Green Finance and Natural Resource Management: A Novel Evidence of Environmental Kuznets Curve Hypothesis in Pakistan

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Abstract

Green financing serves as a vital instrument for driving economic growth while safeguarding the environment by curbing the depletion of natural resources. In this regard, Pakistan is implementing policies aimed at fostering green innovation, particularly within the energy sector, to encourage a sustainable shift in resource utilization patterns. This study uses the period of 1990 to 2023 to explore the relationship between green financing and natural resource management in Pakistan to evaluate the effectiveness of these policies in enhancing natural resource sustainability. The results of Autoregressive Distributed Lag reveal negative impact of renewable energy consumption on resource rent. The findings of the study further reveal that the peak turning point of EKC under green growth 1.696 thousand USD between 2015 to 2016, while the turning point for green financing 48.18 % during 2013. Both turning points lie within the sample period indicating that Pakistan has reached the level where increase in per capita GDP and renewable energy consumption reduces the use of natural resources. This calls for an integrated and sustainable policy framework based on green financing and natural resource management.

Keywords: Renewable energy consumption, natural resource management, green financing, sustainable development, Pakistan.

JEL classification: O13; O44; P28; P48; Q26.

Introduction

Natural resources are considered fundamental to economic development because they serve as a backbone for industrial activities, trade, and technological advancement (Zaidi et al., 2019). However, unregulated use of these resources leads to resource depletion, lowering economic stability and environmental sustainability (Gangadhara, 2020). Although natural resource rents provide substantial income for resource-rich countries, the lack of an effective management strategy not only reduces economic growth but also restricts development opportunities (Seifi & Crowther, 2017). Thus, strategic management of natural resources is not only essential for a sustainable economic future but also critical for mitigating environmental risks and climate change (Hassan et al., 2021).

Renewable energy and green financing have become central to driving economic growth by leveraging alternative energy sources and fostering sustainability. Investments in green financing play a significant role in enhancing economic output as well as helping in reducing environmental degradation (Abramovitz et al., 2001). For example, the BRICS nations' financial development plan stresses innovation, sustainable economic growth, and the utilization of plentiful resources (Nawaz et al., 2021). This approach emphasizes how innovation and resource optimization contribute to equitable and sustainable growth in the global economy (Permana et al., 2024). Natural resources remain critical for economic growth and development, particularly in emerging economies. However, by encouraging sustainable activities and renewable energy sources, technical improvements are essential to attaining green growth. Making green growth a priority reduces the reliance on natural resources, encourages sustainable growth, and slows down environmental deterioration (Kasztelan, 2017). In this regard, this study examines the role of green financing on natural resource management under Environmental Kuznets Curve (EKC) hypothesis.

Green financing has gained significant attention in literature due to the pressing need to address economic and environmental challenges (Mudalige, 2023). It entails providing funding to companies, initiatives, or funds that have a high priority on environmental sustainability (Khan et al., 2024). A more

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sustainable future is ensured by green funding, especially in clean technologies, energy efficiency, and renewable energy. Green financing entails various financial tools to promote economic growth and protect environment, thus it serves as a significant process for any government to address challenges associated with climate change such as reducing emissions and energy transition. The rising concerns regarding climate change, natural resource depletion and environmental degradation have strengthened the debate of sustainable development policy framework. The term sustainable development is used to ensure the ability of natural resources to fulfil the needs of present and future generations (Xing et al., 2024). In this context, the motivation behind green financing is that it facilitates a key mechanism to achieve socio-economic and environmental goals of sustainable development.

Green financing supports economic and business activities that promote efficient use of natural resources and resultantly protect the environment. Additionally, it is an effective instrument to create a balance among economic, social, and environmental goals, promoting long-term economic resilience and bringing about good change (Liang et al., 2024). Due to resource scarcity and the rising climate change, green finance is a crucial tool for promoting sustainable development. It enables investment in resource-efficient methods, renewable energy sources, and eco-friendly technology. The shift from resource-intensive development models to sustainable economic systems can be accelerated by incorporating green finance into policy frameworks. The necessity for green funding is indicated by the worldwide goal to become carbon neutral by 2050. According to analysis, achieving net-zero carbon emissions by 2050 will cost over 125 trillion USD (UNFCCC, 2021). Even though spending on low-carbon technology rose by 20% (USD 755 billion) in 2021 compared to 2020, the targeted investment levels have not yet been reached (Alsagr & Ozturk, 2024). Although there has been a global push to increase green investment, the share of green financing is relatively low in Pakistan.

Natural resource rents and green financing have a complicated and multifaceted interaction. Resource rent is the key source of revenue for resource-rich nations. However, an excessive dependence on extractive sectors results in environmental deterioration, economic instability, and the resource curse (Bashir et al., 2023). Sustainable growth is hampered by this reliance, which frequently takes political and financial resources away from green finance. Notwithstanding these obstacles, many nations are recognizing the need of economic diversification and the use of natural resource rent to fund green development projects. Resource-rich nations have started setting up sovereign wealth funds to finance sustainable infrastructure and renewable energy initiatives (Bellakhal, Kheder & Haffoudhi, 2019). Similarly, major polluting economies have started to use the incomes obtained from natural resources to channel green financing (Bhutta et al., 2022).

Shah et al. (2020) examined the relationship between economic output and natural resource utilization and found that natural resources harmed output. In the process of economic growth natural resources are depleted, therefore countries adopt new and green and environment-friendly technologies for protecting environmental stability and exclusively natural resources. Green technologies promote innovation and introduce environmentally friendly products (Cai & Le., 2023). China used a green finance hub to access international green capital, bridging funding gaps and accelerating sustainable urban development. By aligning regulatory frameworks and creating a transparent cross-border green finance platform, China fully harnesses the potential of green finance, driving its ecological civilization and achieving its sustainable development objectives (Alsagr & Ozturk, 2024). The Rapid development of green finance encompasses various aspects that contribute to a sustainable future. Green finance seeks to balance financial actions with environmental responsibility, supporting projects and investments that promote eco-friendly practices. By fostering an eco-conscious financial system, green finance helps to build infrastructure and pollution that prioritizes environmental sustainability while driving economic growth (Chi et al., 2023).

The prime objective of this study is to examine the impact of green financing on natural resource management. The contribution of this study to existing literature is two-fold. First, there has been limited evidence on establishing the relationship between green finance and natural resource management. The novelty of this study lies in exploring how green financing affects natural resource utilization. This analysis is crucial for aligning natural resource management with sustainable development goals. The study hypothesizes that an increase in green financing enhances resource efficiency, leading to a reduction in natural resource consumption while emphasizing sustainable development and environmental preservation. By doing so, green financing has the potential to convert natural resource rents into a driving force for climate resilience and ecological sustainability. In this regard, this study is the first to empirically examine the impact of green finance on natural resource management. Second, this study contributes to the literature by analyzing the presence of the Environmental Kuznets Curve hypothesis under green growth and green financing regimes. Literature-to-date examines the EKC hypothesis by relating GDP with Emissions (Hashmi et al., 2024; Li et al., 2024; Mohamed et al., 2024; Nizamani et al., 2023). However, confirming EKC under green finance and green growth regimes would provide valuable insights for policymaking, enabling them to design effective policies that promote a sustainable future. The following sections are organized as follows: section 2 explores the research method; section 3 discusses the results while section 4 concludes the paper.

Data and Research Methodology

Data and sample

This study employs natural resource rent to measure natural resource management in Pakistan. This indicator helps to study how the use of green financing affects the sustainable use of natural resources. The negative coefficient implies that an increase in independent variables causes a reduction in natural resources which supports sustainable development goals. The core independent variable in this analysis is renewable energy consumption, which serves as a proxy for green financing (Qadri et al., 2023). Literature indicates that in cases where data on green financing is not available, particularly in developing countries, renewable energy consumption can be used as a suitable measure (Qadri et al., 2023). While the literature employs green credit and green investment as indicators of green financing, data on these measures is limited for Pakistan (Agirman & Osman, 2019; Ye & Dela, 2023). Consequently, this study utilizes renewable energy consumption as a proxy for green financing. This approach aligns with the perspective of Nawaz et al. (2021), who suggest that achieving environmentally sustainable goals is possible through financial investments in green technologies that not only promote growth but lead towards a sustainable economy. Along with this, various control variables including foreign direct investment (FDI), information and communication technology, terms of trade, and economic growth. The data for these variables was obtained from World Development Indicators (WDI) from 1990 to 2023. FDI is measured as net inflow percentage of GDP, GDP growth is used to measure economic growth while Terms of trade of used to measure trade openness. The summary statistics of these variables are shown in Table 1. The dependent variable Natural resource rent has a mean value of 1.74 and has 0.58 percent variation around its mean showing moderate dispersion in resource management strategies in Pakistan. Renewable energy consumption shows a 48.92 mean with a low variability of 4.3 percent indicating a stable policy framework. ICT ranges between 6.52 to 37.45 showing a dispersion of 8.68 in digital infrastructure data in Pakistan. Table 1 shows the variation in economic growth in Pakistan. It lies between -1.27% to 7.8 percent showing diverse economic conditions in the country that could have an impact on resource allocation as well. Per capita GDP is expressed in thousand USD while terms of trade are obtained in billion Rupees.

Table 1. Descriptive Statistics

	Mean	**Std. Dev**	**Minimum**	**Maximum**
Natural Resource Rent	1.742	0.583	0.965	2.891
Renewable Energy Consumption	48.92	4.35	41.6	58.1
Foreign Direct Investment	0.927	0.659	0.31	3.04
Information and Communication Technology	16.561	8.686	6.52	37.45
Economic Growth	4.012	2.090	-1.27	7.83
Per capita GDP	1.260	0.234	0.956	1.696
Terms of Trade	524.209	564.839	-216.46	1685.3

Methodology

Researchers employed different methods and techniques to scrutinize the relationship among the variables in time series. The first step in estimating the desired model involves testing the order of integration of underlying time series because applying OLS on non-stationary time series provides spurious results (Dougherty, 2011). Thus, for reliable results, the unit root among series is checked by employing the Augmented Dickey-Fuller (ADF) test. Several methodologies have been employed to examine long-run relationships among variables, prominently including the residual-based approach by Engle and Granger (1987) and the modified ordinary least squares (OLS) procedures proposed by Phillips and Hansen (1990). Along with this, multivariate cointegration techniques, including maximum likelihood estimation methods developed by Johansen (1988; 1996) and Johansen and Juselius (1990), have been extensively utilized in empirical research. However, these cointegration methods are based on one common assumption of series being stationary at the same order of integration, showing these techniques cannot be employed on the data possessing different levels of integration. Pesaran, Shin, and Smith (2001) proposed the autoregressive distributed lag (ARDL) model, also referred to as the bounds testing approach, that allowed for estimating long-run relation among the variables that are stationary at levels I (0) or at first differences I (1). This flexibility has significantly enhanced its applicability in empirical studies and this study as well.

$$NRM_t = \delta_0 + \delta_1 REC_t + \delta_2 FDI_t + \delta_3 ICT_t + \delta_4 GDP_t + \delta_5 TOT_t + \varepsilon_t \qquad (1)$$

This study employs the ARDL approach to estimate the relationship between green financing and natural resource management in Pakistan. Equation 2 shows the ARDL framework of our model with intercept.

$$\Delta NRM_t = \delta_0 + \delta_{1i} \sum_{i=1}^{n} \Delta NRM_{t-i} + \delta_{2i} \sum_{i=1}^{n} \Delta REC_{t-i} + \delta_{3i} \sum_{i=0}^{n} \Delta FDI_{t-i} + \delta_{4i} \sum_{i=0}^{n} \Delta ICT_{t-i} + \delta_{5i} \sum_{i=0}^{n} \Delta GDP_{t-i} + \delta_{6i} \sum_{i=0}^{n} \Delta TOT_{t-i} + \delta_7 NRM_{t-1} + \delta_8 REC_{t-1} + \delta_9 FDI_{t-1} + \delta_{10} ICT_{t-1} + \delta_{11} GDP_{t-1} + \delta_{12} TOT_{t-1} + \varepsilon_t \qquad (2)$$

A bound test is employed to confirm the existence of the long-run relationship between variables. Bounds test check the null hypothesis of no cointegration ($H_0\colon \delta_7 = \delta_8 = \delta_9 = \delta_{10} = \delta_{11} = \delta_{12} = 0$) against the alternative ($H_1\colon \delta_7 \neq \delta_8 \neq \delta_9 \neq \delta_{10} \neq \delta_{11} \neq \delta_{12} \neq 0$). The bounds test computes the F-statistic and tests it with the upper and lower bound limits proposed by Pesaran et al. (2001). If F-statistic is larger than the upper bound, the null hypothesis will be rejected while if it is lower than the lower bound, the null hypothesis is not rejected. The optimal lag value ‘n’ in equation 2 is selected based on the Akaike lag selection criteria. If bound tests confirm the existence of cointegration, the next step is to estimate long-run ARDL equation 3.

$$NRM_t = \delta_0 + \delta_{1i} \sum_{i=0}^{m} NRM_{t-i} + \delta_{2i} \sum_{i=1}^{n} REC_{t-i} + \delta_{3i} \sum_{i=1}^{o} FDI_{t-i} + \delta_{4i} \sum_{i=1}^{p} ICT_{t-i} + \delta_{5i} \sum_{i=1}^{q} GDP_{t-i} + \delta_{6i} \sum_{i=1}^{r} TOT_{t-i} + \varepsilon_t \qquad (3)$$

$$NRM_t = \delta_0 + \delta_{1i} \sum_{i=0}^{m} NRM_{t-i} + \delta_{2i} \sum_{i=1}^{n} REC_{t-i} + \delta_{3i} \sum_{i=1}^{o} FDI_{t-i} + \delta_{4i} \sum_{i=1}^{p} ICT_{t-i} + \delta_{5i} \sum_{i=1}^{q} PCGDP_{t-i} + \delta_{6i} \sum_{i=1}^{q} PCGDP2_{t-i} + \delta_{7i} \sum_{i=1}^{r} TOT_{t-i} + \varepsilon_t \qquad (4)$$

$$NRM_t = \delta_0 + \delta_{1i} \sum_{i=0}^{m} NRM_{t-i} + \delta_{2i} \sum_{i=1}^{n} REC_{t-i} + \delta_{3i} \sum_{i=1}^{n} REC2_{t-i} + \delta_{4i} \sum_{i=1}^{o} FDI_{t-i} + \delta_{5i} \sum_{i=1}^{p} ICT_{t-i} + \delta_{6i} \sum_{i=1}^{q} PCGDP_{t-i} + \delta_{7i} \sum_{i=1}^{r} TOT_{t-i} + \varepsilon_t \qquad (5)$$

Equations 4 and 5 are estimated to examine the nonlinear relationship between Per capita output, green financing, and natural resource management. The nonlinear relationship between green financing, per capita output, and natural resource management would help to form a cornerstone of policymaking aimed at achieving sustainable development (Xing et al., 2024). By examining the Environmental Kuznets Curve (EKC) hypothesis, this study seeks to understand the intricate dynamics between economic growth, green financing, and natural resource management in Pakistan. The lag values of $m, n, o, p, q, and\ r$ in equations 3, 4 and 5 are selected based on AIC, SIC, and Hannan-Quinn information criteria. The optimal model is the one that has minimum lag or maximum R-squared values. Lastly, to estimate the short-run model, the Error Correction model is expressed in equations 6, 7, and 8 for models 1, 2, and 3.

$$NRM_t = \delta_0 + \delta_{1i}\sum_{i=0}^{m}\Delta NRM_{t-i} + \delta_{2i}\sum_{i=1}^{n}\Delta REC_{t-i} + \delta_{3i}\sum_{i=1}^{o}\Delta FDI_{t-i} + \delta_{4i}\sum_{i=1}^{p}\Delta ICT_{t-i} + \delta_{5i}\sum_{i=1}^{q}\Delta GDP_{t-i} + \delta_{6i}\sum_{i=1}^{r}\Delta TOT_{t-i} + \partial ECM_{t-1} + \epsilon_t \quad (6)$$

$$NRM_t = \delta_0 + \delta_{1i}\sum_{i=0}^{m}\Delta NRM_{t-i} + \delta_{2i}\sum_{i=1}^{n}\Delta REC_{t-i} + \delta_{3i}\sum_{i=1}^{o}\Delta FDI_{t-i} + \delta_{4i}\sum_{i=1}^{p}\Delta ICT_{t-i} + \delta_{5i}\sum_{i=1}^{q}\Delta PCGDP_{t-i} + \delta_{6i}\sum_{i=1}^{q}\Delta PCGDP2_{t-i} + \delta_{7i}\sum_{i=1}^{r}\Delta TOT_{t-i} + \partial ECM_{t-1} + \epsilon_t \quad (7)$$

$$NRM_t = \delta_0 + \delta_{1i}\sum_{i=0}^{m}\Delta NRM_{t-i} + \delta_{2i}\sum_{i=1}^{n}\Delta REC_{t-i} + \delta_{3i}\sum_{i=1}^{n}\Delta REC2_{t-i} + \delta_{4i}\sum_{i=1}^{o}\Delta FDI_{t-i} + \delta_{5i}\sum_{i=1}^{p}\Delta ICT_{t-i} + \delta_{6i}\sum_{i=1}^{q}\Delta PCGDP_{t-i} + \delta_{7i}\sum_{i=1}^{r}\Delta TOT_{t-i} + \partial ECM_{t-1} + \epsilon_t \quad (8)$$

Where the ∂ is the coefficient of error correction term which indicates the speed of adjustment showing how fast the variables reach toward long-run equilibrium. For an appropriate model, ∂ should be negative and significant. Furthermore, the models are tested for various diagnostic tests including auto-correlation, serial correlation, heteroskedasticity, and functional form. Breusch-Godfrey LM test and LM test for autoregressive conditional heteroskedasticity test the null hypothesis of no serial correlation, Breusch-Pagan tests the null hypothesis of constant variance while RESET tests the null hypothesis of the presence of omitted variables in the model (Pang, 2010; Stock & Watson, 2020).

Empirical Results

To test the stationary in the time series data, the Augmented Dickey-Fuller test (ADF) has been employed (Worden et al., 2019). All variables are tested for unit root at level, with intercept and trend. Table 2 shows the results of the unit root test, indicating that natural resource management, foreign direct investment, and economic growth are stationary at the level. Whereas renewable energy consumption, information and communication technology, per capita GDP, and terms of trade follow the I(I) process, these are stationary at first difference.

Table 2. Unit root Test

	t-statistics	Critical Value	Decision
NRM_t	-1.593	0.061*	I(0)
REC_t	-1.198	0.674	
FDI_t	-1.884	0.035**	I(0)
ICT_t	-0.163	0.943	
EG_t	-4.392	0.0003***	I(0)
$PCGDP_t$	0.585	0.987	
TOT_t	-1.043	0.737	
First Difference			
ΔREC_t	-5.455	0.000***	I(1)
ΔICT_t	-5.582	0.000***	I(1)
$\Delta PCGDP_t$	-4.138	0.000***	I(1)
ΔTOT_t	-4.849	0.000***	I(1)

H0: Series has a unit root.
*, **, *** shows significance level at 1%, 5% and 10%.

As stated earlier the ARDL approach allows estimation of the cointegrating vector of the series that follows a different level of stationarity such as I (0) and I (1). Therefore, this study uses the ARDL bound testing approach to estimate the long-run relationship between green finance and natural resource management. To test the presence of cointegration among variables, this study employs the Bounds testing approach which is based on the joint F-statistics (Pesaran et al., 2001). Table 3 shows the results of the Bounds test. It tests the null hypothesis on no cointegration ($H_0: \delta_7 = \delta_8 = \delta_9 = \delta_{10} = \delta_{11} = \delta_{12} = 0$). The lag selection of the variable in all models is based on the Akaike Information Criterion and Shwarz Criteria (SIC). Table 3 shows that the calculated F statistic is 6.53 for model 1, 9.19 for model 2, and 13.93 for model 3. The F statistic in all models is higher than the upper bound proposed by Pesaran et al. (2001) which confirms natural resource management has a long-run relationship with green financing in models 1, 2, and 3.

Table 3. Estimates of ARDL Bound Test

	Model 1		**Model 2**		**Model 3**	
F-Statistics	6.530		9.195		13.939	
	Critical values (Pesaran et al., 2001)					
Critical bound values	Lower	Upper	Lower	Upper	Lower	Upper
1%	3.41	4.68	3.15	4.43	3.15	4.43
2.5%	2.96	4.18	2.75	3.99	2.75	3.99
5%	2.62	3.79	2.45	3.61	2.45	3.61
10%	2.26	3.35	2.12	3.23	2.12	3.23

According to AIC criteria, appropriate lags for model 1 is ARDL (1, 1, 2, 1, 2, 2), for model 2 is ARDL (1, 1, 2, 1, 2, 2, 1) and for model 3 is ARDL (1, 1, 3, 3, 2, 2, 1). The long run estimates are shown in table 4. In all models, the coefficients at their lags are significant. Moreover, various diagnostics tests including Durbin test for autocorrelation, Breusch-Godfrey LM test for serial correlation test, LM test for autoregressive conditional heteroskedasticity and Ramsey Rest have been performed. Table 4 shows the results of diagnostic checks. The probability value of Durbin's alternative and LM test are greater than 0.05 indicating no autocorrelation and no heteroskedasticity. The probability value of Ramsey test also confirms that all models are best fit.

The estimates of model 1 in Table 4 reveal that renewable energy consumption is negative and statistically significant, indicating that a 1 percent increase in green financing reduces the use of natural resources by 25 percent in Pakistan. The results are in line with the theoretical understanding which states that countries may ensure the sustainable use of natural resources by integrating green finance (Dai & Chen, 2023; Xing et al., 2024). Likewise, Cai and Le (2023) found a significant impact of green financing on environmental sustainability. The estimate of model 1 in Table 4 shows that an increase in foreign direct investment reduces natural resource utilization by 37 percent. The finding is in line with Udemba and Yalçıntaş (2021), who found the negative impact of FDI on environmental degradation. Similarly, a 1 percent increase in information and communication technology reduced natural resource use by 7 percent, indicating that Pakistan can reduce the use of natural resources by focusing on innovation, particularly in green technologies. The coefficient of growth is negative and statistically significant revealing that with economic progression, Pakistan can reduce the use of natural resources by 31 percent. Muhammad et al. (2021) found similar results regarding the relationship between GDP and carbon emissions, emphasizing that economic growth helps nations achieve a sustainable environment. The negative impact of green financing on natural resource management in the long run suggests that Pakistan is on a convergence path, aligning with sustainable development objectives. The results further reveal that long-term growth in Pakistan is consistent with green growth.

To further explore the evidence of green growth for Pakistan, model 2 is estimated by including Per capita GDP and Per capita GDP2 to estimate whether the EKC hypothesis holds in the presence of a green financing regime. The objective is to estimate whether the current policy frameworks of Pakistan are allowing the validity of EKC or not. The estimates of Model 2 in Table 4, confirm that all variables exhibit the expected signs and are statistically significant. This alignment with theoretical expectations reinforces the robustness of the model and the validity of the underlying hypotheses (Xing et al., 2024). Li et al. (2024) examined the EKC hypothesis to study the relationship between growth and carbon emission by including natural resource rent as a control variable and found that natural resource rent affects the relationship. The negative and statistically significant coefficient of PCGDP2 on natural resource management implies a nonlinear relationship, where an initial increase in GDP leads to higher natural resource use. However, after reaching a certain income threshold, a further increase in per capita output reduces natural resource consumption, supporting the sustainable use of resources. These findings confirm the significance of green financing and policy frameworks in fostering the transition to sustainable growth in Pakistan.

Table 4. Long run Estimates

	Model 1	**Model 2**	**Model 3**
	Coefficients	Coefficients	Coefficients
REC_t	-0.251***	-0.065	1.777**
	(0.058)	(0.068)	(0.390)
$REC2_t$			-0.018**
			(0.003)
FDI_t	-0.375*	-0.360***	-0.302**
	(0.201)	(0.086)	(0.078)
ICT_t	- 0.078***	-0.049***	-0.101***
	(0.016)	(0.0131)	(0.009)
EG_t	-0.312**		
	(0.106)		
$PCGDP_t$		27.571***	3.829*
		(7.615)	(1.182)
$PCGDP2_t$		-9.462***	
		(2.619)	
TOT_t	-0.0014***	-0.0012***	-0.001***
	(0.0003)	(0.0002)	(0.0001)
Diagnostic Tests			
Durbin's alternative test for autocorrelation	0.14 (P-value =0.70)	1.74 (P-value =0.18)	2.04 (P-value =0.15)
LM test for autocorrelation	0.26 (P-value =0.60)	3.10 (P-value =0.07)	13.78 (P-value =0.003)
Autoregressive conditional heteroskedasticity	2.30 (P-value =0.12)	0.16 (P-value =0.68)	0.78 (P-value =0.37)
Ramsey test	1.08 (P-value =0.39)	0.75 (P-value =0.54)	0.30 (P-value =0.82)

Using the long run estimates of model 2, the peak turning point of EKC can be calculated using formula $\delta_{5i}/|2\delta_{6i}| \cong 1.456$ This value lies inside our sample periods as evident from Table 1, the maximum value of per capita GDP in our sample is 1.696 thousand USD. From the data, it can be seen that the peak point is between 2015 to 2016. This value lies within the sample period where the maximum value of output per capita in the dataset is 1.696 thousand USD (see Table 1). Based on the data, the peak point occurred between 2015 and 2016. During this period, the policy measures undertaken by the government of Pakistan were aligned with green innovation, particularly in the energy sector. These policies facilitated a shift in natural resource utilization, supporting the transition toward sustainable development goals (Fu, Lu & Pirabi, 2023). The results emphasize the effectiveness of these policy actions in promoting the integration of green technologies and fostering sustainable resource management, consistent with the EKC hypothesis.

Model 3 in Table 4 shows that the coefficient of renewable energy consumption is positive while the squared term of renewable energy consumption is negative. These results confirm the validity of the EKC hypothesis in the presence of green finance. The estimates of equation 5, and model 3 help to calculate the peak point of renewable energy consumption that changes its relationship with the use of natural resources in Pakistan. The calculated turning point of renewable energy consumption is $\delta_{2i}/|2\delta_{3i}| \cong 48.18$, which also lies within our sample period. Our analysis implies that Pakistan reached the turning point of green financing in 2013 and after that, any development in improving renewable energy consumption reduced the use of natural resources, helping Pakistan to meet its goal of ensuing the sustainable use of natural resources. However, it is important to note that the data for renewable energy consumption is available till 2021, whereas a significant number of coal power plants in Pakistan were initiated after this period. The inclusion of post-2021 data on coal power plants could potentially alter these findings, likely extending the initial phase of the EKC, where the use of natural resources continues to increase along with economic growth. This suggests that Pakistan's transition toward the turning point of the EKC may take longer due to the increased reliance on coal-based energy, which could offset the sustainability benefits of green finance. The short-run dynamics are presented in table 5. The coefficient of ECM in model 1 is -0.46 indicating that short-run disequilibrium in model 1 would reach equilibrium with the adjustment rate of 46 percent. The coefficients of error correction term in model 2 and model 3 are -0.86 and -0.98 indicating that short-run disequilibrium in model 2 and 3 would reach equilibrium with the adjustment rate of 86 and 98 percent.

Table 5. Short run Estimates

	Model 1	**Model 2**	**Model 3**
ΔREC_t	0.110***	0.106**	-1.042
	(0.032)	(0.041)	(0.661)
$\Delta REC2_t$			0.011
			(0.007)
$\Delta REC2_t(1)$			-0.0009**
			(0.0004)
ΔFDI_t	0.384***	0.387***	0.314**
	(0.122)	(0.111)	(0.109)
$\Delta FDI_t(1)$			0.124
			(0.111)
$\Delta FDI_t(2)$			-0.197**
			(0.082)
$\Delta FDI_t(3)$			-0.367***
			(0.093)
ΔICT_t	0.036**	-0.039**	0.053***
	(0.010)	(.0122)	(0.015)
$\Delta ICT_t(-1)$			0.0312**
			(0.009)
ΔEG_t	0.119***		
	(0.037)		
$\Delta EG_t(1)$	0.050*		
	(0.025)		
$\Delta PCGDP_t$			-1.817
			(1.211)
$\Delta PCGDP_t(1)$		-0.659	-10.369**
		(0.479)	(2.445)
$\Delta PCGDP2_t$		-2.912***	
		(0.683)	
ΔTOT_t	0.0006**	0.0008***	0.0012*
	(0.0002)	(0.0002)	(0.0002)
Constant	8.10***	-10.71	-42.37*
	(1.581)	(8.466)	(16.17)
ECM_t	-0.463***	-0.863***	-0.984***
	(0.107)	(0.159)	(0.196)
R^2	0.76	0.84	0.96
$\overline{R}_2$	0.60	0.72	0.90

The empirical results reveal the significance of green financing in advancing sustainable natural resource management and supporting Pakistan's green growth objectives. From the climate finance perspective, these findings align with the objectives of the Paris Agreement, particularly under Article 2.1(c)[‡], which emphasizes making financial flows consistent with pathways toward reducing carbon emissions and climate-resilient environment. The demonstrated negative relationship between green financing and natural resource use underpins the need for climate-aligned financial instruments to support transitions in energy systems and promote sustainable practices. By incorporating green financing into national development strategies, Pakistan can align its economic progression with its Nationally Determined Contributions (NDCs) while addressing its vulnerability to climate change.

The validation of EKC hypothesis within the context of green financing further supports the relevance of Article 6 of the Paris Agreement, which promotes cooperation in implementing NDCs through mechanisms such as Internationally Transferred Mitigation Outcomes (ITMOs). Recently concluded Conference of Parties (COP) in Baku, Azerbaijan agreed on the implementation of Article 6.2 for ITMOs trading will also have a way for sustainable economy, but it should be capitalized in a just and equitable manner. The results also indicate that Pakistan has reached critical turning points in renewable energy consumption and output per capita where green investments and innovations contribute to sustainable growth. By leveraging mechanisms under Article 6, Pakistan could enhance its access to international climate finance while promoting technology transfer and capacity-building efforts to achieve higher levels of renewable energy integration and reduce its reliance on natural resource exploitation.

These results are also pertinent to discussions on the New Collective Quantified Goal on Climate Finance (NCQG), set to succeed the current USD 100 billion per year commitment under the Paris Agreement. The empirical evidence highlights the need for climate finance tailored to the specific developmental contexts of emerging economies like Pakistan. With renewable energy projects demonstrating long-term reductions in natural resource consumption, scaling financial commitments under the NCQG is imperative to sustain this momentum. The findings advocate for mobilizing additional resources from multilateral, bilateral, and private sources to address funding gaps, particularly in renewable energy and green technology sectors. This targeted climate financing would enable Pakistan to achieve its NDCs while fostering a sustainable and inclusive economic transition.

Conclusion

This study examined the impact of green financing on natural resource management in Pakistan over the period 1990–2023. ARDL approach to cointegration is employed to estimate long-term relationships. The findings of the study reveal a negative relationship between renewable energy consumption and natural resource management. Moreover, the study finds the negative impact of FDI, ICT, economic growth, and terms of trade on natural resource utilization. This negative impact signifies the role of green finance in ensuring the sustainable use of natural resources, which aligns the long-term economic growth in Pakistan with the principles of green growth. Additionally, the study confirms the Environmental Kuznets Curve hypothesis within a green financing regime, identifying the peak turning points of green growth and green financing at per capita GDP of 1.696 thousand USD during 2015 and 2016 and renewable energy consumption of 48.18% in 2013, respectively.

During these critical periods, government policies fostering green innovation, particularly in the energy sector, were instrumental in shifting resource utilization patterns toward sustainability. These results emphasize the effectiveness of policy actions in integrating green technologies, supporting the transition toward sustainable development goals, and validating the EKC hypothesis under green financing. However, the increased reliance on coal-based energy post-2021 highlights the need for ongoing efforts to align energy policies with sustainability goals, potentially delaying the transition to the EKC turning point and diminishing the gains achieved through green financing. Based on the findings, following recommendations are made for public and private sector of Pakistan.

[‡] Article 2.1 (c) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

First, Pakistan should formalize and operationalize the National Climate Finance Strategy as announced on the COP29 in Baku to prioritize and streamline green finance initiatives. This strategy would help the country to align its financial flows with the objectives of the Paris Agreement, particularly Article 2.1(c), by fostering investment in renewable energy, sustainable technologies, and green infrastructure. The national climate finance strategy should further outline clear pathways for integrating public and private resources to support climate mitigation and adaptation projects. Specific emphasis should be given to developing mechanisms for attracting international climate finance under the NCQG, ensuring that sufficient resources are mobilized to meet the country NDCs. This would also include developing clear frameworks for utilizing funds from multilateral financial institutions and green bonds to fund large-scale renewable energy projects and improve resilience to climate impacts.

Second, to utilize mechanisms under the Paris Agreement, namely ITMOs, the government is advised to implement a strong carbon market strategy. Pakistan may draw in private sector investment and encourage voluntary collaboration in the pursuit of NDCs by establishing an efficient and transparent carbon market. To encourage the decrease of greenhouse gas emissions, especially in high-emission industries like manufacturing and energy, carbon pricing tools like carbon credits should be developed. In addition to drawing in foreign buyers for carbon offsets, a well-defined framework for carbon markets will assist Pakistan in bringing its energy and industrial sectors into compliance with international sustainability standards and lowering the possibility of trade barriers brought on by programs like the Carbon Border Adjustment Mechanism (CBAM). Additionally, tying the carbon market policy to regional businesses can spur technological adoption and innovation to lower emissions intensity.

Third, the results show that Pakistan has achieved its peak point in terms of linking green finance with efficient resource management. A recent example of a federal budget in which the Government has staged a public sector development program (PSDP) with climate change streams such as mitigation, adaptation, and resilience. Although this staging will help in achieving the International Monetary Funds' climate public investment management assessment (C-PIMA), the effectiveness of this framework lies in devolving C-PIMA to subnational public sector development planning.

Additionally, tax breaks, subsidies, and access to preferential financing should be used to encourage the private sector to participate in renewable energy and green technology initiatives. Enabling private investments can be greatly aided by establishing a specialized green financing facility in partnership with state financial institutions. Government should facilitate public-private partnerships to speed up the implementation of clean energy solutions, encourage innovation, and scale up the use of renewable energy. To further limit the use of natural resources, the government should also support ICT-based solutions for energy management, resource efficiency, and green innovation. Another important policy stance in this regard is the use of block chain technology in carbon accounting and renewable energy certification which will enhance the efficiency and transparency in the green financing sector,

Fifth, to align with global climate commitments and address the emerging challenges of the CBAM, Pakistan should reduce its reliance on fossil fuel-based power generation. This can be achieved through targeted policies that phase out coal-based power plants by leveraging initiatives such as the Just Energy Transition Partnerships and the ADB's Energy Transition Mechanism. These programs provide financial and technical assistance for the early retirement of coal power plants and their transition to renewable energy sources. Additionally, the Coal to Clean Credit Initiative can be utilized to fund innovative technologies and green projects that reduce dependency on coal-based energy. Expanding renewable energy capacity, particularly in solar, wind, and hydropower, must remain a core focus to ensure that the energy transition does not disrupt national energy security. At the same time, a fair and equitable transition for workers and communities reliant on the coal industry must be ensured through social protection programs and retraining initiatives. This approach will also mitigate potential economic losses due to CBAM and position Pakistan's exports as competitive in carbon-conscious international markets, while reducing its overall carbon footprint.

Lastly, to improve technical capabilities, institutional frameworks, and financial access for climate-resilient development, international collaboration should be pursued. Resources for knowledge transfer, capacity building, and the execution of sustainable projects should be made available through multilateral climate programs such as Green Climate Fund. Fostering bilateral relationships for technology transfer should also be a priority, especially for renewable energy technologies like grid modernization and battery storage. Pakistan's capacity to efficiently manage and mobilize climate money may be further improved by its involvement in regional knowledge-sharing partnerships and international efforts like the Climate Investment Platform. Enhanced technical capacities will not only support the implementation of green projects but also help Pakistan maintain compliance with international climate agreements, ensuring a sustainable and inclusive economic transition.

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