



The Role of Financial Inclusion in Promoting a Green Economy in a Developing Economy

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ABSTRACT

Green economic growth is the main objective of modern-day economies, along with maximum economic growth but sustainability in environment with economic growth on the same track is another major challenge to resolve. Recently, climate change is a real threat to contemporary world economies that cause environmental degradation, rise profit risk, and human loss in developing countries. Pakistan is among the most vulnerable countries to climate change which is in developing stage and has not sufficient resources to stand the cost of climate change. This study investigates the growing challenges of environment and climate change with the help of the outcomes of financial inclusion, renewable energy, and GDP over carbon emission. The findings of Auto Regressive Distribute Lag (ARDL) model show that financial inclusion and renewable energy consumption significantly promote green economy. The data confirmed Environmental Kuznets Curve (EKC) hypothesis and provided that renewable energy consumption is negatively associated with CO₂ emission. Moreover, this study provides effective and efficient solution to the country's climate change challenges and exposes the risk of carbonization. In future, financing green technology, renewable energy consumption, and highly innovative project will further discourage carbonization. Pakistan needs to set high target of renewable energy consumption, increase energy transition, earn carbon credits and provide effective and transparent financial inclusion strategy to promote further green investment. It is also recommended to encourage those global and local financial institution who promote and invest in green projects.

Introduction

A sustainable economic growth along with sustainable environment is the prerequisite of all the nations across the world. Globalization is wrapping our economies and it is bringing economic integration, increasing trade openness that is ultimately increasing production and create huge demand for energy requirements but consequently this is also causing environmental degradation and climate change. The seventh goal of United Nation Sustainable Development Goals (UNSDGs) is to adopt affordable and clean energy consumption procedure to combat the challenges of climate change. In addition to this, 8th goal of the seventeen SDGs is inclusive and sustainable economic growth, in priority in the 8th position shed light on the importance of sustainability. Climate change is the most emerging threat to the Mother Earth since the first industrial revolution. Energy consumption from coal, oil, gas, electronics and nuclear fusion are all responsible for mass carbon emission. In the modern age of technological advancement and fourth industrial revolution we need renewable energy consumption to reduce global warming and save the planet from exhaustion. For redemption, financial advisor and investors need to invest in green sustainable projects which is long lasting and eco-friendly.

In the contemporary world financial inclusion is considered to be the most significant pillar of any economy. It promotes profitability, sustainability, eradicate poverty and inequality, reduce environmental risk, control climate change, and boost green economic development. The term FI is stated as, "The absence or non-price barriers in the use of financial service". The International Monetary Fund (IMF) seminar held on October 14, 2023 in Morocco significantly explained the importance of financial inclusion and its potential of sustainable environmental development like good economic opportunities, and growth. They suggested improving policies for further advancement in financial services to boost savings and investment. This meeting investigated into greater advantage of micro and macro level efficiency and exploring in the field of financial inclusion. Financial inclusion is an efficient tool to promote green economic variables in the short-run and also in the long run.

Financial inclusion is responsive to financial risk, it is developing and expanding with the passage of time, promoting credit services. Its core objective is to provide services to small and medium enterprises (SMEs), farmers and low-income people. Moreover, environmental degradation has significant economic impact on financial risk which can be tackle only by inclusive green finance. The central bank and financial supervise can play a key role in promoting inclusive green finance this can result to eliminate micro and macro financial risk. Volz, U., & Knaack, P. (2023) mentioned in their study that financial supervisors are still unaware of the negative externalities of climate and natural risk on financial inclusion.

This study investigates the growing challenges of environment and climate changing with the help of finding the outcomes of financial inclusion, renewable energy, and GDP over carbon emission. Focusing on financial development is to achieve certain goals of economic growth, reduction of income inequality, poverty alleviation and especially tackling the problems of climate change. Macro-empirical data show that there is a strong positive long-term impact of financial development on economic growth while a sound domestic savings and investment strengthen the indicator of financial inclusion and promote financial stability (Prasad, 2010). Financial supervisors suggest the deregulation of banks for the broad access to financial service and promotion of financial supervisory framework. The term FI is getting increasing attention from many sides specifically academia and policy makers are at the top because financial development is considered to be the main objective of developing countries.

The Environmental Kuznets Curve (EKC) hypothesis is used for environmental economics that provide empirical results of the relationship between economic growth (GDP growth) and environmental degradation. Accordingly, as an economy develops, environmental degradation initially increases but eventually decreases after reaching a certain level of income per capita (Kaika & Zervas, 2013). This creates an inverted U-shaped curve when plotting environmental impact against economic growth. However, as income levels rise, societies tend to demand better environmental quality, invest in cleaner technologies, and implement restrictive environmental regulations, which potentially lead to reduce pollution. The EKC hypothesis has been widely studied and debated. While some research supports its validity in specific contexts, others argue that it oversimplifies the complex interactions between economic growth and environmental sustainability.

Under the supervision of the State Bank of Pakistan (SBP) several steps have been taken to promote financial inclusion in Pakistan; purposely, different programs are been under taken and the most recent are; National Financial Literacy Program Phase II (2022-2027), and NFLPY 2023.

Green Economy and Carbon emission intensity: Green economy measures as low carbon emission, efficient in resource utilization and socially inclusive in use (UNEP 2024). According to a report published by Global Climate Risk Index (2020) Pakistan faces with severe climate challenges, and listed Pakistan on the 5th spot of most vulnerable countries to climate change. As six of the nine planetary boundaries of safety has been overstepped, a battle for survive is need for the inhabitants of this planet against climate change.

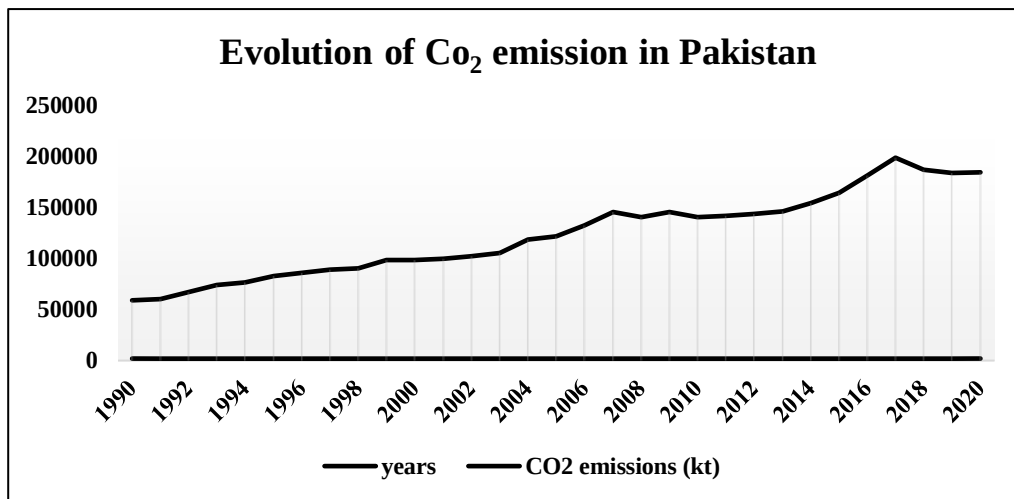


Figure 1: Evolution of Co2 emission in Pakistan since 1990

The given figure 1 highlight the increasing level of carbon dioxide emission in Pakistan since 1990 which require serious attention to curb the level of carbon emission and transform economy into green economy, otherwise the country will face severe climate challenges in the future.

Financial Inclusion: According to the Central Bank of Pakistan (SPB), financial inclusion means a formal use of financial services by everyone and the use of a range of services. In other words, access to formal financial service by individual and business for broad use standard payments, and financial products, this may full fill their needs with dignity and integrity. In May 2015 Government of Pakistan announced a National Financial Inclusion Strategy (NFIS) to increase financial inclusion in the country. The main aim of this strategy was to set a vision for universal payments and financial inclusion in Pakistan and to increase the ratio of formal financial use to 50 % by 2020 in the young generation (ZTB,2024). Different surveys conducted on financial inclusion in Pakistan since 2008 show that there is a significant increase in financial inclusion as stated by (SBP March 2024), “Pakistan successfully jumped to 60% banking services of the adult population plus 43% female citizen. Furthermore, the NFIS focuses on facilitating Mobile-wallet (M- paisa) accounts, increasing access points such as number of financial institutions and ATMs, supporting remittances through e-commerce, supporting banks to provide easy and affordable loans to everyone on micro and macro level, and increasing financial education and awareness among the citizens.

Fig 2 and 3 show the supply and demand side of financial inclusion as given by the central bank of Pakistan. The data show that there is significance increase in financial inclusion.

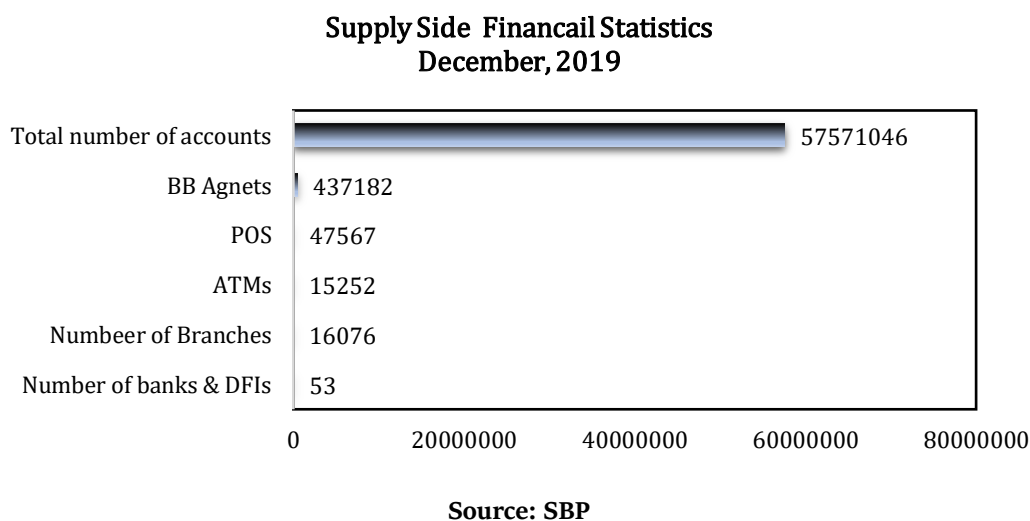
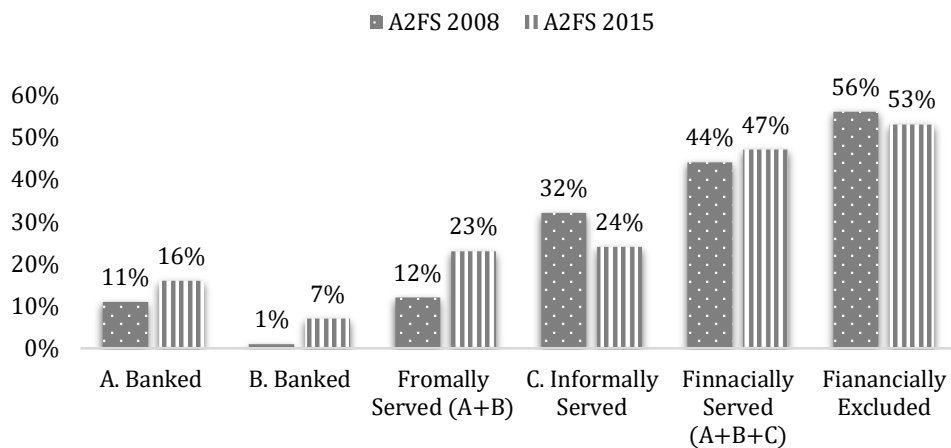


Figure 2: Supply Side Financial Statistics December, 2019

Demand Side Financial Statistics



Source: Access to Finance Survey, 2015

Figure 3: Demand Side Financial Statistics

Linking carbon emission and financial inclusion

Financial inclusion can help in reducing carbon emissions through different channels. It can directly reduce carbon emission like funding in Direct Air Capturing (DAC), investment in energy transition, adopting green finance, and funding in afforestation. On the contrary, financial inclusion has also capable of affecting carbon emission indirectly through other variables like adopting the process of decarbonization, improving the quality of education and creating awareness among the citizens, and lastly, investment in research and development. Presently, there are dozens of MNCs, NGOs, Social groups, Climate activists and intergovernmental organizations working for limiting the earth temperature. Globalization, technological progress and expansion of research and development (R&D) has changed the channel of development, as compare to the previous decade economic growth is now faster and affordable but at a very great price “the climate change”.

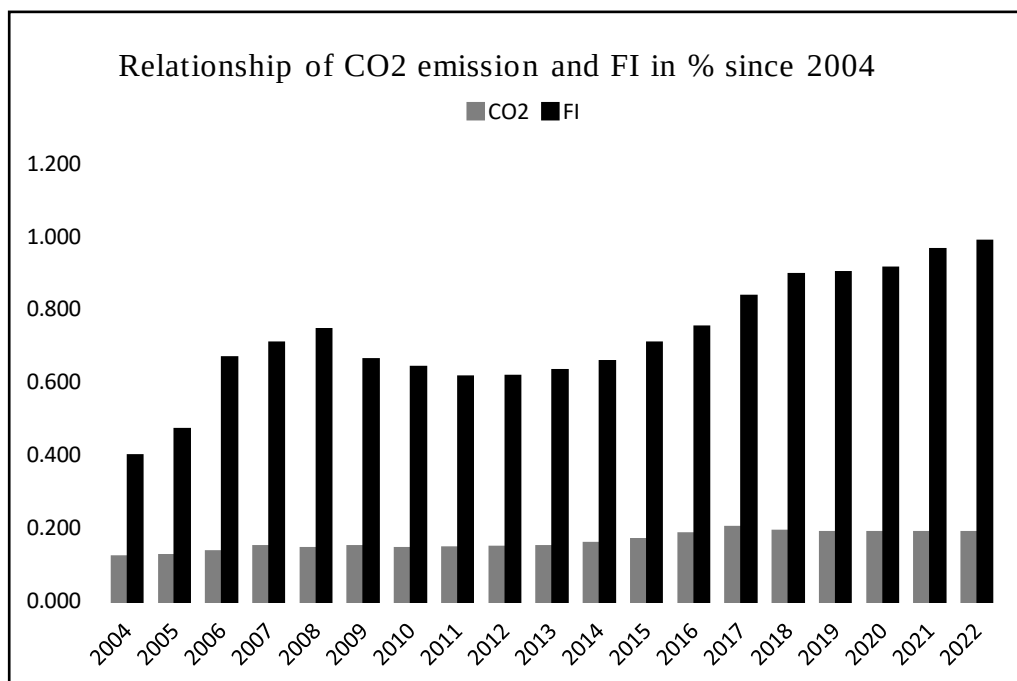


Figure 4: Relationship of CO2 emission and FI since 2004

Fig 4 shows the time relationship between CO₂ emission and growing financial inclusion (FI) in Pakistan since 2004. The data show many turning effects between 2004 and 2020; however, due to increasing attention by researchers, stakeholders, public and private sectors, financial inclusion is increasing day by day.

A direct green economic channel leads to straightforward economic pathway by which a strategy, investment or any other economic activity leads to positive environmental change or gives the outcome of green economy.

Firstly, energy transition is an effective way of reducing carbon emission. It is a process through which the traditional energy resource especially fossil fuel (like, oil, natural gas, coal, wood) transform into renewable energy resources (like hydro, wind, solar, biofuel, etc.). Additionally, replacing our vehicles with electric vehicles (EVs) and investment in renewable energy directly reduce carbon emission, as seen in many countries like in Africa M-KOPA Solar provide affordable solar system to low-income household that lead to reduce emission drastically and promote eco-enterprises. Pakistan needs \$348 billion to solve the problem of climate change in resilience and decarbonization. It is estimated that by financing the country will result by 2030, 60% of energy requirement will be full fill by renewable energy sources and 30% of all vehicles will consume electric-energy.

Secondly, there are dozens of companies working on direct air capturing process. These companies need funds to achieve their target of reducing global temperature to 1.5° (Intergovernmental Panel on Climate Change, IPCC). In addition to this, 1 Pint Five is an international company which captures carbon dioxide directly from atmosphere and store it safely underground through the process geological sequestration. Tertiary, financial organization can play a big role in leading green financing giving credit to individuals and business. Such small steps give great results in promoting green investment, green energy, and energy efficiency. SMEs which are often innovative but face the challenge of lack of funds in such cases FI facilitates SMEs and provide credit at ease. Lastly, digitalization of the financial sector including e-banking, e-wallets, and online pay directly reduce physical activities that link with financial organization, access to their product and services which apparently reduce carbon emission. The use of technology transfer traditional financial inclusion into digital financial inclusion which reduce the consumption pattern and save energy led to underconsumption services (Li Z. et al., 2020), this creates an indirect impact on reducing carbon emission.

Indirect Green Economic Channel

Firstly, decarbonization is a broad process mean to eliminate or reduce carbon emission and carbon footprint from the atmosphere. Decarbonization can be achieved through the process of energy transition, DAC and other eco-friendly techniques. The argument provided by Zaidi et al., (2019) and (S. A. R. Khan et al., 2020) state that financial inclusion removes liquidity restraint and smooth the process of resource allocation in production. Secondly, education plays a vital role in promoting awareness about climate change and environmental challenges. Research shows that countries having high literacy ratio are more aware of sustainable natural environment and prefer a low carbon economy. Tertiary, investing in R&D brings more technological advancement and create efficiency, reduce carbon footprint and advocate ecofriendly products and production processes. Wang and Zhou (2020) found that technological advancement is one of the most important factors that is potential to curb the problem of atmospheric pollution and to bring energy efficiency (Hessburg et al., 2019) while it is provide that R&D is responsible for bringing energy efficiency in production (Churchill et al., 2019; Alam et al., 2019). Lastly, financial inclusion is directly involved in afforestation and green practices because financial supervisors are now promoting practices that are environmentally friendly and less resistant to natural environment.

The problem of climate change in Pakistan needs effective and efficient environmental policies that should be backed by strong financial support and effective response. Financial inclusion is now appeared as one of the major tools in solving environmental problems. Recently, sustainable economic development is much explored by researchers however, to maintain a sustainable economic development along with sustainable environment has given less attention. Moreover, there is limited evidence on this advanced topic and no satisfactory literature has been found on the title financial inclusion and green economy in Pakistan. Contrary to this, Pakistan has been suffered a lot from flood, drought, avalanche, earthquake, heavy rain and storm, and changing season pattern affecting crops and biodiversity.

This study is conducted to response to the given objectives such as:

- Examine the role of Financial Inclusion in promoting green economy

Observation of the possible relationship of Financial Inclusion and carbon emission

The rapid change in climate pattern and weather conditions, financial risk is also increasing due to environmental degradation, global warming, and pollution which can cause low profit and inefficiency in production and leads to inequality in distribution of natural resources. It has been empirically proved that all environmental problems affect economic variables directly or indirectly and cause severe economic and social cost. To overcome the problems, this study holds potential to find the reasons of these challenges and provide empirical evidence. Certainly, this research is useful to financial institutions, financial supervisors, investors and policy makers to help them out of the challenges of high financial risk, social cost,

environmental destruction, and to prevent human loss. Besides, high innovation in the field of energy exploration the next level development in energy projects may require a large amount of finance that is to be further supported by improved and efficient financial inclusion. In addition to this, financial inclusion helps in supporting SME which has the potential to support the energy sector in Pakistan and bring micro-level energy efficiency. As a result, energy transition and energy efficiency will curb the way of carbonization. This study further provides empirical relation of financial inclusion and carbon emission and renewable energy consumption that may help in achieving the targets of the public projects like Green-Tech Hub (G-TH, 2024) project for energy transition.

Notable Efforts of the government in Environmental Policies in Pakistan

The government of Pakistan is serious about climate change and its consequences on the country's sustainable environment. No doubt, Pakistan is among the top 10 countries most vulnerable to climate change and needs \$348 (44% for adaptation plus resilience, and 65% for decarbonization), to address these environmental challenges till 2030 (World Bank estimate, 2022). For this purpose, the government of Pakistan launched a Green-Tech Hub (G-TH) in 2024 to transform the country's energy sector into more innovative, efficient and renewable energy through green technology and eco-friendly innovations in the future. This project was launched in co-operation with stakeholders of private sector, academic institutions and global green investors, the aim of this collaboration was to lead the country at the top position among sustainable economies. Furthermore, government of Pakistan planned to showcase impactful, reasonable, and innovative projects at the UN global summit on climate change the Conferences of the Parties (COP 29) held in November 2024, the aim is set to attract potential global and domestic investors to finance the country green projects and to achieve environmental sustainability. Recently, Government of Pakistan (GoP) launch different schemes to increase the activities of carbon markets in the country which is a part of the global efforts to reduce carbon. Pakistan follows the guidelines of COP29 especially Article 6 of the Baku Summit held in November 2024 but the country needs huge financial support and technical assistance to limit the expansion of carbonization and for energy transition. In addition to this, Ten Billion Tree Tsunami Project (2018-2023) is effective in mitigating CO₂ emission, a way to create jobs through afforestation and restoring natural environment. Other efforts include Renewable energy policy (2019), Pakistan's Updated National Determined Contribution (NDCs) launched in 2021, and Electric Vehicle Policy (2020). In conclusion, to overcome the consequences of climate change in case of Pakistan a huge sum of financial support and technical assistance is required immediately. The country has potential and opportunity to collaborate with global community to seek funds and participate actively in the battle against global warming.

Literature Review

Global efforts are appreciated in the field of environmental sustainability but it is not much according to the requirements. Climate of the world is changing rapidly and the unexpected natural disasters causing huge cost to human lives that make us thoughtful against the shocks of climate changes. According to a report in November 2024 commissioned by International Chamber of Commerce (ICC) the global financial cost is more than \$2 trillion in recent decade by climate changes and extreme weather conditions. Increasing human economic activities causing to rise CO₂ which is responsible for environmental degradation. The United Nations Sustainable Development Goal (SDG 13) is the main objective of the modern economies having the potential to tackle the challenges of climate change and its disastrous outcomes. Tufail et al., (2022) conclude that there is no study on the direct link between financial inclusion and carbon emission and there is satisfactory gap in the present literature which is needed to explore. Linking to this, emerging economies are worried about the unexpected changes in climate and increasing risk due to environmental degradation. The introduction of green practices has been evidently proved that environmental degradation can be potentially limit with the help of affective financial inclusion. Green economy is the need of the modern era and is consider very important subject matter it is a modern phenomenon of growing economy along with sustainable environment for which government, citizen and stakeholders (Song et al., 2023) collaborating to realize a smooth green economic growth..

Financial Inclusive Dynamics and Green Economic Growth

Inclusive financial inclusion is demanded by world economies along with sustainable environment. Increasing financial inclusion and the use of digital transaction system improve speed of economic activities, boosting trade, economic integration, reduce financial and environmental risk. Investment in green technology bring efficiency in energy consumption and reduce carbon emission. Previously, a handful literature is found on the correlation of financial inclusion and green economic growth but there is no literature in relation to Pakistan data from 2004 to 2022. This study investigates the relationship of carbon emission, financial inclusion, renewable energy consumption, GDP, inflation rate and investment, internet users and age dependency.

There exists fluent literature in the field of financial inclusion and environmental sustainability but the relationship of financial inclusion and consumption-based carbon emission still need to explore in case of developing countries like Pakistan. This study provides a composite financial inclusion index to show effectiveness on CO₂ emission along with renewable energy consumption, and GDP to fill the gap in present literature. Financial Inclusion led to Green Financial development which had ultimate effect on green economic development. In addition to this the existing literature was found mostly showing the impacts of renewable energy consumption on carbon emission while the combine effects of financial inclusion, renewable energy consumption and GDP are limited.

Financial inclusion is the subject of most concern which promote economic development but need to study in depth with green economic development. Ali, Z., Jianzhou, Y., Ali, A. et al., (2023) provided the effects of financial inclusion on carbon dioxide emissions (CO₂) for Pakistan and results of the symmetric show no cointegration among the variables over the long run. On the contrary, asymmetric results show a positive long-run relationship among the variables. The study also suggested that Pakistan need to promote its environment and economy towards green growth.

Sustainable development is the slogan of every developing country and is widely used to face the challenges of environmental degradation(Nawaz et al., 2021). The policies of financial institutions affect all sectors of economy including industry, agriculture, mining and commerce as a result business enterprises affect these financial amendments and face challenges. Therefore, green economic investment is the only solution to a steady growth and sustainable development. Furthermore, Mehmood, U., (2022) investigate the role of financial inclusion in relation to green growth and provide a detailed study on the impacts of financial inclusion, renewable energy, globalization, and other control variables on carbon emission (CO₂) to test Environmental Kuznets Curve (EKC) hypothesis.

Many studies empirically provided that financial inclusion helps in promoting a sustainable environment through the process of globalization, green-energy, and green GDP which ultimately reduce carbon dioxide emission. Zeeshan et al., (2021) confirmed the EKC hypothesis for seven emerging economies (E7 countries) through panel quantile regression analysis show that financial inclusion positively affect globalization, renewable energy consumption, and promote green practice signifies the reduction of carbon emission. Environmental sustainability is the most growing concept in the recent time (Ahmad, 2021) and is well emerging era of environmental economics that has the potential to combat the issue of climate change. Technology push forward financial inclusion and play an important role in promoting industry and new innovation. Leading to this (Din et al., 2022) conducted study to test impacts of digital financial inclusion on CO₂ emission intensity the finding conclude that digital financial inclusion has an intensive effect on domestic CO₂ reduction level.

Financial inclusion is critically considered key part of the overall process of economic growth and economic development (Le, Chu et al., 2019). But; consequently, increasing financial inclusion and economic growth potentially influence natural environment, and causing environmental degradation (Lesani et al., 2020) with increasing in demand for energy consumption and other natural resources use in the process of production (Le Quéré et al., 2020; uz Zaman et al., 2021). In some cases, financial inclusion is positive with green growth but some show a negative relation in the early stage of economic phase, this question creates more space in the existed literature (Wan et al., 2021). The conducted research for Egypt show a negative relation between digital financial inclusion and carbon emission in the long-run but not in the short-run provided that the economy is in the initial stage of digitalization (Salman & Ismael, 2023). However, financial inclusion increases economic growth and rise demand for energy which actively contribute to carbon emission and pollution (Zaidi et al., 2021). Developing economies set goals to achieve high economic growth (Renzi & Baek, 2020) without affecting natural environment. (Salman & Hosny, 2021) study on the challenges of carbon emission and a sustainable economic growth where as more funds which are provided for green investment reduce carbon emission (Wan et al., 2021).

Inclusive digital financial inclusion is the way responsible for involving those who are not access in traditional financial inclusion and this also boost economic growth (Singh & Stakic, 2021) which can direct the more funds in an environmental friendly manner and will significantly reduce carbon emission in the long-run (Zhu Liu et al., 2022; Wan et al., 2021). Liu, Z et al. (2022) analyze the connection between financial inclusion and green economy for China. The findings of the data show that the increasing financial inclusion contribute to increase green economic efficiency. Similarly, another study argues that the purpose of FI is to assist cheap, efficient and assessable form of baking system which is affordable to everyone (Ehsanullah et al., 2021).

Financial inclusion is considered as the most effective tool for bringing economic development in the UN SDGs of 2030 (Kaiser and Walters, 2019) which is also believe that financial inclusion brings economic growth (Le et al., 2020). Countries are now battling against carbonization to increase their mitigation strategies, development process including climate change polices and combinedly that can be effective to achieve synergy (Umar et al., 2021). Furthermore, the process of financial development generally attracts more investment in research and development that acquire the methods of eco-economic

development which does not damage environment. It is included that a strong financial inclusion framework encourages investors to adopt environmentally friendly projects and manufacturing process (Masson-Delmotte et al., 2021; Umar et al., 2021).

Literature on the Dynamics of Financial Inclusion and CO₂ emission

The correlation of CO₂ emission and financial inclusion is studied by numerous researchers; notably, (Faheem et al., 2024) study the relationship between financial development and green growth in Pakistan which were found negative. Similarly, Tufail, et al. (2022) inquire that there is long run relationship among CO₂ emission, financial inclusion, GDP, exports and imports. The finding from CS-ARDL show that financial inclusion, imports and GDP raise CO₂ emission on the other hand the remaining two variables energy efficiency and export reduce CO₂ emission. Financial inclusion has a vital role in promoting social inclusion, especially decrease poverty and income disparity (Anaba et al., 2024). Moreover, financial inclusion promotes sustainable development, reduce unemployment, lead to inclusive economic growth, reduce poverty and income inequality. FI is a way of long term participatory in reducing the gap of saving and investment, it facilitates economic agents and allocate economic resource in proportion, provide timely funds and capital accumulation to reduce the cost of capital, enhance efficiency in management specially in managing unexpected financial shocks and improve day today management of finance.

Inaba et al. 2020 study and examine the relationship among the economic variables for Asia, Africa, and South American counties. The study show that GDP and internet users directly affect financial inclusion. On the contrary, they conclude that dependency ration, inflation, and income inequity negatively affect the level of financial inclusion. Financial inclusion reduces carbon emission which is directly promoting green economy this relationship is also confirmed by Renzhi and Baek (2020) and stated that this relationship is an inverted U-shaped. The inverted U-shaped relationship between financial inclusion CO₂ emission state that high level of financial inclusion will force investors to adopt strict environmental policies. Usman et al. (2020) analyzed fifteen top carbon emitter countries and take financial development as a proxy variable for financial inclusion. The results were found that financial development is negatively impact carbon emission. Same is the in the study of Jalil and Feridun (2011) used data from 1953 to 2006 and applied ARDL model the results provide a negative association between CO₂ emission and financial inclusion.

Furthermore, Zaidi et al. (2021) use common correlated estimator technique on panel data for 23 OECD countries and found a positive relationship among financial inclusion, energy consumption and carbon emission both in the short-run as well as in the long-run for OECD countries. Zhao et al. (2021) proved that inclusive financial inclusion provided the speedy process of loan to investors that is going to be further invest in green technologies as a result carbon emission reduce in the short-run and in the long-run as well. The conflicting situation between increasing economic growth and ensuring environmental sustainability is concerning debate over the decade. (Faheem et al., 2024) applied ARDL model to find the association between CO₂, Green Growth (GG), GDP, FDI and Financial Development (FD), suggested that ARDL provide multiple choice to verify the existing of unit roots. Similar model is found in the study of (Salman & Hosny, 2021; Salman & Ismael, 2023).

Developing countries are easily trap in foreign direct investment which has openly a positively impact on economic growth and bring prosperity but on the contrary, it increases energy demand and carbon dioxide emission in the host country (Faheem et al., 2024); consequently, resulting in environmental deterioration. The problem of global warming due to high carbon dioxide emission in the earth's atmosphere is serious threat to global GDP and if global community do not take significant steps against this pandemic; consequently, it is predicted that global GDP to fall by 2% to 4% yearly by 2040 (Faheem et al., 2024). Therefore, green economic growth is an essential tool for the growing concern about climate change. Pakistan the most vulnerable to climate change in this decade and the research has proved that green growth is the most effective way to keep its natural environment on the sustainable path (Ullah & Lin, 2024).

With the time the consumption of huge amount of crude oil-energy a sharp increase in CO₂ emission creating enormous environmental risk and environmental cost. To tackle the problem China is reshaping its energy resources and set targets to limit carbon emission in future (Din et al., 2022; Ding et al., 2022). As a result, these targets of decarbonization are needed to achieve the targets of sustainable economic growth and sustainable environment. However, the target of Green Development is not easy to get a long-term planning is required to handle the explosion of carbonization. Many studies provided that financial inclusion increase technological innovation which bring a positive change in economy and reduce the level of CO₂ emission (Le Quéré et al., 2020) this process further reduce consumption of carbonize energy per unit of GDP (Gao et al., 2022).

UN's policies for Inclusive Green Economy Initiative agree with strong environmentally friendly policies that promote sustainable environment. Rockstrom et al., 2009 proposed planetary boundaries that humans have crossed. Moreover, an inclusive green economy directed towards the process of green production and consumption and the new generation of assets that are necessary for a sustainable environment.

Due to continuous global GDP growth of 3-4% energy demand is rising, which create severe environmental threat to global environmental sustainability. For this purpose, global community is in continuous struggle to lessen carbon dioxide emission while keeping the growth at maximum level (Ali et al., 2021). UN sustainable development goals for 2030 is to tackle the most severe threat of the modern ecosystem which is the to reduce carbon emission (Umar et al., 2021)

(Ding et al., 2022) states that financial inclusion brings technological innovation that has provide a large scale of accessibility and affordability in financial sector due to the use of technology plus traditional finance and revolutionized the way of financial development and leading toward digital financing which is a direct path toward economic development. In addition to this Ma and Gai (2019) divide the factors that influence CO₂ emission in four parts mainly; population, industry, economy, and energy (Iski et al., 2021).

Literature on Carbon emission and Renewable Energy Consumption

Recently, literature on the relationship between carbon emission and renewable energy consumption is found significantly negative, and this effectiveness is getting more attention of researchers. Studies provided that increasing renewable energy consumption cutting down the use of traditional energy resources like coal, gas, and oil that is highly carbonized, this led to reduce carbon emission significantly. (Qin et al., 2021) stress on renewable electricity output in E7 countries and provide empirical evidence in favor of the statement. Similarly, Tufail et al. (2022) and Song et al. (2022) stated that green economic efficiency is inversely associated to carbon emission. Energy economic efficiency is responsible for a significance reduction in carbon emission and promoting a green economy (Zhu Liu et al., 2022; Zhen Liu et al., 2022) while this process enhancing sustainable economic development along with sustainable environment. Moreover, the policies of financial institutions and their strategic framework for investment affect all sectors of economy including industry, agriculture, mining and commerce. The consequences of these reforms affect the motive to invest time to time; therefore, green economic investment is the only solution to a smooth and steady growth of a modern day economy.

Previously, there exists fluent literature in the field of financial inclusion and environmental sustainability but the relationship of financial inclusion and consumption-based carbon emission still need to explore in case of developing countries like Pakistan. This study found that there is no suitable literature and separate study on the title in case of Pakistan; henceforth, we fill this gap. The use of composite financial inclusion index in correlation to CO₂ is new in case of Pakistan; henceforth, this study provides a reliable and concise statement of the country's financial sector, and climate change policies. Having all said it is concluded that financial inclusion has both positive and negative effects on natural environment, and it is very complex to summarize the overall positive effect, this is a point which is worth studying. Moreover, increasing financial inclusion provides capital that create a favorable environment for investment. As a result, more job opportunity creates.

Research Methodology

Theoretical framework

The study implies quantitative approach to investigate the relationship among Financial Inclusion (FI), Renewable energy consumption (RnEn), and GDP over green economy which is measure in total carbon emission due to consumption. In addition to core variable (financial inclusion), renewable energy consumption, gross domestic product and square of gross domestic product are added to the model to test the EKC hypotheses. FI is the main independent variable and is obtain through composite financial inclusion index (CFII). CFII use three dimension and include different variables or indicators to obtain a single financial inclusion indicator for the require time period.

Simple econometric function

$$CO_2 = f(FI, RnEn, GDP, GDP^2)$$

Econometric equation

$$CO_{2t} = \delta + \delta_1 FI_t + \delta_2 RnEn_t + \delta_3 GDP_t + \delta_4 GDP_t^2$$

where,

CO₂ = Carbondioxide; Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.

FI= Financial Inclusion (measure through composite financial inclusion index range between 0 and 1

RnEn = Renewable Energy Consumption in percent

GDP= Gross Domestic Product (per capita =constant 2015 UD dollar)

GDP² = Gross Domestic Product Square

t = time

$\delta, \delta_1, \delta_2$ = Parameters

The main data sources

This study uses secondary data sources collected from International Monetary Fund (IMF) and Word Development indicators (WDI). To construct financial inclusion index, a collection of variables taken from International Financial Statistic (2024) which is reliable source from 2004 to 2022.

Table 1: The main data sources

No	Series	Measurement	Source
1	CO ₂	CO ₂ emissions (tons)	World Development Indicator (World Bank data base)
2	CFI	Derived through composite financial inclusion index ($0 \leq x_i \leq 1$)	International Financial Statistics (IFS)
3	ReEn	Renewable energy consumption (% of total final energy consumption)	World Development Indicator (World Bank data base)
4	GDP	GDP per capita (fixed 2015 US dollar)	World Development Indicator (World Bank data base)
5	GDP ²	GDP per capita (fixed 2015 US dollar)	World Development Indicator (World Bank data base)

Analytical Techniques

Presently, there are multiple approaches to show the relationship of financial inclusion and green economy, most of them adopted ARDL model and advocated that this model is most fit in case of small sample size and is good in case of different order of co-integrations. This study is also advocating ARDL model for conducting further analysis. Faheem and Farooq et al., (2024) applied ARDL model to find the association between CO₂, Green Growth (GG), GDP, FDI and Financial Development (FD), suggested that ARDL provide multiple choice to verify the existing of unit roots. Similar model is found in Salman and Ismael, (2022) study for the data 1990 to 2020 to investigate the relationship among Digital FI, Traditional FI and CO₂ emission. Examining the ARDL model Jalil and Feridun (2011) show a long-run relationship between financial inclusion and carbon emission which provided significant results.

Moreover, (Tufail et al., 2022) study BRICs economies for the same purpose using CS-ARDL model to analysis the relation of FI, CO₂ and other economic variables, where FI constructed with the help of Financial Inclusion Index using three-dimension framework. Sajjad & Altaf (2021), and (Nawaz et al., 2021) conducted research to find the response of green financial development to economic growth, data for Pakistan for this ARDL and Granger Causality were executed. There is long run relationship among CO₂, financial inclusion, renewable energy consumption and globalization (Qin et al., 2021). Salam and Ismael (2022) use ARDL model to find the impacts of digital financial inclusion and traditional financial inclusion on carbon emission; two ARDL models were used to plot the data, and finally the results were found negative between these variables. According to the need of this study ARDL model is selected to test the applicability of the variables.

Auto Regressive Distributive Lag (ARDL) model

Auto Regressive Distributive Lag (ARDL) models an econometrics model which is use to find the long-run relationship and short-run relationship between different time series variables.

$$CO_2 = f(FI, RnEn, GDP, GDP^2) \quad (1)$$

Econometric equation

$$CO_{2t} = \delta + \delta_1 FI_t + \delta_2 RnEn_t + \delta_3 GDP_t + \delta_4 GDP_t^2 \quad (2)$$

ARDL model for estimated equation

$$CO_{2t} = \delta + \sum_{i=1}^p \delta_{1i} CO_{2t-i} + \sum_{i=0}^q \delta_{2i} CFI_{t-i} + \sum_{i=0}^q \delta_{3i} ReEn_{t-i} + \sum_{i=0}^q \delta_{4i} GDP_{t-i} + \sum_{i=0}^q \delta_{5i} GDP_{t-i}^2 + \mu_t \quad (3)$$

$\delta, \delta_1, \delta_2$ = coefficients, p, q = lenth for lags

$$\Delta CO_{2t} = \delta + \sum_{i=1}^p \delta_{1i} \Delta CO_{2t-i} + \sum_{i=0}^q \delta_{2i} \Delta CFI_{t-i} + \sum_{i=0}^q \delta_{3i} \Delta ReEn_{t-i} + \sum_{i=0}^q \delta_{4i} \Delta GDP_{t-i} + \sum_{i=0}^q \delta_{5i} \Delta GDP^2_{t-i} + \delta_1 CO_{2t-1} + \delta_2 CFI_{t-1} + \delta_3 ReEn_{t-1} + \delta_4 GDP_{t-1} + \delta_5 GDP^2_{t-1} + \mu_t \quad (4)$$

ECM equation: represent short-term and long-term equilibrium

$$\Delta CO_{2t} = \delta + \sum_{i=1}^p \delta_{1i} \Delta CO_{2t-i} + \sum_{i=0}^q \delta_{2i} \Delta CFI_{t-i} + \sum_{i=0}^q \delta_{3i} \Delta ReEn_{t-i} + \sum_{i=0}^q \delta_{4i} \Delta GDP_{t-i} + \sum_{i=0}^q \delta_{5i} \Delta GDP^2_{t-i} + \delta_1 CO_{2t-1} + \delta_2 CFI_{t-1} + \delta_3 ReEn_{t-1} + \delta_4 GDP_{t-1} + \delta_5 GDP^2_{t-1} + \nu_t \quad (5)$$

Measurement of financial inclusion

Measuring financial inclusion and creating a precise financial inclusion index is a complex task due to unavailability of data and lack of significant indicators. In the existing literature, multiple direction and methods are used to measure financial inclusion. However, this study follows the composite financial inclusion index of Sarma and Pais (2008) and (Sarma, 2012, 2016). This methodology is use by large number of authors and is consider an efficient way of measuring financial inclusion. (Tufail et al., 2022) also constructed financial inclusion index from the same indicators as provided by Sarma, M. (2012). Umar and Anaba (2020) constructed a comprehensive financial inclusion index using three multiple dimensions taking penetration-dimension, availability-dimension, and the usage-dimension and finally derived a composite financial inclusion index. Sarma, M. (2008) proposed the three-dimension financial inclusion index. This index can be obtained from accessibility, availability, and usage that further uses different variables. Again, Sarma, M. (2012) added a new measure of financial inclusiveness composite Index of financial inclusion assign weights for calculating CFII.

Penetration dimension

Sarma, M. (2012) provided that penetration dimension comprises a large portion of the formal financial system. It reflects the maximum contribution of users having formal withholding account in a financial institution representing as the number of deposit accounts per 1000 adults. In addition to this, the number of depositor accounts per 1000 adults in a formal financial intuition is another indicator in the penetration dimension and it has assigned a weight of 0.4 as per the contribution in the dimension, this weight is assigned because all deposit accounts are not active in the financial sector and contribute less to the dimension (Park and Mer 2015; Amado et al. 2015; Omar et al. 2020).

Construct of three dimension of Composite Financial Inclusion Index (CFII)

Table 2: Composite Financial Inclusion Index (CFII)

Given three Dimensions							
		Penetration (I) d _p		Availability (II)d _a		Usage (III)d _u	
		1	2	3	4	5	6
Given Indicators	Six	Deposit accounts in numbers / 1000 adults	Depositors in numbers / 1000 adults	Commercial banks in numbers / 100,000 adults	ATMs in numbers /100,000 adults	Loans accounts in numbers / 1000 adults	Borrowers in numbers / 1000 adults
		Wight (w _p)		Wight (W _a)		Wight (W _u)	
		0.60	0.40	0.60	0.40	0.60	0.40
		1.00		0.80		0.80	
Weights Assign Overall, weight							

Availability dimension

Availability dimension is based on the demographic performance of the financial sector and it include the total number of branches and the number of Automatic Teller Machine of the financial institutions. This dimension is mainly composed for the accessibility of the financial service consist of two indicators: the total number of branches of commercial banks per 100,000 adults and the number ATM machines per 100,000 adults (Sarma, M. (2012); Amado 2014; Park et al. 2015; Omar 2020). At first, the number of commercial banks branches per 100,000 has assign a wight of 0.6 and the second is the number ATMs which has assign weight of 0.4 because of less contribution in the availability dimension. Although with the use of technology and e-wallet the use of ATMs is decreasing and shifting physical service toward online service or e-service. Omar (2020) assigned average weight of 0.6 to availability dimension providing that this is because of the difficulty of considering some significant variables and because of the hurdle in using these variables. By the way, we assign over all weight of 0.8 to this dimension due its important role in the availability of formal and physical institutions as given in the statement by FATF that formal financial institution helps in reducing the risk of money-laundering and fraud.

Usage dimension

This dimension is mainly composed for the measurement of efficiency of a financial institution like borrowing, transaction, saving, remittances, transfers, payments and other financial services. Usage dimension take only two indicators; the total number of loan accounts with financial institution per 1000 adults (Sarma 2012; Camara and Tuesta 2014; Inaba 2020) and the number of borrowers per 1000 adults (Sarma, M. (2012); Omar 2020). Using 0.6 weight to the number of loans accounts because of more contribution in the financial sector as all and 0.4 to the number borrowers because the ratio of lenders and borrowers are not always the same and loan accounts hold large portion in financial institution. Finally, due to lack of data and some significant variables in this dimension we assign less weight of 0.8 to over all usage dimension.

$$d_i = w_i \frac{A_i - m_i}{M_i - m_i} \quad (6)$$

Where,

w_i = wieght attacchrd to the dimension i, $0 \leq w_i \leq 1$

A_i = Actual value of the dimension i

m_i = lower limit on the value of the dimension i, (fixed)

M_i = upper limit on the value of the dimension i, (fixed)

$(X = d_1, \dots, d_n)$ where, $0 \leq d_i \leq w_i$

Provide distance of achievement point consider $(X = 0, 0, 0, 0 \dots)$ as the worst and as 1 $(W = w_1, \dots, w_n)$ as the best or an ideal situation. Both the values of w and X are normalized distances to place them between the value of 0 and 1.

$(W = w_1, \dots, w_n)$ where, $0 \leq w_i \leq 1$

Eq. (6) d_i provide a value of dimension $\square$ this case representing the economy the high the value of d_i the higher the achievement in the economy.

$$X_1 = \frac{\sqrt{d_1^2 + d_2^2 + \dots + d_n^2}}{\sqrt{w_1^2 + w_2^2 + \dots + w_n^2}} \quad (7)$$

$$X_2 = 1 - \frac{\sqrt{(w_1 - d_1)^2 + (w_2 - d_2)^2 + \dots + (w_n - d_n)^2}}{\sqrt{w_1^2 + w_2^2 + \dots + w_n^2}} \quad (8)$$

$$CFII = \frac{1}{2} (X_1 + X_2) \quad (9)$$

Results and Discussion

Descriptive statistics

The choice of ARDL provide a range of benefits including the problem of stationarity in time series data with different order of autoregression. This section provides empirical results and their meaningful description. Before applying ARDL the unit root is provided in table 4.5. Further, the Matrix of correlation, Co -integration and long run bound test is applied to test the long run and short run relationship among the variables.

Table 3 show descriptive statistics of the variables.

Table 3: Descriptive Statistics

	CO2	CFI	RNEN	GDP	GDP2
Mean	157.789	0.72056	45.7199	1406.63	2005023.
Median	145.993	0.7030	46.6000	1346.28	1812495.
Maximum	198.738	0.98355	48.1300	1696.95	2879661.
Minimum	118.313	0.3948	41.6978	1151.28	1325447.
Std. Dev.	24.6274	0.1596	2.13583	166.936	479967.1
Skewness	0.12300	-0.07257	-0.80174	0.36271	0.469128
Kurtosis	1.70368	2.4585	2.24456	1.77277	1.814322
Jarque-Bera	1.37825	0.2487	2.48729	1.60894	1.809874
Probability	0.50201	0.8830	0.28833	0.44732	0.404567
Sum	2997.99	13.690	868.679	26726.0	3809542
Sum Sq. Dev.	10917.24	0.458664	82.11248	501619.3	4.15E+12
Observations	19	19	19	19	19

Table 3 is constructed for correlation matrix shows the relation among variables, and highlight the issue of multicollinearity the finding reflects that GDP, GDP2 are positively correlated due to its mathematical relationship and non-linearity, while GDP also positively correlated with CO2 and CFI because of the limited sample size. Contrary to this, RnEn has no issue of multicollinearity at all and free of the other variables with negative correlation.

Table 4: Matrix of Correlation

	CO2	CFI	RnEn	GDP	GDP2
CO2	1.00				
CFI	0.89	1.00			
RnEn	-0.802	-0.774	1.00		
GDP	0.950	0.933	-0.779	1.00	
GDP2	0.941	0.929	-0.783	0.998	1.00

Unit Root (ADF) Test

Before applying ARDL model we test the stationarity of all the time series variables (Salman & Hosny, 2021; Salman & Ismael, 2023) to find the order of stationarity; weather the variables are stationary at level I (0), at first difference I (1), at second difference I (2), or of mix order of integration. ADF provides better understanding about the stationarity of time series data. It is easier and simple to interpret. Table 4.5 show the stationarity of the series at different condition, and different order based on the ADF test. CO2 is stationary at first difference with P-(0.0433) at 5 percent level of significance, CFI show stationarity at level including trend and intercept P-(0.0435) at $\alpha = 5\%$. Furthermore, RnEn P-(0.0079), GDP P-(0.0271) and square of GDP2 P-(0.0260) are stationary at first difference. In case of different orders of stationarity, we can move toward ARDL model. The figures mentioned in table 4.5 also show that none of the variable is integrated at second difference I (2) and all the series are I (0) or I (1), hence we can apply ARDL bound test.

Table 5: Unit Root results

ADF	Order	t-statistic	p-values
		intercept	
CO2	I(0)	-1.252746	0.6273
	I(1)	-3.129477**	0.0433
		trend and intercept	
CFI	I (0)	-3.816153**	0.0435
	I (1)	-	-
		intercept	
RnEn	I (0)	-1.402439	0.5578

	I (1)	-4.087433***	0.0079
	intercept		
GDP	I (0)	0.073718	0.9540
	I (1)	-3.376062**	0.0271
	intercept		
GDP2	I (0)	0.446292	0.9792
	I (1)	-3.397998**	0.0260

Note: ***1%, **5%, *10%

Co-integration Analysis

The F-statistic (2.756661) lies below the critical value for I (1) at the 5% and 2.5% levels, indicating no strong evidence of cointegration based on the bounds test.

The result is inconclusive since the F-statistic is higher than I (0) but lower than I (1) at conventional significance levels.

Table 6 Results of F-bound test

F-Bounds Test				
Test Statistic	Value	Significance	I (0)	I (1)
F-statistic	2.756661	10%	1.9	3.01
k	4	5%	2.26	3.48
		2.5%	2.62	3.9
		1%	3.07	4.44

Results of Auto Regressive Distributive Lage (ARDL) Model

Coefficients analysis of significant variables

ARDL results found that the coefficient of the main independent variable Composite Financial Inclusion Index (CFII) (-13.3478) is negatively associated with Carbon emission (CO₂) which is significant at 5%, conclude that as financial inclusion increases by one unit the dependent variable carbon emission reduces by -130.3478 units. These results imply that due to financial inclusion, environmental sustainability increase through technological progress and carbon emission reduce which is directly promoting green economy. This relationship is also confirmed by (Renzhi & Baek, 2020) and stated that this relationship is an inverted U-shaped. The inverted U-shaped relationship between financial inclusion CO₂ emission state that high level of financial inclusion will force investors to adopt strict environmental policies. Usman et al. (2020) analyzed fifteen top carbon emitter countries and take financial development as a proxy variable for financial inclusion. The results were found that financial development is negatively impact carbon emission mean that financial development reduce the carbon emission. Jalil and Feridun (2011) used data from 1953 to 2006 and applied ARDL model the results provide a negative association between CO₂ emission and financial inclusion. Similarly to the result in this study, Zaidi et al., (2021) also found the negative relationship between financial inclusion and carbon emission in both short-run as well as in the long-run for OECD countries. This result is expected because Pakistan is in development stage and financial inclusion is an effective instrument to reduce carbon dioxide emission and promote green economy.

On the contrary, (Tufail et al., 2022) inquire into BRIS economics for a period of 1990-2020 and the results of CS-ARDL found a positive relationship between financial inclusion and carbon dioxide emission. In conclusion of their study, financial inclusion degrades environmental sustainability in BRICS economics in the short-run.

Zhao et al. (2021) proved that inclusive financial inclusion provided the speedy process of loan to investors that is going to be further invest in green technologies as a result carbon emission reduce in the short-run and in the long -run as well.

In addition to this, renewable energy consumption reduces CO₂ emission by 6% as we increase 1% in renewable energy it is due to the consumption of energy resource that is less resistive to environment. The coefficient of renewable energy consumption is highly significant at 1% and has negatively correlated with carbon emission, and these results were found matched in the study of Z. Khan, S. Ali et al. (2020) and Fahim et al. (2024). There also exist a negative effect of Renewable energy consumption on CO₂ emission (Ali et al., 2021; S. A. R. Khan et al., 2020; Z. Khan et al., 2020; Le Quéré et al., 2020). This results also indicate that the immediate effects of renewable energy consumption can be results in environmental sustainability.

Increasing GDP growth create pressure on energy requirements that is positively affecting CO₂ emission to increase and the study found a positive correlation between CO₂ emission and GDP (Z. Khan, S. Ali et al. 2020). In contrast to CFI and RnEn Gross Domestic Product (GDP) is positively associated with carbon emission with 1.499 percent and is significant at $\alpha=5\%$. Conclude that a one unit increase GDP boost CO₂ emission by 1.499 unites. There is found a short -run positive relationship between CO₂ emission and GDP. These results were also found by Jebli et al. (2016); Le et al. and Khan et al. (2020). This figure also confirms that in the initial stage of economic growth increasing GDP causing environmental degradation and high carbon emission.

GDP square provides -0.000519 coefficient with significance level of $P = 0.0167$ which indicate that GDP is negatively related and provide an inverted U-shaped relationship between GDP and carbon emission, and confirm the Environmental Kuznets (EKC) hypothesis. After high economic growth carbon emission reduce as the country invest in green technology. Similar results were found in the study of (Hassan et al., 2022; Tufail et al., 2022) and Wahab et al., (2021) which confirmed environmental theories of the ECK hypothesis and STIRPAT model in case of the relationship between GDP and carbon emission. Finally, researchers provided that increasing GDP will consequently increase carbon dioxide emission.

Table 7: Results of ARDL

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
CO ₂ (-1)	0.008332	0.452491	0.018414	0.9859
CFI	-130.3478	50.48135	-2.582097	0.0417
RNEN_	-6.233298	0.785055	-7.939953	0.0002
RNEN (-1)	-3.001738	3.281405	-0.914772	0.3956
RNEN_(-2)	-1.998095	1.051965	-1.899393	0.1063
GDP	1.499483	0.476036	3.149938	0.0198
GDP(-1)	0.890565	1.299974	0.685064	0.5189
GDP(-2)	-1.496867	0.902132	-1.659254	0.1481
GDP_2	-0.000519	0.000158	-3.287059	0.0167
GDP_2(-1)	-0.000238	0.000428	-0.556799	0.5978
GDP_2(-2)	0.000514	0.000325	1.582837	0.1645

Insignificant Variables

The coefficient (0.008332) of CO₂ (-1) with $P = 0.9859$ implies that there is positive but insignificant relation which its lagged dependent variable. It is concluded that previous value of carbon emission does not affect current value of carbon emission. In addition, the lagged values of RENE (-1) also indicate that current value are more effective than the previous value and same in the case of RENE (-2). Coefficients of GDP (-1), GDP (-2), GDP² (-1), and GDP² (-2) are also insignificant, which indicate that their lagged effects do not contribute strongly to the model.

In addition to this, the value of R-squared (0.9948) Indicates that 99.5% of the variance in CO₂ emissions is explained by independent variables which is obtain within the model. The high R-squared and adjusted R-squared values indicate a well-fitting model, although due to small sample size the overfitting may a concern given many numbers of forecasters. While the value of Durbin-Watson Statistic (2.2787) provides that there is no significant autocorrelation in the residuals.

ARDL Long Run Form and Bounds Test

ARDL Bound test provide insight into the long-run relationship between CO₂ and CFII, and the other series including RNEN, and GDP. The test of stationarity of Table 4.5 shows that none of the variable is integrated at second difference I (2) and all the series are I (0) or I (1), hence we can apply ARDL bound test (Salman & Ismael, 2023). (Tufail et al., 2022) confirmed a long-run co-integration among CO₂, financial inclusion, energy efficiency, and other control variables in BRICS economies. carbon emission in the short-run and

Long-run relationship

ARDL long relationship or level relationship show a long-run relationship between variables. The coefficient of FI (-131.44) is significant at 5 percent with P-value of 0.0041 which indicate that increasing financial inclusion (FI) reduce carbon emission (CO₂) in the long-run. Renewable Energy Consumption (RnEn) is also negatively associated with carbon emission, as the coefficient -11.327 is highly significant with $P=0.0003$ and the figures conclude that increasing the use of renewable energy consumption bring down carbon emission in the long run.

Furthermore, Gross Domestic Product (GDP) is responsible for increasing proportion of 0.9006 units addition into consumption-based Carbon dioxide in the long-run. Contrary to this, taking the square of GDP (GDP²) show a negative association of -0.0002 units with carbon emission and is highly significant with P-value of 0.0006. This indicate that as GDP grow in the long-run the rate of carbon emission reduces due to technological advancement and economic expansion. This this also satisfy the validity of Environmental Kuznets Curve (EKC).

Table 8: ARDL Long-run relationship

Levels Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
CFI	-131.4430	29.19357	-4.502463	0.0041
RNEN_	-11.32751	1.490317	-7.600742	0.0003
GDP	0.900686	0.109036	8.260432	0.0002
GDP_2	-0.000245	3.68E-05	-6.644348	0.0006

Short-run relationship or Short-run dynamics

Table 3 show the short-run dynamics of variables and Error Correction Term (ECT)-0.991668 is significance at 10% (P = 0.0709) indicate that 99% of the deviation from the point of equilibrium is corrected after a shock in one period and this show a moderate adjustment toward equilibrium. In addition, D-RNEN with negative coefficient -6.233298* show that due to renewable energy consumption carbon dioxide emission reduce immediate by 6 units as a respond to one unit increase in FI. D-GDP (-1) has an increasing effect on carbon emission as stated the coefficient of 1.499483 and significant at 1% which means that GDP is responsible for 1.4 units increase in carbon emission. Briefly, renewable energy reduces carbon emission very significantly while GDP increase CO₂ temporarily.

Table 9: Conditional Error Correction Regression

Conditional Error Correction Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO ₂ _TONS (-1)*	-0.991668	0.452491	-2.191577	0.0709
CFI**	-130.3478	50.48135	-2.582097	0.0417
RNEN_(-1)	-11.23313	4.324695	-2.597439	0.0408
GDP(-1)	0.893182	0.342880	2.604937	0.0404
GDP_2(-1)	-0.000243	9.03E-05	-2.686074	0.0362
D(RNEN_)	-6.233298	0.785055	-7.939953	0.0002
D(RNEN_(-1))	1.998095	1.051965	1.899393	0.1063
D(GDP)	1.499483	0.476036	3.149938	0.0198
D(GDP(-1))	1.496867	0.902132	1.659254	0.1481
D(GDP_2)	-0.000519	0.000158	-3.287059	0.0167
D(GDP_2(-1))	-0.000514	0.000325	-1.582837	0.1645

The above table also show that the coefficients of short-run variables are consistent with long-run coefficient of the variables as proved by the identical signs of the long-run and short-run estimators. The ECT indicates the system gradually returns to equilibrium after a shock.

Table 10: Results of T-Bounds Test

t-Bounds Test				
Test Statistic	Value	Signif.	I (o)	I (1)
t-statistic	-2.191577	10%	-1.62	-3.26
		5%	-1.95	-3.6
		2.5%	-2.24	-3.89
		1%	-2.58	-4.23

The t-statistic (-2.191577) does not exceed the critical value for I (1) at the 5% level but exceeds I (o). This further supports the bounds test result: no conclusive evidence of cointegration.

Conclusion and Suggestions

The main objective of this study observed that the data appear negative between composite financial inclusion (CFI) and consumption-based carbon emission (CO₂). The effects of renewable energy consumption (RENE), gross domestic product (GDP) and GDP square are also studied as control variables. ARDL results found that the coefficient of the main independent variable Composite Financial Inclusion Index (-13.3478) is negatively associated with Carbon emission (CO₂) which is significant at 5%. These results imply that due to financial inclusion, environmental sustainability increase through technological progress and carbon emission reduce which is directly promoting green economy. In addition to this, renewable energy consumption reduces CO₂ emission by 6% as we increase 1% in renewable energy, it is due to the consumption of energy resource that is less resistive to environment and do not permit CO₂ emission.. Increasing GDP growth create pressure on energy requirements that is positively affecting CO₂ emission to increase, this study found a positive correlation between CO₂ emission and GDP. In contrast to CFI and RnEn; GDP is positively associated with carbon emission with 1.499** percent. There is a short -run positive relationship between CO₂ emission and GDP which confirms that in the initial stage of economic growth increasing GDP causing environmental degradation and high carbon emission. GDP square provides - 0.000519** coefficient which indicate that GDP is negatively related and provide an inverted U-shaped relationship between GDP and carbon emission, and confirm the Environmental Kuznets (EKC) hypothesis.

It is recommended that Pakistan need to reduce carbon dioxide emission and increase green growth through financial inclusion process which is more effective in promoting green economic growth. It has been provided that financial inclusion increases energy efficiency by bringing technological advancement and research and development. This role may further extend to establish polices framework for the country to increase financial inclusion and promote green growth. Moreover, financial inclusion shares more benefits with investors who promote green investment and ensure sustainable environment. Green-Tech Hub (G-TH, 2024) is an efficient project of the country to reduce carbon emission which can be finance by financial inclusion and green investment. It is need of the time to support and provide finance in the sectors like Electric vehicle (EV) companies, renewable energy sector and ensure energy efficiency through technology.

The study also provided that renewable energy sources are effective in the short-run as well as in the long-run that reduce carbon emission directly while this also indicate that Pakistan needs to invest more in renewable energy resource to bring efficacy and environmental sustainability. Pakistan is facing sever environmental challenges and it can be solved through the development in financial inclusion and renewable energy consumption. Additionally, financial inclusion will be more effective in reducing carbon emission when it is diverted into projects like green investment, green bonds, green energy and green agriculture.

Due to limited data in financial sector the core variable, financial inclusion data is selected since 2004 because there is no data available earlier than 2004. Consequently, the results obtain would not specifically represent the exact analysis. Additionally, this study base on composite financial inclusion index composes by Sarma (2012) which is limited to selected variables, dimension and weight criteria is very sensitive to choose. In further, more study is in need in the field to over these challenges. In case of Pakistan limited control variables (renewable energy, GDP and GDP²) are selected due lack of data, further studies can expand the channel and the addition of more variables.

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