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Towards a Green Economy in Pakistan: Climate Change, Energy Consumption and Environmental Quality

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Abstract

Pakistan is among the nation’s most vulnerable to climate change while its contribution to GHG emissions is very less. Due to the increased temperatures, glacial melt, frequent flooding and dwindling water supply, the economy, agricultural activities and the common people are experiencing heavy and frequent costs. The objective of this study is to have two aims. First, it addresses drivers of climate change and sectoral implications in Pakistan and the policies and institutions the country has developed to respond to these drivers. Second, it estimates the macroeconomic determinants of Pakistan's CO2 emissions using Environmental Kuznets Curve (EKC) framework. The study employs the ARDL model for the yearly data from 1980-2023, using the WDI. The results suggest that a transition to a low carbon green economy with better institutions and international cooperation along with climate finance will be essential to ensure climate resilience for the long term in Pakistan.

Keywords: Green Economy; Sectoral Implication; ARDL model; Environmental Kuznets Curve; Pakistan

JEL classification: Q54; Q56; Q43; O44; C22

1. Introduction

Despite the rapid growth of South Asia over the last few decades, a consideration portion in the region continues to be poor and progress has been unevenly distributed across regions, classes and genders. Since agriculture remains the backbone of most of rural households, even a slight change in climate, translates into lost income, hunger, migration. The indicators of the changing climate in the region are now well known: the monsoon and winter rainfall has become more unpredictable; the Himalayan glaciers are melting; and cyclones, floods and droughts are becoming more frequent. Farming and frontier communities are the most affected by those shocks, and have the least resources to help them deal with them (Abbas, 2009; Oxfam GB, 2009).

This injustice is starkly highlighted in Pakistan. The nation's share of global cumulative GHGs emission is less than one per cent, but it is consistently listed among the countries worst affected by climate change worldwide (Ahmad et al., 2011). Warming, glacier melt, changing rainfall and extreme weather wreak havoc on an economy where agriculture accounts for approximately a quarter of GDP and a large proportion of the workforce. The cost was revealed during the flood of 2022, which submerged approximately one-third of nation, impacted some thirty-three million individuals, caused over 1700 deaths and destruction and economic damage exceeding US$30 billion (World Bank, 2022; Nanditha et al., 2023). These occurrences of this magnitude are no longer uncommon, but are becoming a regular occurrence in national life.

This study combines two perspectives, often separated, into one. The first is about the causes of climate change in Pakistan and their response, specifically policies and institutions in Pakistan. The first is the question "Why climate change occurring in the country, and how climate change policies and institutions in Pakistan are responding". The second question is more probing from an economic perspective: what is causing Pakistan's CO_2 emissions? To solve it, we estimate an emissions model based on the hypothesis of Environmental Kuznets Curve by applying ARDL bounds-testing. The policy discussion doesn't matter much if it isn't complemented by the econometric evidence, as any coherent green economy approach should both understand how the country should react to climate change and understand which economic forces are driving emissions up.

The study presents a meaningful advancement in existing literature. It brings to light empirical evidence based on Pakistan's annual data up to 2023 for the Environmental Kuznets

Curve and integrates the latest advances in the field of climate governance and climate finance, while also establishing connections between the emissions drivers and the policy priorities for the green transition. The study creates a climate vulnerability-based analytical framework that embeds climate vulnerability within the context of environmental governance and econometric modelling, offering a broader picture of sustainable development issues in Pakistan.

Most of the rural poor (500 million) in Asia are farmers (Shakoor et al., 2011). The recent environmental catastrophes in Pakistan and India which were extensively affected by massive floods, and also in the USA with Hurricane Katrina has underlined the devastating effects of climate change. Rising temperatures resulting from global warming are a symptom of persistent droughts in Australia, Pakistan, China, India and Texas. Climate-related disasters have hit or impacted seventy times more people in the 21st century than in previous years, and have grown five times in number. Pakistan is among the nation's most vulnerable to disasters globally due to the meteorological diversity it witnessed (Ahmad et al., 2011). The 20th century experienced the warmest temperature of the last millennium because of increase in greenhouse gases. The human and natural systems will be adversely impacted by climate change: floods, droughts, extreme climatic events, decreased agricultural productivity, migration and conflicts over dwindling resources (Royal Society, 2010). Rising sea levels could displace 125 million people in India, Pakistan and Bangladesh, if current trends continue (Oxfam GB, 2009).

South Asia's water supply is severely impacted by a changing climate because of its dependence on monsoons and melting glaciers (Ashraf, 2013). The "Himalayan glaciers" are the 9th major source of freshwater in Asia and they help supply major rivers in Asia like Ganges, Brahmaputra and Indus that supports more than 500 million people. For millions of people in the region food security may be under threat because of severe droughts followed by heavy flooding (Oxfam GB, 2009b). The past 40 years have seen substantial shift in climate in Pakistan. At Karachi, a heat wave in June 2015 took the lives of 1000 people, and dust pollution is a regular occurrence in Lahore during winter season.

In Pakistan, climatic change and its implication are often overlooked and the urgency of addressing them is neglected. This study provides a brief overview of the effect of climate change on South Asia and emphasis on Pakistan. It looks at the main drivers of climatic shifts and the consequences it has on the different sectors. In addition, this research also focuses on the planning and adaptation measures of Pakistan to mitigating the effects of climatic change. Furthermore, it assesses impact of management on the individual, domestic and multinational action needed for tackling global warming and creating implementation strategies. As the importance of this issue is crucial, a detailed study was considered to be required. Thus, the aim of this research is to be a pivotal step towards the understanding and solution of climate change problems.

2. Literature Review

2.1 South Asian climate change: The nature of disaster risks and impacts

Climate change is defined by Parry et al. (1998) as "a change in the average state of the climate, or in some measure of the climate's variability, on a global or regional scale". It is often widely termed to as global warming and the impacts of the phenomenon are usually expressed worldwide environmental related transformation (Dietz et al., 2002). The instrumental measure indicates that the last few years have some of the warmest in the modern observational record, and have been primarily linked to the buildup of heat-trapping gases in the air (IPCC, 2023).

The literature provides a consistent picture for South Asia for exposure and the lack of adaptation capacity. The water supply is particularly vulnerable in the region, depending heavily on monsoonal rains and rivers fed by glaciers (Ashraf, 2013). The Himalayan snow and ice melt the Indus, Ganges and Brahmaputra rivers that provide water to a population of hundreds of millions of people, making regional food security extremely vulnerable to the occurrence of deep droughts punctuated by sudden floods (Oxfam GB, 2009b). The detrimental impacts of warming can be summarized under a few categories by Frimpong (2015): higher temperatures, increased threats to wildlife, increased seawater and water scarcity, increase in floods and droughts, increased storm damage, increased burden of climate-related disease and economic losses.

This literature also reflects the international cooperation. The International Organization for Standardization (ISO) has developed instruments for quantifying and verifying GHG emissions, including the ISO 14064 and ISO 14065 family, and has collaborated with other organisations like the UNFCCC and World Bank on mitigation and adaptation standards (ISO, 2018; UNFCCC, 2009). Each country's answer is evaluated in the context of the intergovernmental process, from the "Kyoto Protocol to the Paris Agreement".

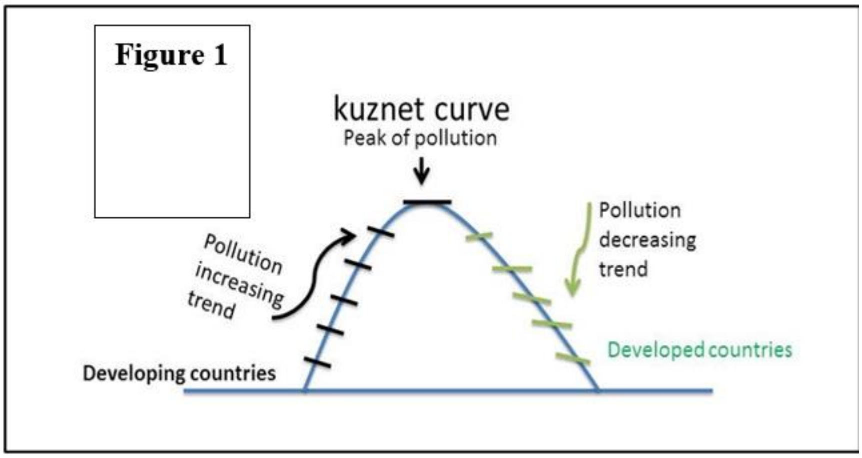
The 2.1 emissions-income-energy nexus and the EKC can also be detailed.

The huge amount of empirical research on the association among economic activity, energy use and environmental quality. The hypothesis used to organize the study “Environmental Kuznets Curve (EKC) hypothesis” which states that the relationship between income per head and environmental damage is inverted U-shaped: pollution increases at the beginning of development with increasing output, peaks, and then declines as higher incomes allow for investment in cleaner technology, service as opposed to production, and more stringent policy control (Grossman & Krueger, 1995; Torras & Boyce, 1998). Galbraith (2007) warns part of the decline in later years could be due to dirty production being exported to countries with less stringent regulations, and the actual improvement may be an overstatement.

The analysis of cross-country studies sorting economies by income level, like that of Huang et al. (2008), suggests the positive associating among environmental quality and income levels, with improved environmental quality in richer income groups as firms and households become more efficient in their energy consumption. It's less clear in the case of developing economies. Many of the LMICs, such as Pakistan, have also seen continued increase in CO2 emissions along with the growth and energy consumption, making these economies to be on the upward side of the curve.

The EKC has been directly tested in Pakistan in several studies, which are closely related to the present model. An inverted-U connection between income and carbon emissions is found in a quadratic specification by Nasir and Ur Rehman (2011) and they end up saying that policy should strive for cleaner energy sources. Using bounds testing and Granger causality over 1971 to 2009, Shahbaz et al., (2012) find evidence of long-run association among emissions and energy use and also confirm the inverted-U for income and energy use is strongly correlated with the rise in emissions. Much of the same results are identified by Ahmed and Long (2012) using the ARDL method: population growth negatively affects degradation, and openness to trade can alleviate degradation. Recent studies also provide evidence in favor of the EKC hypothesis for Pakistan and also highlight the impact of energy efficiency and institutional quality and transition towards renewable energy (Javid & Khan, 2020; Khan et al., 2022; Muhammad et al., 2024; Rehman & Ma, 2023).

Figure 1 is known as Kuznets curve, the “pollution in poor countries increase with the production of goods, its means increase in production increase in pollution, further, above figure is also indicating that pollution increase at start but gradually pollution comes down in developed countries with increase of production of goods" (Galbraith ,2007)



While there is a significant amount of literature on the EKC hypothesis in Pakistan, the majority of those researches limit their scope to connection among GDP, energy use and environmental degradation. Attention to the integration of empirical emissions modelling with the wider policy issues related to climate vulnerability, adaptation, and shift to a sustainable economy, has been relatively neglected. Moreover, numerous previous research studies are based on data prior to recent climate events such as floods in 2022 and Pakistan's most recent climate commitments under the Paris Agreement.

This study has a few things to offer to the field of literature. The first is it updates the analysis with annual data to the end of 2023, reflecting the changes in the economy and environment of the last five years. Secondly, it presents an econometric analysis of emissions drivers and a detailed review of the climate governance framework and policy responses in Pakistan. Thirdly, it produces policy suggestions that directly connect empirical evidence of emission determinants with the country's long term green economy transition policy.

3. Geography, population and climate

Pakistan is located in South Asia; it is bordered by "India in the East, China in North East, Afghanistan and Iran in the West and by Arabian Sea in South". It is spread over an area of approximately 796,096 sq. km. having a coastline of approximately 990 km. (Geography of Pakistan, 2018). The Digital Census 2023, the population was 241.5 million, with an average yearly growth rate of around 2.55 per cent, the highest among the region and it is one of the biggest factors putting pressure on energy and resources (Pakistan Bureau of Statistics, 2023).

The land is also variable from sea level on the Arabian coast to 8,611 m at K2, the second highest peak and much of the communities concentrated in coastal areas and river deltas vulnerable to rising seas and floods (Farooqi et al., 2005). In total area of 79.6 million hectares of land, twenty-one point two million hectares are under cultivation and 80 percent of this area is irrigated, which makes Pakistan possesses among the largest and continuous canal systems globally (FAO, 2018). Climate is generally dry to sub-humid, and is markedly different across the geographic areas (Chaudhry & Rasul, 2004; Sajjad, 2004).

3.1 Drivers and sectoral impacts

Climate change is natural and induced by man. Natural causes are plate tectonics, solar activity, orbital cycles, volcanic eruptions and ocean variations (IPCC, 2001; Ledley et al., 1999), but the warming of the industrial era is unarguably due to human activity. The main human sources for Pakistan include CO2 emissions produced in power generation, transport and industry from fossil fuels combustion, aerosols released from industrial and transport activities, emissions from cement manufacturing and land use change, deforestation which reduces carbon sinks and methane emissions from livestock and waste.

As in most developing countries, the country is very vulnerable to long-term trends in temperature and precipitation in its major sectors (Ministry of Environment, 2003). Climate risks that have been identified through national and international assessments include increased warming, which impacts ecosystems, agricultural production and water availability; reduced water availability due to the melting of glaciers and variability in rainfall patterns; increased risk to crops productivity and nutritional security; and increased occurrence and magnitude of floods and droughts (IPCC, 2007; SDPI, 2012). These pressures are on top of an increasing emissions trajectory. On the same BUSA scenario, Mir and Ijaz (2015) forecast a significant rise in GHG output at the national level in each of the major sectors, with energy and agriculture being the two most significant. The inventory and projections for them are presented in Table 1.

Table 1. Estimated and projected greenhouse-gas emissions by sector, business as usual scenario (MtCO2e)

Sector	1994	2008	2012	2020	2050
Energy	86	157	169	358	2,685
Agriculture	72	120	165	245	1,395
Industrial processes	13	18	14	26	67
Land-use change and forestry	7	9	10	14	38

Sector	1994	2008	2012	2020	2050
Waste	4	6	10	7	15

Note. “MtCO2e = million tonnes of carbon-dioxide equivalent”. Source: adapted from Mir and Ijaz (2015).

It is this dominance of energy and agriculture in current emissions and in projected growth that forms the crux of the argument in this paper. The first step towards a credible green economy transition in Pakistan needs to be a package of energy supply clean-up, climate smart agriculture and a massive expansion of food production with a reduction in poverty.

4. Data and Methodology

4.1 Data and variables

For this research employ annual data for Pakistan spanning 1980-2023, sourced from WDI. The dependent variable is per-capita CO2 emissions while energy consumption, real income (GDP per capita), FDI and population growth serve as the explanatory variables. The level variables (CO2, ENC and GDP) are given in natural log form, the ratio variable (FDI) remains in its natural unit and the growth variable (PG) is also in its natural unit.

4.2 Conceptual frame work

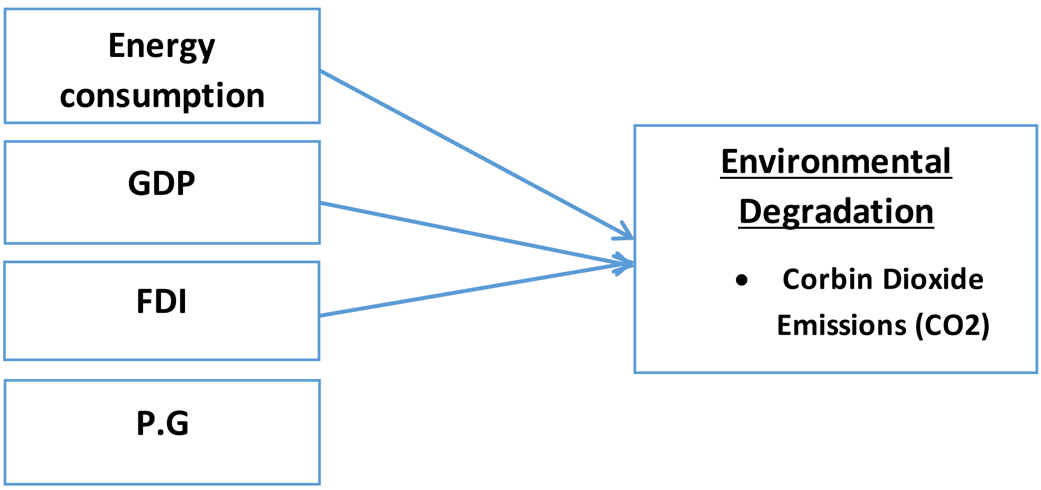


Figure 2

Table 2. Variable definitions

Variable	Description	Units	Source
CO2	Carbon-dioxide emissions	Metric tons per capita	WDI
ENC	Energy consumption	Kg of oil equivalent per capita	
GDP	Real gross domestic	GDP per capita	

Variable	Description	Units	Source
	product	(constant 2015 US$)	
FDI	Foreign direct investment	Net inflows (% of GDP)	
PG	Population growth	Annual %	

Note. WDI = World Development Indicators.

4.3 Model specification

For the EKC of Pakistan, ENC, GDP, square of income, foreign direct investment and population growth are used as the emission factors. The squared income term allows the identification of the inverted-U shape and the turning point of the income. The long run relationship is expressed as:

$$\boldsymbol{ln\ CO2_t = \beta_0 + \beta_1\ ln\ ENC_t + \beta_2\ ln\ GDP_t + \beta_3\ (ln\ GDP_t)^2 + \beta_4\ FDI_t + \beta_5\ PG_t + \mu_t}\text{-------(1)}$$

Where t indexes time, β0 is the intercept, β1-β5 are coefficients and μt is a white noise error. The EKC is supported by a positive and significant β2, and a negative and significant β3. The values of dependent variable are carbon dioxide emissions (CO2) and explanatory variables are energy consumption (ENC), gross domestic product (GDP), foreign direct investment (FDI) and population growth (PG).

Both the ln GDP and the squared term of the log of GDP (lnGDP)2 are included to test the "Environmental Kuznets Curve (EKC) hypothesis". The EKC is supported if both the coefficient of lnGDP (β2) and the coefficient of (lnGDP)2 (β3) are statistically significant and of the opposite sign: positive for the first and negative for the second suggesting an inverted U shape for the associating between GDP and environmental degradation.

The conditional error correction version of the ARDL model is:

$$\Delta ln\ CO2_t = \alpha_0 + \sum_{\{i=1\}}^{p} \delta_i \Delta \backslash ln\ CO2_{\{t-i\}} + \sum_{\{j=0\}}^{q} \theta_j \Delta X_{\{t-j\}} + \lambda_1 \backslash ln\ CO2_{\{t-1\}} + \sum_{\{k=2\}}^{m} \lambda_k X_{\{t-1\}} + \epsilon_t \text{ ---------------------- (2)}$$

The first difference operator is denoted by Δ and the regressors are X = vector {ln ENC, ln GDP, (ln GDP)2, FDI, PG}. The short-run terms are the differenced terms, the level terms are the long run terms and the coefficient of the ECT indicates the speed of the system's return to equilibrium following a shock.

4.4 Estimation strategy

Time-series data can be non-stationary and regressions can be performed on a non-stationary series, but they can produce spurious results (Gujarati & Porter, 2009). The ARDL method doesn't assume that all series have the same order of integration; however, it does require that none of the series be integrated of order 2 or more, because according to the critical value bounds of Pesaran et al., (2001) and Narayan (2005), I(2) regressor renders the bounds invalid. To establish that all the variables are I(0) or I(1), the ADF test is carried out on every series in levels and first differences.

The lag order of each variable is selected applying the Schwarz Information Criterion (SIC) that is appropriate for small sample sizes. When a long-run connection is found, then the dynamics of the short run and the error correction term are estimated in the ARDL error-correction model corresponding to the long-run association.

4.5 Hypotheses

In the light of the literature available in the field of EKC and focus on the structure of the economy in Pakistan, the analysis tests the following four hypotheses which are presented in the alternative form:

H1: The proportionality of CO_2 emissions to energy consumption changes over time.H3: the long-term trend of CO_2 emissions is determined by energy consumption.

H2: CO_2 emissions are negatively related to income, but only up to a certain point.

H3: The relationship between foreign direct investment and the emissions can vary depending on whether the relationship is mediated by pollution-haven or pollution-halo channels.

H4: The interaction between population and CO_2 emissions in the long-run is positive.

Table 3. Hypothesized relationships and expected signs

Variable	Expected sign	Rationale
ln ENC	+	Energy use, dominated by fossil fuels, raises emissions directly.
ln GDP	+	Early in development, output growth pushes emissions up (rising arm of the EKC).
$(\ln GDP)^2$	-	Past a turning point, higher

Variable	Expected sign	Rationale
		income can fund cleaner technology and tougher regulation.
FDI	+ / -	Ambiguous: pollution-haven effects raise emissions; pollution-halo effects may lower them.
PG	+	A larger, faster-growing population adds to energy demand, land-use pressure and total emissions.

5. Results and Discussion

5.1 Descriptive statistics

Descriptive statistics for the variables covering 1980-2023 are provided in table 4.

Table 4. Descriptive statistics

Variable	Mean	Std. dev.	Minimum	Maximum	Obs.
ln CO2	-0.354	0.197	-0.844 (1980)	-0.010 (2021)	44
ln ENC	5.995	0.132	5.760 (1980)	6.156 (2023)	44
ln GDP	7.049	0.205	6.730 (1980)	7.429 (2022)	44
(ln GDP)^2	49.772	2.858	45.289 (1980)	55.191 (2022)	44
FDI	0.972	0.754	0.130 (1980)	3.670 (2007)	44
PG	2.448	0.581	1.550 (2023)	4.180 (1981)	44

Per-capita CO2 emissions increased 0.43 metric tons in 1980 to 0.99 metric tons in 2021 and energy use per capita rose from 318 kg of oil equivalent to 472 kg. Real GDP per capita more than doubled over the period, from US$837 to US$1,684 in constant 2015 US dollars.

5.2 Unit-root tests

The ADF tests are present in Table 5 and there, the variables ln CO2, ln ENC, ln GDP and (ln GDP)2 are found to be non-stationary in levels but stationary at first difference. FDI is stationary in levels. Since there is no variable I(2), the ARDL bounds-testing method is valid.

Table 5. Augmented Dickey-Fuller unit-root test results

Variable	Level (intercept)	Level (intercept + trend)	First diff. (intercept)	Order
ln CO2	-2.104	-2.356	-7.812***	I(1)

Variable	Level (intercept)	Level (intercept + trend)	First diff. (intercept)	Order
ln ENC	-1.985	-2.101	-6.543***	I(1)
ln GDP	-1.432	-1.897	-5.891***	I(1)
(ln GDP)^2	-1.378	-1.845	-5.923***	I(1)
FDI	-3.542**	-3.789**	-8.234***	I(0)
PG	-2.456	-2.876	-7.123***	I(1)

Lag length selected by SIC.

5.3 Bounds test for co-integration

The bounds test is presented in Table 6. The computed F-statistic value of 5.876 is higher than the upper critical value.

Table 6. ARDL bounds test for cointegration (selected model: ARDL (1,1,1,1,1,1))

Test / significance level	Value	Lower bound I(0)	Upper bound I(1)
F-statistic	5.876	-	-
1% level	-	3.06	4.15
5% level	-	2.32	3.20
10% level	-	1.95	2.76

Note. Critical-value bounds are taken from Narayan (2005) for k = 5 and n = 44.

5.4 Long-run and short-run estimates

Table 7. Estimated long-run coefficients (dependent variable: ln CO2)

Regressor	Coefficient	Std. error	t-statistic	p-value
ln ENC	0.487**	0.151	3.225	0.003
ln GDP	1.843**	0.491	3.754	0.001
(ln GDP)^2	-0.124**	0.035	-3.543	0.001
FDI	-0.032	0.028	-1.143	0.261
PG	0.098*	0.041	2.390	0.023
Constant	-5.123	1.723	-2.973	0.006

Note. * and ** denote significance at the 5% and 1% levels, respectively.

The long term effect of energy use is positive and significant, a 1% increase in ENC leads to an increase of 0.49% in CO2 per capita. Positive effects are also due to population growth. As the units of measurement are not logs, but percentage points, the increase in annual population growth corresponds to an increase in the log of CO2 emissions per capita of about 0.098. The sign of both the coefficients of ln GDP and (ln GDP)2 are in the expected direction and are both significant, thus supporting the inverted U shape relationship. This would be the implied turning-point income of exp (1.843/(2 x 0.124)) = about US$1,698 per capita in constant 2015 US dollars. By the end of the sample period Pakistan had come closer to this but had not yet definitely crossed it. The statistical significance of FDI is not evident, neither supporting the pollution-haven hypothesis nor the pollution-halo hypothesis view Fatima et al. (2026).

Table 8. Short-run dynamics and error-correction term

Regressor	Coefficient	Std. error	t-statistic	p-value
Delta ln ENC	0.312**	0.098	3.184	0.003
Delta ln GDP	1.256**	0.374	3.358	0.002
Delta $(\ln GDP)^2$	-0.084**	0.027	-3.111	0.004
Delta FDI	-0.021	0.019	-1.105	0.277
Delta PG	0.067*	0.028	2.393	0.022
ECT(-1)	-0.683**	0.127	-5.378	0.000

ECT (-1) is the lagged error-correction term.

The average speed of adjustment is around 68% per year for any deviation from equilibrium.

5.5 Diagnostic tests

Model passes the diagnostics as reported in Table 9.

Table 9. Diagnostic and stability tests

Test	Statistic	p-value	Conclusion
Breusch-Godfrey LM	1.452	0.228	No serial correlation
Breusch-Pagan-Godfrey	0.897	0.479	Homoskedastic
Jarque-Bera	1.234	0.539	Residuals normal
Ramsey RESET	1.567	0.128	Model correctly specified

5.6 Discussion

The findings consist of four main conclusions. First, the energy use has a positive and a significant sign, which is similar with the previous research for Pakistan by Khan et al., (2022), Rehman & Ma (2023), and Shahbaz et al., (2012). This suggests that energy consumption rises by nearly 0.5 percent in CO_2 emissions for every one percent increase in energy use per person, where fossil fuels are still the primary energy source. It is therefore essential that the decarbonisation of energy supply plays a pivotal role in any green-economy strategy, to be achieved by solar, wind and hydropower and via improvements in energy efficiency.

Secondly, the EKC hypothesis is confirmed. The estimated turning point income of US$1,698 per capita is just above the maximum income per capita of Pakistan during the sample period (US$1,684 in 2022). In essence, Pakistan is moving towards the downward phase of the EKC as opposed to being significantly lower than the downward phase. The discovery underscores the need to shift towards more efficient resource utilization and cleaner technologies to reduce emissions and to decouple growth from emissions.

Thirdly, the population grows slightly positively. This coefficient is low but, considering the high population growth rate in Pakistan, it means there is an additional burden on emissions due to population. Indirect but real climate benefits of investments in girls education, health and family planning.

Fourth, FDI does not have a statistically significant long run effect on emissions. The coefficient is negative but not very big and not well estimated. This could be offsetting effects; some FDI may have entered high emission manufacturing, and other investment, like infrastructure and renewable energy projects may have been in cleaner technologies. Overall, the net effect is not statistically different from zero.

The estimates put the discussion into a policy perspective by highlighting the fact that with energy and agriculture being the two key sectors for future emissions, energy consumption is the single greatest lever, while the rate of adjustment is relatively fast, meaning that policy measures designed to reduce emissions can have a relatively fast impact.

6. Policy implications: towards a ‘Green Economy'

Pakistan is one of the founding signatories of the “United Nations Framework Convention on Climate Change” which seeks to limit the accumulation of GHGs to a level that would not lead to "dangerous anthropogenic interference with the climate system" (Malik, 2017). In that time it has developed a large, but not consistent, jurisprudence and institutions about climate and the empirical evidence revealed here provides an explanation for why some areas of it have failed to bring the emissions curve down.

Each student's policy and institutional record. Each student's policy and institutional record.

The Ordinance was replaced by the “Pakistan Environmental Protection Act 1997” which established the Pakistan Environmental Protection Agency (Pakistan Environmental Protection Act ,1997) and laid the legal foundation for the control of pollution and restoration of polluted land. The National Environmental Policy 2005 then had the following activities:

Water pollution and air pollution related, Deforestation, Coastal degradation and Disasters. A commission on Climate Change was established under the Planning Commission in 2008 which produced an early comprehensive Policy on Emissions, Forestry and Food and Water Security (Iqbal et al., 2014) while the National Climate Change Policy (2012) aimed at protecting the vulnerable communities and directing the country towards climate-resilient development.

Climate governance was legally established to take a concrete shape under the Pakistan Climate Change Act (2017), which introduces a Climate Change Council and a Climate Change Authority. The National Adaptation Plan 2023 also brought the focus of adaptation agenda to a better focus by presenting a long-term time-bound strategy for climate resilient communities, gender responsive planning, and sectoral resilience and equitable resource use (Government of Pakistan, 2023). Much of the implementation is still to be done and is not guaranteed to be uniform, requiring a great deal of collaboration among the federal and provincial levels.

A Memorandum of Understanding was signed with a partner from India on 6.2 International engagement and climate finance.

Pakistan has adhered to ("UNFCCC, Kyoto Protocol, and Paris Agreement") and has been increasingly engaged in climate-diplomacy. Pakistan, as chair of the G77+China, a vital role in getting the agreement at COP27 in 2022 on the formation of a Loss and Damage Fund for vulnerable countries that had been demanded by the developing world for years (UNFCCC, 2022). This Fund transitioned to a more operational stage following COP28 and COP29, and the World Bank acted as interim trustee until the Philippines will chair the board of the RRLD (UNFCCC, 2024a, 2024b).

In the field of mitigation, Pakistan has presented its first NDC in 2016 and revised the 2016 NDC in 2021, which included a conditional mitigation target to cut projected emissions by 50% by 2030. In September 2025, Pakistan have submitted their NDC 3.0, which includes a 17% unconditional domestic action and a 33% conditional with international finance, technology transfer and capacity support. The NDC Partnership (2025) estimates total investment needs of around US$565.7 billion (NDC 3.0) to achieve these NDCs. While there are serious doubts regarding delivery capacity in Pakistan, these commitments firmly put Pakistan on the global decarburization and climate finance agenda.

6.1 Priorities for a transition towards a green-economy

In conjunction with the emissions analysis, there are three key aspects that should be noted. Energy and agriculture are the biggest contributors and the biggest growth areas – these are the first to be addressed. Floods of 2022 demonstrate the need for adaptability, which has become imperative, and the fact that climate shocks are now a direct input to macroeconomic fragility, debt and food insecurity. In Pakistan, the transition will rely in reality on the mobilization of external finance and technology as it emits less, but pays more.

Energy is the largest and fastest growing source of emissions identified by the econometric model and, therefore, scale up solar, wind and hydropower and improve efficiencies in the energy sector to decarbonise the energy sector.

Invest in water security – storage, modern irrigation and integrated water management, to provide water security cushioning to the economy during droughts and floods.

Improve disaster preparedness and resilient infrastructure, and prioritize the investment of flood defence and early warning infrastructure as a key economic investment.

Increase afforestation and climate-smart, low-emission agriculture while looking after carbon sinks and rural livelihoods at the same time.

Scale up international climate finance, such as the Loss and Damage Fund, as well as the conditional part of Pakistan's NDC, to support adaptation and mitigation.

Develop institutional capacity for implementation, monitoring and evaluation with clear project pipeline processes that can facilitate concessional finance.

7. Conclusion

The objective of research was twofold: First, to examine the causes, impact and governance of climate change in Pakistan and second, to measure, within the framework of EKC, the drivers of carbon emissions in the country. The outcomes of study show that energy consumption and population growth are significant positive factors in the increase of per capita CO_2 emissions using ARDL cointegration analysis of annual data from 1980 to 2023. Based on the income coefficients, the association between income and life expectancy is estimated as an inverted U, with the turning point around US$1,698 per capita. Pakistan had only reached this stage towards the end of the sample period and cleaner growth policies will be required if further development is not to lead to greater emissions. The insignificant impact of FDI. The ECT coefficient of -0.683 suggests that the adjustment process is relatively fast, such that policy actions can have a real effect within 3–4 years.

For many years climate change was a peripheral issue in Pakistan's policy. That position is no longer available due to repeated heatwaves, water shortages and droughts and most importantly the flooding in 2010 and 2022. Pakistan has demonstrated this with a robust body of law, institutions, ranging from PEPA to the climate policies for 2012, the National Adaptation Plan for 2023 and its prominent position in climate-finance diplomacy. However, much of this is short term or under-implemented and climate change is still susceptible to the 'push to the back of the queue' caused by economic and political pressures.

What Pakistan must do is not stop economic growth, but to struggle to make it more climate-resilient and to use resources more efficiently. The findings reveal the conditions for sustainable development are that renewable energy needs to be deployed faster, adaptative measures strengthened and climate finance should be mobilized on the international market, to achieve the goals of the study. Such a shift to a green economy would have positive impacts on economic resilience, energy security and set aside future generations from the increasing costs of climate change, as well as lower environmental degradation.

Limitations

The following points are limitations of this study.

This study works with energy consumption of the aggregates, not with disaggregated energy consumption, which would split the total energy consumption between fossil fuels and renewables. It does not also cover policy dummies or the structural-break tests of flood events (2010 floods), Climate Change Act (2017), the updated NDC (2021) nor the floods (2022). The study could be expanded in the future by utilizing sectoral data and institutional quality indicators, renewable energy shares, structural-break tests (for example, Zivot-Andrews and Bai-Perron tests) and robustness checks (using alternate cointegration methods).

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