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Examining the Impact of Financial Inclusion, Tourism and Renewable Energy on Environmental Sustainability: Evidence from NARDL Approach

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ABSTRACT

This paper aims at examining the effects of financial inclusion, renewable energy, tourism and economic growth on the environmental stability in Pakistan. It uses the Nonlinear Autoregressive Distributed Lag (NARDL) and Environmental Kuznets Curve (EKC) hypothesis. The goal of the study to uncover the non-linear relationship and long-run co-movement between such variables which spans through 2000-2023. Financial inclusion emerges as a critical factor, consistently reducing emissions in both the short and long run, with negative shocks having a more pronounced effect. The findings highlight the EKC pattern, where economic growth initially increases emissions, but beyond a certain point, further growth reduces them, signaling a transition toward environmental improvement. Renewable energy consumption plays a crucial role in lowering emissions, while tourism slightly increases them. The findings of this study can be useful for policy makers as this study also emphasized the fact that for the sustainability in Pakistan there is need to encourage financial commensurate with the need for green economy through sustainable tourism and renewable energy for the improved environmental sustainability_

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Introduction

Pakistan as a nation need to focus on its environmental sustainability because the environmental impacts of climate change, lack of afforestation and increased pollution. These factors can be said to be a great threat to water sources and food production. Therefore, financial inclusion is also crucial as it assists individuals in acquiring the necessary financial services needed to improve the economy's stability (Danisman & Tarazi, 2020). Thus, concept of financial inclusion linking with the environmental sustainability. Pakistan can promote the development of tourism, green technology, renewable energy (RE) sources, and economic growth to achieving the goal of sustainable environment. Financial inclusion helps the communities to engage in sustainable activities and use renewable resources of energy with the help of financial services (Ozturk & Ullah, 2022; Renzhi & Baek, 2020). Hence, financial inclusion is an appropriate strategy to financial and climate vulnerability since they are so entwined. Also, it improves the financial resilience that in turn strengthens the capacity to deal with impacts of climate change thus catalyzing economic growth (Ozili, 2023). This multifaceted approach not only ensures that the company's long-term development is possible and healthy but also decreases the negative impact of climate change by facilitating the financing of projects that are eco- and resource-friendly (Le et al., 2020).

Another one of the recent concern is the study of connection among economic development and the tourism industry (Dogan & Aslan, 2017). Economists have anchored the nexus among economic development and tourism sector on two assumptions including; tourism-led development hypothesis, and; growth-led tourism development hypothesis. Moreover, in very recent research, a new correlation of tourism with environmental sustainability has been explored (Balsalobre-Lorente et al 2023). The focus of tourism-energy is more focused on the energy-growth-environment nexus (Ahmad et al ,2022; Baloch et al ,2023; Erdoğan et al ,2022) because, as noted earlier, the tourism sector is very much related to environment. Tourism activities require energy directly through the use of fossil energy or indirectly through electricity power in all sectors of tourism including transport and accommodation (Azam et al 2018). In the same regard, the effects of the service on the natural environment could vary through the policy support and governmental actions for the low emission level in the sphere, and utilization of clean technologies in the sphere of tourism. Although the fact that tourism is closely connected with the environment, little heed is paid to the potential impact of environmental factors on tourism and, more to the point, the results are rather ambiguous.

GDP is one of the factors that influence carbon emanations (Zhu et al ,2016). As per the EKC hypothesis it is predicted that the GDP leads to surge in carbon emanations; although after a certain threshold levels of GDP, will lead to decrease in carbon emissions meaning thereby that there is an inverted 'U' connection among economic development and carbon emanations. Moreover, RE is clear compared to the fossil energy in terms of pollution and impact on sustainable environment (Cheng et al., 2019). Thus, they are helpful to decrease carbon emission. In connection with the discussion made above, utilization of renewable energy production has offered essential remedy for managing environmental degradation and Climate Change sensitization (Ahmad et al., 2016). However, there are very limited literatures that look at relationship among expansion of the RE and CO_2.

The present investigation posited the existence of a sustained association between financial inclusions, renewable tourism, GDP, and CO_2 emanations in Pakistan during the period from 2000 to 2023. While the current research has a similar breadth with earlier work, it offers distinct additions to the existing body of knowledge. In contrast to other endeavors, this research extends the evaluation of financial inclusion index with CO_2 emissions model. Furthermore, it is noteworthy to mention that this study is unique in its use of a specific research methodology to examine the notion of environmental sustainability in Pakistan. Finally, this study use the NARDL model to analyze both short-term and long-term relationships that exhibit asymmetry.

The succeeding sections of this work are planned in the following way: The 2nd section of the article is designated as the 'literature review'. Section 3 of the document presents the data and the methods used for estimation. The fourth portion of this article is dedicated to the "results and discussions," while the 5th section presents the "Conclusion and Policy Suggestions."

Literature Review

The literature has examined the determinants of environmental quality through a variety of studies. In particular, connection among economic development and RE is discussed often to spill over environmental issues. Consequently, theoretically, economic development has been viewed as having more than a passing relationship with environmental degradation. Literature on the link among economic progress and CO_2 emanation is well explained by the EKC based on the inverted U-shape hypothesis (Ozturk et al., 2024). In its earlier phase of development therefore, industrial growth and utilization of fossil energy sources contribute to more pollution and environmental destruction, a 'wring now, clean later' culture (Usenata, 2018). This helps to stimulate the use of RE and cleaner technologies while the rate of degradation of environment is reduced as economy grows. Therefore, the EKC hypothesis posits that from a level of higher income, there is an option of growth and ecologically sound development with the use of RE to lower CO_2 emissions and climate change.

Financial Inclusion with Environmental Sustainability

Ahmad & Satrovic, (2023) examined how financial inclusion affected environmental sustainability by employing MMQR with fixed effects which covered seven OECD countries from 1995-2018. The outcomes of the study established that increased in financial Inclusion (FIN) for the poor is negatively associated with environmental quality especially in countries with better efficiency in energy use thru carbon intensity index and energy intensity index. Similarly, Anu et al., (2023) used the data from 2000-2018 with the help of a novel quantile regression model to explore the connection among FIN and CO2 . This study provides evidence that, overall, FIN leads to a surge in the level of CO2 emanations in a country, and the effect is heightened when the ecological footprint of a country is already relatively high. On the other hand, Shahbaz et al (2022) examining the factor of FIN in the synergy toward the reduction of pollutants and CO_2 in 30 provinces of China over the period of 2011-2017. FIN negatively affects CO_2 emissions but this in an indirect impact as it positively impacts RE use, changes energy consumption and structure, hence flagging environmental sustainability (ES).

Ozturk & Ullah, (2022) provided a comprehensive review to discover the effect of DF on both GDP and ES in 42 OBRI states during 2007-2019. The result, using 2OLS, 2SLS, and GMM estimation, suggested that digital FIN has a strong and significant affirmative effect on economic development. However, it leads to a negative effect of environmental quality due to increased CO2 emission as a downside of economic growth. Ansari et al., (2024) analyzed the effects of the FIN, digital finance and RE, and institutional quality on ES in Pakistan in the period from 2004-2021 by employing the ARDL method and testing the long-run and short-run relationship. The study established that, indeed, increased access to financial services is associated with reduced levels of CO2 emissions. Moreover, this conveys the role of sound institutions and RE in responding to climate change and fostering SD particularly in the developing states like Pakistan. Tanveer et al ,(2023) analyzed how FIN affected ES in Pakistan based on the years of 1975-2018 and applied the STIRPAT model and econometrical techniques for both symmetrical and asymmetrical influences. The outcomes established that the connection among FIN with CO_2 emission is nonlinear in the short as well as the long run.

H1: FIN has a significant effect on ES.

Tourism with Environmental Sustainability

The study done by Ahmad et al (2022) looked at the influence of innovation and TOR on ES of G7 countries for the year 2000-2019. By employing panel data analysis techniques FMOLS and DOLS methodologies the study discovered that TOR have affirmative impact on lowering of CO2 emissions that in turn provide support towards ES. Balsalobre-Lorente et al ,(2023) looked at the trend of environmental sustainability in 36 member countries of OECD for the period 2000 to 2018 based on tourism, urbanization, natural resources rents, and ICT. Analyzing tourism combined with urbanization and NRR as the determinant of CO2 emanations using AMG and GMM techniques, the presence of ICT cuts these emanations. Dogan & Aslan (2017) analyzed the direction of causality among CO_2, Real GDP, EC and TOR in EU nations for 1995-2011 in applying OLS with fixed effect, FMOLS and DOLS. The findings show that a higher level of TOR has helped in the reduction of emissions of CO2 thereby proposing a greater environmental quality.

The work by Erdoğan et al., (2022) explored the connection among TOR and CO_2 in the countries most visited by tourist, using PQR, for 1995-2018. The outcomes displayed that international tourism tends to enhance CO_2, mainly in the fifth to ninth quantiles from transportation. However, the introduction and adoption of eco-friendly know-hows in the transport sector substantially reduce these emissions and showcase that advancements in eco-friendly technologies may minimize the adverse social impact of TOR on the environment and improve ES irrespective of the quantile. The quantitative study of Baloch et al., (2023) aimed at identifying the connection between the development of tourism and environmental sustainability through the application of hierarchical regression analysis employing the data from the 650 participants involved in the tourism activities. The study showed that although tourism enhances the socio-economic growth through employment opportunities, establishment of businesses and infrastructural development, but it equally has negative effects which include pollution of the environment, over utilization of the land among others and vulnerability. Tian et al., (2021) examined the effects of TOR development, RE consumption, and real GDP on CO_2 emissions in the G20 nations with the help of FMOLS method from 1995 to 2015. The findings revealed that a surge in TOR development growth by 1% will cause a 0.05% reduction in pollution emanations in the long-term; this points that tourism enhances environmental quality.
H2: Tourism has a significant effect on ES.

Renewable Energy with Environmental Sustainability

Sun et al., (2022) examined the influence of REC, GI, globalization, and GDP on carbonization in 10 prominent developed nations throughout the period of 1991-2018. Applying MMQR, the authors confirmed that increased consumption of RE decreases the levels of emissions from CO2. The conclusions also presented that the benefits in terms of the reduction of carbon emissions are most conspicuous at the highest quantiles of the distribution which underlines the significance of the management of increased shares of RE in minimizing emissions in the most contaminated areas. Bekun et al., (2019) investigate the connection among RE consumption, NRE consumption, GDP and natural resources rent on CO2 emanations for 16 EU nations from 1996-2014. The PMG-ARDL model results displayed that an increase in RE consumption significantly reduces the CO_2 emission level which supports the hypothesis that enhanced renewable energy consumption enhances environmental quality. In their study, Cheng et al., (2019) used a PQR approach with carbon emissions and GDP, RE, and innovation in OECD nations. The research indicated that RE consumption is related with an inverted U-shape with carbon emissions that is, expanding the usage of RE, in the first instance, contributes to emissions of carbon dioxide but decreases the emissions of carbon dioxide as its usage increases progressively.

Anwar et al (2021) identified the MMQR to reconnoiter the connection among energy, income, and environment in ASEAN nations, specifically in the roles of RE and NRE consumption. The study showed that RE consumption lowers CO_2 emissions among all quantiles, but the impact fades away when the quantiles range from quantile 6^{th} to 9^{th}. Farooq et al., (2023) examined how geopolitical risk, renewable energy, and GDP have affected environmental sustainability in China through 1990-2018 using nonlinear and linear ARDL analysis. In fact, the utilization of actual and RE consumption decreased CO_2 and enhanced the environmental quality of China. This positive

impact strengthens the call to pursue the development of RE as a component of the energy sources for the sustainable development strategy since the management of geopolitical risks and FDI were identified to have negative effects on the environment.
H3: RE has a significant effect on ES.

Economic Growth with Environmental Sustainability

Raihan et al , (2022) examined the effect of economic growth and RE consumption, on ES in Bangladesh over 1990-2019 using the ARDL and DOLS. This study's conclusion highlighted that economic development enhance CO_2 emissions, which negatively impacts environmental sustainability in Bangladesh. Raihan & Tuspekova, (2022) examined the connection among the economic growth, RE consumption, and technology advancement on ES for the period 1996-2018 employed the DOLS approach. Consequently, it is deducible from this study that there is a direct positive connection among the GDP and CO_2. The study also highlighted that the CO2 emissions are also low where the use of RE and technology is high. The quantitative study of Begum et al (2020) used the DOLS method to evaluate the dynamic effect of economic growth and forested area with CO2 emission Malaysia for the period of 1990 to 2016. These results assert that enhanced economic development leads to raised CO_2 emissions. Sharif et al., (2023) analyzed how RE, and economic growth affected ES in ASEAN-6 from 1995-2018 depending on the results of CS-ARDL test. The presented results showed that GDP affects GTI in a positive manner, which helps ensure environmental sustainability and promote clean output and energy efficiency.
H4: GDP has a significant effect on ES.

Data Descriptions and Research Methodology

In the present study, CO_2 emission, used as proxy of ES, with FIN, TOR, RE, and GDP in the case of Pakistan will be explored. The study employs yearly data ranging from 2000-2023 and an explanation of the variables can be found in the Table 1 below. To test this association, the study uses both the symmetric and asymmetric econometric models in a bid to capture positive and negative shocks of FIN on CO_2 emanations. This approach relies on previous work (Ansari et al., 2024; Tanveer et al., 2023), where it was found that FIN and ES have strong correlation. In the current context, the NARDL model is relevant since it can identify the bi-directional causal relationship where the impacts of FIN on CO_2 emission may be asymmetric. It needs to be mentioned that while extending the basic ARDL model which used for symmetrical conclusions (Fatima Farooq et al., 2024; Sajid et al 2023), the NARDL model relaxes the assumption of linear and symmetric co-integrating vector thus permitting asymmetric impacts of positive and negative changes in these variables on CO_2 emissions. For instance, if FIN is complimented by a push for more economic activities through use of financial services, then it might lead to high usage of energy and hence high CO_2 emissions. On the same note, the same fee could spur investments in RE and green technologies which will help to lower emissions. This is where the NARDL model can help to untangle these effects and provide a clearer picture of how financial inclusion and the like interrelate with environmental sustainability. Information regarding these dynamics can be captured with the help of the NARDL model since it permits nonlinear adjustments and allows for different reactions to positive and negative shocks**.**

Table # 1: Variables Descriptions

Variable	*Symbol*	*Descriptions*	*Source*
CO_2 *Emission*	CO_2	CO_2 *emissions per capita in metric tons*	*WDI*

Financial Inclusion	*FIN*	*An overall index has been created using the density of automated teller machines (ATMs) per 100,000 adults, the share of deposit money bank assets to the total deposit money bank assets and central bank assets, the ratio of deposit money bank assets to the GDP, the ratio of domestic credit furnished by the financial sector to the private sector to the GDP, the ratio of financial system deposits to the GDP, the ratio of liquid liabilities to the GDP and the density of the number of commercial bank branches per 100,000 adults.*	*Author's own calculation*
Renewable Energy	*RE*	*Proportion of total final energy consumption*	*WDI*
Economic Growth	*GDP*	*GDP (constant 2015 US$)*	*WDI*
Tourism	*TOR*	*A comprehensive index including the data on international tourism, including the number of arrivals and international tourist earnings in current US dollars.*	*Author's own calculation*

$CO_2 = f(FIN, TOR, RE, GDP, GDP^2)$ *(1)*

In the first equation, CO_2 represents Carbon emission, FIN stands for the level of financial inclusion, TOR represents tourism, RE indicate renewable energy, while GDP relates to economic growth.

Econometric Equation of basic model:

$$CO_{2t} = \gamma_3 + \gamma_4 FIN_t + \gamma_5 TOR_t + \gamma_6 RE_t + \gamma_7 GDP_t + \gamma_8 GDP2_t \qquad (2)$$

Mathematical function of NARDL model:

$CO_2 = f(FIN+, FIN^-, TOR, RE, GDP, GDP^2)$ *(3)*

In the this equation, CO_2 represents Carbon emission, FIN + stands positive shocks of financial inclusion, FIN – indicate negative shocks of financial inclusion, TOR represents tourism, RE indicate renewable energy, while GDP relates to economic growth.

The econometric equation of NARDL is as given below:

$$\Delta CO_{2t} = \gamma_0 + \sum_{i=1}^{O} \gamma_1 \Delta CO_{2t-1} + \sum_{i=0}^{P1} \gamma_2 \Delta FIN^{+}{}_{t-1} + \sum_{i=0}^{P2} \gamma_3 \Delta FIN^{-}{}_{t-1} + \sum_{i=0}^{Q} \gamma_4 \Delta TOR_{t-1} + \sum_{i=0}^{R} \gamma_5 \Delta RE_{t-1} + \sum_{i=0}^{S} \gamma_6 \Delta GDP_{t-1} + \sum_{i=0}^{T} \gamma_7 \Delta GDP2_{t-1} + \alpha_1 CO_{2t-1} + \alpha_2 FIN^{+}{}_{t-1} + \alpha_3 FIN^{-}{}_{t-1} + \alpha_4 TOR_{t-1} + \alpha_5 RE_{t-1} + \alpha_6 GDP_{t-1} + \alpha_7 GDP2_{t-1} + \mu_t \qquad (4)$$

ECM equation:

$$\Delta CO_{2t} = \gamma_0 + \sum_{i=1}^{O} \gamma_1 \Delta CO_{2t-1} + \sum_{i=0}^{P1} \gamma_2 \Delta FIN^{+}{}_{t-1} + \sum_{i=0}^{P2} \gamma_3 \Delta FIN^{-}{}_{t-1} + \sum_{i=0}^{Q} \gamma_4 \Delta TOR_{t-1} + \sum_{i=0}^{R} \gamma_5 \Delta RE_{t-1} + \sum_{i=0}^{S} \gamma_6 \Delta GDP_{t-1} + \sum_{i=0}^{T} \gamma_7 \Delta GDP2_{t-1} + \lambda ECT_{t-1} + \upsilon_t \qquad (5)$$

Results and Discussions

The descriptive statistics indicate that LNCO_2 emissions, LNFIN (financial inclusion index), LNTOR (tourism), LNRE (renewable energy consumption), and LNGDP (GDP) generally exhibit low variability, with LNFIN showing the highest standard deviation, suggesting more fluctuation. LNCO_2 is moderately negatively skewed, while LNFIN shows a more pronounced negative skewness and a significant departure from normality. The correlation matrix reveals a strong negative correlation between LNCO_2 and LNRE (-0.8765), indicating that higher RE consumption is linked with lower CO_2 emanations. Additionally, LNFIN has a strong positive correlation with LNGDP (0.8392), suggesting that LNGDP is closely linked to LNFIN, while LNRE and LNGDP have a strong negative correlation (-0.8050), highlighting potential trade-offs between economic growth and environmental sustainability.

Table 2: Descriptive Statistics and Correlation Matrix

	LNCO_2	LNFIN	LNTOR	LNRE	LNGDP
Mean	-0.267215	0.222094	13.72387	3.819379	26.36950
Median	-0.278508	0.400683	13.72322	3.837946	26.34527
Maximum	-0.085043	1.043149	13.96479	3.873906	26.71519
Minimum	-0.366268	-2.177884	13.38165	3.739810	26.00375
Std. Dev.	0.077132	0.866068	0.122115	0.043559	0.212789
Skewness	0.713923	-1.260550	-0.764179	-0.332785	0.048847
Kurtosis	2.734868	4.199552	4.854643	1.612456	1.840581
LNCO_2	1	-0.5048	0.1996	-0.87645	0.57459
LNFIN		1	0.3773	-0.6474	0.8392
LNTOR			1	-0.1578	0.4309
LNRE				1	-0.8050
LNGDP					1

The unit root tests using ADF and PP methods reveal that LN CO_2, LNFIN, LNRE, and LNGDP are non-stationary at level I(0) but become stationary at first difference I(1), indicating that these variables are integrated of order one. LNTOR, however, is found to be stationary at both levels I (0) and first difference I (1), suggesting it is integrated of order zero and one. The results imply that most variables exhibit unit roots, necessitating first differencing to achieve stationarity, with the exception of LNTOR, which shows mixed integration properties.

Table 3: Unit Root Tests

	ADF		PP		Decisions
	I(0)	I(1)	I(0)	I(1)	
LNCO_2	-1.7174	-2.8186*	-1.8516	-2.8186*	I(1)
LNFIN	-2.0127	-7.5496***	-1.2319	-10.6923***	I(1)
LNTOR	-3.8165**	-5.7262***	-3.8091**	-5.7262***	I(0) & I(1)
LNRE	-1.3471	-3.7122**	-1.3959	-3.7122**	I(1)
LNGDP	-0.6409	-3.6885**	-0.6290	-3.7859**	I(1)

Note:*,**,*** denotes 10%, 5% & 1%, respectively.

The ARDL and NARDL bound tests (see table 4) provide evidence on the existence of cointegration among the variables. The ARDL model yields an F-statistic of 2.1638, which is below the critical values at all significance levels, indicating no cointegration in the linear ARDL model. In contrast, the NARDL model produces a significantly higher F-statistic of 5.8650, which exceeds the critical values at the 5% significance level. This suggests that when accounting for potential asymmetric relationships, there is strong evidence of cointegration among the variables in the NARDL framework, implying a long-run equilibrium relationship with possible asymmetries.

Table 4: ARDL & NARDL Bound Tests

	F-Stat	Level of Significance	I(0)	I(1)	Decision

ARDL	2.1638	10%	2.2	3.09	No Co-integration
NARDL	5.8650	5%	2.56	3.49	Co-integration
		2.5%	2.88	3.87	
		1%	3.29	4.37	

The NARDL results reveal both short-run and long-run dynamics between CO_2 emissions and the explanatory variables, highlighting notable asymmetries and nonlinear relationships. In the short run, both positive and negative changes in the financial inclusion index (LNFIN) significantly reduce CO_2 emissions, with negative shocks having a stronger impact. Tourism (LNTOR) slightly increases emissions, while renewable energy consumption (LNRE) reduces them. Economic growth (LNGDP) initially raises emissions, but beyond a certain threshold, further growth leads to a reduction, indicating an Environmental Kuznets Curve (EKC) pattern. The error correction term (ECT) confirms the presence of a stable long-run equilibrium, with approximately 83% of deviations from this equilibrium corrected each period. In the long run, similar patterns persist, with financial index changes continuing to reduce emissions, tourism increasing CO_2, and renewable energy consumption leading to significant reductions in CO_2 emissions. The EKC relationship between GDP and emissions is evident, suggesting that economic growth eventually contributes to environmental improvements.

Table 5: NARDL Results

Variables	Coefficient	S.E	t-ratio	P-Value
Short Run				
D(LNCO$_2$(-1))	0.8301***	0.1666	4.9821	0.0003
D(LNFIN$^+$	-3636***	0.1046	-3.4774	0.0046
D(LNFIN$^-$	-0.4380***	0.1384	-3.1653	0.0081
D(LNTOR)	0.0456**	0.0179	2.5487	0.0243
D(LNRE)	-0.3755	0.09677	-3.8796	0.0019
D(LNGDP)	0.5325*	0.2341	2.2751	0.0720
D(LNGDP^2)	-0.8208***	0.2558	-3.2082	0.0083
ECT	-0.8326**	0.2898	-2.8728	0.0166
Long Run				
LNFIN$^+$	-0.3086**	0.0913	-3.3793	0.0197
LNFIN$^-$	-0.1299*	0.0515	-2.5217	0.0531
LNTOR	0.4756*	0.2089	2.2757	0.0719
LNRE	-0.5278***	0.1074	-4.9139	0.0008
LNGDP	0.1232***	0.0270	4.5568	0.0014
LNGDP^2	-0.2247**	0.0936	-2.3991	0.0475
Constant	20.0181***	4.8894	4.0941	0.0015

Note: *,**, *** indicate the level of significance at 10%, 5% & 1% respectively.

The diagnostic tests for the NARDL model indicate that the model is well-specified and the residuals are appropriately behaved. The Jarque-Bera (J.B) test shows that the residuals are normally distributed (p-value = 0.6243). The heteroscedasticity test (Hetero Test) suggests that there is no evidence of heteroscedasticity (p-value = 0.4501). The Breusch-Godfrey LM test indicates no serial correlation (p-value = 0.1638). The Ramsey RESET test confirms that the model is correctly specified (p-value = 0.6050). The Wald tests (WLR and WSR) show that both the long-run and short-run relationships are statistically significant. The model effectively accounts for a significant percentage of the variability seen in the dependent variable, as shown by a coefficient of determination (R^2) of 0.9883. Based on the Durbin-Watson statistic of 2.1572, it may be inferred that there is no empirical evidence of autocorrelation in the residuals. Both the CUSUM and CUSUMQ tests evaluate the long-term structural stability of the model. The findings suggest that the model exhibits stability, as shown by the fact that both tests fall within the defined acceptable range.

Table 6: NARDL Diagnostic Tests

Test	Stat	P-Value
J.B	0.9419	0.6243
Hetero Test	1.1033	0.4501
LM Test	2.6552	0.1638
Ramsey RESET Test	0.2978	0.6050
W_{LR}	22.7456	0.0000
W_{SR}	5.0023	0.02521
R^2	0.9883	CUSUM (Stable)
D.W	2.1572	CUSUMQ (Stable)

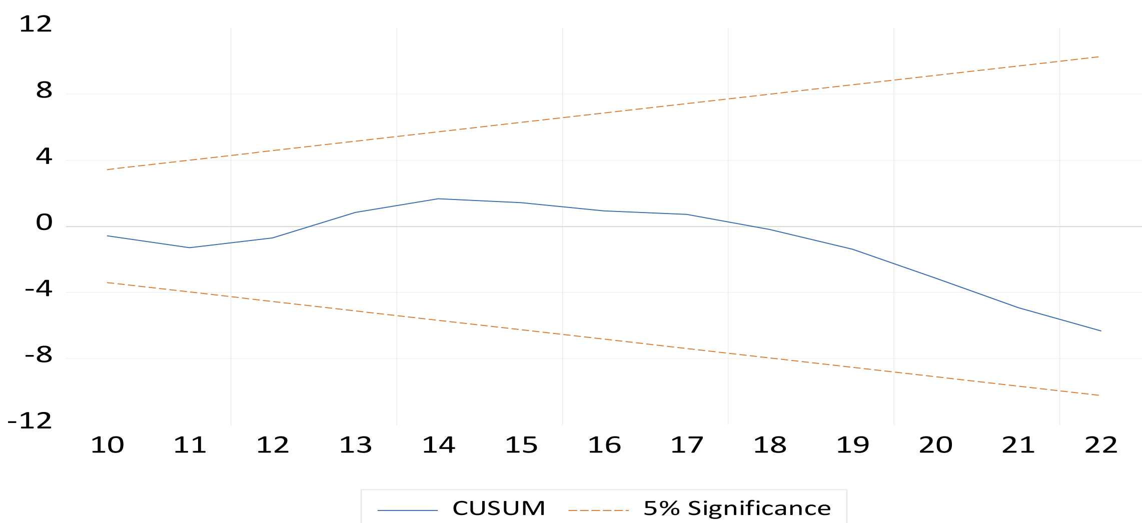

Figure 1: CUSUM Graph

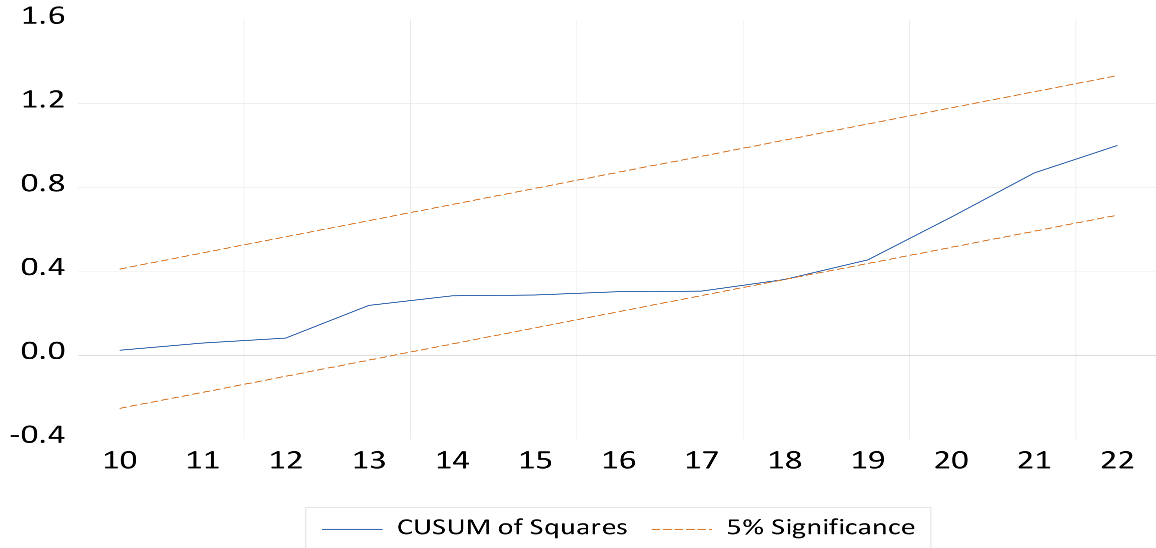

Figure 2: CUSUMQ Graph

Conclusion and Policy Suggestion

The NARDL results for Pakistan's economy underscore significant short-run and long-run relationships between CO_2 emissions and key economic variables, revealing asymmetries and nonlinear effects. Financial inclusion (LNFIN) emerges as a critical factor, consistently reducing emissions in both the short and long run, with negative shocks having a more pronounced effect. The findings highlight the Environmental Kuznets Curve (EKC) pattern, where economic growth (LNGDP) initially increases emissions, but beyond a certain point, further growth reduces them, signaling a transition toward environmental improvement. Renewable energy consumption (LNRE) plays a crucial role in lowering emissions, while tourism (LNTOR) slightly increases them. The error correction term (ECT) indicates a stable long-run equilibrium, with swift adjustments toward it. These results suggest that policymakers in Pakistan should focus on enhancing financial inclusion and renewable energy consumption to mitigate CO_2 emissions, while also fostering sustainable economic growth to achieve environmental objectives. Additionally, managing the environmental impact of tourism through green practices is essential to balance economic benefits with ecological sustainability.

References

Ahmad, A., Zhao, Y., Shahbaz, M., Bano, S., Zhang, Z., Wang, S., & Liu, Y. (2016). Carbon emissions, energy consumption and economic growth: An aggregate and disaggregate analysis of the Indian economy. *Energy Policy*, *96*, 131–143. https://doi.org/10.1016/j.enpol.2016.05.032

Ahmad, M., & Satrovic, E. (2023). Relating fiscal decentralization and financial inclusion to environmental sustainability: Criticality of natural resources. *Journal of Environmental Management*, *325*, 116633. https://doi.org/https://doi.org/10.1016/j.jenvman.2022.116633

Ahmad, N., Youjin, L., & Hdia, M. (2022). The role of innovation and tourism in sustainability: why is environment-friendly tourism necessary for entrepreneurship? *Journal of Cleaner Production*, *379*, 134799. https://doi.org/https://doi.org/10.1016/j.jclepro.2022.134799

Ansari, M. A. A., Sajid, M., Khan, S. N., Antohi, V. M., Fortea, C., & Zlati, M. L. (2024). Unveiling the effect of renewable energy and financial inclusion towards sustainable environment: Does interaction of digital finance and institutional quality matter? *Sustainable Futures*, *7*(April), 100196. https://doi.org/10.1016/j.sftr.2024.100196

Anu, Singh, A. K., Raza, S. A., Nakonieczny, J., & Shahzad, U. (2023). Role of financial inclusion, green innovation, and energy efficiency for environmental performance? Evidence from developed and emerging economies in the lens of sustainable development. *Structural Change* *and Economic Dynamics*, *64*, 213–224. https://doi.org/https://doi.org/10.1016/j.strueco.2022.12.008

Anwar, A., Siddique, M., Eyup Dogan, & Sharif, A. (2021). The moderating role of renewable and non-renewable energy in environment-income nexus for ASEAN countries: Evidence from Method of Moments Quantile Regression. *Renewable Energy*, *164*, 956–967. https://doi.org/https://doi.org/10.1016/j.renene.2020.09.128

Azam, M., Alam, M. M., & Hafeez, M. H. (2018). Effect of tourism on environmental pollution: Further evidence from Malaysia, Singapore and Thailand. *Journal of Cleaner Production*, *190*, 330–338.

Baloch, Q. B., Shah, S. N., Iqbal, N., Sheeraz, M., Asadullah, M., Mahar, S., & Khan, A. U. (2023). Impact of tourism development upon environmental sustainability: a suggested framework for sustainable ecotourism. *Environmental Science and Pollution Research*, *30*(3), 5917–5930. https://doi.org/10.1007/s11356-022-22496-w

Balsalobre-Lorente, D., Abbas, J., He, C., Pilař, L., & Shah, S. A. R. (2023). Tourism, urbanization and natural resources rents matter for environmental sustainability: The leading role of AI and ICT on sustainable development goals in the digital era. *Resources Policy*, *82*, 103445. https://doi.org/https://doi.org/10.1016/j.resourpol.2023.103445

Begum, R. A., Raihan, A., & Said, M. N. M. (2020). Dynamic impacts of economic growth and forested area on carbon dioxide emissions in malaysia. *Sustainability (Switzerland)*, *12*(22), 1–15. https://doi.org/10.3390/su12229375

Bekun, F. V., Alola, A. A., & Sarkodie, S. A. (2019). Toward a sustainable environment: Nexus between CO2 emissions, resource rent, renewable and nonrenewable energy in 16-EU countries. *Science of The Total Environment*, *657*, 1023–1029. https://doi.org/https://doi.org/10.1016/j.scitotenv.2018.12.104

Cheng, C., Ren, X., & Wang, Z. (2019). The impact of renewable energy and innovation on carbon emission: An empirical analysis for OECD countries. *Energy Procedia*, *158*, 3506–3512. https://doi.org/10.1016/j.egypro.2019.01.919

Danisman, G. O., & Tarazi, A. (2020). Financial inclusion and bank stability: evidence from Europe. *European Journal of Finance*, *26*(18), 1842–1855. https://doi.org/10.1080/1351847X.2020.1782958

Dogan, E., & Aslan, A. (2017). Exploring the relationship among CO2 emissions, real GDP, energy consumption and tourism in the EU and candidate countries: Evidence from panel models robust to heterogeneity and cross-sectional dependence. *Renewable and Sustainable Energy Reviews*, *77*, 239–245. https://doi.org/https://doi.org/10.1016/j.rser.2017.03.111

Erdoğan, S., Gedikli, A., Cevik, E. I., & Erdoğan, F. (2022). Eco-friendly technologies, international tourism and carbon emissions: Evidence from the most visited countries. *Technological Forecasting and Social Change*, *180*, 121705. https://doi.org/https://doi.org/10.1016/j.techfore.2022.121705

Farooq, F., Tanveer, A., & Faheem, M. (2023). Analyzing the Impact of Geopolitical Risk, and Renewable Energy Towards Sustainable Development in China. *IRASD Journal of Economics*, *5*(2), 422–440. https://doi.org/10.52131/joe.2023.0502.0137

Fatima Farooq, Sajid, M., Faheem, M., & Khan, K. H. (2024). Evaluating the influence of Green Growth, Foreign Direct Investment and Financial Development towards Sustainable Environment: Evidence by Green Finance Theory Fatima. *Bulletin of Business and Economics*, *13*(2), 44–52. https://doi.org/10.2207/jjws.91.328

Le, T.-H., Le, H.-C., & Taghizadeh-Hesary, F. (2020). Does financial inclusion impact CO2 emissions? Evidence from Asia. *Finance Research Letters*, *34*, 101451. https://doi.org/https://doi.org/10.1016/j.frl.2020.101451

Ozili, P. K. (2023). *Financial Inclusion and Environmental Sustainability BT - Digital Economy, Energy and Sustainability: Opportunities and Challenges* (M. El Amine Abdelli & M. Shahbaz (eds.); pp. 25–39). Springer International Publishing. https://doi.org/10.1007/978-3-031-22382-2_2

Ozturk, I., Farooq, S., Majeed, M. T., & Skare, M. (2024). An empirical investigation of financial development and ecological footprint in South Asia: Bridging the EKC and pollution haven hypotheses. *Geoscience Frontiers*, *15*(4), 101588. https://doi.org/https://doi.org/10.1016/j.gsf.2023.101588

Ozturk, I., & Ullah, S. (2022). Does digital financial inclusion matter for economic growth and environmental sustainability in OBRI economies? An empirical analysis. *Resources, Conservation and Recycling*, *185*(December 2021), 106489. https://doi.org/10.1016/j.resconrec.2022.106489

Raihan, A., Muhtasim, D. A., Farhana, S., Pavel, M. I., Faruk, O., Rahman, M., & Mahmood, A. (2022). Nexus between carbon emissions, economic growth, renewable energy use, urbanization, industrialization, technological innovation, and forest area towards achieving environmental sustainability in Bangladesh. *Energy and Climate Change*, *3*, 100080. https://doi.org/https://doi.org/10.1016/j.egycc.2022.100080

Raihan, A., & Tuspekova, A. (2022). Role of economic growth, renewable energy, and technological innovation to achieve environmental sustainability in Kazakhstan. *Current Research in Environmental Sustainability*, *4*, 100165. https://doi.org/https://doi.org/10.1016/j.crsust.2022.100165

Renzhi, N., & Baek, Y. J. (2020). Can financial inclusion be an effective mitigation measure? evidence from panel data analysis of the environmental Kuznets curve. *Finance Research Letters*, *37*, 101725. https://doi.org/https://doi.org/10.1016/j.frl.2020.101725

Sajid, M., Ansari, M. A. A., Tanveer, A., Faheem, M., & Waseem, A. (2023). Evaluating the influence of green growth, institutional quality and financial inclusion on financial stability: evidence by sustainable finance theory. *Environmental Science and Pollution Research International*, *30*(54), 115965–115983. https://doi.org/10.1007/s11356-023-30362-6

Shahbaz, M., Li, J., Dong, X., & Dong, K. (2022). How financial inclusion affects the collaborative reduction of pollutant and carbon emissions: The case of China. *Energy Economics*, *107*, 105847. https://doi.org/https://doi.org/10.1016/j.eneco.2022.105847

Sharif, A., Kocak, S., Khan, H. H. A., Uzuner, G., & Tiwari, S. (2023). Demystifying the links between green technology innovation, economic growth, and environmental tax in ASEAN-6 countries: The dynamic role of green energy and green investment. *Gondwana Research*, *115*, 98–106. https://doi.org/https://doi.org/10.1016/j.gr.2022.11.010

Sun, Y., Anwar, A., Razzaq, A., Liang, X., & Siddique, M. (2022). Asymmetric role of renewable energy, green innovation, and globalization in deriving environmental sustainability: Evidence from top-10 polluted countries. *Renewable Energy*, *185*, 280–290. https://doi.org/https://doi.org/10.1016/j.renene.2021.12.038

Tanveer, A., Song, H., Faheem, M., Daud, A., & Safdar, N. (2023). Navigating the asymmetric influence of financial inclusion on environmental sustainability: Dynamic role of energy consumption and human capital. *Energy and Environment*. https://doi.org/10.1177/0958305X231159439

Tian, X.-L., Bélaïd, F., & Ahmad, N. (2021). Exploring the nexus between tourism development and environmental quality: Role of Renewable energy consumption and Income. *Structural Change and Economic Dynamics*, *56*, 53–63. https://doi.org/https://doi.org/10.1016/j.strueco.2020.10.003

Usenata, N. (2018). Environmental Kuznets Curve (EKC): A Review of Theoretical and Empirical literature. *Mpra*, *85024*. http://search.proquest.com/docview/2059124395/

Zhu, H., Duan, L., Guo, Y., & Yu, K. (2016). The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: Evidence from panel quantile regression. *Economic Modelling*, *58*, 237–248. https://doi.org/https://doi.org/10.1016/j.econmod.2016.05.003