development to analyze how inflation disturbs these countries' resource utilization policies (Duong, 2022). High inflation reduces the purchasing power because the value of currency reduces, affecting the economic stability of the country (Cai et al., 2022).

3.3.5.6 Industrial Development

Countries strengthen industrial infrastructures by transitioning their energy systems from fossil fuels to renewable sources of energy to attain sustainable environmental goals (Huang et al., 2023). Likewise, high economic growth and local industrial

development also result in the adoption of energy-efficient technology that reduces substantial CO_2 emissions. Sustainable economic growth demands an efficient industrial structure, and green finance can facilitate achieving that goal. In the context of N11 and BRICS countries Yao et al. (2021) found that industrialization is adversely affecting the energy efficiency and environment.

3.3.5.7 Population

Population growth rate adversely affects sustainable development. According to the law of conservation of mass, economic productivity is contingent on the utilization of resources. The higher the resource utilization higher the CO_2 emission. Further, income growth and the low quality of the environment increase the cost of living which negatively affects fertility. This results in a tradeoff between income and population growth. Therefore, it is necessary to encourage 'green' technologies and policies that promote income growth with less pollution and CO_2 emissions (Dzhumashev and Kazakevitch, 2025).

TABLE 3.1: Variable and Data Sources

Variables	Title	Symbol	Proxy	Source	Reference
DV	Sustainable Development	SDi,t	The logarithm of carbon dioxide emissions (Kt) is divided by gross domestic product in current US dollars.	WDI	Chen et al. (2022)
IV	Natural Resource Rent	$NRR_{i,t}$	Total natural resources rents (% of GDP) The calculation involves adding together the amounts of revenue generated from oil, natural gas, coal, minerals, and forests.	WDI	Chen et al. (2022), Ali et al. (2022), Zaidi et al. (2019), Hadj and Ghodbane (2021)
IV	Green Finance	$GF_{i,t}$	The natural logarithm is employed to quantify the magnitude of green finance. Financial assistance for research and development in clean energy and renewable energy production, encompassing hybrid systems. The measurement unit for this data is a million US dollars, adjusted to constant 2016 values.	World in Data	Wang et al. (2022b)
IV	Green Technology	$GT_{i,t}$	Percentage of renewable energy in relation to total energy consumption, measured in terms of GDP in US dollars.	WDI	Chen et al. (2022), Wang et al. (2023b)
MED	Financial Development	$FD_{i,t}$	Banking Development + Stock Market Development	WDI	Javed et al. (2025)
MOD	Fintech Index	$FINT_{i,t}$	The total number of mobile cellular subscriptions for every 100 individuals,	WDI	Emara (2022), Emara and Mohieldin (2022), Tan et al. (2023), Xu et al. (2023b)

Continued on next page...

Variables	Title	Symbol	Proxy	Source	Reference
			The fraction of fixed broadband subscribers per hundred persons, The ratio of the population in country i with internet usage at time t,		
CV	Economic Growth	$EG_{i,t}$	Logarithm of GDP per capita (constant 2015 US$) (Model 1)	WDI	Hadj and Ghodbane (2021), Henri (2019) Jahanger et al. (2022)
CV	Institutional Quality	$IQ_{i,t}$	**Control of Corruption:** It evaluates to what extent public authority is utilized for personal interest, encompassing both small and large types of corruption, as well as the effect of elites and private interests on the government. **Government Effectiveness:** refers to the perceived quality of public services, the competence and impartiality of the civil service, the effectiveness of the development and execution of policy, and the trustworthiness and dedication to these policies by the government.	World Governance Indicators	Ali et al. (2022)

Continued on next page...

Variables	Title	Symbol	Proxy	Source	Reference
			Political Stability and Absence of Violence/Terrorism: The indicator measures the public's opinion of political uncertainty and acts of violence motivated by politics, such as terrorism. **Regulatory Quality**: measures the perception of the masses regarding the government's ability towards creation and enforcement of efficient rules and regulations that assist and promote the growth of the private sector. **Rule of Law:** subjective assessment of citizens on their confidence in and adherence to societal rules. This includes evaluating the effectiveness of contract enforceability, property rights, law enforcement agencies, and the judicial system, assessing the level of danger associated with crime and violence. **Voice and Accountability:** This term pertains to the perception of individuals regarding their capacity to participate in the selection of their government, together with the presence of freedom of speech, freedom of assembly, and an independent media.		

Continued on next page...

Variables	Title	Symbol	Proxy	Source	Reference
CV	Human Capital	$HC_{i,t}$	The Human Capital Index includes comparative income levels, input, output, and productivity data.	PWT 10.01	Wang et al. (2023b)
CV	Industrial Growth	$IND_{i,t}$	Log of industry (together with construction), value added (% of GDP)	WDI	Huang et al. (2023), Yao et al. (2021)
CV	Foreign Direct Investment	$FDI_{i,t}$	Net inflows of foreign direct investment as a percentage of gross domestic product (GDP)	WDI	Ibrahiem and Sameh (2022)
CV	Population	$POP_{i,t}$	The annual percentage growth rate of the population for year t is the product of the midyear population's exponential increase from year t-1 to t. All inhabitants, regardless of citizenship or legal status, are considered part of the population	WDI	Yao et al. (2021)
CV	Inflation	$Inf_{i,t}$	Inflation, consumer prices (annual %)	WDI	Yu et al. (2024)

Note: WDI stands for the World development indicator, IMF stands for the International Monetary fund, PWT stands for Penn World Table

3.3.6 Econometric Model 1 for Natural Resource Rents

The model is tested in two steps. In Step I, to assess Hypotheses 1, 2, 3, and 4, FD is incorporated as a mediating variable between NRR and sustainable development. In Step II, the Fintech is introduced as a moderating factor in the model, positioned between NRR and FD.

$$SD_{it} = \beta_0 + \beta_1 NRR_{it} + \Sigma^5{}_{j=1}\beta_j Z_{jit} + \varepsilon_{it} \quad (1)$$

Where NRR_{it} signifies the natural resource rents of country i at time t, SD_{it} refers to the level of sustainability development of country i at time t, Z_{jit} denotes the list of control variables institutional quality, economic growth, inflation, industrial growth, and foreign direct investments, and ε_{it} is a random error term. Equation 1 represents the Path c that explains the total effect of NRR_{it} on SD_{it}. β_0 is constant, β_1 is the coefficient of NRR_{it}, and β_j is the vector of betas. Following paths, a, b, and ć are developed to explain step I.

Path a

$$FD_{it} = \beta_0 + \beta_1 NRR_{it} + \Sigma^5{}_{j=1}\beta_j Z_{jit} + \varepsilon_{it} \quad (2)$$

If the coefficient of NRR_{it} is significant, it will show that NRR_{it} impacts FD_{it}, fulfilling the first condition of mediation.

Path b

$$SD_{it} = \beta_0 + \beta_1 FD_{it} + \Sigma^5{}_{j=1}\beta_j Z_{jit} + \varepsilon_{it} \quad (3)$$

If the coefficient of FD_{it} is statistically significant, it indicates that FD_{it} impacts SD_{it}. it indicates that FD can be employed as a mediating variable.

Path ć

The following econometric specification is employed to examine the mediating function of FD_{it}.

$$SD_{it} = \beta_0 + \beta_1 NRR_{it} + \beta_2 FD_{it} + \Sigma^5{}_{j=1}\beta_j Z_{jit} + \varepsilon_{it} \quad (4)$$

The NRR-SD connection is entirely mediated by FD, if FD is significant and NRR is insignificant, then there exists full mediation. If both the coefficients of NRR and FD are significant, this shows that there exists a partial mediating effect of FD between NRR and SD. If the coefficient of NRR is statistically significant and FD has a statistically insignificant coefficient, it suggests that FD does not have a mediating effect between NRR and SD. Path ć signifies the direct impact of NRR_{it} on SD_{it}, controlling for the mediator FD_{it}. The value of the coefficient for path ć < path c, confirms the existence of mediation. it shows that a portion of the effect of NRR_{it} on SD_{it} is mediated through FD_{it}.

In step II, the moderation hypothesis (H_5) and moderation-mediation (H_6) are tested empirically. The following regression model is developed.

$$FD_{it} = \beta_0 + \beta_1 NRR_{it} + \beta_2 Fint_{it} + \beta_3 NRR_{it} * Fint_{it} + \Sigma^5{}_{j=1}\beta_j Z_{jit} + \varepsilon_{it} \quad (5)$$

$$SD_{it} = \beta_0 + \beta_1 NRR_{it} + \beta_2 FD_{it} + \beta_3 Fint_{it} + \beta_4 NRR_{it} * Fint_{it} + \Sigma^5{}_{j=1}\beta_j Z_{jit} + \varepsilon_{it} \quad (6)$$

Where $Fint_{it}$ refers to the Fintech adoption by country i in time t, NR_{it}* $Fint_{it}$ denotes the interaction term. This hypothesis of moderation mediation, known as conditional indirect effects (Hayes, 2017), examines whether or not the expected simple relationships of mediation, as proposed in the preceding hypothesis (H_4), alter as a result of the study's corresponding moderating variable.

3.3.7 Econometric Model 2 for Green Environment

3.3.7.1 Econometric Model 2a for Green Finance

The model measures Hypotheses 7, 8, 3, and 9, FD is incorporated as a mediating variable between GF and SD.

$$SD_{it} = \beta_0 + \beta_1 GF_{it} + \Sigma^5{}_{j=1}\beta_j Z_{jit} + \varepsilon_i \quad (7)$$

Where GF_{it} represents the green finance of country i at time t, SD_{it} refers to the level of sustainable development of country i at time t, Z_{it} denotes the list of control variables Fintech, natural resource rents, human capital, industrial growth, and populations, and β_j is the vector of betas. ε_{it} is a random error term. Equation 7 represents the Path c that explains the total effect of GF_{it} on SD_{it}. FD will be introduced as an intervening or mediating variable between GF, and SD to evaluate Hypotheses 8 and 9. Following paths, a, b, and ć are developed.

Path a

To test whether the GF affects FD the following equation is developed

$$FD_{it} = \beta_0 + \beta_1 GF_{it} + \Sigma^5{}_{j=1}\beta_j Z_{jit} + \varepsilon_{it} \quad (8)$$

If the coefficient of GF is significant, this will show that GF has an impact on FD. It will fulfill the first condition of mediation

Path b

The influence of FD on the dependent variable, SD, is studied through the use of the subsequent econometric equation.

$$SD_{it} = \beta_0 + \beta_1 FD_{it} + \Sigma^5{}_{j=1}\beta_j Z_{jit} + \varepsilon_{it}$$

The main goal is to examine how FD acts as a mediator in the interaction between GF and SD. If the coefficient of FD is statistically significant, it shows that FD can be employed as a mediating variable. The same is mentioned as equation 3 in econometric model 1.

Path ć

Path-ć is created in the third stage to evaluate FD's mediating function. To examine this impact, the following econometric specification is employed.

$$SD_{it} = \beta_0 + \beta_1 GF_{it} + \beta_2 FD_{it} + \Sigma^5{}_{j=1}\beta_j Z_{jit} + \varepsilon_{it} \tag{9}$$

The GF-SD connection is fully mediated by FD if FD is significant but GF is not significant. If both the coefficients of GF and FD are significant, then it indicates that SD has a partial mediation effect on the link between GF and SD. If the coefficient of GF is statistically significant and FD has an insignificant coefficient, it suggests that FD does not have a mediating influence on GF and SD. The value of the coefficient for path ć < path c, confirms the existence of mediation. it shows that a portion of the effect of GF_{it} on SD_{it} is mediated through FD_{it}.

3.3.7.2 Econometric Model 2b for Green Technolog

The study focuses on assessing the impact of green technology on sustainable development. The model measures Hypotheses 10, 11, 3, and 12. FD is incorporated as a mediating variable between GF and SD.

$$SD_{it} = \beta_0 + \beta_1 GT_{it} + \Sigma^6{}_{j=1}\beta_j Z_{jit} + \varepsilon_i \tag{10}$$

Where GT_{it} represents the green technology of country i at time t, SD_{it} refers to the level of sustainable development of country i at time t, the Z_{jit} denotes the list of control variables Fintech, institutional quality, natural resource rents, economic growth, population, and industrial growth and β_j is the vector of betas. ε_{it} is a random error term. Equation 10 represents Path c which explains the total effect

of GT_{it} on SD_{it}. β_0 is constant, β_1, and β_2 are coefficients of exogenous variables, and controlling variables. Following paths, a, b, and c are developed.

Path a

To test whether the GT affects FD the following equation is developed

$$FD_{it} = \beta_0 + \beta_1 GT_{it} + \Sigma^6{}_{j=1}\beta_j Z_{jit} + \varepsilon_{it} \tag{11}$$

If the coefficient of GF is significant, this will show that GT has an impact on FD. It will fulfill the first condition of mediation

Path b

The impact of FD on the dependent variable, namely SD, is studied using the subsequent econometric formulation.

$$SD_{it} = \beta_0 + \beta_1 FD_{it} + \Sigma^6{}_{j=1}\beta_j Z_{jit} + \varepsilon_{it}$$

The main goal is to examine how FD influences the connection between GT and SD. If the coefficient of FD is statistically significant, this shows that FD can be employed as a mediating variable.

Path ć

The development of path-ć is the third phase in investigating the mediating function of FD. To examine this impact, we employ the following econometric specification.

$$SD_{it} = \beta_0 + \beta_1 GT_{it} + \beta_2 FD_{it} + \Sigma^6{}_{j=1}\beta_j Z_{jit} + \varepsilon_{it} \tag{12}$$

The GT-SD connection is fully mediated by FD if GT is insignificant and FD is significant. If both GT and FD exhibit significant coefficient values, it indicates that SD plays a role as a partial mediator between GT and SD. If the coefficient of

GT is statistically significant and FD has a statistically insignificant coefficient, it suggests that FD does not have a mediating influence on the link between GT and SD. Path ć signifies the direct effect of GT_{it} on SD_{it}, controlling for the mediator FD_{it}. The value of the coefficient for path ć $<$ path c, confirms the existence of mediation. it shows that a portion of the effect of GT_{it} on SD_{it} is mediated through FD_{it}.

Chapter 4

Empirical Results and Discussions

4.1 Natural Resource Rents and Sustainable Development

4.1.1 Diagnostic Analysis

It is used to identify any outlier in the dataset. It ensures the data quality. It increases the validation of the advanced econometric technique test applied to the dataset afterwards. For the diagnostic analysis, the study used descriptive analysis, variance inflation factor, stationarity test, and correlation test. The descriptive statistics are exhibited in Table 4.1, which includes average, standard deviation, minimum, and maximum values for every variable. It explains the central tendency, the dispersion, and the range of the data.

The mean value of FD is 0.412, with low variation as the value of standard deviation is low, showing a moderate level of financial development of countries in the sample. The value of SD reflects moderate variation in the sample, the range of data, minimum value (3.227), and maximum value (4.936) shows that all the countries in the sample are balancing between economic and environmental sustainability, and focusing on achieving sustainable development. The data of NRR shows variation, with the minimum value (-1.421)

showing that some economies have earned negative returns from natural resources during the observed time frame. The data of FINT has variation in the data and a

TABLE 4.1: Descriptive Statistics Results

Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
FD_{it}	256	0.412	0.132	0.211	0.627
SD_{it}	256	4.130	0.552	3.227	4.936
NRR_{it}	256	1.150	1.219	-1.421	2.860
$FINT_{it}$	256	-1.41e-08	1.526	-2.474	4.215
IQ_{it}	256	-0.525	0.445	-1.443	0.705
EG_{it}	256	8.359	0.869	6.632	10.362
IND_{it}	256	3.416	0.242	2.896	3.905
INF_{it}	256	1.759	0.744	-0.959	3.687
FDI_{it}	256	2.023	1.271	0.408	5.011

small mean value, reflecting that, due to infrastructural barriers, some countries are adopting Fintech at a slow pace. The value of FINT is calculated through PCA as discussed in Table 3. IQ has a mean value of -0.525 with low variation in the data, the minimum (-1.443) and maximum (0.705) values of the data reflect that some countries have strong institutional quality, and some countries are with weak institutional quality. The control of corruption is used as a proxy for IQ. The values of EG show robust and steady economic growth across the data. The values of IND reflect the uniform industrial growth pattern among the economies; the mean value of INF is 1.759, with a dispersion of 0.744. The minimum value (-0.959) reflects that some countries faced deflation during the selected time frame. The FDI data shows variation reflecting high and low flows of foreign direct investment among the economies.

TABLE 4.2: Variance Inflation Factor

Variables	**VIF**
FD_{it}	3.49
NRR_{it}	2.10
$FINT_{it}$	3.18
EG_{it}	3.73
IQ_{it}	3.13
INF_{it}	1.64
FDI_{it}	1.24
IND_{it}	1.211
Mean VIF	2.47

Table 4.2 contains the variance inflation factor (VIF) outcomes. The values for all variables <10 reflect no multicollinearity in the sample. For testing the level of stationarity, the study applied the Levin test and the Fisher–Augmented Dicker Fully (ADF) test. The findings are displayed in Table 4.3. All the variables in the model are significant and exhibit stationarity at L(0) (level zero) or L(1) (level 1). Thus, the result asserts that the series of a variable is stationary, accepting the alternative hypothesis. Furthermore, Table 4.4 displays the correlations among the variables. It explains the magnitude and the direction of the relationship among the variables.

TABLE 4.3: Unit Root Results

Variables	**Lin, Levin, and Chu**	**Stationarity**	**Fisher ADF**	**Stationarity**
SD_{it}	-3.91***	Smooth	48.81**	Smooth
FD_{it}	-8.43***	Smooth	131.39***	Smooth
NRR_{it}	-6.44***	Smooth	72.84***	Smooth
IQ_{it}	-4.01***	Smooth	52.29**	Smooth
EG_{it}	-2.18**	Smooth	69.26***	Smooth
FDI_{it}	-6.11 ***	Smooth	90.19***	Smooth
IND_{it}	-4.07***	Smooth	59.35***	Smooth
INF_{it}	-6.28 ***	Smooth	82.58***	Smooth
$FINT_{it}$	-4.82***	Smooth	67.78***	Smooth

*Note: The significance level is indicated by *** for 1%, ** for 5%*

4.1.2 Moderation and Mediation Analysis

The study used Baron and Kenny (1986) to identify mediation and the Sobel (1982) and Preacher and Hayes (2008) to validate it statistically. The combined approach increases the authenticity of the results. Table 4.5 summarizes the outcomes of the first four hypotheses.H_1 suggested that NRR positively affects SD.

The results obtained from the total effect [b =0.223, S.E =0.030, p =0.000, C.I (0.164, 0.281)] confirmed that NRR significantly and positively raises SD. The N11 and BRICS countries are developing their natural resource management strategies with a focus on sustainable use of natural resources. The results are aligned with the resource dependence theory. Natural resources are blessings for those economies,

TABLE 4.4: Correlations Matrix

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
(1) FD_{it}	1.000								
(2) SD_{it}	0.136**	1.000							
(3) NRR_{it}	-0.239***	0.447***	1.000						
(4) IQ_{it}	0.695***	-0.025	-0.516***	1.000					
(5) EG_{it}	0.729***	-0.124**	-0.249***	0.618***	1.000				
(6) IND_{it}	0.032	0.427***	0.225***	0.045	0.156**	1.000			
(7) INF_{it}	-0.393***	0.181***	0.485***	-0.483***	-0.352***	-0.100	1.000		
(8) FDI_{it}	0.180***	0.162***	0.255***	-0.019	-0.014	0.151**	-0.046	1.000	
(9) $FINT_{it}$	0.646***	-0.119	-0.362***	0.463***	0.769***	0.081	-0.436***	-0.047	1.000

*Note: The significance level is indicated by *** for 1%, ** for 5%.*

where they do not cause Dutch disease by diverting the financial resources generated by them towards expanding other economic sectors like agriculture, manufacturing, and service.

For attaining SD, NRRs can promote renewable energy consumption and green ventures through supporting economic diversification and reducing economic efficiencies. By this means, NRRs support environmental sustainability and economic growth. Revenues earned by natural resources are invested in research and development projects, generating green finance, green technology adoption, and uplifting the green economy. NRRs can support sustainable initiatives like protecting the ecosystem, forests, and habitats.

Zafar et al. (2019) stated that in N-11 economies, high consumption of renewable energy is reducing CO_2 emissions and improving environmental sustainability. The usage of cutting-edge technologies in exploring and refining the NRs instead of conventional technologies can support environmental sustainability and generate more revenues for these economies (Bekun et al., 2019).

Table 4.5: Moderation-Mediation Results

Structural Relationships	**Coefficient**	**S.E**	**P-value**	**C.I**
EG_{it}	-0.264[a]	0.044	0.000	-0.351 , -0.178
IQ_{it}	0.597 [a]	0.089	0.000	0.422 , 0.772
IND_{it}	0.852 [a]	0.119	0.000	0.620 , 1.08
INF_{it}	0.088 [b]	0.045	0.049	0.001 , 0.175
FDI_{it}	-0.004	0.022	0.860	-0.047 , 0.039
Total Effects				
Natural resource rents → Sustainable development (path c)	0.223 [a]	0.030	0.000	0.164 , 0.281
Natural resource rents → Financial development (path a)	0.017 [a]	0.005	0.001	0.007 , 0.027
Financial development→ Sustainable development (path b)	2.530 [a]	.323	0.000	1.897 , 3.162
Direct Effects				
Natural resource rents → Sustainable development (path ć)	0.179 [a]	0.027	0.000	0.126 , 0.233
Indirect Effect				
Natural resource rents→ Financial development → Sustainable development (path ab)	0.043 [a]	0.014	0.002	0.016 , 0.071
Moderation				
Financial development				
Fintech * Natural resource rents	0.005 [b]	0.002	0.037	0.000 , 0.010
Fintech	0.120 [a]	0.040	0.003	0.041 , 0.198
Sustainable development				
Fintech * Natural resource rents	0.013 [b]	0.006	0.045	0.000 , 0.025
Fintech	0.302 [a]	0.108	0.005	0.091 , 0.514
CFI	TLI	RMSE	SRMR	CD
0.988	0.901	0.083	0.014	0.862

Note: [a] represents a 1% significance level, [b] represents a 5% significance level, and [c] represents a 10% significance level, SE = standard error, LR = likelihood ratio.

TABLE 4.6: Significance Testing of Indirect Effect

Estimates	**Indirect Effect**	**Std. Err.**	**Z-value**	**P-value**	**C.I**
Sobel	0.043^a	0.014	3.053	0.002	0.017 , 0.078
Delta	0.043^a	0.014	3.053	0.002	0.017 , 0.078
Monte Carlo	0.043^a	0.014	3.053	0.002	0.017 , 0.078

Path a - NRR -> FD with B=0.017^a and p=0.001

Path b - FD -> SD with B=2.530^a and p=0.000

Path ć - NRR -> SD with B=0.179^a and p=0.000

Note: [a] represents a 1% significance level, [b] represents a 5% significance level, and [c] represents a 10% significance level.

The H_2 is accepted [b =0.017, S.E =0.005, p =0.001, C.I (0.007, 0.027)] suggesting that NRRs are blessings for N-11 and BRICS countries. This highlights the vital role the financial sector performs in these economies.

Financial development with the support of strong institutional quality prohibits rent-seeking behavior and exploitation of finite natural resources (Sepehrdoust and Shabkhaneh, 2018). Appropriate incorporation of advanced accounting standards and information disclosure increases investor protection, transparency, and competition in the financial sector. Similarly, Li and Umair (2023) reported the existence of natural resource blessings for the BRICS economies.

In Pakistan, Atil et al. (2020) discovered that natural resource rents support financial development. The financial industry in Pakistan, particularly the banking sector, has experienced a tremendous expansion in recent years because of considerable financial reform (Ulucak et al., 2021). H_3 anticipated the financial

development's impact on sustainability. The results support this association [b = 2.530, S.E. =0.323, p =0.000, C.I (1.897, 3.162)]. It demonstrates that financial development supports sustainable development by financing activities that reduce CO_2 emissions and increase economic productivity. The same results were witnessed by Sherif et al. (2022), stating that in N-11 countries, FD promotes economic progress in the long run without damaging the environment.

The financial sector provides capital for sustainable projects like energy efficiency, renewable energy, green technology, R&D, and green infrastructure development. Developed financial systems frequently follow stricter regulations and are more transparent, which can promote ethical business practices. This guarantees the efficient utilization of resources to achieve sustainable development objectives.

H_4 suggests that financial development mediates the association between NRRs and sustainable development. H_4 is supported through indirect effects [b =0.043, S.E. =0.014, p =0.002, CI (0.016, 0.071)]. The coefficient value for path ć < path c confirms the existence of mediation. The results support institutional theory, indicating that financial development in N11 and BRICS countries plays a pivotal part in attaining SDGs. They channel rents from natural resources towards green initiatives essential for meeting SDGs. A robust financial sector facilitates economic diversification by assisting a range of companies.

Further, H_5 assumes that Fintech adoption moderates the association between natural resource rents and financial development. The interaction term in the context of the resource-finance nexus is significant and positive [b = 0.005, S.E. =0.002, p =0.039, C.I (0.000, 0.010)]. Therefore, the result supports that Fintech adoption as a moderator strengthens the resource-finance nexus. Tan et al. (2023) discovered that the high level of Fintech adoption plays an important role in the economy by facilitating the efficient administration and safeguarding of natural resources.

He and Zhang (2024) reported that digital advancements can transform the Financial resource curse into a blessing for resource-intensive economies. Capital formation and technological innovation strengthen resource finance linkage (Çetin et al., 2023).

Fintech adoption optimizes financial institutional access and efficiency by increasing financial inclusion and returns. Robust digital infrastructure in collaboration with the financial sector enhances funding, deepens the financial system, and boosts efficiency. Fintech improves transparency and mitigates fraud in financial transactions by offering a secure and unchangeable record. This guarantees that NRRs are well managed in the economy, resulting in blessings; this enhances transparency and mitigates corruption. The results also support H_6 [b = 0.013, S.E. =0.006, p = 0.039, C.I (.000 , 0.025)].

The indirect effect of NRR through FD on sustainable development is predicted to be stronger for those with a higher level of Fintech adoption. Fintech offers numerous opportunities to support the achievement of SDGs, including activities such as land restoration, mitigating carbon emissions, and poverty alleviation. In the case of China, Zhang et al. (2021) discovered the positive role of Fintech towards sustainable development. Employing digital payment systems decreases the necessity for physical currency, minimizing the requirement for paper-based processes and reducing the carbon footprint. Fintech platforms can enable the financing of renewable energy projects through processes such as peer-to-peer lending, crowdfunding, and green bonds. Hence, there is less reliance on fossil fuels and low greenhouse gas emissions.

Fintech adoption reduces operational cost, increases the speed of transactions, and boosts transparency of the financial sector through the secure settlement of transactions. Blockchain technologies eliminate many financial intermediaries, thus boosting global trade and efficiency. Financial technology has introduced new asset classes that are offering high returns as compared to traditional investments. Cryptocurrencies like Bitcoin and Ethereum are assisting in cross-border transactions (Daud et al., 2022).

The result showed following control variables have a significant and positive effect on sustainable development: institutional quality, industrialization, and inflation. Whereas, economic growth is negatively affecting the SD. FDI has an insignificant relationship with SD. The goodness-of-fit indices indicate that the mediation model aligns well with the data.

A CFI of 0.988 suggests that the measured model fits with the data as compared to the baseline model. The measurement model has a TFI of 0.901, which indicates a good fit. The value of RMSEA measures how well the model fits the data while considering model complexity. The value of SRMR ranges from 0 to 1. It measures the average difference between observed and anticipated correlations in the model. A value close to zero suggests a perfect match, with 0.000 representing that the model reproduces the observed correlations.

A CD of 0.959 reflects that the model explains 95.9% of the data's variation. RMSEA of 0.083 indicates that the model presents a satisfactory match. SRMR of 0.014 signifies a highly favorable model fit with little residual between the observed and predicted values. CD of 0.862 signifies that 86.2% of the dependent variables variation is elucidated by the independent variables. This is significantly elevated and signifies a robust correlation between the variables in the model. In terms of regression analysis, it is similar to R^2.

Table 4.6 presents the cross-verification of results obtained through the Sobel test, with the results found from Baron and Kenny's method previously. The Sobel test, along with the Delta and Mote Carlo approach, show significant results and the existence of partial mediation. This shows that NRR has both a direct effect on SD and an indirect effect through the FD. The results for Path a, Path b, and Path ć are significant.

Tables 4.7 and 4.8 display the outcomes of the robustness checks. The study uses SEM to conduct a robustness check with an alternative proxy for FD, domestic credit to the private sector as a % of GDP. Several studies have used it to measure FD (Liu et al., 2022; Henri, 2019). Robustness results for Fintech (moderation) and financial development (mediation) are aligned with the estimated coefficients of the variables. The result confirmed the existence of partial mediation as Path a, Path b, and Path ć as well as Sobel's test above are significant indicating the mediation is partial. The results also validated the existence of natural resource blessings. The result confirmed the existence of partial mediation and validated that the natural resources are blessings for N-11 and BRICS countries.

TABLE 4.7: Robustness Moderation-Mediation Results

Structural Relationships	**Coefficient**	**S.E**	**P-Value**	**C.I**
Control variables				
EG_{it}	-0.364 [a]	0.046	0.000	-0.454 , -0.273
IQ_{it}	0.645 [a]	0.087	0.000	0.474 , 0.816
IND_{it}	0.853 [a]	0.115	0.000	0.628 , 1.079
INF_{it}	0.112 [a]	0.043	0.010	0.027 , 0.197
FDI_{it}	-0.004	0.021	0.856	-0.046 , 0.038
Total Effects				
Natural resource rents → Sustainable development (path c)	0.239 [a]	0.029	0.000	0.182 , 0.297
Natural resource rents → Financial development (path a)	0.061 [b]	0.031	0.05	0.000 , 0.122
Financial development→ Sustainable development (path b)	0.494 [a]	0.044	0.000	0.411 , 0.589
Direct Effects				
Natural resource rents → Sustainable development (path ć)	0.209 [a]	0.025	0.000	0.160 , 0.257
Indirect Effect				
Natural resource rents→ Financial development → Sustainable development (path ab)	0.030 [b]	0.0157	0.050	-0.000 , 0.061
Moderation				
Financial development				
Fintech * Natural resource rents	0.027 [c]	0.014	0.058	-0.001 , 0.056
Fintech	1.561 [a]	0.240	0.000	1.091 , 2.030
Sustainable development				
Fintech * Natural resource rents	0.014 [c]	0.007	0.062	-0.001 , 0.028
Fintech	0.772 [a]	0.138	0.000	0.502 , 1.041
CFI	TLI	RMSE	SRMR	CD
0.984	0.860	0.039	0.008	0.829

Note: [a] *represents a 1% significance level,* [b] *represents a 5% significance level, and* [c] *represents a 10% significance level. SE = standard error, and LR = likelihood ratio.*

TABLE 4.8: Significance Testing of Indirect Effect

Estimates	**Indirect Effect**	**Std. Err.**	**Z-value**	**P-value**	**C.I**
Sobel	0.030^{b}	0.016	1.932	0.05	-0.000, 0.061
Delta	0.030^{b}	0.016	1.932	0.05	-0.000, 0.061
Monte Carlo	0.030^{b}	0.015	1.940	0.05	0.001, 0.060
Path a – NRR -> FD with B=0.065^{b} and p=0.035					
Path b – FD -> SD with B=0.500^{a} and p=0.000					
Path ć – NRR -> SD with B=0.207^{a} and p=0.000					

Note: ^{a} *represents a 1% significance level,* ^{b} *represents a 5% significance level, and* ^{c} *represents a 10% significance level.*

Green Environment

4.2 Green Finance and Sustainable Development

4.2.1 Diagnostic Analysis

This study used various tests to assess the data and associations among variables. Firstly, a descriptive analysis was conducted to explain the fundamental features of the data. The results are shown in Table 4.9. Descriptive statistics measure minimal variation in the average values of variables, suggesting consistent dispersion of the data. Table 4.10 shows the variance inflation factor (VIF) results. All variables in the sample have VIF values <10 and show no multicollinearity.

The Levin test and Fisher-Augmented Dickey-Fuller (ADF) tests were employed in the study to assess stationarity. Table 4.11 summarizes the findings. The results for all variables are significant, representing that they are stationary at level L(0) and first level L(1). The study rejected the null hypothesis and accepted the alternative hypothesis, which suggests that all variables are stationary. Table 4.12 displays the correlations among the variables.

The value of SD reflects moderate variation in the sample, the range of data, minimum value (2.772), and maximum value (5.550) shows that all the countries in the sample are balancing between economic and environmental sustainability, and focusing on achieving sustainable development. The mean value of FD is 0.388,

TABLE 4.9: Descriptive Statistics Results

Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Sobel	0.030[b]	0.016	1.932	0.05	-0.000, 0.061
SD_{it}	224	4.125	0.621	2.772	5.550
FD_{it}	224	0.388	0.127	0.138	0.674
GF_{it}	224	9.351	2.077	6.143	11.996
NRR_{it}	224	1.257	1.083	-1.400	3.549
$FINT_{it}$	224	-0.347	1.209	-2.474	2.811
IND_{it}	224	3.409	.257	2.896	3.905
HC_{it}	224	2.333	.354	1.610	3.163
POP_{it}	224	1.388	.547	.238	2.764

with low variation as the value of standard deviation is low, showing a moderate financial development in the sample. The standard deviation (2.077) of GF is high, showing variation in the spending pattern of economies in green initiatives.

The data of NRR shows variation, with the minimum value (-1.40) showing that some economies have earned negative returns from natural resources during the observed time frame. The data of FINT has variation in the data, reflecting that, due to infrastructural barriers, some countries are adopting Fintech at a slow pace. The values of IND reflect the uniform industrial growth pattern among the economies. The values of HC show the level of skills and education in the human capital, which shows less variation across the countries. The mean value of POP is 1.388, and the standard deviation is .547, reflecting a moderate variance of population size across the sample.

TABLE 4.10: Variance Inflation Factor

Variables	**VIF**
FD_{it}	2.48
GF_{it}	1.16
NRR_{it}	1.40
$FINT_{it}$	2.93
IND_{it}	1.66
HC_{it}	3.81
POP_{it}	1.95
Mean VIF	2.20

Table 4.11: Unit Root Results

Variables	**LLC**	**Stationarity**	**Fisher ADF**	**Stationarity**
SD_{it}	-3.229***	Smooth	95.248***	Smooth
FD_{it}	-6.922***	Smooth	108.305***	Smooth
GF_{it}	-12.141***	Smooth	56.961***	Smooth
NRR_{it}	-6.346***	Smooth	70.216***	Smooth
$FINT_{it}$	-4.659 ***	Smooth	60.810 ***	Smooth
HC_{it}	-3.809 ***	Smooth	108.514***	Smooth
IND_{it}	-4.163***	Smooth	54.953***	Smooth
POP_{it}	-3.570***	Smooth	62.225***	Smooth

*Note: The significance level is indicated by *** for 1%, and ** for 5%.*

Table 4.12: Correlation Matrix

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
(1) SD_{it}	1							
(2) FD_{it}	0.154**	1						
(3) GF_{it}	0.283**	0.120*	1					
(4) NRR_{it}	0.376***	-0.108*	-0.279***	1				
(5) $FINT_{it}$	-0.128**	0.553***	0.0604	-0.191***	1			
(6) IND_{it}	0.488***	-0.011	-0.244***	0.356***	0.033	1		
(7) HC_{it}	0.0383	0.636***	-0.0592	-0.09	0.786***	0.264***	1	
(8) POP_{it}	-0.210***	-0.609***	0.076	0.218***	-0.410***	-0.221***	-0.489***	1

*Note: The significance level is indicated by *** for 1%, ** for 5%.*

4.3 Mediation Analysis

The study analyzed the association between green finance, financial development, and sustainable development in N-11 and BRICS economies. Table 4.13 displays the outcomes of the H_7, H_8, H_3, and H_9. The results for H_7 suggest the total influence of green financing on SD is positive [b = 0.0478, S.E = 0.016, p-value = 0.004, CI (0.015, 0.080)], signifying that green finance supports the achievement of SDGs. A positive and significant coefficient of green finance shows that sustainable development increases with increased mobilization of green finance in the economies. Global problems including global warming and environmental pollution have gained attention in recent years. Green bonds are one of the major sources of green financing, and they are exploding globally as a means of addressing and resolving

the issue of inadequate funding for the development of the green economy (Jian et al., 2022). Green finance is sometimes referred to as sustainable finance or environmental finance. Its goal is to reduce the environmental issues and financial industry gaps to protect the environment (Xu et al., 2022).

Green finance is a multidisciplinary area of research. Green bonds, green loans, green mortgages, and green offset credit are common examples of green financial securities. Renewable energy, green buildings, clean transportation, sustainable land use, biodiversity, and clean water are all examples of ecologically or climate-friendly activities that may be financed or refinanced using green bonds. Green bonds enable the issuer to generate funds for eco-friendly projects, while providing investors with a stable income through interest payments. Upon reaching maturity, the initial amount is refunded.

Green bonds are essentially similar to other corporate bonds, but they are specifically labeled as "green" due to the issuer's commitment to using the funds for environmentally supportive initiatives in compliance with sustainability criteria. Other features, such as reputation, transparency, and disclosure, are also covered by the characteristics of green bonds (Agliardi and Agliardi, 2019). Green finance and financial development are closely linked with each other. Green finance helps to expand and diversify the financial sector by encouraging innovation and promoting sustainable practices inside financial institutions.

To accomplish the SDGs, BRICS and N11 economies use sustainability considerations in their energy consumption plans for efficient economic development. Zhang (2023) found similar findings in Pakistan, Bangladesh, and India. Green financing mitigates CO_2 emissions, aiding environmental preservation and sustainable economic recovery. The BRICS nations have effectively reduced their CO_2 emissions through more consumption of renewable energy and acquiring green financing resources (Mngumi et al., 2022; Udeagha and Muchapondwa, 2023).

Green finance improves environmental sustainability by reallocating investments from energy-intensive enterprises to resource-efficient commercial activities. The progression of the renewable energy sector is closely linked to the availability of substantial green financing (Behera et al., 2024; Xiong and Dai, 2023). Green

financing supports green initiatives and adopting green technology (Bei and Wang, 2023). This results in increased economic activity and the reduction of CO_2 emissions.

TABLE 4.13: Mediation Results

Structural Relationships	**Coefficient**	**S.E**	**P-value**	**C.I**
Control variables				
NRR_{it}	0.178[a]	0.036	0.000	0.109, 0.247
$FINT_{it}$	0.109 [b]	0.047	0.019	0.201, 0.018
HC_{it}	0.008	0.168	0.962	0.962, 0.338
IND_{it}	0.843 [a]	0.154	0.000	0.541, 1.144
POP_{it}	-0.335 [a]	0.073	0.000	-0.478, -0.193
Total Effects				
Green Finance → Sustainable development (path c)	0.0478 [a]	0.016	0.004	0.015, 0.080
Green Finance → Financial development (path a)	0.006[b]	0.003	0.026	0.000, 0.012
Financial development→ Sustainable development (path b)	1.708[a]	0.392	0.000	0.939, 2.476
Direct Effects				
Green Finance → Sustainable development (path ć)	0.037[b]	0.017	0.028	0.004, 0.070
Indirect Effect				
Green Finance→ Financial development → Sustainable development (path ab)	0.011[b]	0.005	0.048	0.000, 0.021
CFI	TFI	RMSE	SRMR	CD
1	1	0.00	0.000	0.758

Note: [a] represents a 1% significance level, [b] represents a 5% significance level, and [c] represents a 10% significance level.

The results support the H_8 [b = 0.006, S.E = 0.003, S.E = 0.026, p-value = 0.028, CI (0.000, 0.012)]. Green finance encourages an inclusive and sustainable financial system, which leads to long-term economic growth. Green finance attracts capital from the public and private sectors for sustainable projects like the adoption of clean technology and conducting research & development for attaining energy efficiency and renewable energy. This capital mobilization fosters the growth of the financial markets by introducing new opportunities and products.

Green finance transforms the financial landscape, generating new investment opportunities, improving market stability, and promoting a more resilient economy. Corporate green bonds enhance the performance of environmental and financial sectors (Agliardi and Agliardi, 2019). Green finance enhances liquidity within the financial industry Xiong and Dai (2023). Market dynamics in the financial sector and government regulations concerning green finance determine the extent to which green financing can positively affect the development of renewable energy sources Wang and Zhi (2016). Increased accessibility of green bonds and other green financial instruments enhances market liquidity, enabling investors to sell their bonds or shares at their discretion (Meltzer, 2016).

The liquidity factor is essential for institutional investors, as they face laws limiting investments in renewable energy infrastructure or long-term investments. Pension funds generally participate in asset-liability management, and insurance companies face continuous payment responsibilities to policyholders, necessitating substantial investments in liquid assets, such as green bonds. Financial institutions consolidate numerous smaller projects into larger ones so that they can attract institutional investors (Hafner et al., 2020). Green financing guarantees high returns on investment to private investors (Rasoulinezhad and Taghizadeh-Hesary, 2022; Chen et al., 2024).

H_3 is accepted as financial development significantly affects sustainable development [coefficient = 1.708, S.E = 0.392, p-value = 0.000, CI (0.939, 2.476)]. This indicates that improvements in financial development significantly impact sustainable development. H_9 proposes that financial development mediates the relationship between green finance and SD. The indirect effect of green finance on SD through financial development is positive [b =0.011, S.E. =0.005, p =0.048, CI (0.000, 0.021)]—the value of the coefficient for path ć < path c that confirms the existence of partial mediation.

The developed financial market guarantees sufficient capital for projects that yield social and environmental advantages. These markets reallocate resources from unsustainable projects and businesses that badly affect the environment and society into activities that consider climate action plans and green recovery (Hunjra et al., 2023; Li and Umair, 2023). Similarly, Zhang (2023) stated that South

Asian countries are potential world leaders in executing green finance strategies. Authorities should increase financial institutions' capacity to offer green loans for green economic recovery and environmental protection. The study found that natural resource rents, Fintech adoption, human capital, and industrial growth positively affect sustainable development. Population expansion adversely impacts sustainable development.

Table 4.13 presents the goodness of fit indices used in SEM. Each index proposes a unique point of view on how well the data fits with the model. The CFI compares the measured model's fit to a baseline (null) model (that is based on the assumption that no relationship exists between the variables). It shows how well the model fits with the data compared to its baseline model. The value varies from 0 to 1. A CFI of 1 suggests that the measured model highly fits with the data as compared to the baseline model. The measurement model has a TFI of 1, which indicates a good fit.

The RMSEA and SRMR values (0.00 and 0.00) show a good model fit. The value of RMSEA measures how well the model fits the data while considering model complexity. The value of SRMR ranges from 0 to 1. It measures the average difference between observed and anticipated correlations in the model. A value close to zero suggests a perfect match, with 0.000 representing that the model reproduces the observed correlations. The CD calculates the explanatory power of the model. It is similar to R^2 that is used in regression. The explanatory power of the model is very high if the value approaches 1. A CD of 0.758 reflects that the model explains 75.8% of the data's variation.

Table 4.14: Significance Testing of Indirect Effect

Estimates	**Indirect Effect**	**Std. Err.**	**Z-value**	**C.I**
Sobel	0.011^b	0.005	1.978^b	0.000, 0.021
Delta	0.011^b	0.005	1.978^b	0.000, 0.021
Monte Carlo	0.010^b	0.005	1.947^b	0.001, 0.024
Path a FD: GF (X -> M) with B=0.006 ^{b} and p=0.026				
Path b SD: FD (M -> Y) with B=1.708^a and p=0.000				
Path ć SD: GF (X -> Y) with B=0.048^a and p=0. 0.004				

Note: ^{a} represents a 1% significance level, ^{b} represents a 5% significance level, and ^{c} represents a 10% significance level.

Table 14.14 highlights the cross-comparison of results that are measured through the Sobel test with the results obtained previously from Baron and Kenny's technique. The Sobel, Delta, and Monte Carlo tests, all verify the existence of partial mediation. This validates that GF has both a direct effect on SD and an indirect effect on SD via FD. Paths a, b, and ć all show significant results.

TABLE 4.15: Robustness Mediation Results

Structural Relationships	**Coefficient**	**S.E**	**P-Value**	**C.I**
Control variables				
NRR_{it}	0.024 ^{a}	0.005	0.000	0.015 , 0 .033
$FINT_{it}$	0.030 ^{a}	0.006	0.000	0.018 , 0.043
HC_{it}	0.062 ^{b}	0.023	0.005	0.018 , 0.107
IND_{it}	0.001	0.021	0.967	-0.039 , 0.041
POP_{it}	0.018^{c}	0.010	0.064	-0.001, 0.037
Total Effects				
Green finance → Sustainable development (path c)	0.006 ^{b}	0.002	0.014	0.001 , 0.010
Green finance → Financial development (path a)	0.006 ^{b}	0.003	0.026	0.001 , 0.012
Financial development→ Sustainable development (path b)	0.170 ^{a}	0.053	0.001	0.066 , 0.275
Direct Effects				
Green finance → Sustainable development (path ć)	0.004 ^{a}	0.053	0.001	0.066 , 0.275
Indirect Effect				
Green finance → Financial development → Sustainable development (path ab)	0.001^{b}	0.001	0.068	0.000 , 0.002
CFI	TFI	RMSE	SRMR	CD
1	1	0.00	0.000	0.691

Note: ^{a} *indicates a 1% significance level,* ^{b} *suggests a 5% significance level, and* ^{c} *indicates a 10% significance level.*

Tables 14.15 and 14.16 represent the outcomes of the robustness checks. The study uses SEM to conduct a robustness check with another proxy of SD i-e the sustainable development index. The results of robustness tests for green finance, FD (mediator), and SD are significant. The results obtained from Sobel's test above, are significant, indicating that the mediation is partial as Path a, Path b, and Path ć are all significant.

TABLE 4.16: Significance Testing of Indirect Effect

Estimates	**Indirect Effect**	**Std. Err.**	**Z-value**	**P-value**	**C.I**
Sobel	0.001^{c}	0.001	1.822	0.068	0.000, 0.002
Delta	0.001^{c}	0.001	1.822	0.068	0.000, 0.002
Monte Carlo	0.001^{c}	0.001	1.763	0.078	0.001, 0.003
Path a - FD:GF (X -> M) with B=0.006^{b} and p=0.026					
Path b - SD:FD (M -> Y) with B=0.170^{a} and p=0.001					
Path ć - SD:GF (X -> Y) with B=0.006^{a} and p=0.014					

Note: ^{a} *represents a 1% significance level,* ^{b} *represents a 5% significance level, and* ^{c} *represents a 10% significance level.*

The finding suggests that the mobilization of green finance increases green ventures that increase sustainable development. The results validate the Institutional theory and the Resource dependence theory, reflecting that financial development in N11 and BRICS countries can play a significant role in economic development and a reduction in CO_2 emissions. The SDGs 2030 require global collaborative initiatives to promote SD, emphasizing the crucial role of financial institutions and markets. Financial institutions are essential in allocating money to businesses that promote green recovery projects. A strong and liquid financial market improves the demand for green financial instruments, boosting green finance and ecologically sustainable initiatives. These initiatives, subsequently, aid in attaining long-term SDGs and competitive advantage for the country.

4.4 Green Technology and Sustainable Development

4.4.1 Descriptive Statistics

Initially, a descriptive analysis was carried out to explain the fundamental features of the data. The outcomes are presented in Table 4.17. The results of the variance inflation factor (VIF) are displayed in Table 4.18. All variables in the sample have VIF values <10 and show no multicollinearity. Table 4.19 summarizes the findings of the Levin test and Fisher-Augmented Dickey-Fuller (ADF) to assess the stationarity of the data. The results for all variables are significant, representing that they are stationary at level L(0) and first level L(1). The study rejected the

null hypothesis and accepted an alternative hypothesis, which suggests that all variables are stationary. Table 4.20 displays the correlations among the variables.

TABLE 4.17: Descriptive Statistics Results

Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
FD_{it}	256	0.412	0.132	0.211	0.627
SD_{it}	256	4.130	0.552	3.227	4.936
GT_{it}	256	23.072	17.312	1.300	50.050
$FINT_{it}$	256	-1.41e-08	1.526	-2.474	4.215
IQ_{it}	256	9.26e-09	2.103	-3.466	6.065
NRR_{it}	256	1.150	1.219	-1.421	2.860
POP_{it}	256	1.244	0.647	-0.381	2.764
EG_{it}	256	8.359	0.869	6.632	10.362
IND	256	3.416	0.242	2.896	3.905

The mean value of FD is 0.412, with low variation as the value of standard deviation is low, showing a moderate level of financial development in the sample. The value of SD reflects moderate variation in the sample, the range of data, minimum value (3.227), and maximum value (4.936) shows that all the countries in the sample are balancing between economic and environmental sustainability, and focusing on achieving sustainable development. The standard deviation GT is high, with a minimum value of 1.3 and a maximum value of 50.05, reflecting high variation of green technology adoption among the economies. FINT has variation in the data, reflecting that, due to infrastructural barriers, some countries are adopting Fintech at a slow pace. The IQ is calculated through Principal component analysis. All the 5 components are reported in Table 3.1.

IQ has a mean value of 9.26e-09 with high variation in the data, the minimum (-3.466) and maximum (6.065) values of the data reflect that some countries have strong institutional quality, and some countries are with weak institutional quality. The data of NRR shows variation, with the minimum value (-1.421) showing that some economies have earned negative returns from natural resources during the observed time frame. The data on the values of IND reflect the uniform industrial growth pattern among the economies. The mean value of POP is 1.388 and SD is .547, reflecting a moderate variance of population size across the sample. The values of EG show robust and steady economic growth across the data.

Table 4.18: Variance Inflation Factor

Variables	**VIF**
FD_{it}	5.84
GT_{it}	2.64
$FINT_{it}$	3.07
IQ_{it}	3.85
NRR_{it}	1.87
POP_{it}	2.00
EG_{it}	4.72
IND_{it}	1.49
Mean VIF	3.19

Table 4.19: Unit Root Results

Variables	**Lin, Levin, and Chu**	**Stationarity**	**Fisher ADF**	**Stationarity**
SD_{it}	-3.8273 ***	Smooth	121.8474 **	Smooth
FD_{it}	-6.7767***	Smooth	106.9529***	Smooth
GT_{it}	-1.9469**	Smooth	53.2981**	Smooth
$\mathbf{FINT}_{it}$	-4.8171***	Smooth	54.6145***	Smooth
$\mathbf{IQ}_{it}$	-4.6704 ***	Smooth	65.4148***	Smooth
$\mathbf{NRR}_{it}$	-6.6602 ***	Smooth	62.8873***	Smooth
POP_{it}	-2.8567***	Smooth	43.1970*	Smooth
$\mathbf{EG}_{it}$	-2.1809***	Smooth	69.2607***	Smooth
IND_{it}	-4.0741***	Smooth	59.3550 ***	Smooth

*Note: The significance level is indicated by *** for 1%, ** for 5%.*

Table 4.20: Matrix of Correlations

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
(1) SD_{it}	1.000								
(2) FD_{it}	0.511***	1.000							
(3) GT_{it}	-0.431***	-0.444***	1.000						
(4) $FINT_{it}$	-0.125**	0.709***	-0.521***	1.000					
(5) IQ_{it}	-0.106*	0.801***	-0.353***	0.533***	1.000				
(6) NRR_{it}	0.402***	-0.457***	0.049	-0.407***	-0.611***	1.000			
(7) POP_{it}	-0.231**	-0.654***	0.414***	-0.566***	-0.44***	0.218***	1.000		
(8) EG_{it}	-0.119*	0.777***	-0.670***	0.769	0.634***	-0.321***	-0.517***	1.000	
(9) IND_{it}	0.449***	0.064	-0.490***	0.081	0.043	0.168***	-0.210***	0.156**	1.000

*Note: The significance level is indicated by *** for 1%, ** for 5% and * for 10%.*

4.5 Results of Mediation

This section explains the association between green technology, financial development, and sustainable development. Table 4.21 presents the results for H_{10}, H_{11}, H_3, and H_{12}. Green technology positively affects sustainable development [b =0.030, S.E. =0.002, p =0.000, CI (0.026, 0.033)], supporting H_{10}, the direct impact of green technology on sustainable development (path c). This relationship verifies the necessity of using green technologies to promote sustainability. Green technology, comprising renewable energy solutions and energy-efficient practices, is essential for mitigating environmental degradation and fostering long-term economic growth.

Robust green technologies and the expansion of green financial markets can support economic growth in the long run. Adoption of GT in the transport sector (electric vehicles) can reduce energy consumption and pollution, thus supporting sustainable development (Hasan and Du, 2023). Green technological innovation results in pollution reduction, product stewardship, and sustainable development (Hart and Dowell, 2011). Financially rich nations are consuming and extracting more natural resources, resulting in high financial development, greater energy consumption, and industrialization. Green technological innovation must result in pollution avoidance, product stewardship, and sustainable development (Hart and Dowell, 2011).

Financially rich nations are consuming and extracting more natural resources, resulting in tremendous financial development, greater energy consumption, and industrialization. The use of renewable energy is thought to be one of the most effective ways to reduce the planet's growing ecological imprint (Usman et al., 2022). Alternative sources of energy should be emphasized rather than continuing to extract natural resources. Additionally, anticipating the supply and demand of natural resources should be prioritized to attain the goal of sustainability (Shahbaz et al., 2018).

The results of total effect [b =0.011, S.E. =0.002, p =0.000, C.I (0.07, 0.015)] supports H_{11}. Green technology and financial development have a significant positive relationship, indicating that the adoption of green technology can promote

financial development by attracting investments. These funds are later used to support activities that can preserve the green economy. Governments should make it mandatory for the banking institutions to reserve a portion of their loan portfolio for funding green projects (including funding electric vehicles, recycling processes, power generation through renewable energy sources, and R&D projects conducted by the institutions).

Environmental sustainability improves when digital financial growth results in green technological advancement, resulting in efficiency of green credit. To achieve SD, governments should increase the affordability and accessibility of green finance for business and household sectors. The government should divert the subsidies it gives on fossil fuel consumption towards green finance, which will result in advancements and the adoption of green technology(Hasan and Du, 2023). In South Asian countries, Zulfiqar et al. (2025) identified the positive role of green technology and financial development on environmental sustainability.

GT reduces energy consumption and improves productivity. FD supports R&D funding in GT, thus increasing environmental quality. In BRICS Waqas et al. (2025), FD results in environmental degradation due to industrial development. However, with the inclusion of technological and renewable energy consumption, FD has a positive effect in reducing CO_2 emissions. Industry 4.0 and agricultural activities have played an important role in combating carbon emissions in BRICS economies.

Financial development significantly impacts sustainable development [b =2.98, S.E. =0.277, p =0.000, C.I (2.438, 3.522)]. The results suggest that developed financial institutions supply the essential resources to increase sustainable development activities, like investments in renewable energy, environmental conservation activities, and sustainable infrastructure. The direct and indirect paths, in addition to the total effect, are necessary for explaining the mechanism through which green technology impacts sustainable development.

In N-11 economies, Javed et al. (2025) suggested that financial development and green technology are crucial for economies in attaining their carbon neutrality goals by 2050. The financial sector can play a significant role in mobilizing

TABLE 4.21: Mediation Results

Structural Relationships	**Coefficient**	**S.E**	**P-Value**	**C.I (95%)**
Control variables				
$FINT_{it}$	0.044^{c}	0.025	0.081	0.005 , 0.009
NRR_{it}	0.146^{a}	0.020	0.000	0.105 , 0.186
EG_{i}	-0.533^{a}	0.051	0.000	-0.634, -0.432
IQ_{it}	0.067^{a}	0.016	0.000	0.034, 0.100
IND_{it}	0.155	0.111	0.164	-0.064, 0.375
POP_{it}	-0.310^{a}	0.043	0.000	-0.397, -0.224
Total Effects				
Green Technology → Sustainable development (path c)	0.030^{a}	0.002	0.000	0.026, 0.033
Green Technology → Financial development (path a)	0.011^{a}	0.002	0.000	0.007, 0.015
Financial development→ Sustainable development (path b)	2.98^{a}	0.277	0.000	2.438, 3.522
Direct Effects				
Green Technology → Sustainable development (path ć)	0.026^{a}	0.002	0.000	0.023, 0.031
Indirect Effect				
Green Technology → Financial development → Sustainable development (path ab)	0.033^{b}	0.001	0.029	0.001, 0.037
CFI	TFI	RMSE	SRMR	CD
1	1	0.00	0.000	0.959

Note: [a] represents a 1% significance level, [b] represents a 5% significance level, and [c] represents a 10% significance level.

TABLE 4.22: Significance Testing of Indirect Effect

Estimates	**Indirect effect**	**Std. Err.**	**z-value**	**p-value**	**C.I (95%)**
Sobel	0.003	0.001	2.401	0.016	0.001 , 0.005
Delta	0.003	0.001	2.401	0.016	0.001 , 0.005
Monte Carlo	0.003	0.001	2.408	0.016	0.001 , 0.005
Path a - STEP 1 – FD:GT (X -> M) with B=0.001 and p=0.014					
Path b - STEP 2 - SD:FD (M -> Y) with B=2.980 and p=0.000					
Path ć - STEP 3 - SD:GT (X -> Y) with B=0.030 and p=0.000					

Note: [a] represents a 1% significance level, [b] represents a 5% significance level, and [c] represents a 10% significance level.

funds in the form of investment and thus supports the green energy consumption. Well-organized financial sector, along with effective rules and regulations, can direct private investments in the financial system and boost the infrastructure for renewable energy production.

The direct impact of green technology on sustainable development (path ć) is significant [b =0.026, S.E. =0.002, p =0.000, C.I (0.023, 0.031)]. This direct linkage shows that green technology promotes sustainable development in the absence of financial development. The indirect effect states [b =0.033^{a}, S.E. =0.001, p =0.029, C.I. (0.001, 0.037)] that green technology affects financial development (path a) and financial development affects sustainable development (path b). This shows that green technology indirectly boosts sustainable development by initially fostering financial growth and later sustainable development.

The global demand for achieving SDGs 2030 requires highlighting the importance of green technology adoption for financial and economic growth. Green technology adoption increases financial sector growth. In the long run, green technology boosts economic growth, enabling economies to overcome their energy crisis and climate change. At the initial stage, there is a high cost of investing in green technology, but the future returns are more than the initial investment cost, resulting in high profits for businesses and cost efficiency for consumers, which attracts more investors towards this sector.

In all three sectors of renewable energy, energy efficiency, and sustainable construction, green technology is creating innovative business and employment opportunities, boosting economic development and demand for green financial products. Financial development through mobilizing savings from previously mentioned sectors can boost green finance and sustainable businesses, resulting in sustainable development through increasing economic growth and reducing carbon dioxide emissions.

The control variables, institutional quality, Fintech adoption, natural resource rents, and population growth, have positive and significant impacts on achieving sustainable development goals. Fintech adoption strengthens the infrastructure of the financial sector. It increases outreach and access to strong financial institutions that can supply the financial resources to advance sustainable development projects.

Fintech adoption supports the financial sector's role in achieving SDGs by making it easier for more people to access funds, making better use of resources, and encouraging the growth of green businesses. The availability of natural resources may aid the shift to more sustainable practices because they are the main source of finance that can be invested in green technologies promoting SD. A high level of institutional quality positively impacts sustainable development. Robust institutions, with well-organized governance, transparency, and legal structures, are necessary for facilitating and implementing policies that foster sustainability. Economic growth and industrial development do not significantly impact sustainable development.

The goodness-of-fit indices indicate that the mediation model aligns well with the data. A CFI of 1 suggests that the measured model highly fits with the data as compared to the baseline model. The measurement model has a TFI of 1, which indicates a good fit. The RMSEA and SRMR values (0.00 and 0.00) shows a good model fit. The value of RMSEA measures how well the model fits the data while considering model complexity. The value of SRMR ranges from 0 to 1. It measures the average difference between observed and anticipated correlations in the model. A value close to zero suggests a perfect match, with 0.000 representing that the model reproduces the observed correlations. A CD of 0.959 reflects that the model explains 95.9% of the data's variation.

Table 14.22 highlights the cross-comparison of results that are measured through the Sobel test with the results obtained previously from Baron and Kenny's technique. The results of the Sobel test, Monte Carlo test, and Delta test are significant, highlighting the importance of financial development in adapting green technology innovations to attain concrete sustainable results.

Table 4.23: Robustness Mediation Results

Structural Relationships	**Coefficient**	**S.E**	**P-value**	**C.I**
Control variables				
FINT	0.023^{a}	0.007	0.001	0.009 , 0.037
IQ	0.012^{b}	0.005	0.013	0.003 , 0.021
NRR	0.019^{a}	0.006	0.001	0.008 , 0 .031
POP	0.023^{c}	0.012	0.067	-0.002, 0 .047
EG	0.004	0.015	0.808	-0.025, 0 .032
IND	0.045	0.032	0.151	-0.017, 0.107
Total Effects				
Green technology → Sustainable development (path c)	0.021^{a}	0.002	0.000	0.017, 0.025
Green technology → Financial development (path a)	0.112^{a}	0.001	0.000	0.110, 0.114
Financial development→ Sustainable development (path b)	0.307^{a}	0.092	0.001	0.127, 0.488
Direct Effects				
Green technology → Sustainable development (path ć)	0.012^{a}	0.005	0.017	0.002, 0.022
Indirect Effect				
Green technology→ Financial development → Sustainable development (path ab)	0.034^{c}	0.015	0.024	0.005, 0.064

Continued on next page...

Structural Relationships	**Coefficient**	**S.E**	**P-value**	**C.I**
Model Fitness Indices				
Comparative Fit Index (CFI)	Tucker-Lewis's Index (TLI)	Root Mean Square Error of Approximation (RMSE)	Standardized root mean squared residual (SRMR)	Coefficient of determination (CD)
1.000	1.000	0.000	0.000	0.848

Note: [a] represents a 1% significance level, [b] represents a 5% significance level, and [c] represents a 10% significance level.

Tables 14.23 and 14.24 represent the outcomes of the robustness checks. The study uses SEM to conduct a robustness check with another proxy of SD i-e the sustainable development index. The results of robustness tests for green finance, financial development (mediator), and sustainable development are significant.

TABLE 4.24: Significance Testing of Indirect Effect

Estimates	**Indirect Effect**	**Std. Err.**	**Z-value**	**P-value**	**C.I**
Sobel	0.000	0.000	1.981	0.048	0.000 , 0.001
Delta	0.000	0.000	1.981	0.048	0.000 , 0.001
Monte Carlo	0.000	0.000	1.931	0.054	0.000 , 0.001
Path a - GT -> FD with B=0.001[b] and p=0.014					
Path b - FD -> SD with B=0.307[a] and p=0.001					
Path ć - GT -> SD with B=0.002[a] and p=0.003					

Note: [a] represents a 1% significance level, [b] represents a 5% significance level, and [c] represents a 10% significance level.

The results obtained from Sobel's test above, are significant, indicating that the mediation is partial as Path a, Path b, and Path ć are all significant. The finding suggests that the mobilization of green finance increases green ventures that increase sustainable development.

Chapter 5

Conclusion, Implications, and Future Aspects of Research

This chapter summarizes the objective and results of the study. It gives suggestions for the policy formulation. It explains the limitations of the study and the direction for future research.

5.1 Conclusion

Environmental degradation occurs when natural resources are over-exploited for the mining and processing of various basic materials. These activities have a direct impact on the environment by intensifying global warming, leading to water shortages, disturbing biodiversity, causing soil erosion, and compromising natural characteristics (Arslan et al., 2022). The attendees of the United Nations Framework Convention on Climate Change (UNFCCC) at the 21st Conference of the Parties (COP 21) in Paris achieved a momentous consensus to tackle climate change and expedite financial commitments required to guarantee a sustainable, low-carbon future. The study presented significant evidence that the N11 and BRICS countries are receiving significant assistance from natural resource rents, green finance, and green technology, supporting Financial Resource Blessings. The study employed data from N11 and BRICS countries from 2005 to 2020.

In this study, SEM is used to test the hypotheses. Financial development has a significant role in achieving affordable and clean energy (SDG 7), promoting economic growth (SDG 8), innovation of green technologies (SDG 9), and climate action (SDG 13). Environmental and socially responsible financial practices are essential to combat the serious problems caused by environmental degradation due to human interference. Restructuring business processes, such as disassociating economic growth from adverse impacts on ecological systems, can produce significant outcomes. The findings show that FD mediates the linkage between NRR, GF, GT, and SD. The comprehensive measure of financial development recommends that both financial markets and institutions facilitate projects and efforts to decrease CO_2 emissions and increase economic growth.

Fintech adoption strengthens the resource-finance nexus, resulting in an indirect and positive impact on sustainable development. Since the COVID-19 pandemic, a substantial rise in the financial institutional access ratio has been observed due to internet banking usage. Fintech adoption supports financial development in promoting green initiatives in N 11 and BRICS countries that result in reducing CO_2 emissions and supporting efficient utilization of natural resources.

The study highlights the importance of the Triple Helix model, suggesting that in today's knowledge-based economies, the alliance between academia, industry, and government should be strengthened to manage natural resource rents and adopt Fintech solutions effectively. This will further support financial development in achieving the Sustainable Development Goals. Natural resource rents are significant in capital formation. Therefore, it is necessary to adopt sustainable methods of extracting and consuming resources.

National-level policies should prioritize strategies and methods to reduce resource wastage and minimize environmental damage while effectively utilizing these finite resources, helping economies attain SDG 7 (affordable and clean energy). Countries should avoid deforestation and conserve water resources and energy (Chen et al., 2022). The mining sector should be incentivized to use cutting-edge and energy-efficient technologies to regulate the effective utilization of scarce mineral resources. Moreover, the financial sector, including markets and institutions, should jointly collaborate for sustainable growth.

The financial sector can supply green finance for adopting green technologies, and help companies that show their concerns for the environment by giving loans with low interest rates and flexible terms for repayment. Wang et al. (2021) stated that for countries that have high carbon emissions, restructuring the economy is necessary to foster the use of renewable energy and other ecologically sustainable energy sources. The government should provide more subsidies for promoting renewable energy projects while reducing subsidies for the projects that are linked with the exploration and extraction of fossil fuels. For this matter, effective regulations and governance are essential for the financial sector. Finally, financial development can reduce the damage caused by fossil fuels and the exploitation of other natural resources by reallocating their revenues to projects that foster a green environment.The government's policies can enable the economy to shift from conventional paper-based processes to a digital economy, to lower carbon emissions. Paper manufacturing is highly energy-intensive, encompassing activities such as logging, pulping, bleaching, and transportation, all of which contribute to releasing greenhouse gas emissions. The decrease in paper demand will reduce deforestation and safeguard forests that can preserve the environment by reducing CO_2.

Furthermore, a well-built regulatory framework for Fintech tools can solve concerns like cybercrime and intellectual property rights. This will increase customers' trust and the adoption rate of Fintech. Investment in IT infrastructure is significant in boosting financial accessibility. At the institutional level, adoption of Fintech tools such as Blockchain and Artificial Intelligence can raise transparency, cost efficiency, and customer convenience. Crowdfunding can ease the raising funds for green ventures. Fintech allows natural resource firms and investors to make well-informed decisions and control the price volatility of natural resources. Lastly, encouraging financial literacy among individuals is necessary to empower them to make well-informed financial decisions, thus contributing to economic growth.

5.2 Implications of the Study

In the domain of natural resources, recent literature has begun to investigate the hedging performance of cryptocurrencies, particularly Bitcoin, in portfolio

diversification and has provided extensive data (Cevik et al., 2022). Although cryptocurrencies differ from other types of assets, their performance in this setting highlights the question of whether these instruments represent a new asset class. As previously noted, being a separate asset class necessitates conventional reactions to market volatility. This pattern may also imply that these assets can be used to hedge oil or gold holdings. Fintech techniques such as blockchain can improve supply chain management by lowering transaction costs and enhancing transparency. This might lead to larger profits for resource firms, which could lead to higher rents.

AI may assist financial firms in better managing risks such as fraud, credit default, and other sorts of financial losses through the analysis of extensive amounts of data, one may uncover patterns and trends that may go unnoticed by individuals. During e-banking, AI in the form of chatbots and virtual assistants guides and supports customers, resulting in high ease and convenience for customers. AI also supports institutions in automatic loan underwriting, loan approvals, and facilitates early detection of fraud.

Thus adoption of AI may result in lowering operating costs and risk management for financial institutions. P2P lending has received a lot of attention as a result of its explosive growth in developing nations like China. With approximately $550 billion in P2P lending transactions in 2017, China has the biggest volume worldwide. Importantly, China also has the highest rate of market diffusion (Safiullah and Paramati, 2022). In the natural resource sector, they can be used to finance natural resources management-related projects such as forestry, conservation, and renewable energy. This can facilitate in the promotion of sustainable resource usage and the reduction of the negative impact of resource extraction.

The Fintech industry provides innovative methods for mitigating risks. The Fintech sector may utilize developing technologies like cloud computing, analytics, and big data to provide valuable insights into the likelihood, seriousness, and timely identification of threats (Thakor, 2020). Thus, resulting in efficient operations of stock markets. Fintech firms facilitate the acquisition and dissemination of information, simplifying the evaluation and control of risks, as well as reducing

the expenses associated with external funding. These methods are beneficial for maintaining financial stability and controlling the resource pricing mechanism.

Regulators should motivate Public-Private Partnerships (PPPs). Together government support and private funding can support environmentally sustainable projects. Therefore, the government must provide guarantees, subsidies, support for financial market access, and soft or low-cost finance to attract private capital. The level of private investment can be increased for green projects by offering financial incentives such as tax credits and exemptions. Regulatory bodies should also monitor that these incentives must be used in a real sense for the projects that have measurable contributions towards sustainable development goals.

Further, in emerging and developing countries, creating a sustainability-focused green environment at the local level necessitates alliances with international or private organizations to obtain expertise and resources. To attract capital, minimize risks linked with green projects, and boost investor returns, regulatory bodies must ensure that companies disclose all the necessary information related to green projects publicly. The process involves thorough reporting on the utilization of funds, establishing or endorsing specific auditing criteria for green finance efforts, and highlighting the unique contributions of funded projects to the Sustainable Development Goals (SDGs) and their measurable impacts.

For emerging and developing countries, the financial sector must formulate comprehensive but separate green finance rules along with the involvement of Fintech firms for the following sectors, renewable energy, sustainable agriculture, and waste management. It will help to promote and address concerns of sectors at the individual level. Technology Spillover theory suggests that Fintech adoption can facilitate financial inclusion. The adoption of Fintech can accelerate the achievement of the 2030 SDGs more effectively and cost-effectively through boosting financial inclusion. It can facilitate in raising green capital and allocating loans towards green initiatives at the local level, thereby supporting the banking industry and the green economy. Artificial Intelligence and Blockchain technology increase transparency and reduce the likelihood of fraud and greenwashing.

Finally, Governments by providing financial incentives in the form of subsidies,

loans with low interest rates, and tax credits to the enterprises adopting green technologies can facilitate financial sector in attracting more green projects for investments. Regulators can attract local and foreign investments for green ventures by developing policies that encourage carbon trading and sustainable reporting.

5.3 Limitations and Future Research Directions

The study suggests the following limitations that can be addressed by future studies to increase the applicability and generalizability of the results. This research used the data from 2005–2020 because limited data was available for the parameters used in the computation of the Fintech index of all the countries. Secondly, using the data of developed economies in the sample would improve the generalizability of the results. Thirdly, Future studies can use alternative proxies for sustainable development, green finance, and green technology to confirm the findings. Further studies could examine the extent to which globalization, urbanization, and technological innovation influence financing for a green environment, especially in developing countries, and measure whether these factors facilitate or hinder efforts to achieve the SDGs in these countries.

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Appendix

Illustrates the summary of the most relevant literature on the resource-finance nexus

Reference	Country	Data	Methodology	Variables	Relationships	Hypothesis
Bhattacharyya et al. (2014)	133 countries	1970- 2005	Panel regression	PI; FD; NR	↓PI→NR-FD	Financial resource curse
Moradbeigi et al. (2017)	63 oil-producing countries	1980-2010	Panel regression	FD; GR; OV	OV – GR; FD moderating→OV+EG	Financial resource blessings
Shahbaz et al. (2018)	USA	1960–2016	Bayer-Hanck co-integration approach	EG; FD; NR	NR + FD; Edu + FD; EG + FD; Cap – FD	Financial resource blessings
Shahbaz et al. (2020)	8 natural resource–rich countries	1970–2016	ARDL	FD; FC; NR	↑FD →NR+FC	Financial resources blessings
Asif et al. (2020)	Pakistan	1975- 2017	ARDL; VAR decomposition analysis	FD; NR; GFCF	(S.R) NR+FD; (L.R) NR-FD; GFCF+ FD	Both
Atil et al. (2020)	Pakistan	1972–2017	CQT; LRC	NR; FD; EG; Glob	EG + FD; glob– FD; NR+ FD	Financial resources blessings
Naseer et al. (2020)	South Asian countries	1990- 2017	CS; Co-integration; CS-ARDL	NR; InvFre; TI; Trade; FD	NR-FD; InvFre – FD; TI +FD; Trade + FD	Financial resources curse
Kassouri et al. (2020)	21 oil-exporting countries	1984−2016	PSTR	OP; Dem; FD; CapG	↑Dem→OP+FD; CapG +FD	Financial resources curse
Shobande et al. (2021)	Nigeria and Ghana	1970–2019	Co-integration tests; VECG	NR; SF; ENV; HDI	SF-NRA ; ENV+ NRA ; HDI + NRA	Financial resource curse
Khan et al. (2021)	Pakistan	1985-2017	ARDL	OP; Remin; FDI; XR; SMD	OP +SMD, Remin + SMD, FDI+SMD, XR – SMD	Financial resource blessings
Gu et al. (2021)	G7	1990- 2017	Co-integration test	TI; NR; FD; INC; HC; R&D	(L.R) NR; TI; INC; HC; R&D influence FD	Financial resource curse
Wang et al. (2021)	USA	1980–2018	QARDL; GCQ	NR; FD; EG; REN; NEN	NR-FD; EG +FD; REN + FD; NEN insig	Financial resource curse
Jiang et al. (2021)	China	1981–2018	QARDL	NR; GDP; GFCF; TO	NR-FD; GDP+FD; GFCF + FD; TO + FD	Financial resource curse
Umar et al. (2021)	12 oil-producing countries	2001-2019	Panel regressions	OP; BE; CRINF; DEFAULT	↑ OP – BE; ↑ OP + CRINF; ↑ OP +DEFAULT	Financial resource curse

Ma et al. (2021)	Resources-rich economies	1990-2018	Panel regressions	Remitt; Glob; GDP; HC	Remitt- FD; Globa +FD; GDP+FD; HC+FD	Dutch disease
Hadj, & Ghodbane (2021)	Countries with high & low NR income, top 34 countries in terms of NR	1984–2016	Panel regression	FD; NR; HC; Law & Order	NR-FD (countries with better-developed financial systems); NR+ FD (countries with high natural resource income); Law and order + FD ; HC + FD ↓ ; corruption + FM (countries with a developed financial sector)	Financial resource blessings
Li et al. (2021)	G7 countries	1980-2018	ARDL; Panel Co-integration test	NR; Trade; GDP; GCF; FD; FI; FM	NR+FD; Trade insig. FD; GDP+ FD; GCF- FD; NR+FM; Trade + FM; GDP insig. FM; GCF insig. FM; NR+ FI; TI+ FI; GDP+ FI; GCF- FI	Financial resource blessings
Anser et al. (2021)	81 different countries	2019-2020	Panel regression	Covid 19, EQ; OR; FD; GS; POP; F&IC; FM; RP	OR U FD; OR + GS; POP insig. FD; F&IC – FM; RP + FD	Financial resource (oil) curse
Nassani et al. (2021)	top 10 mineral abundant economies	1990-2019	GMM; ARDL	EF; FD; IP; POP; EG; EE; Trade	EF ? NR; FD-NR; IP-NR; POP – NR; EG-NR; EE+NR; Trade+ NR	Financial resource curse
Hussain et al. (2021)	23 resource-rich high-income economies	1992-2017	CS-ARDL; AMG;CCMG	NR; HC; TI; IQ; FD	IQ + FD; HC+FD; NR+FD; TI +FD	Financial resource blessings
Haque et al. (2022)	6 GCC	2000-2019	Co-integration; Granger causality; Panel regression	MS; FD; EG; OR; IQ	MS+FD; EG+FD; O R isig. FD; IQ-FD; ↓ IQ →Oil R- FD	——
Ali et al. (2022b)	Malaysia	2002- 2018	ARDL, Co-integration, Dynamic Ordinary Least Square	NR; BD; SMD; FD	NR+ SMD; EG+ SMD; IQ-SMD, NR-BD; EG + BD	Financial resource blessing (SMD), Financial resource curse (BD)
Feng et al. (2022)	11 resource-rich MENA countries	1987-2015	PMG	FD; NR; Corruption	↑ Corruption- FD; NR – FD	Financial resource curse
Han et al. (2022)	Top-10 NR abundant countries	1990-2020	The panel unit root tests; co-integration test; L.R elasticities, Panel causality approach	NR; EG; EXD; INF; FD	EXD + FD; EG+FD; INF + FD; NR-FD	Financial resource curse
Zhang, & Dilanchiev (2022)	China	2005–2020	Entropy weights	FS; NR; IS; Urban; GovTI; FDI+NR; R & D; EG	FS+ NR; IS-NR; Urban-NR; GovTI - NR; FDI+NR; R& D+NR; EG+NR	Financial resource blessing
Li et al. (2022b)	China	1990-2020	QARDL	NR; FD; Fiscal; FI; EPU	NR-FD; Fiscal+FD; FI+FD; EPU-FD	Financial resources curse

Sandow et al. (2022)	25 Sub-Saharan African	1996-2017	GMM	PI; FD; Law; INF; GDP per capita; IQ	PI+ FD; Law + FD; INF − FD; GDP per capita + FD; NR X IQ → + FD	Financial resource curse
Yıldırım et al. (2022)	Top highest natural resource 10 countries	1993–2017	Co-integration; Panel KPSS unit root test	NR; FD	NR-FD	Financial resource curse
Oryani et al. (2022)	Iran	1979-2018	QARDL; Co-integration	NR, FD, RGDP, RGFCF, HC	NR + FD; RGDP - FD; RGFCF - FD; HC - FD	Financial resource blessings
Liu et al. (2022)	MENA countries	1996- 2020	Co-integration; ARDL	Gov; NRV; FD; Glob; INC	GoV + NRV; FD-NRV; Glob- NRV; INC-NRV	Financial resource curse
Rizvi et al. (2022)	G5	2000-2019	CS ARDL; PRT; Co-integration	INF, GDP; FD; XR, OP, SMD; GP	L.R → OP+SMD; INF+SMD; GDP+ SMD; XR+SMD S.R →OP+SMD S.R → GP-SMD; L.R → GP insig.SMD	—-
Gokmenoglu et al. (2022)	Saudi Arabia	1970–2017	Co-integration, ARDL	EG; NR; Edu; CF, HC	NR-FD, HC → NR + FD, EG+FD, Edu +FD	Financial resource curse
Salari et al. (2022)	Iran	1990–2018	Regression	NR; FD; HDI; CF;PG; FDI	NR-FD; HDI → NR + FD; CF+ FD; PG+FD; FDI-FD	Financial resource curse
Ibrahiem, & Sameh (2022)	Egypt	1971–2014	ARDL	NR; FDI; Edu; CE; FD	NR- FD; FDI+FD; Edu + FD; CE+FD	Financial resource curse
Çetin et al. (2023)	33 developing countries	1983–2019	ARDL; Panel causality tests	NR; EG; Sav; CAB; FD	NR –FD; EG -FD, CAB − FD, Sav + FD	Financial resource curse
Nurmakhanova et al. (2023)	20 selected African countries	1995- 2020	TST	NR; FI; FM	NR-FI; NR-FM	Financial resource curse

VECG: Vector Error Correction Granger, CS: Cross-Sectional Dependence Test; CQT: Cross-Quantilogram technique; LRC: Long Run Covariability approach; PSTR: Panel Smooth Transition Regression; GMM: Generalized Method of Moments; VECG: Vector Error Correction Granger Causality Tests; QARDL: Quantile Autoregressive Distributed Lag: GCQ: Granger-causality in Quantiles; AMG: Augmented Mean Group; CCMG: Common Correlated Effect Mean Group; PMG: Pooled Mean Group; CS-ARDL: Cross-Sectionally augmented Auto-Regressive Distributed Lag Model; PRT: Panel unit Root Testing; TST: The spatial technique.

PI: political institutions; FD; financial development; NR: natural resource; GR: growth rate; OV: oil volatility; Edu: Education; Cap: capitalization; FC: foreign capital; GFCF: gross fixed capital formation; Glob: globalization; InvFre: investment freedom; TI: technological innovation; OP: oil prices; Dem: democracy; CapG: capital globalization; Remin: remittances inflow; HDI: human development index; XR: exchange rate; INC: income; HC: human capital, R&D: research & development; REN: renewable energy; NREN: non-renewable energy ; GFCF: gross fixed capital formation; TO: trade openness; SR: short run; LR: long run; BE: banking efficiency; CRINF: credit infection; DEFAULT: the probability of default; Remitt: Remittance; FI: financial institutions; FM: financial markets; EQ: environmental quality; ES: global sustainability; POP: population; F&IC: fatalities and infected cases; CM: capital market; RP: recovered patients; EF: ecological footprints; IP: insurance premium; EE: energy efficiency; MS: Money Supply; BD; Banking development; SMD: stock market development; EXD: export diversity, INF: inflation; SF: sustainable finance; ENV: environment; SMD: stock market development; FS: financial stability; IS: industrial structure; Urban: urbanization; GovtI: Government investment; FI: financial innovation; Fiscal: fiscal decentralization; EPU: economic policy uncertainty; Law: rule of law; RGDP: real gross domestic production; RGFCF: real gross fixed ??pit?l f?rm?ti?n; Gov: governance; NRV: natural resource volatility; INC: income; GP: gas price; CF: capital formation; PG: production growth; CE: clean energy; SAV: savings; CAB: current account balance.