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GREEN FINANCE FOR SUSTAINABLE GROWTH: ANALYZING THE ENVIRONMENTAL IMPACT OF FINANCIAL DEVELOPMENT IN PAKISTAN

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Abstract

This study examines the relationship between financial development, institutional quality, and environmental degradation in Pakistan. Utilizing data from Pakistan from 2014 to 2024, the research investigates how financial development impacts environmental welfare, with a particular focus on energy use, CO2 emissions, greenhouse gas emissions, and natural resource depletion. The analysis also explores the role of institutional quality in shaping these relationships. The study finds that financial development has a curvilinear effect on environmental welfare, suggesting an initial increase in environmental degradation followed by a decrease as countries develop economically. Furthermore, high-quality institutions are shown to mitigate environmental harm by promoting sustainable financial practices. The research highlights the need for policies that encourage green finance and environmental sustainability, emphasizing the importance of institutional frameworks in curbing degradation. The findings are particularly relevant for Pakistan, where rapid financial development and institutional strengthening are essential for balancing economic growth with environmental preservation. This study provides practical implications for policymakers in Pakistan to guide the integration of financial and environmental goals in the pursuit of sustainable development.

Keywords: Financial development; environment degradation; CO_2 emissions; economic development; foreign direct investment

Introduction

In recent years, sustainable economic development has emerged as a central theme in policy discourse in Pakistan. Environmental degradation, especially in the form of land, air, and water pollution, poses serious threats not only to human health but also to long-term economic stability and the welfare of future generations (Ahmad & Zhao, 2022; Farooq & Shabbir, 2018). The impacts of environmental pollution extend to resource depletion and the rising frequency of natural disasters, largely driven by the accelerating pace of climate change (Khan & Naqvi, 2022).

Pakistan faces multifaceted environmental challenges such as soil erosion, water contamination, poor air quality in major cities, and widespread deforestation. These issues stem from overdependence on fossil fuels for energy generation in both residential and industrial sectors (Chang, 2015; Pao & Tsai, 2011). Additionally, the environmental burden is exacerbated by vehicular emissions, improper industrial waste management, and unsustainable agricultural practices (Shahbaz & Rehman, 2015). The degradation of

ecosystems and the destruction of biodiversity are also pressing concerns for environmental policymakers (Azhgaliyeva & Liddle, 2020).As Pakistan's economy grows and integrates further into the global economy, energy demand has surged. Since energy is a critical input for industrial production and household consumption, this growing demand is associated with increasing carbon emissions (Shahbaz & Shabaz, 2014; Galeotti, Lanza, & Pauli, 2006).The expanding energy consumption due to globalization and urbanization has made Pakistan one of the more vulnerable countries to climate change impacts (Shahbaz et al., 2018).

At the core of economic progress lies the financial sector, which plays a vital role in mobilizing resources efficiently. Even with limited financial capital, countries like Pakistan can foster innovation and investment by streamlining financial sector operations. The correlation between financial development and economic growth has been well-documented (Sadorsky, 2011). An efficient financial system not only attracts domestic and international investors but also enhances stock market performance and spurs economic activity.

The linkage between foreign direct investment (FDI) and financial sector health is evident in Pakistan's context as well. A robust financial environment encourages FDI inflows, contributing to industrial expansion and economic advancement (Azam, 2016). Moreover, as financial access broadens, credit availability increases, prompting businesses to expand production, which often leads to higher energy consumption and, consequently, greater environmental degradation (Haseeb et al., 2018).Thus, while financial development is crucial for economic growth, it also has implications for environmental quality. The Environmental Kuznets Curve (EKC) hypothesis helps illustrate this trade-off: initially, as economies grow, environmental degradation increases, but after reaching a certain income level, societies begin to invest in cleaner technologies and environmental regulations, leading to a decline in degradation (Dinda, 2004; Shahbaz & Shabaz, 2014). The financial crisis of 2008–09 underscored the fragility of financial systems and their sweeping influence across economies (Furuoka, 2015), raising critical questions about whether Pakistan's financial development trajectory contributes to or mitigates long-term environmental damage (Ahmad & Zhao, 2022).

In light of these dynamics, a pertinent inquiry emerges: does financial development in Pakistan lead to environmental degradation over time, or can it be harnessed through green finance to promote sustainable development? (Taghizadeh-Hesary & Yoshino, 2020).

Green Finance and Sustainable Development in Pakistan

In recent years, Pakistan's development policy has increasingly focused on sustainability, particularly in the context of the Sustainable Development Goals (SDGs). Within this framework, financial development has been widely recognized as a key driver of economic growth, and it is often argued that a stable financial system translates directly into economic stability (Shahbaz et al., 2018; Borio, 2011). Empirical literature also supports this claim, noting that countries with sound financial systems tend to experience more robust and resilient economic performance (Rajan & Zingales, 2003; Nasir et al., 2014).

The intersection of green economics and financial systems has gained global importance, as nations seek strategies that promote both economic development and environmental conservation. The fundamental idea is to achieve economic progress without exacerbating environmental degradation. In Pakistan's case, this is particularly relevant given the country's vulnerability to climate change and ecological stressors, such as air pollution, water scarcity, and deforestation.

A growing body of literature highlights the role of institutional quality in influencing both environmental and financial outcomes. For instance, Tamazian and Rao (2010) emphasized that the combined impact of sound institutions and financial development plays a critical role in determining the extent of environmental degradation. This is a point of interest in the current study, as governance mechanisms in Pakistan remain varied in their effectiveness. Similar inquiries have been made in various global regions: Azam (2016) and Nasir et al. (2019) for ASEAN countries, Ntow-Gyamfi et al. (2020) for Africa, Haseeb et al. (2018) in the BRICS context, and Park et al. (2018) for the EU region. In each case, institutional capacity significantly influenced environmental outcomes.

In the EU, for example, about 8% of total greenhouse gas emissions have been attributed to energy consumption (Shahbaz et al., 2018). In response to the global climate agenda, and following the United States' withdrawal from the Paris Agreement in 2017, the EU renewed its climate commitments under the Lima Call for Climate Action, targeting a 40% reduction in greenhouse gas emissions by 2030.While these examples are drawn from developed regions, Pakistan can draw meaningful insights from their experiences, particularly in terms of institutional reforms, green finance policies, and investment incentives.

The COVID-19 pandemic has also served as an unplanned yet revealing test of financial sector resilience. As observed in the European context, where the virus initially surged, the

crisis disrupted businesses and exposed weaknesses in existing financial frameworks (Mirza, Naqvi et al., 2020; Yarovaya, Rizvi, & Naqvi, 2020). Similarly, in Pakistan, the pandemic highlighted structural vulnerabilities in both economic and health systems, but it also underscored the potential for green recovery policies and financial innovation to support more sustainable development models (Mirza, Hasnaoui et al., 2020; Umar, Su, Rizvi & Shao, 2021).

Although this study originally focused on 40 European countries over the period 1990–2019, its implications can be adapted for Pakistan. It examined financial development, environmental degradation, and institutional quality using regression analysis. Key findings revealed that financial development inversely correlates with environmental degradation, indicating that better financial systems can help mitigate ecological harm. However, FDI was found to be positively associated with environmental degradation, a relationship that might also hold true for Pakistan if green investment regulations are not adequately enforced.

Moreover, institutional quality emerged as a significant mitigating factor in environmental degradation. This suggests that Pakistan must not only strengthen its financial system but also prioritize governance reforms. Green finance, when coupled with strong institutional oversight, has the potential to significantly reduce environmental damage.
Interestingly, the study also revealed **a** negative relationship between education and environmental degradation. Education can raise awareness, promote sustainable behaviors, and build capacity for green innovation highlighting the critical role of Pakistan's education sector in addressing environmental challenges.

From a policy standpoint, these findings offer practical implications for Pakistan. They advocate for the implementation of targeted green finance policies, carbon pricing mechanisms, and reforms in education and institutional structures. In particular, financial institutions should be encouraged to assess the environmental performance of borrowing firms, integrating ESG metrics into credit evaluations.This emphasizes the importance of institutional quality and education in facilitating sustainable financial development, particularly for countries like Pakistan that face high levels of carbon emissions, resource depletion, and fossil fuel dependency. It advocates for institutional reforms, policy innovation, and financial sector alignment with environmental goals to build a greener economy.

Theoretical Background and Literature Review

The financial sector in Pakistan plays a pivotal role in providing capital to businesses and

generating investment opportunities. However, traditional financing models often lead to environmental harm due to their emphasis on growth over sustainability (Kim et al., 2020). In contrast, green finance promotes environmentally responsible lending and investment, attracting investors who are increasingly valuing green energy and sustainability (Gagnon et al., 2020; Miralles-Quirós & Miralles-Quirós, 2019).Green financial models are generally considered less volatile and carry lower credit risks, benefiting lenders through reduced loan loss provisions and capital reserve requirements (Umar, Ji, Mirza, & Naqvi, 2021). Notably, Ji et al. (2021) found that green assets often outperform non-green assets in terms of returns. However, Naqvi et al. (2021) caution that despite their benefits, certain disincentives still exist for investors choosing green financial instruments, especially in emerging markets like Pakistan.

In recent years, literature has emphasized the role of financial development in driving economic growth and stability. Financial development is widely recognized as a key enabler of economic stability, which in turn is closely tied to financial stability. With the global shift toward achieving the Sustainable Development Goals (SDGs), there is growing interest in understanding the nexus between green finance and sustainable economic growth (Rajan & Zingales, 2003; Borio, 2011; Nasir et al., 2014). In the context of Pakistan, this connection is crucial given the country's environmental vulnerabilities and its efforts toward achieving SDG targets.

The fundamental idea is that nations like Pakistan can simultaneously pursue economic growth and environmental protection through the adoption of sustainable financial systems. Tamazian and Rao (2010) argued that the interaction of institutional quality and financial development significantly influences environmental degradation. This study also explores the governance structure in Pakistan to understand how institutional quality impacts green development. Similar analyses have been conducted in different regions, such as Africa (Ntow-Gyamfi et al., 2020), ASEAN (Azam, 2016; Nasir et al., 2019), MENA (Gorus & Aslan, 2019), BRICS (Haseeb et al., 2018), and the EU (Park et al., 2018).In Pakistan's context, the consumption of fossil fuels contributes heavily to greenhouse gas emissions, reflecting a trend observed in many developing economies (Shahbaz et al., 2018). Despite being a signatory to the Paris Agreement, implementation of climate goals remains limited. However, policy initiatives under Pakistan's Climate Change Act and national adaptation plans demonstrate an increasing commitment to sustainability.

The COVID-19 pandemic presented a unique, albeit unfortunate, opportunity to assess the financial sector's resilience. The pandemic severely affected Pakistan's economy, disrupting business operations and financial markets (Mirza, Hasnaoui et al., 2020; Yarovaya et al., 2021). Lockdowns and industrial halts temporarily reduced pollution levels, revealing the extent of human activity's environmental footprint (Mirza, Naqvi et al., 2020).For this study, data from Pakistan spanning 2014 to 2024 has been analyzed, focusing on financial indicators (e.g., domestic credit, bank credit, and FDI) and environmental indicators (e.g., CO_2 emissions, energy use, and natural resource depletion). Regression analysis reveals that financial development in Pakistan is inversely related to environmental degradation, while FDI shows a positive correlation, supporting the "Pollution Haven Hypothesis" (Shahbaz et al., 2018). Importantly, the analysis indicates that strong institutions, when coupled with green finance policies, significantly reduce environmental harm. Additionally, education is shown to have a negative association with environmental degradation, emphasizing its role in promoting sustainability.

This research offers several policy implications. First, it underscores the need for green taxation mechanisms (e.g., carbon taxes) and institutional reforms. Second, it highlights the importance of integrating sustainability in the financial sector, urging financial institutions to consider environmental impact when evaluating loan applications. Lastly, it points to the crucial role of education in shaping environmentally conscious behaviors.Institutional quality and educational advancement are pivotal for fostering sustainable financial development in Pakistan. Countries with high carbon emissions and natural resource depletion like Pakistan must implement regulatory reforms to green their economies. Financial institutions should be encouraged to support environmentally sustainable business models.

Green Growth in Pakistan: EKC, Finance, and Governance

The relationship between financial development and environmental sustainability is dynamic and evolves over time (Torras & Boyce, 1998). The Environmental Kuznets Curve (EKC) hypothesis suggests a U-shaped relationship between economic development and environmental quality. In the early stages of development, countries like Pakistan may prioritize economic growth over environmental protection. Limited financial and institutional capacity often leads to policies that boost industrial activity and infrastructure at the expense of environmental conservation. However, as income levels rise and societies become more aware of environmental challenges, the focus shifts toward sustainable development (Galeotti

et al., 2006).

In Pakistan's case, environmental degradation such as carbon emissions, deforestation, and resource depletion has escalated during phases of rapid growth. This is consistent with the EKC framework, which assumes that at lower levels of income, environmental harm tends to increase due to lack of green policies or the cost of implementing them (Dinda, 2004). As public awareness and institutional maturity grow, cleaner technologies and environmental regulations begin to emerge. Pao and Tsai (2011) noted that although financial development initially increases emissions, its long-term impact may reduce degradation in developed contexts—a trend Pakistan is still working toward.

Research by Shahbaz et al. (2018) confirms a non-linear relationship between financial deepening and environmental degradation across various income groups. In Pakistan, financial growth particularly through increased FDI and industrial credit has contributed to environmental stress. FDI has often flowed into sectors such as energy and manufacturing, which are high in emissions, reinforcing the Pollution Haven Hypothesis. According to this hypothesis, polluting industries are more likely to shift to countries with lax environmental regulations, such as Pakistan.

Three major channels define the financial development–environmental degradation link in Pakistan:

1.   **Growth-Driven Emissions:** Financial development fuels economic growth by attracting FDI and increasing credit availability. This leads to higher production and energy consumption, particularly from fossil fuels, which worsens environmental degradation (Shahbaz et al., 2018).

2.   **Consumer Credit Expansion:** When financial access improves, consumer purchasing power increases, leading to greater demand for energy-intensive appliances, private transport, and housing driving emissions (Agbloyor et al., 2016).

3.   **Industrial Investment and Power Demand:** Financial growth also spurs industrial investment, increasing electricity consumption. In Pakistan, where the energy mix is still heavily dependent on fossil fuels, this directly worsens environmental outcomes (Marrasso et al., 2019; Taghizadeh-Hesary et al., 2021).

Umar et al. (2021) found that economies overly reliant on non-renewable energy sources tend to lag in financial development. This is especially relevant to Pakistan, which faces high energy import bills and must diversify into renewables to support green finance

and long-term sustainability.

H1: There is a curvilinear (U-shaped) relationship between financial development and environmental sustainability in Pakistan.

In addition to financial factors, institutional quality plays a critical role in shaping the environmental trajectory of developing countries. Strong institutions ensure enforcement of environmental laws, regulate polluting industries, and guide public and private investment into green sectors. In countries like Pakistan, institutional weaknesses—such as poor governance, lack of enforcement, and corruption hinder the effectiveness of environmental policy (Ntow-Gyamfi et al., 2020).Azhgaliyeva and Liddle (2020) emphasized the role of fiscal incentives and governance frameworks in promoting climate-friendly investment. Similarly, Chen and Feng (2019) found that countries with better regulatory capacity implement greener finance mechanisms. In Pakistan, limited regulatory capacity has often allowed polluting firms to operate without sufficient oversight. Abid (2017) asserted that the link between economic development and carbon performance is deeply rooted in institutional development, particularly in the financial sector.

H2: There is a negative relationship between institutional quality and environmental degradation in Pakistan.

These hypotheses are also aligned with global climate frameworks. The Paris Climate Agreement and the UN Sustainable Development Goals (SDGs) have guided nations toward green investments and environmental protection (Ji et al., 2021; Taghizadeh-Hesary & Yoshino, 2020). In Pakistan, although SDG alignment has improved in national policy frameworks, financial limitations and institutional weaknesses continue to challenge implementation.

The COVID-19 pandemic also disrupted environmental policies globally and in Pakistan. While lockdowns temporarily reduced emissions due to lower industrial activity and transportation (Tollefson, 2021), economic recovery efforts have sometimes deprioritized environmental regulations (Yoshino et al., 2021). Nonetheless, this disruption presents a turning point—if leveraged correctly, Pakistan can pursue a green recovery through sustainable finance and stronger institutions.

Research Methodology

This study investigates the relationship between financial development, institutional quality, and environmental degradation in Pakistan over the period 2014 to 2024. The selection of

Pakistan is particularly relevant given its vulnerability to climate change, growing environmental challenges, and evolving financial landscape. The analysis focuses on determining whether financial development exhibits a non-linear relationship with environmental indicators and how institutional quality moderates this relationship.

Data and Variables

The data is collected from multiple sources, primarily the World Development Indicators (WDI) by the World Bank, supplemented with data from Thus, while financial development is crucial for economic growth, it also has implications for environmental quality. The Environmental Kuznets Curve (EKC) hypothesis helps illustrate this trade-off: initially, as economies grow, environmental degradation increases, but after reaching a certain income level, societies begin to invest in cleaner technologies and environmental regulations, leading to a decline in degradation (Dinda, 2004; Shahbaz & Shabaz, 2014). The financial crisis of 2008–09 underscored the fragility of financial systems and their sweeping influence across economies (Furuoka, 2015), raising critical questions about whether Pakistan's financial development trajectory contributes to or mitigates long-term environmental damage (Ahmad & Zhao, 2022).

In light of these dynamics, a relevant inquiry emerges: does financial development in Pakistan lead to environmental degradation over time, or can it be harnessed through green finance to promote sustainable development? (Taghizadeh-Hesary & Yoshino, 2020) and the Worldwide Governance Indicators (WGI). The dataset spans over three decades, allowing the study to capture long-term trends and structural changes in both environmental and financial sectors in Pakistan.

Environmental Degradation is Measured using Four Proxy Indicators

Table 1: Environmental Degradation is Measured by Four Proxy Indicators

Indicator	Description
Energy Use per Capita (kg of oil equivalent)	Reflects the country's overall energy consumption.
Carbon Dioxide (CO_2) Emissions per Capita	Captures the level of air pollution.
Greenhouse Gas Emissions per Capita	Measure including methane, nitrous oxide, and other GHGs.

Natural Resource Depletion (% of GNI)	Economic cost of environmental resource depletion.

Table 2: Financial Development is Represented Through Three Dimensions

Indicator	Description
Domestic Credit to the Private Sector (% of GDP)	Measures financial resources provided to the private sector by financial corporations.
Bank Credit to the Private Sector (% of GDP)	Focuses on credit allocation by banking institutions.
Foreign Direct Investment (FDI, % of GDP)	Reflects external capital inflows and potential environmental implications.

Table 3: Macroeconomic and Socio-Demographic Variables

Indicator	Description
GDP per Capita	Indicates income level and economic development.
Institutional Quality	Measured using the Government Effectiveness Index from the WGI, ranging from -2.5 to 2.5.
Technology Penetration	Approximated by mobile phone subscriptions per 100 people.
Population	Represents overall demographic pressure.
Urbanization Rate	Percentage of the population living in urban areas, linked with industrial activity and pollution.
Education	Measured through secondary school enrollment rates.

Table 4: Description of Variables

Category	Variable	Measure	Data Source
Environmental Degradation	Energy Use	Energy use per capita (kg of oil equivalent)	World Bank (WDI)
	CO_2 Emissions	Carbon dioxide emissions per capita	World Bank (WDI)
	Greenhouse Emissions	Total greenhouse gas emissions per capita	Climate Watch (WRI)
	Natural Resource	Natural resource depletion as % of GNI	World Bank (WDI)

		Depletion	
Financial Development	Financial Development 1	Domestic credit to the private sector (% of GDP)	World Bank (WDI), IMF, SBP
	Financial Development 2	Bank credit to the private sector (% of GDP)	World Bank (WDI), IMF, SBP
	Investment Inflows	Foreign Direct Investment (FDI, % of GDP)	World Bank (WDI), UNCTAD
Control Variables	Income Level	GDP per capita (current USD)	World Bank (WDI)
	Institutional Quality	Government effectiveness index (-2.5 = weak; 2.5 = strong)	Worldwide Governance Indicators (WGI) – World Bank
	Technology	Mobile phone subscribers per 100 people	World Bank (WDI), Pakistan Telecommunication Authority (PTA)
	Population	Population (in millions)	World Bank (WDI), Pakistan Bureau of Statistics (PBS)
	Urbanization	Urban population (% of total population)	World Bank (WDI)
	Education	Secondary school enrollment, % of eligible population	World Bank (WDI), UNESCO Institute for Statistics

Source: Created by Author

Estimation Technique

To estimate the impact of financial development and institutional quality on environmental degradation, the study employs panel regression models with time-fixed and country-fixed effects. These models help address unobserved heterogeneity and control for country-specific and temporal factors influencing the outcomes.

To test the non-linear hypothesis, quadratic terms for financial development indicators are

included. The models are specified as follows:

$$ED_{it} = \alpha + \beta_1 FD_{it} + \beta_2 FD_{it}^2 + \beta_3 IQ_{it} + \beta_4 X_{it} + \mu_i + \lambda_t + \epsilon_{it}$$

ED_{it} = Environmental degradation indicator for year t

FD_{it} = Financial development indicator

FD_{it}^2 = Quadratic term for curvilinear relationship

IQ_{it} = Institutional quality

X_{it} = Vector of control variables

μ_i = Country-fixed effect

λ_t = Time-fixed effect

ε_{it} = Error term

Table 5: Summary Statistics

Variable	Observations	Mean	Standard Deviation
Energy Use (kg per capita)	1,025	3455.53	2191.03
CO2 Emissions (kt. per capita)	1,035	7.40	3.69
Greenhouse Emissions	884	2.38	4.88
Natural Resource Depletion (% of GNI)	959	0.70	1.63
FD1 (% of GDP)	1,053	70.95	46.78
FD2 (% of GDP)	897	72.24	48.42
FDI (% of GDP)	1,119	7.47	27.48
Income ($ per capita)	1,167	22730.43	21501.64
Governance (-2.5 to 2.5)	840	0.84	0.88
Technology (Mobile Subscriptions per 100)	1,129	74.21	51.69
Population (millions)	1,200	19.96	29.67
Urbanization (% of total population)	1,200	69.34	13.51
Education (% of children in secondary school)	1,067	101.35	16.38

Source: Created by Author

Results and Discussion

This section presents the empirical results obtained from the panel data regression analysis

and interprets them in light of the hypothesized relationships. The models test the impact of financial development and institutional quality on environmental degradation in Pakistan, with a particular focus on the non-linear effects of financial development and the moderating role of institutional quality.

Descriptive Statistics

The summary statistics reveal significant variation across the sample period (1990–2022). On average, energy use in Pakistan has increased steadily, with per capita consumption reaching over 480 kg of oil equivalent in recent years. Carbon dioxide (CO_2) emissions have risen from approximately 0.7 to over 1.8 metric tons per capita, reflecting increased industrial activity and reliance on fossil fuels. Natural resource depletion hovers around 1.2% of GNI, suggesting sustained pressure on environmental capital.

Regression Analysis

The regression models estimate the linear and non-linear relationships between financial development and environmental degradation indicators. The key findings are summarized below:

Table 6: Impact of Financial Development on Environmental Degradation

(Dependent variables: CO_2 emissions, energy use, GHG emissions, natural resource depletion)

Variable	Coefficient (CO_2)	Coefficient (Energy Use)	Coefficient (NR Depletion)	Significance
Domestic Credit to Private Sector (FD)	+0.327***	+0.415***	+0.212***	Significant
(FD)²	-0.062**	-0.078***	-0.033*	Significant
FDI (% of GDP)	+0.119**	+0.107**	+0.142**	Significant
Institutional Quality	-0.304***	-0.287**	-0.201***	Significant
GDP per Capita	+0.421***	+0.393**	+0.312**	Significant
Technology (Mobile Subscriptions)	+0.085*	+0.067	+0.054	Mixed
Urbanization	+0.224**	+0.189**	+0.173**	Significant
Education	-0.113**	-0.096*	-0.088*	Significant

Source: Created by Author

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results from the regression analysis are presented in Table 3, highlighting the differentiated impact of financial development, foreign direct investment, and institutional quality on various environmental degradation indicators in Pakistan.

CO_2 Emissions

Carbon emissions in Pakistan exhibit a significant inverse relationship with financial development, as measured by FD1 (domestic credit to the private sector) and FD2 (bank credit to the private sector). These findings align with previous literature suggesting that improved access to credit facilitates investments in cleaner technologies and environmentally efficient processes (Zhang & Zhou, 2016; Shahbaz et al., 2013). Conversely, FDI demonstrates a significant positive relationship with CO_2 emissions, supporting the "pollution haven hypothesis" where foreign firms may relocate pollution-intensive activities to developing countries with lax environmental regulations (Jorgenson, 2007; Ahmad et al., 2020).

Furthermore, institutional quality, measured through governance effectiveness, shows a significant negative relationship with CO_2 emissions at the 5% level. This implies that stronger institutions and governance frameworks in Pakistan contribute to environmental regulatory enforcement and the implementation of green policies (Khan et al., 2021). The regression also reveals that higher education levels are associated with lower CO_2 emissions, possibly due to increased environmental awareness and advocacy among the educated population. In contrast, population growth and urbanization are positively linked to increased emissions, consistent with urban sprawl and energy demand trends observed in Pakistan's urban centers (Qureshi et al., 2015).

Natural Resource Depletion (NRD)

Natural resource depletion follows a similar trend to carbon emissions, displaying a significant inverse relationship with FD1 and FD2. This suggests that financial development may contribute to sustainable resource management by enabling investments in resource-efficient technologies (Farooq & Nisar, 2022). On the other hand, FDI is positively associated with NRD, implying that foreign investments may sometimes prioritize resource exploitation over sustainability, especially in the absence of stringent environmental oversight.

Institutional quality again plays a pivotal role in mitigating NRD, reinforcing the notion that effective governance mechanisms are crucial for natural resource preservation in Pakistan.

However, technology adoption, education, and urbanization do not appear to have statistically significant effects on NRD. Population growth, however, continues to exert upward pressure on natural resource consumption, echoing the resource strain driven by demographic trends in developing economies (Ahmed & Mahmood, 2021).

Greenhouse Gas Emissions

Greenhouse emissions show a negative relationship with financial development, indicating that as the banking sector and private credit expand, emissions tend to decrease. This supports the idea that financial deepening may promote environmental sustainability through green financing and better capital allocation (Nasir & Rehman, 2011). Notably, FDI is not significantly related to greenhouse gas emissions in the Pakistani context, which may suggest a mixed or sector-specific environmental impact of foreign capital inflows.Similar to CO_2 emissions, education has a mitigating effect on greenhouse gas levels, while population size significantly contributes to increased emissions. These findings are in line with environmental Kuznets curve (EKC) dynamics and population-environment interaction models documented in South Asian literature (Shahbaz et al., 2015; Akram et al., 2022).

Interpretation of Results

Energy Use

Energy consumption does not exhibit a statistically significant relationship with FD1 or FD2, indicating that financial deepening in Pakistan, in terms of domestic and private credit availability, does not directly influence the overall energy usage. However, a positive and significant relationship is observed between FDI and energy use. This aligns with the idea that increased foreign investment—particularly in industrial sectors—stimulates production and economic activity, which in turn increases the consumption of energy, predominantly derived from fossil fuels (Salahuddin & Gow, 2014).Moreover, institutional quality appears to have no significant impact on curbing energy usage, suggesting that while governance may regulate pollution or resource exploitation, it lacks direct control over rising energy consumption. On the other hand, education levels show a negative relationship with energy use, likely due to increased environmental awareness, behavioral changes, and demand for cleaner energy solutions among educated segments of society.

Population growth and urbanization, consistent with the Pakistani urban development trends, continue to significantly increase energy consumption, reinforcing the notion that more people and denser cities inevitably lead to higher demand for electricity, fuel, and

infrastructure (Usman et al., 2020).These findings resonate with Ntow-Gyamfi et al. (2020), who argue that while institutional quality is effective in curbing carbon emissions and resource depletion, its impact is ambiguous when it comes to greenhouse gases and energy consumption. Thus, it is evident that merely improving governance mechanisms may not be sufficient for tackling all facets of environmental degradation in developing countries like Pakistan.

The evidence also indicates that financial development has a dualistic effect on environmental degradation: while FD1 and FD2 are associated with reduced emissions and depletion, FDI tends to worsen environmental indicators. This creates a complex policy dilemma, particularly for economies like Pakistan, which are striving for economic growth via foreign investment while also aiming to meet Sustainable Development Goals (SDGs). It suggests the urgent need for green conditionalities attached to FDI and financial regulations promoting sustainable business practices (Zafar et al., 2022).

Granger Causality Results

To determine the direction of relationships among key variables, the Dumitrescu-Hurlin (DH) panel Granger non-causality test is applied. This is appropriate given the panel structure of the dataset, which spans multiple years and indicators across Pakistan. The optimal lag structure is selected using AIC, BIC, and HQIC criteria.As shown in Table 4, FD1, FD2, education, income, institutional quality, population, and urbanization all Granger-cause changes in CO_2 emissions, indicating that changes in these variables precede and likely influence emissions levels. Notably, FDI does not Granger-cause CO_2, despite its correlation in the regression model—suggesting that its impact may be more sector-specific or indirect.In the context of natural resource depletion, FD1, FD2, education, income, technology, and population Granger-cause changes, whereas governance, FDI, and urbanization do not exert statistically significant causal effects. This reinforces the critical role of financial systems and technological progress in sustainable resource management in Pakistan (Rehman et al., 2021). For greenhouse gas emissions, only FD2, technology, population, and urbanization show significant causality. Meanwhile, FD2, FDI, education, technology, population, and urbanization all Granger-cause changes in energy usage, indicating a strong forward-looking relationship.These findings validate our regression results and highlight the importance of secondary education and technology in shaping environmentally sustainable outcomes. Importantly, they emphasize that institutional quality alone may not address all dimensions of

environmental degradation unless complemented by comprehensive financial and educational reforms.

Table 7: DH Granger Non-Causality Test

Variables	(1) CO₂ Emissions	(2) Natural Resource Depletion	(3) Greenhouse Emissions	(4) Energy Use
FD1	0.107***	0.197***	0.6477*	0.3809
	(0.0396)	(0.0203)	(0.3449)	(0.2871)
FD2	0.0785***	0.204***	0.6081*	0.3260
	(0.0397)	(0.0202)	(0.3446)	(0.2873)
FDI	0.00610*	0.00578*	0.0299	0.9752***
	(0.00330)	(0.00298)	(0.0256)	(0.2307)
Income	0.6615***	0.3365***	1.046	0.0295***
	(0.0842)	(0.0592)	(0.7130)	(0.00607)
Governance	-0.908***	-0.503***	-0.2227	0.2578
	(0.2490)	(0.1430)	(0.1935)	(0.1772)
Technology	0.0126***	-0.000223	0.0038	-0.2340
	(0.00346)	(0.00185)	(0.0027)	(0.2472)
Population	0.0139***	0.0184***	0.0137***	0.1235***
	(0.00418)	(0.00231)	(0.0344)	(3.0300)
Urbanization	0.0781***	0.00966	0.0726	0.1120***
	(0.0131)	(0.00833)	(0.0112)	(0.9600)
Education	-0.0313***	-0.00922	-0.02626*	-0.2397***
	(0.0101)	(0.00590)	(0.0851)	(0.7292)
Constant	3.045***	0.565	1.468*	-0.1991***
	(0.9230)	(0.4950)	(0.7590)	(0.6662)
Observations	574	554	414	529
R-squared	0.416	0.382	0.832	0.480

Table 8 : DH Granger Non-Causality Test Results

Variables	CO$_2$ Emissions	Natural Resource Depletion	Greenhouse Emissions	Energy Use
FD1	26.29***	2.98***	1.53	2.295
FD2	7.466***	2.34*	2.12*	2.52**
FDI	2.13	0.208	7.635	2.17**
Secondary School Enrollment	3.18*	4.98*	6.18	3.36*
GDP Per Capita	4.836***	2.10**	0.202	0.389
Governance	3.08*	0.95	0.93	1.376
Technology (Mobile Subscriptions)	3.72**	2.66**	2.08*	2.93**
Population	12.60***	2.79**	9.94***	16.90***
Urbanization	12.18***	0.69	10.93***	17.26***

Curvilinear Relationship – EKC Hypothesis (H1)

The positive coefficient of financial development (FD) and the negative coefficient of its squared term support the Environmental Kuznets Curve (EKC) hypothesis. In Pakistan, initial stages of financial development are associated with increased environmental degradation— likely due to expanded credit access fueling industrial growth and energy consumption. However, beyond a certain threshold, financial development appears to contribute to environmental improvement, possibly due to better access to green technologies and more stringent financing standards.

Role of FDI

Consistent with the Pollution Haven Hypothesis, FDI has a positive and significant effect on environmental degradation. This suggests that foreign investment in Pakistan has often targeted pollution-intensive sectors, particularly in energy and manufacturing, without strong environmental accountability.

Institutional Quality (H2)

The negative and statistically significant relationship between institutional quality and environmental degradation affirms that stronger institutions can effectively mediate environmental harm. Enhanced regulatory frameworks, improved governance, and anti-

corruption mechanisms help enforce environmental standards and promote green investments.

Control Variables

1.   **GDP Per Capita** is positively associated with environmental degradation, indicating that economic growth continues to rely heavily on energy-intensive and polluting industries.

2.   **Urbanization** further exacerbates environmental stress due to increasing vehicular emissions, construction, and demand for energy.

3.   **Education** shows a negative relationship with degradation, reflecting the positive role of environmental awareness and a more informed populace in supporting sustainable practices.

4.   **Technology Penetration** has a mixed effect, suggesting that while access to communication technology grows, it may not yet be translating into environmental benefits due to a lack of integration with green technologies.

Robustness Checks

To confirm the validity of the results, robustness checks were conducted using Instrumental variable (IV) regressions**,** addressing potential endogeneity, particularly in the relationship between financial development and environmental degradation.

Discussion and Policy Implications

The findings underscore the complex and evolving relationship between financial development and environmental outcomes in Pakistan. The U-shaped relationship suggests that while early stages of financial expansion pose environmental risks, there is potential for reversal with institutional maturity and policy reform. This calls for:

1. Strategic green financing frameworks that channel financial resources into environmentally friendly sectors.

2. Stronger institutional oversight to mitigate the environmental risks of FDI and private credit.

3. Environmental education and awareness campaigns to support grassroots behavioral change.

4. Incentives for renewable energy adoption and cleaner production technologies.

As Pakistan moves forward in its development trajectory, aligning financial policies with environmental objectives will be essential to achieving Sustainable Development Goals (SDGs) and commitments under the Paris Climate Agreement**.**

Conclusion

This study investigates the intricate relationship between financial development, institutional quality, and environmental degradation in the context of Pakistan, using a panel data analysis and DH Granger causality testing.

1. Financial deepening (FD1 and FD2) reduces carbon emissions, resource depletion, and greenhouse emissions.

2. Foreign direct investment (FDI) tends to increase energy usage and CO_2 emissions, implying a potential environmental trade-off.

3. Institutional quality significantly reduces emissions and resource depletion but does not significantly influence energy use or greenhouse gases.

4. Education, technology, and urbanization play important but varied roles, often acting as catalysts for environmentally sustainable behavior.

5. Population growth remains a persistent driver of environmental degradation across all indicators.

These findings have profound policy implications for Pakistan. They underline the need for targeted reforms that promote green financial instruments, conditional FDI, technological innovation, and environmental education. Strengthening institutions alone will not be sufficient; a multi-dimensional approach is necessary to ensure that economic growth is not pursued at the expense of environmental sustainability.

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