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NONLINEAR DYNAMICS OF GROWTH, RESOURCE USE, ENVIRONMENT, AND CLIMATE POLICY EFFECTIVENESS IN PAKISTAN: THE ROLE OF CULTURAL MULTIPLIERS—A PROVINCIAL DYNAMIC PANEL ANALYSIS

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Abstract

Economic growth, resource utilization, environmental degradation, and climate policy effectiveness are deeply interconnected dimensions of sustainable development, particularly in climate-vulnerable developing economies. Pakistan faces a complex sustainability challenge where rapid economic expansion, increasing energy demand, natural resource pressure, and climate risks interact with heterogeneous institutional and cultural structures across provinces. This study investigates the nonlinear dynamics between economic growth, resource use, environmental quality, and climate policy effectiveness in Pakistan using a provincial dynamic panel framework. The study introduces the concept of cultural multipliers as a moderating mechanism through which social norms, environmental awareness, community participation, traditional resource management practices, and governance culture influence the effectiveness of climate policies.Using a balanced provincial panel dataset covering four major provinces of Pakistan (Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan) during 2000–2024, the study applies advanced panel econometric techniques, including Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL), Panel Quantile Regression, Dynamic Common Correlated Effects Mean Group (DCCEMG), Augmented Mean Group (AMG), and System Generalized Method of Moments (System-GMM). The nonlinear relationship is examined through Environmental Kuznets Curve (EKC) specifications incorporating growth, growth squared, energy intensity, natural resource dependency, renewable energy adoption, climate policy effectiveness, and cultural multipliers.Expected findings suggest that economic growth initially increases environmental pressure but improves environmental outcomes after reaching a provincial sustainability threshold. Climate policy effectiveness is expected to reduce environmental degradation; however, its impact varies significantly across provinces depending on cultural adaptability, institutional capacity, and community-level environmental engagement. The study provides

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novel evidence that cultural factors amplify or weaken climate policy outcomes and highlights the importance of socially embedded climate governance for sustainable development in Pakistan.
aught the international community's attention with regards to Pakistan's role in facilitating dialogue and mediation in the "Islamabad Peace Talks". As digital diplomacy continued to expand, political narratives were being built and international perceptions formed through social media platforms like X (formerly Twitter) by world leaders in a public manner. The purpose of this study is to analyze the discursive representation of Pakistan as a mediator by global leaders in their tweets and the underlying meanings of these representations in the context of the ideology and geopolitics. The study is qualitative in nature and employed Norman Fairclough's three-dimensional model of CDA to the purposively selected tweets of international political leaders and official spokespersons from their verified X/Twitter accounts, posted on 7th & 8th April, 2026. The findings reveal that Pakistan is consistently built with positive evaluative language that is connected to mediation, peace and diplomacy and is intertextually repeated, collectively affirmed and institutionally supported by various global actors. The study concludes that these tweets create a coherent discourse that validates the emerging role of Pakistan as a mediator, thereby highlighting the role of social media's diplomacy in influencing world perceptions and providing an insight into the underlying power and ideology perspective discourse.

1. Introduction

1.1 Background of the Study

Sustainable economic development has become a major global challenge in the twenty-first century as developing countries seek to achieve economic growth while ensuring environmental sustainability, resource security, and climate resilience. The conventional development model, based largely on industrialization, fossil fuel consumption, and intensive exploitation of natural resources, has improved living standards and economic opportunities but has also accelerated environmental degradation, carbon emissions, biodiversity loss, and ecological vulnerability. Consequently, understanding the relationship between economic growth, resource utilization, and environmental sustainability has become a central issue in environmental economics and development research.

Pakistan provides an important case for examining the growth–resource–environment relationship because the country faces the dual challenge of promoting economic development while addressing increasing environmental and climatic pressures. Despite contributing a small share of global greenhouse gas emissions, Pakistan remains highly vulnerable to climate change due to its dependence on climate-sensitive agriculture, water scarcity, rapid urbanization, fragile ecosystems, and limited adaptive capacity. Increasing occurrences of floods, droughts, heatwaves, and other climate-related disasters have negatively affected agricultural productivity, infrastructure, livelihoods, and economic stability. Historically, Pakistan's economic growth has been driven by resource-intensive sectors, including agriculture, manufacturing, construction, and energy production. Industrial expansion, urban development, and rising energy demand have increased dependence on fossil fuels, contributing to higher carbon emissions and environmental stress. Similarly, population growth and intensified economic activities have placed significant pressure on forests, water resources, agricultural land, and natural ecosystems.

However, the relationship between economic growth and environmental degradation is not necessarily linear. The Environmental Kuznets Curve (EKC) hypothesis suggests that environmental degradation increases during the early stages of economic development due to industrialization and resource consumption but declines after achieving a certain income level through technological progress, cleaner production systems, structural transformation, environmental awareness, and stronger institutions. Although the EKC framework has been widely examined at national levels, growing evidence highlights the importance of subnational analysis because environmental outcomes differ significantly across regions due to variations in economic structures, governance capacity, resource availability, and social characteristics.

Pakistan's provinces provide a suitable framework for examining these differences. Punjab, as the country's largest economic center, experiences significant environmental pressure due to industrialization, urban expansion, and intensive agricultural activities. Sindh faces challenges related to industrial pollution, coastal vulnerability, and water scarcity. Khyber Pakhtunkhwa possesses considerable forest resources, hydropower potential, and community-based conservation practices but remains vulnerable to climate-induced disasters. Balochistan faces severe ecological constraints, including water scarcity, fragile ecosystems, and limited institutional capacity. These differences indicate that environmental policies may produce varying outcomes depending on regional conditions.

Therefore, evaluating climate policy effectiveness requires moving beyond a uniform national approach and considering the social and cultural factors that influence policy implementation. This study introduces the concept of **cultural multipliers**, referring to social norms, environmental awareness, community participation, collective action, and traditional conservation practices that strengthen or weaken the effectiveness of climate policies. By incorporating these factors, the study provides a broader understanding of how economic development, environmental governance, and social characteristics interact to shape sustainability outcomes in Pakistan.

1.2 Climate Policy Effectiveness and the Role of Cultural Multipliers

Climate policy effectiveness is no longer limited to the presence of environmental regulations or government investment; rather, it depends on institutional quality, policy implementation, public participation, technological capacity, and social acceptance. Policies developed without considering local conditions often face implementation barriers because communities may lack awareness, trust, incentives, or willingness to adopt sustainable practices.

Recent environmental research emphasizes that cultural and social factors significantly influence environmental behavior. Collective values, community cooperation, environmental awareness, traditional knowledge, and social responsibility can enhance conservation efforts and improve the outcomes of climate policies. In contrast, weak social participation and limited environmental awareness may reduce policy effectiveness even when formal institutions and regulations exist.

In Pakistan, cultural practices have historically contributed to natural resource management, particularly in rural communities through traditional approaches to water conservation, forest protection, agricultural adaptation, and ecosystem management. However, increasing urbanization, population growth, and changing economic incentives have weakened some indigenous environmental practices. Revitalizing these social mechanisms can therefore play an important role in strengthening climate resilience.

This study conceptualizes cultural factors as multipliers rather than direct determinants of environmental sustainability. A climate policy may have limited impact when social acceptance and community engagement are weak; however, the same policy can generate stronger environmental improvements when supported by local knowledge, collective action, and environmentally responsible social norms. Integrating cultural dimensions into climate policy analysis provides a more comprehensive framework for understanding sustainability transitions.

1.2 Research Objectives

Based on the study framework, the following three main objectives are formulated:

1. To examine the nonlinear relationship between economic growth and environmental degradation across Pakistani provinces by testing the validity of the Environmental Kuznets Curve (EKC) hypothesis.
2. To investigate the role of resource utilization, energy consumption, and renewable energy transition in determining environmental sustainability outcomes in Pakistan.
3. To evaluate the effectiveness of climate policies and analyze the moderating role of cultural factors in strengthening environmental sustainability while identifying differences in provincial sustainability pathways.

2. Literature Review

2.1 Introduction

The relationship between economic growth, resource utilization, environmental degradation, and climate sustainability has become a major research area in environmental economics and sustainable development. Developing economies face the challenge of achieving economic growth and poverty reduction while minimizing environmental costs associated with industrialization, energy consumption, and natural resource exploitation. The Environmental Kuznets Curve (EKC) hypothesis provides an important theoretical framework for explaining this relationship, suggesting that environmental degradation initially increases with economic growth but declines after a certain income threshold due to technological progress, structural transformation, institutional improvements, and rising environmental awareness (Grossman & Krueger, 1995).

However, recent studies highlight that the growth–environment relationship is not universal and depends on factors such as energy structure, resource dependency, institutional quality, technological innovation, and environmental policies. Therefore, understanding environmental sustainability requires an integrated approach that considers economic, ecological, institutional, and social dimensions.

2.2 Economic Growth and Environmental Degradation Nexus

The relationship between economic growth and environmental quality has been extensively studied through the EKC framework. Grossman and Krueger (1995) proposed that economic expansion initially increases environmental pressure through scale effects associated with industrial production and resource consumption. However, at higher development levels, composition and technology effects contribute to environmental improvement through cleaner technologies, efficient production systems, and stronger environmental regulations.

Stern (2004) argued that economic growth alone cannot guarantee environmental sustainability because EKC outcomes depend on institutional quality, technological capacity, and the type of pollutants considered. Similarly, Dinda (2004) emphasized that technological innovation and structural transformation can reduce environmental pressure, but developing countries often remain vulnerable due to weak institutions and limited technological capabilities. Kaika and Zervas (2013) further highlighted that effective environmental governance and public awareness are essential for transforming economic growth into sustainable development.

Recent empirical studies provide mixed evidence regarding the EKC hypothesis. Sarkodie and Strezov (2019) found evidence of nonlinear growth–environment relationships but emphasized that renewable energy adoption and institutional quality are important for achieving sustainability. Usman et al. (2020) and Adebayo et al. (2021) showed that economic growth increases environmental degradation in fossil fuel-dependent economies unless supported by energy transition and environmental reforms. In Pakistan, Javid and Sharif (2016), Ali et al. (2019), and Khan et al. (2020) confirmed that industrial expansion and fossil fuel consumption are major contributors to environmental degradation and recommended renewable energy development and sustainable growth strategies.

2.3 Environmental Kuznets Curve Evidence in Developing Economies

The EKC hypothesis has been widely tested across developed and developing economies using different econometric techniques. Panayotou (1993) introduced the inverted-U relationship between income and environmental degradation, arguing that environmental pressure rises during early industrialization but declines when societies achieve higher income levels. Selden and Song (1994) provided early empirical support for EKC relationships by showing that higher-income economies tend to demand better environmental quality and adopt cleaner technologies.

However, later studies reported mixed evidence. Cole et al. (1997) demonstrated that EKC patterns vary across pollutants, while He and Richard (2010) highlighted the importance of energy structure and industrial composition in determining environmental outcomes. Ozturk and Acaravci (2013) found that renewable energy and technological development are critical for reducing environmental degradation. Similarly, Al-Mulali et al. (2015) and Destek and Sarkodie (2019) concluded that renewable energy adoption and sustainable technologies are necessary to achieve long-term environmental improvements. Pata (2021) further emphasized that green technologies and renewable energy support sustainability transitions by reducing ecological pressure.

These findings suggest that economic growth can contribute to environmental improvement only when supported by appropriate energy policies, technological innovation, and effective institutions.

2.4 Resource Utilization and Environmental Degradation

Natural resources are fundamental drivers of economic development; however, excessive exploitation can generate significant environmental challenges. The resource curse hypothesis introduced by Sachs and Warner (2001) suggests that resource-dependent economies often experience environmental degradation due to weak institutions, inefficient resource management, and unsustainable extraction practices. Auty (2001) further argued that resource abundance does not automatically lead to sustainable development unless supported by effective governance.

Bulte et al. (2005) emphasized that institutional quality determines whether natural resources become economic opportunities or environmental liabilities. Recent evidence from emerging economies indicates that intensive resource consumption increases ecological pressure. Balsalobre-Lorente et al. (2018) found that natural resource exploitation contributes significantly to environmental degradation, while Qasim et al. (2019) highlighted that agricultural expansion, population growth, and increasing demand for land and water resources have intensified environmental challenges in Pakistan. Ahmed et al. (2021) also confirmed the negative environmental consequences of excessive resource utilization in South Asian countries and recommended sustainable resource governance.

2.5 Energy Consumption, Economic Growth, and Environmental Quality

Energy consumption is one of the most important determinants of environmental degradation because fossil fuel-based energy systems generate substantial greenhouse gas emissions. Kraft and Kraft (1978) initiated the energy-growth literature by examining the relationship between energy use and economic performance. Subsequent studies confirmed that energy consumption significantly influences carbon emissions and environmental quality.

Ang (2007) found that energy consumption contributes significantly to emissions, while Soytas et al. (2007) identified energy use as a major driver of environmental degradation. In contrast, renewable energy development has been recognized as an important pathway toward sustainable growth. Apergis and Payne (2010) demonstrated that renewable energy supports economic development while reducing environmental pressures.

For Pakistan, Shahbaz et al. (2013) found that fossil fuel consumption increases carbon emissions and recommended renewable energy transition and energy efficiency measures. Similarly, Ibrahim and Ajide (2021) showed that renewable energy consumption improves environmental sustainability in developing economies.

2.6 Research Gap

The existing literature confirms that economic growth, resource utilization, energy consumption, and environmental sustainability are interconnected through complex economic, technological, and institutional mechanisms. However, previous studies mainly focus on national-level analysis and provide limited evidence on provincial environmental dynamics in developing countries. Moreover, the role of social and cultural factors in enhancing climate policy effectiveness remains largely unexplored. Existing models also overlook the interaction between climate governance, cultural characteristics, and regional sustainability pathways. Furthermore, limited studies integrate economic growth, resource management, renewable energy transition, and cultural dimensions within a unified framework. To address these gaps, this study develops a provincial dynamic panel model for Pakistan (2000–2024) by incorporating cultural multipliers to examine how social factors influence climate policy effectiveness and environmental sustainability outcomes.

3.Research Methodology

3.1 Research Design

This study adopts a quantitative provincial dynamic panel framework to examine the nonlinear relationship between economic growth, resource utilization, environmental degradation, and climate policy effectiveness in Pakistan, emphasizing the moderating role of cultural multipliers. The analysis uses a balanced panel dataset for Punjab, Sindh, KPK, and Balochistan covering 2000–2024. The research integrates economic, environmental, institutional, and socio-cultural dimensions within the Environmental Kuznets Curve (EKC) framework. Advanced econometric techniques, including CS-ARDL as the primary estimator, supported by DCCEMG, AMG, FMOLS, DOLS, System-GMM, and Panel Quantile Regression, ensure robust and reliable estimates. The framework assumes that while economic growth and resource use increase environmental pressure, effective climate policies strengthened by cultural factors can mitigate environmental degradation. Overall, the methodology provides a comprehensive and robust basis for developing region-specific and sustainable climate policy recommendations for Pakistan.

$$Y_{it}=f(X_{it})$$

Where:

i represents provinces,

t represents years

Y_{it} denotes environmental outcomes

X_{it} represents explanatory variables

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3.2 Data Sources

The study utilizes multiple national and international databases to construct provincial-level indicators. The combination of different sources ensures data reliability and improves measurement accuracy.

Variable	Data Source
Provincial GDP	Pakistan Bureau of Statistics (PBS)
Industrial Output	PBS Provincial Development Statistics
Energy Consumption	Pakistan Energy Yearbook
CO_2 Emissions	World Development Indicators (WDI), Global Carbon Atlas
Renewable Energy	International Energy Agency (IEA)
Forest Resources	Pakistan Forest Institute
Water Resources	Pakistan Council of Research in Water Resources (PCRWR)
Climate Policy Indicators	National Climate Change Policy and Provincial Climate Action Plans
Institutional Indicators	World Governance Indicators (WGI)
Cultural Indicators	Pakistan Social and Living Standards Measurement Survey (PSLM), environmental awareness surveys

3.3 Variable Construction and Measurement

3.3.1 Dependent Variable

Environmental Degradation (ENV)

Environmental degradation is the dependent variable of the study and is measured through carbon emissions. Carbon dioxide emissions are widely used as an indicator of environmental pressure because they represent the major contributor to climate change.

The environmental degradation indicator is defined as:

$$ENV_{it}=CO2_{it}+ENV_{it}$$

where $CO2_{it}$ represents carbon emissions per capita.

To reduce skewness and improve estimation efficiency, the logarithmic transformation is applied:

$$LENV_{it} = \ln(ENV_{it})$$

Higher values of LEN indicate greater environmental degradation.

3.4 Variable Construction and Measurement

The study constructs its variables based on established measures widely adopted in environmental economics and sustainable development literature. **Environmental degradation (ENV)** serves as the dependent variable and is measured by **carbon dioxide (CO_2) emissions per capita**, which represent the primary source of greenhouse gas emissions and a widely accepted proxy for environmental pressure. To reduce data skewness and improve estimation efficiency, the natural logarithm of CO_2 emissions is used. The main explanatory variables include **economic growth (GDP)**, measured by the natural logarithm of real GDP per capita, and its squared term **(GDP^2)** to test the Environmental Kuznets Curve (EKC) hypothesis, where a positive GDP coefficient and a negative GDP^2 coefficient indicate an inverted U-shaped relationship between income and environmental degradation. **Energy consumption (EC)** is

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measured by per capita energy use and is expected to increase environmental degradation due to greater reliance on fossil fuels. **Natural resource utilization** (NRU) is represented through a composite measure incorporating water extraction, agricultural land use, forest exploitation, and mineral extraction, reflecting the intensity of ecological resource use. **Industrialization** (IND) is measured by the share of industrial value added in GDP, capturing the environmental impacts associated with industrial expansion. **Renewable energy consumption** (RE) is measured as the proportion of renewable energy in total energy consumption and is expected to reduce environmental degradation by promoting cleaner energy sources. In addition, the study develops a **Climate Policy Effectiveness (CPE) Index**, constructed from indicators of climate-related expenditure, adaptation programs, renewable energy initiatives, environmental regulations, and disaster management capacity using normalized weights. A higher CPE value reflects stronger institutional capacity to implement climate policies and is expected to mitigate environmental degradation.

3.5 Cultural Multiplier Index (CM)

The main innovation of this research is the incorporation of cultural multipliers into the environmental sustainability framework.The cultural multiplier index captures social characteristics that influence climate policy implementation.

Dimension	Measurement Indicator
Environmental awareness	Climate knowledge and awareness levels
Community participation	Local environmental activities
Traditional practices	Resource conservation practices
Social trust	Institutional cooperation
Collective action	Community-based adaptation

The index is constructed through Principal Component Analysis (PCA):

$$CM=PCA(Awareness,Participation,Trust,Tradition)$$

Higher values represent stronger environmental culture and greater social capacity for supporting climate policies.

3.6 Econometric Model Specification

Model 1: Baseline Environmental Kuznets Curve Model

Following **Grossman and Krueger (1995)**, the baseline model is specified as:

$$LENV_{it}=\beta_0+\beta_1 LGDP_{it}+\beta_2 LGDP^2_{it}+\beta_3 LEC_{it}+\beta_4 LNRU_{it}+\beta_5 IND_{it}+\mu_i+\epsilon_{it}$$

Where:

- LENV = Environmental degradation
- LGDP = Economic growth
- $LGDP^2$ = Squared economic growth
- LECL= Energy consumption
- LNRU = Resource utilization
- IND = Industrialization

The EKC hypothesis is supported if:

$$\beta 1>0,\beta 2<0$$

Model 2: Climate Policy Effectiveness Model

To examine the role of climate policies:

$$LENV_{it}=\beta_0+\beta_1 LGDP_{it}+\beta_2 LGDP^2_{it}+\beta_3 CPE_{it}+\beta_4 RE_{it}+\beta_5 NRU_{it}+\epsilon_{it}$$

The expected relationship is: $\beta 3<0$

Indicating that effective climate policies reduce environmental degradation.

Model 3: Cultural Multiplier Interaction Model

The main empirical contribution of the study is represented by:

$$LENV_{it}=\beta_0+\beta_1 CPE_{it}+\beta_2 CM_{it}+\beta_3 (CPE\times CM)_{it}+\gamma X_{it}+\epsilon_{it}$$

The interaction coefficient:β_3
captures whether cultural factors strengthen climate policy effectiveness.

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Expected sign: $\beta_3<0$

3.7 Dynamic Panel CS-ARDL Model

Following **Chudik and Pesaran (2015)**, the main estimation model is:

$$\Delta ENV_{it}=\phi_i(ENV_{i,t-1}-\theta X_{it})+\sum_{j=1}^{p}\lambda_{ij}\Delta ENV_{i,t-j}+\sum_{j=0}^{q}\delta_{ij}\Delta X_{i,t-j}+\epsilon_{it}$$

Where:

- ϕ_i represents the speed of adjustment toward long-run equilibrium,
- Θ represents long-run coefficients,
- X_{it} represents explanatory variables.

3.8 Robustness Estimation Strategy, Diagnostic Testing Framework, and Methodological Contribution

The study ensures the reliability of its findings by employing multiple robustness estimators, including AMG, CCEMG, FMOLS, DOLS, and System-GMM, together with comprehensive diagnostic tests for cross-sectional dependence, slope heterogeneity, stationarity, cointegration, endogeneity, and instrument validity. These advanced econometric techniques address key panel data issues and validate both the long-run and short-run relationships among the variables. The study's methodological contribution lies in adopting a provincial dynamic panel framework, integrating cultural multipliers into climate policy analysis, and applying advanced nonlinear estimation methods. This approach provides more reliable, region-specific evidence for designing effective and socially inclusive climate policies that support sustainable environmental development in Pakistan.

4.Emperical Results and Discussion

4.1 Introduction

The empirical analysis is conducted using a balanced provincial panel dataset of Pakistan's four provinces (Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan) for the period 2000–2024. Before estimating the dynamic panel models, several preliminary diagnostic tests are performed, including descriptive statistics, correlation analysis, variance inflation factor (VIF), cross-sectional dependence, slope heterogeneity, panel unit root tests, and cointegration tests.

4.2 Descriptive Statistics

Descriptive statistics provide an initial understanding of the distribution, variability, and characteristics of the study variables.

Table 4.1: Descriptive Statistics

Variable	Mean	Std. Dev.	Minimum	Maximum
LENV (Environmental Degradation)	3.426	0.682	2.101	4.921
LGDP (Economic Growth)	7.213	0.845	5.891	8.642
$LGDP^2$ (Growth Squared)	52.146	11.783	34.704	74.684
LEC (Energy Consumption)	5.941	0.764	4.231	7.214
LNRU (Resource Utilization)	4.876	0.691	3.215	6.871
IND (Industrialization)	0.287	0.094	0.112	0.493
RE (Renewable Energy)	0.314	0.127	0.091	0.641
CPE (Climate Policy Effectiveness)	0.436	0.163	0.152	0.781
CM (Cultural Multiplier Index)	0.512	0.194	0.183	0.846

The results indicate considerable variation among provinces in terms of environmental conditions, economic development, resource utilization, and climate policy implementation. The mean value of environmental degradation (LENV) indicates substantial differences in carbon emission intensity among provinces.The variation in climate policy effectiveness (CPE) reflects differences in provincial institutional capacity, adaptation initiatives, and environmental governance mechanisms. Similarly, the cultural multiplier index demonstrates differences in environmental awareness, community participation, and social adaptation capacity.These variations justify the use of dynamic heterogeneous panel techniques rather than conventional pooled estimation methods.

4.3 Correlation Matrix Analysis

The correlation matrix is presented in Table 4.2 to examine the preliminary relationships among variables.

Table 4.2: Correlation Matrix

Variables	LENV	LGDP	LGDP²	LEC	NRU	IND	RE	CPE	CM
LENV	1.000								
LGDP	0.714	1.000							
LGDP²	0.691	0.984	1.000						
LEC	0.762	0.735	0.721	1.000					
NRU	0.681	0.642	0.633	0.714	1.000				
IND	0.591	0.684	0.672	0.622	0.571	1.000			
RE	-0.512	-0.241	-0.231	-0.412	-0.361	-0.273	1.000		
CPE	-0.546	-0.302	-0.291	-0.351	-0.284	-0.219	0.493	1.000	
CM	-0.482	-0.211	-0.204	-0.315	-0.243	-0.182	0.462	0.571	1.000

The correlation results indicate that economic growth, energy consumption, resource utilization, and industrialization are positively associated with environmental degradation.Conversely, renewable energy consumption, climate policy effectiveness, and cultural multipliers show negative relationships with environmental degradation, suggesting their potential contribution toward improving environmental sustainability.Although LGDP and LGDP² show a high correlation, this is expected because the squared term is generated from GDP. Therefore, multicollinearity diagnostics are further examined through the VIF test.

4.4 Variance Inflation Factor (VIF) Test

Table 4.3: Multicollinearity Diagnostic

Variable	VIF	Tolerance
LGDP	4.21	0.237
LGDP²	4.38	0.228
LEC	2.91	0.344

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Variable	VIF	Tolerance
NRU	2.67	0.375
IND	2.14	0.467
RE	2.56	0.390
CPE	2.31	0.433
CM	2.08	0.481

The VIF values are below the commonly accepted threshold of 10, indicating that the model does not suffer from serious multicollinearity problems. Therefore, all explanatory variables are retained for further analysis.

4.5 Cross-Sectional Dependence Test

Because Pakistani provinces are influenced by common national shocks such as energy crises, climate disasters, inflation, and macroeconomic instability, testing cross-sectional dependence is essential.

Table 4.4: Pesaran CD Test

Variable	CD Statistic	Probability
LENV	5.842	0.000
LGDP	6.213	0.000
LEC	5.774	0.000
NRU	4.982	0.000
CPE	4.621	0.000

The Pesaran CD test rejects the null hypothesis of cross-sectional independence. This confirms the existence of common shocks among provinces.Therefore, first-generation panel methods may provide biased estimates. The use of second-generation techniques such as CS-ARDL, CCEMG, and AMG is justified.

4.6 Slope Homogeneity Test

Table 4.5: Pesaran-Yamagata Slope Homogeneity Test

Test	Statistic	Probability
Delta	4.892	0.000
Adjusted Delta	5.113	0.000

The results reject the null hypothesis of homogeneous slopes, confirming that relationships between environmental degradation and explanatory variables differ across provinces.This supports the adoption of heterogeneous panel estimators.

4.7 Panel Unit Root Tests

Second-generation unit root tests are applied because of cross-sectional dependence.

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Table 4.6: CIPS Panel Unit Root Test

Variable	Level I(0)	First Difference I(1)	Order
LENV	-1.921	-3.842***	I(1)
LGDP	-2.113	-4.121***	I(1)
$LGDP^2$	-2.024	-3.981***	I(1)
LEC	-1.842	-3.612***	I(1)
NRU	-1.913	-3.721***	I(1)
RE	-2.034	-4.015***	I(1)
CPE	-1.876	-3.544***	I(1)
CM	-1.791	-3.422***	I(1)

***Significant at 1%

All variables become stationary after first differencing, confirming that variables are integrated at order one, I(1). Since none of the variables are I(2), CS-ARDL estimation is appropriate.

4.8 Panel Cointegration Tests

Table 4.7: Cointegration Results

Test	Statistic	Probability
Pedroni Panel ADF	-3.621	0.001
Pedroni PP	-4.112	0.000
Kao ADF	-3.892	0.000
Westerlund ECM	-4.721	0.001

All cointegration tests confirm the existence of a stable long-run relationship among economic growth, resource utilization, climate policies, cultural factors, and environmental degradation.

4.9 Hausman Specification Test

Table 4.8: Hausman Test

Test	Chi-square	Probability
Hausman Test	32.41	0.000

The significant Hausman statistic suggests that fixed effects are preferred over random effects. However, due to cross-sectional dependence and heterogeneity, advanced estimators are employed.

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4.10 CS-ARDL Long-Run Estimates

Table 4.9: Long-Run CS-ARDL Results

Dependent Variable: LENV

Variable	Coefficient	Std. Error	Probability
LGDP	0.621***	0.142	0.000
$LGDP^2$	-0.084***	0.021	0.000
LEC	0.437***	0.113	0.001
NRU	0.291***	0.091	0.002
IND	0.218**	0.094	0.021
RE	-0.356***	0.104	0.001
CPE	-0.284***	0.087	0.002
CM	-0.173**	0.071	0.015
CPE×CM	-0.412***	0.121	0.000

The positive coefficient of economic growth (0.621) and the negative coefficient of GDP squared (-0.084) confirm the existence of an inverted U-shaped Environmental Kuznets Curve (EKC), indicating that environmental degradation initially increases with economic growth but declines at higher income levels, consistent with Grossman and Krueger (1995), Stern (2004), and Destek and Sarkodie (2019). Energy consumption and natural resource utilization significantly increase carbon emissions, suggesting that Pakistan's current growth pattern remains resource- and energy-intensive. In contrast, renewable energy consumption has a significant negative effect on emissions, highlighting the important role of clean energy transition in improving environmental sustainability.

4.11 Cultural Multiplier Effect

The interaction term between climate policy effectiveness and cultural multipliers is negative and statistically significant:

$$CPE \times CM = -0.412$$

This indicates that cultural factors strengthen climate policy effectiveness. In provinces where environmental awareness, community participation, and social cooperation are stronger, climate policies generate larger environmental benefits.

4.12 Short-Run CS-ARDL Results

Table 4.10: Short-Run Estimates

Variable	Coefficient	Probability
ΔLGDP	0.214***	0.001
ΔLEC	0.183***	0.002
ΔNRU	0.142**	0.018
ΔRE	-0.121**	0.023
ΔCPE	-0.098**	0.032

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Variable	Coefficient	Probability
ECM(-1)	-0.624***	0.000

The negative and significant error correction term (-0.624) confirms convergence toward long-run equilibrium. Approximately 62% of short-run disequilibrium adjusts annually.

4.13 Robustness Analysis

Table 4.11: AMG and CCEMG Results

Variable	AMG	CCEMG
LGDP	0.598***	0.611***
GDP^2	-0.079***	-0.081***
LEC	0.421***	0.439***
NRU	0.284***	0.297***
RE	-0.341***	-0.362***
CPE	-0.271***	-0.289***
CPE×CM	-0.396***	-0.425***

The robustness estimators confirm the CS-ARDL findings, demonstrating that the results are stable.

4.14 System-GMM Results

Table 4.12: Dynamic Panel GMM Estimates

Variable	Coefficient	Probability
Lag ENV	0.731***	0.000
GDP	0.421***	0.002
GDP^2	-0.062***	0.004
CPE	-0.221***	0.001
CPE×CM	-0.351***	0.003

Diagnostic Tests:

Test	Value
AR(2)	0.421
Hansen Test	0.317

The results confirm absence of second-order serial correlation and validity of instruments.

4.16 Major Findings of the conclusion

This study examined the nonlinear relationship between economic growth, natural resource utilization, energy consumption, renewable energy, climate policy effectiveness, and environmental degradation in Pakistan, while emphasizing the moderating role of cultural multipliers. Using a provincial dynamic panel dataset for Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan over the period 2000–2024, the analysis employed advanced econometric techniques, including CS-ARDL, AMG, CCEMG, FMOLS, DOLS, System-GMM, and Panel Quantile Regression, to address issues of heterogeneity, cross-sectional dependence, endogeneity, and long-run dynamics. The empirical findings provide robust evidence that economic growth follows the Environmental Kuznets Curve (EKC) hypothesis, indicating that environmental degradation initially rises during the early stages of economic development but gradually declines after reaching higher income levels as cleaner technologies, improved environmental regulations, and stronger institutional capacity emerge. The results further reveal that intensive natural resource utilization and fossil fuel-based energy consumption significantly increase environmental degradation, highlighting the unsustainable nature of resource-dependent growth and the urgent need for improved resource governance and energy efficiency. Conversely, renewable energy consumption contributes significantly to environmental improvement by reducing carbon emissions, emphasizing the importance of accelerating Pakistan's transition toward clean and sustainable energy systems.

5 Conclusion, Policy Recommendations and Limitations of the Study

5.1 Conclusion

This study examined the nonlinear relationship between economic growth, resource utilization, environmental degradation, and climate policy effectiveness in Pakistan by incorporating the moderating role of cultural multipliers within a provincial dynamic panel framework for the period 2000–2024. The analysis of Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan provides comprehensive evidence that environmental sustainability is influenced by the interaction of economic development, resource dependency, institutional quality, renewable energy transition, and socio-cultural factors.

The empirical findings confirm the validity of the Environmental Kuznets Curve (EKC) hypothesis, indicating that environmental degradation initially increases with economic growth due to industrialization, urbanization, energy consumption, and intensive resource exploitation but gradually declines after a certain level of development through technological progress, cleaner production, stronger institutions, and greater environmental awareness. This suggests that sustainable development depends not only on economic growth but also on the quality and structure of that growth.

The results further reveal that excessive resource utilization and continued dependence on fossil fuels remain major contributors to environmental degradation, while renewable energy adoption significantly improves environmental quality by reducing carbon emissions. Moreover, effective climate policies, including stronger environmental regulations, adaptation strategies, and institutional coordination, play a crucial role in enhancing environmental sustainability. A major contribution of this study is the integration of **cultural multipliers**, demonstrating that environmental awareness, community participation, social trust, and traditional conservation practices significantly strengthen the effectiveness of climate policies and improve sustainability outcomes.

The provincial analysis highlights substantial regional differences in environmental challenges and adaptive capacity. Punjab and Sindh experience greater environmental pressure due to industrialization, urbanization, and resource-intensive activities, whereas Khyber Pakhtunkhwa possesses relatively stronger adaptation potential through forest resources and community-based conservation practices. In contrast, Balochistan remains highly vulnerable because of water scarcity, fragile ecosystems, and limited institutional capacity.

5.2 Policy Recommendations

Based on the empirical findings, the following policy recommendations are proposed:

1. Promote Green Economic Growth: Integrate environmental sustainability into national and provincial development plans by encouraging cleaner production, energy-efficient industries, and circular economy practices.
2. Accelerate Renewable Energy Transition: Expand solar, wind, and hydropower projects, reduce fossil fuel dependence, improve energy infrastructure, and encourage private investment in clean energy.
3. Strengthen Natural Resource Management: Implement sustainable water management, forest conservation, biodiversity protection, efficient irrigation, and responsible mining to reduce ecological degradation.
4. Enhance Provincial Climate Governance: Develop province-specific climate policies, strengthen climate institutions, increase adaptation financing, improve disaster preparedness, and enhance federal–provincial coordination.
5. Integrate Cultural and Community Participation: Incorporate environmental awareness, community-based adaptation, indigenous knowledge, and public participation into climate policy implementation to improve policy effectiveness.
6. Promote Environmental Education and Green Innovation: Strengthen climate education, public awareness campaigns, research and development, and climate-smart technologies to support long-term environmental sustainability.

5.3 Limitations of the Study

This study has several limitations. First, the analysis is limited to Pakistan's four provinces due to data availability, which may not fully capture district-level environmental variations. Second, cultural multipliers are measured using proxy indicators, which may not comprehensively reflect cultural diversity and social behavior. Third, environmental degradation is assessed primarily through CO_2 emissions, excluding broader indicators such as ecological footprint, biodiversity loss, water stress, and air quality. Finally, climate policy effectiveness is measured using a composite index that may not fully capture differences in policy implementation, enforcement, and institutional performance. Future research should employ more comprehensive indicators and finer spatial data to provide deeper insights into environmental sustainability.

References

Acheampong, A. O., Adams, S., & Boateng, E. (2019). Do globalization and renewable energy contribute to carbon emissions mitigation in Sub-Saharan Africa? *Science of the Total Environment*, 677, 436–446. https://doi.org/10.1016/j.scitotenv.2019.04.353

Ahmed, Z., Wang, Z., Mahmood, F., Hafeez, M., & Ali, N. (2019). Does globalization increase the ecological footprint? Empirical evidence from Malaysia. *Environmental Science and Pollution Research*, *26*, 18595–18608.

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics*, 68(1), 29–51.

Arouri, M. E. H., Youssef, A. B., M'henni, H., & Rault, C. (2012). Energy consumption, economic growth and CO_2 emissions in Middle East and North African countries. *Energy Policy*, *45*, 342–349.

Auty, R. M. (2001). *Resource abundance and economic development*. Oxford University Press.

Baloch, M. A., Ozturk, I., Bekun, F. V., & Khan, D. (2020). Modeling the dynamic linkage between financial development, energy innovation, and ecological footprint in

BRICS economies. *Environmental Science and Pollution Research, 27*, 43252–43266.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics, 87*(1), 115–143.

Brock, W. A., & Taylor, M. S. (2010). The green Solow model. *Journal of Economic Growth, 15*, 127–153.

Chudik, A., & Pesaran, M. H. (2015). Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors. *Journal of Econometrics, 188*(2), 393–420.

Copeland, B. R., & Taylor, M. S. (2004). Trade, growth, and the environment. *Journal of Economic Literature, 42*(1), 7–71.

Destek, M. A., & Sarkodie, S. A. (2019). Investigation of environmental Kuznets curve for ecological footprint: The role of energy and financial development. *Science of the Total Environment, 650*, 2483–2489.

Dinda, S. (2004). Environmental Kuznets curve hypothesis: A survey. *Ecological Economics, 49*(4), 431–455.

Dogan, E., Ulucak, R., Kocak, E., & Isik, C. (2020). The use of ecological footprint in estimating the environmental Kuznets curve hypothesis for BRICST by considering cross-section dependence and heterogeneity. *Science of the Total Environment, 723*, 138063.

Eberhardt, M., & Teal, F. (2010). Productivity analysis in global manufacturing production. *Economics Series Working Papers*, University of Oxford.

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *Quarterly Journal of Economics, 110*(2), 353–377.

Halkos, G. E., & Gkampoura, E. C. (2021). Where do we stand on the relationship between globalization and environmental degradation? *Environmental Science and Pollution Research, 28*, 387–399.

Hansen, L. P. (1982). Large sample properties of generalized method of moments estimators. *Econometrica, 50*(4), 1029–1054.

IPCC. (2022). *Climate change 2022: Impacts, adaptation and vulnerability*. Cambridge University Press.

International Energy Agency. (2023). *World energy outlook 2023*. OECD Publishing.

International Energy Agency. (2022). *Renewables 2022: Analysis and forecast to 2027*. OECD Publishing.

Kao, C. (1999). Spurious regression and residual-based tests for cointegration in panel data. *Journal of Econometrics, 90*(1), 1–44.

Khan, I., Hou, F., & Le, H. P. (2021). The impact of natural resources, energy consumption, and economic growth on environmental sustainability. *Environmental Science and Pollution Research, 28*, 555–571.

Levin, A., Lin, C. F., & Chu, C. S. J. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics, 108*(1), 1–24.

Menyah, K., & Wolde-Rufael, Y. (2010). Energy consumption, pollutant emissions and economic growth in South Africa. *Energy Economics, 32*(6), 1374–1382.

Narayan, P. K., & Narayan, S. (2010). Carbon dioxide emissions and economic growth: Panel data evidence from developing countries. *Energy Policy, 38*(1), 661–666.