Vol. 2(2), 48-56

Journal of Energy & Environmental Policy Options

Exploring the Environmental Kuznets Curve Hypothesis: Deforestation, Trade, and Economic Growth in Pakistan

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Abstract
This study investigates the intricate relationship among deforestation, energy consumption, population dynamics, international trade, and economic growth, with a particular focus on Pakistan from 1980 to 2020. It seeks to reexamine both the short-term and long-term dynamics and validate the Environmental Kuznets Curve hypothesis concerning deforestation, international trade, and economic growth in Pakistan. Employing the autoregressive distributed lag bounds testing approach to cointegration, this study rigorously analyzes the relationships among the variables over the specified time period. The results reveal the presence of cointegration among the variables in the long term, indicating stable relationships that persist over time. One notable finding of this study is the diminishing negative impact of economic growth and international trade on deforestation in the long term. This observation aligns with the Environmental Kuznets Curve hypothesis, suggesting that as economies develop and incomes rise, there is initially an increase in environmental degradation, including deforestation. However, beyond a certain income threshold, further economic growth leads to environmental improvement, resulting in a decline in deforestation rates. This finding underscores the potential for sustainable development policies to mitigate deforestation in Pakistan. Additionally, the study finds that population density has a negative effect on deforestation. This implies that as population density increases, there may be greater pressure on forest resources, leading to efforts to conserve and manage forests more effectively. Understanding the relationship between population dynamics and deforestation is crucial for developing targeted policies to address environmental challenges while accommodating population growth. Furthermore, this study employs various diagnostic tests to ensure the reliability of the results for policy development. By conducting robustness checks and sensitivity analyses, the study enhances the validity and credibility of its findings, providing policymakers with valuable insights for informed decision-making.
Keywords: Deforestation, Environmental Kuznets Curve, Energy Consumption, International Trade, Economic Growth
JEL Codes: Q23, Q56, O13

1. INTRODUCTION

The escalating threat of global warming and climate change has emerged as a prominent and ongoing global concern over the past two decades. Carbon emissions, constituting a significant portion of greenhouse gases (GHG), approximately 58.5%, alongside various other environmental pollutants, have been identified as key contributors to climate change. In response to the growing awareness and impacts of climate change, particularly on international trade, there has been a heightened focus on embodied carbon emissions and their relationship with trade dynamics in recent years. The intersection of carbon emissions and trade has become a focal point of active research, with efforts concentrated on quantifying energy-related carbon emissions in international trade and assessing the carbon emissions embodied in trade activities. This research area seeks to understand the carbon footprint associated with consumption-based emissions, shedding light on the environmental impact of consumption patterns and global supply chains. As concerns about climate change intensify, policymakers, researchers, and businesses are increasingly recognizing the importance of incorporating carbon emissions considerations into trade policies, supply chain management practices, and consumer behavior. This heightened attention reflects a growing recognition of the interconnectedness between trade activities, carbon emissions, and environmental sustainability. The exploration of embodied carbon emissions and their implications for international trade represents a critical area of research and policy development in the context of addressing climate change and promoting sustainable development. By better understanding the carbon footprint associated with trade activities and consumption patterns, stakeholders can work towards implementing strategies to mitigate carbon emissions and foster more environmentally sustainable trade practices.

In recent years, research on environmental degradation has become a focal point of discussion among scientists and policymakers worldwide. Recognizing the critical importance of this issue, interdisciplinary teams of professionals are

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collaborating to address the complex relationship between energy and economic growth and their environmental impacts. Various factors contribute to environmental degradation, and deforestation stands out as a significant concern. As nations strive to sustain economic growth, there is a growing demand for energy, which often leads to increased pressure on natural resources, including forests.

Deforestation not only contributes to habitat loss and biodiversity decline but also exacerbates climate change by releasing carbon stored in trees into the atmosphere. To mitigate the adverse effects of deforestation and meet the growing energy demand sustainably, innovative approaches and policies are needed. This includes promoting renewable energy sources such as solar, wind, and hydroelectric power, as well as improving energy efficiency and conservation practices. Additionally, efforts to protect and restore forests through sustainable land management practices and conservation initiatives are essential for preserving environmental quality and supporting long-term economic growth. Addressing the energy and growth nexus while minimizing environmental impacts requires a coordinated and holistic approach. By integrating environmental considerations into energy policies and economic development strategies, societies can strive towards achieving sustainable and inclusive growth while safeguarding the planet for future generations. The relationship among deforestation, energy consumption, and economic growth has been a neglected area in the literature, particularly in low-income countries like Pakistan. While much of the existing research has focused on developed economies, there is growing evidence suggesting the importance of understanding this relationship in the context of countries facing environmental challenges such as deforestation. The primary objective of this study is to contribute to the existing literature on the environment, energy, and growth networks by empirically investigating the relationship among economic growth, energy consumption, trade openness, and deforestation in Pakistan. By filling this research gap, the study aims to shed light on the complex interactions between economic development, energy use, trade patterns, and environmental degradation in a low-income country context. Through empirical analysis, the study seeks to evaluate the environmental quality of Pakistan by examining the extent to which economic growth, energy consumption, and trade openness contribute to deforestation and environmental degradation. By uncovering these relationships, policymakers and stakeholders can gain valuable insights into the drivers of deforestation and identify potential policy interventions to promote sustainable development and environmental conservation in Pakistan.

Pakistan has experienced significant economic growth over the past few decades and continues to exhibit potential for future development. The role of international trade and globalization has been instrumental in boosting economic activities within the country, driving increased demand for energy resources to sustain this growth momentum. However, Pakistan also faces a range of challenges that could potentially impede its continued economic progress, with one of the most prominent being the adverse impact of environmental pollution on economic growth. Despite its economic achievements, Pakistan grapples with environmental pollution resulting from rapid industrialization, urbanization, and energy consumption. This pollution poses a direct threat to public health, environmental sustainability, and ultimately, economic development. The inverse relationship between environmental pollution and economic growth underscores the need for concerted efforts to address environmental challenges while fostering continued economic expansion.

To sustain its economic growth trajectory, Pakistan must adopt a balanced approach that prioritizes environmental sustainability alongside economic development. This entails implementing policies and initiatives aimed at mitigating pollution, promoting energy efficiency, and transitioning towards cleaner and more sustainable energy sources. By investing in renewable energy infrastructure, improving waste management practices, and enhancing environmental regulations, Pakistan can minimize the adverse impacts of pollution on economic growth while safeguarding public health and environmental quality. Furthermore, integrating environmental considerations into economic planning and decision-making processes is essential for fostering sustainable development in Pakistan. This includes incorporating environmental impact assessments into development projects, promoting sustainable land use practices, and fostering public awareness and engagement on environmental issues. While Pakistan has made significant strides in economic growth, it must address the challenges posed by environmental pollution to ensure continued prosperity and sustainable development. By adopting a proactive and holistic approach to environmental management, Pakistan can create a conducive environment for long-term economic growth while preserving its natural resources and protecting the well-being of its citizens.

Pakistan's economy relies heavily on the agriculture sector, which serves as a primary source of livelihood for a significant portion of the population. However, the increasing population growth rate exacerbates the demand for agricultural land, leading to deforestation and environmental degradation. According to the World Wide Fund (WWF), Pakistan faces a dire situation, with the highest deforestation rate in Asia estimated at 2.1% per year (WWF, 2010). The expansion of agricultural activities often comes at the expense of forests and natural habitats, as forests are cleared to make way for farmland and other forms of development. This rampant deforestation not only threatens biodiversity and ecosystem health but also contributes to soil erosion, loss of water resources, and exacerbation of climate change. The consequences of deforestation are particularly concerning given Pakistan's vulnerability to environmental risks such as water scarcity, desertification, and natural disasters. Deforestation undermines the resilience of ecosystems and exacerbates the impacts of climate change, posing significant challenges to agricultural productivity, food security, and rural livelihoods. Addressing the root causes of deforestation in Pakistan requires a multifaceted approach that addresses both the drivers of forest loss and the underlying socio-economic factors. This includes promoting sustainable land management practices, enhancing forest conservation

efforts, and incentivizing reforestation and afforestation initiatives. Additionally, measures to improve agricultural productivity, enhance rural livelihoods, and promote alternative sources of income can help reduce the pressure on forests and alleviate the need for further deforestation. By prioritizing forest conservation and sustainable land use practices, Pakistan can protect its valuable natural resources, preserve biodiversity, and promote long-term environmental sustainability while supporting the economic well-being of its people. Collaboration between government agencies, civil society organizations, and local communities is essential to achieve these goals and ensure a prosperous and sustainable future for Pakistan.

In recent years, Pakistan has faced the devastating consequences of environmental degradation, leading to an increased frequency of dangerous natural disasters, with projections indicating a continuation of such trends in the future. The rapid pace of industrialization, coupled with the growing demand for agricultural land driven by population growth, has significantly heightened the risk to Pakistan's environmental quality. Despite the wealth of studies available on environmental quality, many have overlooked the crucial role of afforestation and reforestation in mitigating environmental degradation. Forestation plays a pivotal role in enhancing biodiversity, improving environmental quality, and mitigating the impacts of natural disasters such as floods. However, deforestation rates in Pakistan remain alarmingly high, driven primarily by the conversion of forested land for agriculture to meet the demands of a growing population, as well as the use of forests as a source of energy in rural areas. The consequences of deforestation are far-reaching, contributing to increased temperatures and serving as a significant driver of natural disasters such as floods. Afforestation efforts are therefore essential for improving environmental quality and enhancing livelihoods in Pakistan. By restoring forest cover and promoting sustainable land management practices, Pakistan can mitigate the adverse effects of deforestation, protect valuable ecosystems, and reduce the vulnerability of communities to environmental risks.

Investing in afforestation initiatives not only helps to preserve biodiversity and ecosystem services but also provides socio-economic benefits, including improved soil and water quality, enhanced carbon sequestration, and increased resilience to climate change. Furthermore, afforestation projects can create employment opportunities, support rural livelihoods, and contribute to poverty alleviation. In this study, we aim to analyze the complex relationships among deforestation, population dynamics, energy consumption, economic growth, and the Environmental Kuznets Curve (EKC), particularly within the context of Pakistan. While extensive research exists on these topics globally, there is a notable gap in literature concerning Pakistan's specific situation regarding deforestation. Over the past few decades, Pakistan has experienced alarmingly high rates of deforestation compared to other Asian countries. This makes it imperative to understand the interplay between deforestation and various socio-economic factors, including population growth, energy consumption, and economic development, within the Pakistani context. Our study employs the Autoregressive Distributed Lag (ARDL) bounds testing approach for cointegration, recognized as a suitable econometric tool for analyzing the long-run relationships among variables. By utilizing this method, we seek to unravel the interconnectedness between deforestation and other key variables, shedding light on the underlying drivers and implications for environmental sustainability and economic growth in Pakistan.

Through rigorous empirical analysis, we aim to contribute to the existing body of knowledge on the environmental-economic nexus, specifically focusing on the unique challenges and opportunities facing Pakistan. By identifying the determinants of deforestation and examining their interactions with population dynamics, energy consumption patterns, and economic growth trajectories, our study endeavors to inform evidence-based policy interventions aimed at promoting sustainable development and environmental conservation in Pakistan. Our research aims to fill a significant gap in the literature by providing insights into the relationship between deforestation and socio-economic factors in Pakistan, thereby facilitating informed decision-making and fostering a more sustainable future for the country.

2. LITERATURE REVIEW

Numerous studies have provided empirical evidence of cointegration, temporary dynamics, and causal relationships between economic growth and carbon emissions, as well as bidirectional causality between energy consumption and economic growth. Among these studies, researchers such as Saboori & Sulaiman (2013), Shahbaz et al. (2013a, 2013b, 2013c), Yang & Zhao (2014), Cowan et al. (2014), Mensah (2014), Bölük & Mert (2014), Bastola & Sapkota (2015), and Wang et al. (2016) have consistently found significant associations between these variables across various countries and time periods. Furthermore, Saboori, Sapri, and bin Baba (2014) specifically investigated the relationship between carbon emissions and economic growth in the road sector energy consumption in OECD countries from 1960 to 2008. Their findings revealed a positive long-term bidirectional causality between carbon emissions and economic growth, highlighting the complex interplay between energy consumption, economic activity, and environmental considerations in the road transportation sector. Saidi and Hammami (2015) conducted a study on the role of energy consumption and carbon emissions in economic growth, utilizing simultaneous-equations models on panel data for 58 countries spanning from 1990 to 2012. Their findings indicated a direct relationship between energy consumption and economic growth, while carbon emissions were inversely related to economic growth.

Similarly, Omri (2013) employed simultaneous-equations models and identified bidirectional causality between economic growth and CO2 emissions across 14 MENA countries. On the other hand, Salahuddin and Gow (2014) discovered a

unidirectional link from economic growth to carbon emissions in Gulf Cooperation Council countries. Azam et al. (2015) investigated causal dynamics in five ASEAN countries and found diverse patterns. In the case of Indonesia, no unilateral causality was observed for all three variables. For Malaysia, economic growth was found to cause energy consumption. For Thailand and the Philippines, causality ran from gross fixed capital formation to energy consumption, while for Singapore, bidirectional causality existed between exports and gross fixed capital formation. Additionally, Long et al. (2015) explored the relationships between economic growth, energy consumption, and carbon emissions in China from 1952 to 2012. Their analysis, employing co-integration and Granger causality tests, revealed that coal had a dominant impact on economic growth and carbon emissions. Moreover, they found a bidirectional relationship between GDP and CO2 emissions, coal, gas, and electricity consumption. These studies underscore the importance of understanding the complex interrelationships between economic growth, energy consumption, and carbon emissions, as well as the heterogeneity of these relationships across different countries and regions. Such insights are crucial for policymakers and stakeholders seeking to develop effective strategies for sustainable development and environmental conservation.

Ahmed et al. (2015) conducted a study on the dynamics of deforestation, energy consumption, and economic growth concerning environmental degradation in Pakistan, covering the period from 1980 to 2013. Their research confirmed both long and short-run dynamics, revealing unidirectional causality from energy consumption and economic growth to deforestation. This suggests that increased energy consumption and economic activity contribute to deforestation, thereby exacerbating environmental degradation in Pakistan. Similarly, Heidari et al. (2015) examined the relationship between environmental degradation, CO2 emissions, and economic growth across ASEAN countries. Their findings indicated that environmental degradation increases alongside CO2 emissions and economic growth. Additionally, they validated the Environmental Kuznets Curve (EKC) hypothesis, which suggests that environmental degradation initially worsens with economic growth but eventually improves as income levels rise further. These studies provide valuable insights into the complex interplay between economic growth, energy consumption, environmental degradation, and deforestation. By highlighting the causal relationships between these variables, policymakers and stakeholders can develop targeted strategies to mitigate environmental degradation and promote sustainable development in Pakistan and other countries across the ASEAN region.

Jammazi and Aloui (2015) conducted a study examining the interconnections between economic growth, energy consumption, and carbon emissions across six GCC (Gulf Cooperation Council) countries spanning from 1980 to 2013. Employing a novel approach known as wavelet window cross-correlation (WWCC), they sought to uncover the dynamic relationships between these variables over time. Their findings revealed the presence of bilateral causal effects between energy consumption and economic growth, indicating a mutually reinforcing relationship between these two factors. However, they identified only a unidirectional relationship from energy consumption to CO2 emissions, suggesting that increased energy consumption contributes to higher carbon emissions in the GCC countries. By employing the WWCC methodology, Jammazi and Aloui were able to capture the time-varying nature of the relationships between economic growth, energy consumption, and carbon emissions, providing valuable insights into the temporal dynamics of these interconnections. Their findings have implications for policymakers and stakeholders seeking to develop effective strategies for promoting sustainable development and mitigating carbon emissions in the GCC countries.

Shahbaz et al. (2014) conducted a comprehensive study investigating the interrelationships between environmental degradation, economic growth, urbanization, and electricity consumption in the United Arab Emirates (UAE). Utilizing quarter-frequency data spanning from 1975 to 2011, they applied the Autoregressive Distributed Lag (ARDL) approach and the Vector Error Correction Model (VECM) Granger causality tests to analyze the dynamics among these variables. Their research confirmed the presence of co-integration among the series, indicating a long-term relationship between environmental degradation, economic growth, urbanization, and electricity consumption in the UAE. Specifically, they found that electricity consumption exerted a negative effect on carbon emissions, suggesting that increased electricity usage was associated with lower levels of carbon emissions. Furthermore, the study revealed that urbanization was positively linked to CO2 emissions, indicating that rapid urban development contributed to higher levels of carbon emissions in the UAE. However, exports were found to have a beneficial impact on environmental quality, leading to a decrease in CO2 emissions. Additionally, Shahbaz et al. (2014) identified causal relationships between economic growth, urbanization, and CO2 emissions, highlighting the role of these factors in influencing environmental degradation in the UAE.

Wang et al. (2014) delved into the intricate relationship between urbanization, CO2 emissions, and energy consumption using panel data from 30 Chinese provinces spanning from 1995 to 2011. Employing a panel data model, their investigation uncovered several significant findings regarding the dynamics among these variables. Firstly, their analysis unveiled a long-term bi-directional positive relationship among energy consumption, urbanization, and CO2 emissions across the Chinese provinces. This suggests that changes in energy consumption and urbanization levels were accompanied by corresponding alterations in CO2 emissions, and vice versa. Furthermore, Wang et al. (2014) observed variations in these relationships between provinces, indicating that regional factors may influence the extent and nature of the interconnections between urbanization, CO2 emissions, and energy consumption. Their study also identified a two-sided causal relationship between urbanization, CO2 emissions, and energy consumption. Specifically, they found evidence of positive and bi-directional causality between urbanization and CO2 emissions, as well as between energy consumption and CO2 emissions. This

implies that urbanization and energy consumption exert reciprocal influences on CO2 emissions, with changes in one variable impacting the others.

Moreover, Wang et al. (2014) observed a positive and one-way causal relationship from urbanization to energy consumption. This suggests that urbanization drives increased energy consumption, potentially due to the greater demand for energy-intensive infrastructure and services in urban areas. Begum et al. (2015) conducted a study to explore the dynamic impacts of GDP growth, population growth, and energy consumption on CO2 emissions in Malaysia. Employing the ARDL bounds testing approach, they discovered that both per capita energy consumption and per capita GDP exhibit positive associations with per capita carbon emissions. However, they found that the population growth rate did not significantly affect per capita CO2 emissions in Malaysia. On the other hand, Liu et al. (2015) investigated the relationship between population density, energy consumption, and environmental pollution in China. They found that higher population density led to a decrease in energy consumption across China and its eastern, central, and western regions. However, the effect of population density on the environment varied depending on the type of pollutants. Specifically, higher population density was associated with increased wastewater discharge but decreased solid waste production in China and its three regions. Furthermore, Wang et al. (2016) empirically examined the impact of urbanization on energy consumption and CO2 emissions in China, considering provincial differences. Their results indicated that urbanization contributes to increases in both energy consumption and CO2 emissions in China, although it is not the most significant factor driving these increases. Additionally, they found significant variations between provinces regarding the impact of urbanization on energy consumption and CO2 emissions. Li and Lin (2015) conducted a comprehensive analysis utilizing a balanced panel database of 73 countries spanning from 1971 to 2010, categorized into four income groups. Their findings revealed nuanced relationships between urbanization, energy consumption, and CO2 emissions across different income levels. Specifically, they found that urbanization led to a decrease in energy consumption but an increase in CO2 emissions for low-wage countries. In middle-low and higher-income countries, industrialization was associated with decreased energy consumption but increased carbon emissions. Moreover, urbanization was found to significantly increase both energy consumption and CO2 emissions across various income groups. Interestingly, urbanization did not significantly impact energy consumption but did hinder the growth of emissions in the middle-lower income group.

While much of the existing literature focuses on exploring the relationships between energy consumption, CO2 emissions, and economic growth while validating the Environmental Kuznets Curve (EKC) hypothesis, there's a notable gap in considering the role of deforestation in environmental quality. Therefore, the current study aims to address this gap by examining the relationship between environmental quality and deforestation, economic growth, trade openness, energy consumption, and population, along with investigating the EKC hypothesis for economic growth and trade openness. The study employs the ARDL approach for co-integration analysis and the Vector Error Correction Model (VECM) for Granger causality testing to comprehensively explore the interconnections between these variables.

3. METHODOLOGY

The study investigates the interplay among deforestation, economic growth, trade openness, energy consumption, and population dynamics in Pakistan using yearly time series data spanning from 1980 to 2020. The data, sourced from the World Bank indicator database in secondary form, includes forestation land ratio as a proxy for deforestation, energy consumption per capita, Trade as a percentage of GDP for international trade, real GDP per capita for economic growth, and Population density from World Development Indicators. To reevaluate the relationships among environmental quality, economic growth, and trade openness, all variables are considered in their natural logarithmic form instead of ratios. The ARDL bound testing approach, established by Pesaran, Shin, and Smith (2001), is employed to examine both the long and short-term relationships among the variables. This method is chosen for its suitability in analyzing mixed orders of integration in time series data, without the requirement that all series should be stationary at the same level. Other methods for cointegration, such as those proposed by Johansen and Juselius (1990), Phillips and Hansen (1990), and Engle and Granger (1987), typically necessitate this condition.

The model employed in this study offers flexibility by not imposing the condition that variables must be stationary at either level or first difference. This wide applicability makes it suitable for datasets where series may exhibit different orders of integration (I(0), I(1), or a mixture of both) and even if there is the presence of I(2) integration. Moreover, this method is advantageous for small sample sizes and effectively addresses the issue of serial correlation in time series data. Before examining the relationships among the aforementioned series, it's essential to assess the characteristics of the data and verify if the assumptions of the model are met. Different unit root tests are applied for this purpose to determine if the model is applicable to the data. The ARDL model requires that all series should be stationary at either I(0) or I(1), or a mixture of both, but not at I(2). Various unit root tests, such as the Augmented Dickey Fuller (ADF) test by Dickey and Fuller (1979), the Phillips Perron (PP) test introduced by Phillips and Perron (1988), and the KPSS test developed by Kwiatkowski et al. (1992), are utilized to examine the presence of unit roots in the data.

Once the data's characteristics and assumptions are confirmed, the ARDL bound test approach for cointegration can be employed. The ARDL model proceeds through two straightforward steps. Firstly, it involves selecting the optimal lag

structure of the model, often determined by criteria like the Schwarz Information Criterion (SIC). This criterion balances the model's fit with its complexity, aiding in identifying the lag length that best captures the data's dynamics without overfitting. Subsequently, the next step entails running a regression within the ARDL framework. Here, the selected optimal lag length is utilized, and the regression involves regressing the dependent variable (e.g., environmental quality represented by deforestation) on the independent variables (e.g., economic growth, trade openness, energy consumption, and population), alongside their lagged values. This comprehensive regression captures both long-run and short-run relationships in a unified equation. By adhering to these steps, the ARDL bound test approach provides valuable insights into the cointegrating relationships among the variables. It facilitates a deeper understanding of the system's long-term dynamics and interactions, shedding light on how factors such as economic growth, trade openness, energy consumption, and population influence environmental quality, as measured by deforestation, over time.

RESULTS AND DISCUSSIONS

Table 1 summarizes the results of the unit root analysis conducted using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests for various variables. The unit root tests are performed at both the level and first difference of the variables to determine their stationarity properties. For the variable DF (not explicitly defined), both the ADF and PP tests indicate significant stationarity at the first difference level, with t-statistics of -5.939 and -10.539 respectively, indicating a rejection of the null hypothesis of a unit root at the 1% significance level. Similarly, for variables lnEC (natural logarithm of EC), lnY (natural logarithm of Y), lnY2 (natural logarithm of Y squared), T (time), and T2 (time squared), both the ADF and PP tests demonstrate significant stationarity at the first difference level, with t-statistics exceeding critical values at the 1% significance level. However, for the variables lnP (natural logarithm of P), neither the ADF nor the PP test results indicate significant stationarity at either the level or the first difference. The notation * and ** denote significance at the 1% and 5% levels respectively, providing clarity on the level of significance associated with each test statistic.

Table 1: Unit root analysis Results

Variable	ADF Unit Root Test		PP Unit Root Test		Decision
	Level	1st Difference	Level	1st Difference	
DF	-0.039	-5.939*	1.345	-10.539*	(1)
lnEC	-2.285	-4.585*	-2.241	-4.579*	(1)
lnP	-3.419**	-	-13.721*	-	(0)
lnY	-1.077	-3.615**	-1.621	-3.607**	(1)
lnY^2	-1.013	-3.598**	-1.512	-3.594**	(1)
T	-2.876	-7.785*	-2.969	-7.967*	(1)
T^2	-2.879	-7.771*	-2.974	-7.991*	(1)

Note: * and ** show significant at 1% and 5% levels respectively.

Table 2 provides the outcomes of the ARDL bounds testing for cointegration. The analysis reveals an ARDL F-Statistic of 10.763*, indicating the presence of cointegration among the variables under investigation. The optimal lag order identified in the analysis is specified as 0, 1, 1, 1, 0, 1, 1, suggesting the inclusion of lagged terms in the model for robustness. It's noteworthy that the model includes an unrestricted intercept and no trend. The significance of the ARDL F-Statistic, denoted by *, underscores its robustness at the 1% level. These findings suggest a stable long-run relationship among the variables considered, providing valuable insights into their dynamic interactions over time.

Table 2: ARDL bounds testing cointegration

Estimated Model	
ARDL F-Statistic	10.763*
Optimal Lag Order	0,1,1,1,0,1,1

Notes: Unrestricted Intercept and no Trend. And * shows significance at 1% level.

Results of table-3 showing that energy consumption havepositive relationship with environmental quality that shows wood is used as a source of fuelto meet energy demand in Pakistan rural areas. Population has negative relationship with deforestation that shows increase in population density does not affect environment negatively in long term. The negative relationship results of population density are consistent with studies by Bhattarai and Hammig (2001), Templeton and Scherr (1999), and DeFries et al. (2010), but contrary to the findings in Ahmed et al. (2015). Consistently, Trade openness and economic growth have inverted U-shaped relationship with environmental quality and validate the EKC hypothesis in

long-term and the threshold point at 520.07 US$ per capita economic growth and 30.86% international of GDP level. It meansinternational trade of wood and economic growth increase the deforestation rate initially but after a specific point of them deforestation rate would be decreases. Same as in long-term energy consumption and deforestation has positive but significant relation in short run and population density has negative but statistical insignificant in short run. Economic growth and trade openness validate the EKC hypothesis in short run also at 10% significance level.The speed of adjustment of long term equilibrium is indicated by ECT_{t-1}in table-3. The coefficient value of $ECT_{t-1}$is .985 that means the speed of adjustment towards long term equilibrium by 98.5% and t statistics is also negative significantly.

Table 3: Long and short-term outcomes

Long-term Elasticities	
Constant	-96.702 (-5.321)*
lnEC	1.218 (1.765)***
lnP	-2.518 (-5.439)*
lnY	32.383 (5.529)*
lnY^2	-2.5888 (-5.904)*
T	0.247 (2.213)**
T^2	-0.004 (-2.285)**
Short-term Elasticities	
Constant	0.045(0.5489)
ΔlnE	1.641(2.165)**
ΔlnP	-5.348(-1.577)
ΔlnY	47.460(1.916)***
ΔlnY^2	-3.713 (-1.902)***
ΔT	0.117(1.786)***
ΔT^2	-0.002(-1.89)***
ECT-t	-0.977(-5.531)*

4. CONCLUSION

This study undertakes a thorough reexamination of the intricate relationship among various factors influencing environmental degradation, focusing on deforestation, energy consumption, population density, economic growth, and trade openness in Pakistan. Spanning the years 1980 to 2020, it aims to elucidate both the long-term and short-term dynamics through the application of the Autoregressive Distributed Lag (ARDL) model. A significant aspect of this study is the exploration of the Environmental Kuznets Curve (EKC) relationship between deforestation and economic growth, as well as deforestation and trade openness. By scrutinizing the data over the specified time period, the study aims to validate whether there exists a turning point beyond which economic growth and trade openness contribute to forestation rather than deforestation. Preliminary findings suggest the presence of a long-term relationship among the variables under investigation. Moreover, the study provides evidence supporting the existence of an EKC relationship with both economic growth and trade openness. Specifically, it indicates that while economic growth and international trade of wood products may initially lead to an increase in deforestation rates, there appears to be a turning point beyond which they promote forestation in the long term. These findings hold significant implications for policymakers and stakeholders involved in environmental conservation and sustainable development efforts in Pakistan. By understanding the nuanced relationships among economic growth, trade openness, and environmental degradation, policymakers can formulate targeted strategies to promote sustainable practices and mitigate deforestation while fostering economic development and international trade. The study reveals intriguing insights into the relationship dynamics among energy consumption, population density, economic growth, trade openness, and deforestation in Pakistan.

Notably, it uncovers a positive long-term association between energy consumption and deforestation, indicating the prevalent use of wood as a fuel source in rural areas, thereby contributing to deforestation. Conversely, the study unveils a negative long-term relationship between population density and deforestation, challenging the conventional assumption that population growth is a primary driver of deforestation in the long run. In the short term, energy consumption continues to exhibit a positive and significant relationship with deforestation, reflecting the immediate impact of wood consumption as a fuel source. On the other hand, while population density shows a negative relationship with deforestation in the short term, this relationship is deemed insignificant, suggesting that population density may not be a significant factor influencing deforestation in the short run. Furthermore, the study elucidates an inverted U-shaped relationship between economic growth, trade openness, and deforestation in the short term. This suggests that while initial phases of economic growth and

international trade may contribute to deforestation, there exists a turning point beyond which they facilitate forestation efforts. Overall, the study underscores the complex interplay among economic, demographic, and environmental factors in shaping deforestation trends in Pakistan. It highlights the bidirectional relationships between economic growth, international trade, and population dynamics with deforestation, while emphasizing the unidirectional influence of energy consumption on deforestation. These findings provide valuable insights for policymakers seeking to develop targeted strategies for sustainable forest management and environmental conservation in Pakistan.

The study draws a conclusive insight that economic growth and international trade serve as pivotal contributors to deforestation trends in Pakistan. Given Pakistan's status as a developing country, its emphasis on economic development has led to the attraction and authorization of industrial activities. Moreover, with agriculture being a cornerstone of Pakistan's economy, efforts to bolster this sector often involve expanding agricultural land, which, in turn, may exacerbate deforestation pressures. However, the study underscores a nuanced perspective, suggesting that beyond a certain threshold of economic growth, initiatives promoting afforestation become paramount. This highlights the potential for sustainable land management practices to counterbalance the adverse effects of economic development on deforestation rates. Similarly, international trade of wood products emerges as another significant driver of deforestation in Pakistan. Yet, the study unveils an intriguing inverted U-shaped relationship between international trade and deforestation, suggesting a potential shift in deforestation trends in response to heightened awareness of its detrimental impacts or government policies aimed at mitigating deforestation.

These findings illuminate the complexities surrounding deforestation dynamics in Pakistan and underscore the imperative for balanced strategies that prioritize economic growth while simultaneously addressing environmental concerns. By fostering a synergistic approach that integrates sustainable development practices with conservation efforts, Pakistan can strive towards achieving both economic prosperity and environmental sustainability. The analysis from this study underscores the urgent need for governmental and policymaker intervention to address the environmental challenges posed by deforestation in Pakistan. It calls for a comprehensive review of existing environmental policies to identify and rectify shortcomings, emphasizing the importance of proactive measures to safeguard and enhance the nation's forest resources. One of the key recommendations is the implementation of large-scale reforestation initiatives at the national level, aimed at replenishing depleted forest areas and expanding forest cover. Concurrently, concerted efforts are needed to protect existing forested areas from further degradation and encroachment. Furthermore, the study highlights the necessity of transitioning away from reliance on wood fuel by promoting the adoption of alternative energy sources, particularly renewable energy technologies. This could involve the development of new dams to harness hydropower, as well as initiatives to import natural gas to diversify the energy mix and reduce pressure on forests. Importantly, addressing the rising energy demand is paramount to mitigating further environmental deterioration and ensuring sustainable development. By reducing reliance on wood fuel and embracing cleaner energy alternatives, Pakistan can mitigate the adverse impacts of deforestation on environmental quality and forest ecosystems. Moreover, the study underscores the link between deforestation and natural disasters in Pakistan, emphasizing the need for proactive measures to mitigate these risks. Strengthening forest conservation efforts can help buffer against the adverse effects of climate change and reduce the vulnerability of communities to disasters such as floods and landslides. Overall, the findings of this study offer valuable insights for policymakers, providing a basis for refining trade, economic, and energy-related policies to foster sustainable development and environmental conservation in Pakistan. By prioritizing forest protection, promoting renewable energy, and enhancing disaster resilience, Pakistan can chart a path towards a more sustainable and resilient future.

REFERENCES

Ahmed, K., Shahbaz, M., Qasim, A., & Long, W. (2015). The linkages between deforestation, energy and growth for environmental degradation in Pakistan. *Ecological Indicators*, 49, 95-103.

Azam, M., Khan, A. Q., Bakhtyar, B., & Emirullah, C. (2015). The causal relationship between energy consumption and economic growth in the ASEAN-5 countries. *Renewable and Sustainable Energy Reviews*, 47, 732-745.

Bastola, U., & Sapkota, P. (2015). Relationships among energy consumption, pollution emission, and economic growth in Nepal. *Energy*, 80, 254-262.

Begum, R. A., Sohag, K., Abdullah, S. M. S., & Jaafar, M. (2015). CO2 emissions, energy consumption, economic and population growth in Malaysia. *Renewable and Sustainable Energy Reviews*, 41, 594-601.

Bhattarai, M., & Hammig, M. (2001). Institutions and the environmental Kuznets curve for deforestation: A cross-country analysis for Latin America, Africa and Asia. *World Development*, 29(6), 995-1010.

Bölük, G., & Mert, M. (2014). Fossil & renewable energy consumption, GHGs (greenhouse gases) and economic growth: Evidence from a panel of EU (European Union) countries. *Energy*, 74, 439-446.

Cowan, W. N., Chang, T., Inglesi-Lotz, R., & Gupta, R. (2014). The nexus of electricity consumption, economic growth and CO2 emissions in the BRICS countries. *Energy Policy*, 66, 359-368.

DeFries, R. S., Rudel, T., Uriarte, M., & Hansen, M. (2010). Deforestation driven by urban population growth and agricultural trade in the twenty-first century. *Nature Geoscience*, 3(3), 178-181.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74, 427-431.

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica: Journal of the Econometric Society*, 251-276.

Heidari, H., Katircioğlu, S. T., & Saeidpour, L. (2015). Economic growth, CO2 emissions, and energy consumption in the five ASEAN countries. *International Journal of Electrical Power & Energy Systems*, 64, 785-791.

Jammazi, R., & Aloui, C. (2015). On the interplay between energy consumption, economic growth and CO2 emission nexus in the GCC countries: A comparative analysis through wavelet approaches. *Renewable and Sustainable Energy Reviews*, 51, 1737-1751.

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, 52, 169-210.

Kwiatkowski, D., Phillips, P. C., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *Journal of Econometrics*, 54(1), 159-178.

Li, K., & Lin, B. (2015). Impacts of urbanization and industrialization on energy consumption/CO2 emissions: Does the level of development matter? *Renewable and Sustainable Energy Reviews*, 52, 1107-1122.

Liu, Y., Zhou, Y., & Wu, W. (2015). Assessing the impact of population, income and technology on energy consumption and industrial pollutant emissions in China. *Applied Energy*, 155, 904-917.

Long, X., Naminse, E. Y., Du, J., & Zhuang, J. (2015). Nonrenewable energy, renewable energy, carbon dioxide emissions and economic growth in China from 1952 to 2012. *Renewable and Sustainable Energy Reviews*, 52, 680-688.

Mensah, J. T. (2014). Carbon emissions, energy consumption and output: A threshold analysis on the causal dynamics in emerging African economies. *Energy Policy*, 70, 172-182.

Omri, A. (2013). CO2 emissions, energy consumption and economic growth nexus in MENA countries: Evidence from simultaneous equations models. *Energy Economics*, 40, 657-664.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16, 289-326.

Phillips, P. C., & Hansen, B. E. (1990). Statistical inference in instrumental variables regression with I(1) processes. *The Review of Economic Studies*, 57, 99-125.

Phillips, P. C., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, 75, 335-346.

Saboori, B., & Sulaiman, J. (2013). CO2 emissions, energy consumption and economic growth in Association of Southeast Asian Nations (ASEAN) countries: A cointegration approach. *Energy*, 55, 813-822.

Saboori, B., Sapri, M., & bin Baba, M. (2014). Economic growth, energy consumption and CO2 emissions in OECD (Organization for Economic Co-operation and Development)'s transport sector: A fully modified bi-directional relationship approach. *Energy*, 66, 150-161.

Saidi, K., & Hammami, S. (2015). The impact of CO2 emissions and economic growth on energy consumption in 58 countries. *Energy Reports*, 1, 62-70.

Salahuddin, M., & Gow, J. (2014). Economic growth, energy consumption and CO2 emissions in Gulf Cooperation Council countries. *Energy*, 73, 44-58.

Shahbaz, M., Khan, S., & Tahir, M. I. (2013). The dynamic links between energy consumption, economic growth, financial development and trade in China: Fresh evidence from multivariate framework analysis. *Energy Economics*, 40, 8-21.

Shahbaz, M., Mutascu, M., & Azim, P. (2013). Environmental Kuznets curve in Romania and the role of energy consumption. *Renewable and Sustainable Energy Reviews*, 18, 165-173.

Shahbaz, M., Sbia, R., Hamdi, H., & Ozturk, I. (2014). Economic growth, electricity consumption, urbanization and environmental degradation relationship in United Arab Emirates. *Ecological Indicators*, 45, 622-631.

Shahbaz, M., Tiwari, A. K., & Nasir, M. (2013). The effects of financial development, economic growth, coal consumption and trade openness on CO2 emissions in South Africa. *Energy Policy*, 61, 1452-1459.

Templeton, S. R., & Scherr, S. J. (1999). Effects of demographic and related microeconomic change on land quality in hills and mountains of developing countries. *World Development*, 27(6), 903-918.

Wang, S., Fang, C., Guan, X., Pang, B., & Ma, H. (2014). Urbanisation, energy consumption, and carbon dioxide emissions in China: A panel data analysis of China's provinces. *Applied Energy*, 136, 738-749.

Wang, S., Li, Q., Fang, C., & Zhou, C. (2016). The relationship between economic growth, energy consumption, and CO2 emissions: Empirical evidence from China. *Science of The Total Environment*, 542, 360-371.

World Wide Fund (WWF). (2010). Living Planet Report.

Yang, Z., & Zhao, Y. (2014). Energy consumption, carbon emissions, and economic growth in India: Evidence from directed acyclic graphs. *Economic Modelling*, 38, 533-540.