

# **Untangling the Relationship Between Economic Growth and Environmental Degradation: A Statistical Analysis of CO2 Damage in Pakistan**

## **Abstract**

This study investigates the relationship between economic activities and carbon dioxide damage in Pakistan using a multi-variable regression model. Analyzing data from the World Bank's World Development Indicators spanning 1990 to 2021, key economic factors including Gross Domestic Product (GDP), urbanization rate, trade volume, inflation, and current account balance are examined. Findings reveal a positive association between GDP and carbon dioxide damage, indicating the environmental impact of economic growth. Additionally, urbanization emerges as a significant driver of carbon emissions, while the impact of trade is comparatively minor. An unexpected negative relationship between inflation and carbon dioxide damage is noted, warranting further exploration. The study underscores the importance of integrating environmental considerations into economic policy for achieving sustainable development in Pakistan.

## **Introduction**

Sustainable development, an imperative for balancing economic growth with environmental preservation, presents a complex challenge, particularly for nations like Pakistan undergoing rapid economic expansion. This study focuses on Pakistan's context to explore the intricate relationship between economic activities and carbon dioxide damage. Employing multi-variable regression analysis and leveraging data from the World Bank's World Development Indicators spanning 1990 to 2021, we investigate the impact of key economic factors including Gross Domestic Product (GDP), urbanization rate, trade volume, inflation, and current account balance. By delving into Pakistan's specific economic and environmental dynamics, our research aims to shed light on the nuanced interplay between economic growth and environmental degradation. These insights hold significant implications for policymakers,

researchers, and stakeholders striving to navigate Pakistan towards a trajectory of sustainable development, where economic prosperity aligns with environmental sustainability.

This research contributes to the existing body of knowledge by providing empirical evidence and insights tailored to Pakistan's unique socio-economic landscape. By examining how various economic activities influence carbon dioxide damage within Pakistan, we aim to inform targeted policy interventions that reconcile economic progress with environmental stewardship. Ultimately, our findings aim to facilitate informed decision-making and strategic planning, guiding Pakistan towards a future where economic development is pursued hand-in-hand with environmental responsibility, ensuring a healthier and more resilient society for future generations.

## **Literature Review**

The research essay titled "Examining the Validity of the Environmental Kuznets Curve" by Nicole Marie Karsch critically assesses the Environmental Kuznets Curve (EKC) hypothesis, which posits a non-linear relationship between economic development and environmental degradation. According to the EKC, initial stages of economic growth are associated with increased environmental degradation, followed by a reversal once a certain income threshold is attained, leading to environmental improvement. While some proponents of the EKC theory have presented empirical evidence supporting its validity, this essay challenges the assumption that economic growth invariably leads to environmental benefits. Through rigorous analysis, it demonstrates that the notion of income growth as inherently beneficial for the environment lacks consistent empirical support. The essay underscores the complexity of the relationship between income and environmental quality, cautioning against overreliance on simplistic models like the EKC in environmental policy-making.

Paper titled "Relationship Between Pollution and Economic Growth in China: Empirical Evidence from 111 Cities" by Haitao Zheng, Wenxin Huai, and Lele Huang highlights the significance of balancing economic growth and environmental protection, particularly within the context of China's developmental goals outlined in the 2016–2020 Planning Project. The research focuses on the role of cities in both economic and environmental spheres,

recognizing their pivotal importance in shaping developmental patterns. By classifying these cities into distinct clusters, the study reveals varied pollution-economic relationships among them, with some aligning with the Environmental Kuznets Curve (EKC) theory. The findings underscore the significance of city-specific characteristics, scale effects, and composition effects in shaping developmental patterns. This research provides valuable insights for policymakers and urban planners, informing decisions aimed at achieving sustainable development amidst the challenges of economic growth and environmental protection in China.

The paper by Badi H. Baltagi, Georges Bresson, Jean-Michel Etienne proposes a novel approach to estimate the relationship between CO<sub>2</sub> emissions and economic activities across 81 countries from 1991 to 2015. Using a mixed fixed- and random-coefficients panel data model, it considers factors such as energy intensity, population density, and urbanization. Results reveal a strong and complex link between CO<sub>2</sub> emissions and GDP, enriching climate change models with diverse responses across countries and variables.

## **Methodology**

### **Data Collection:**

The data utilized in this study was sourced from the World Development Indicators (WDI), a comprehensive database maintained by the World Bank that provides access to a wide range of development data from across the globe. The dataset encompassed a diverse set of variables crucial for understanding economic dynamics and environmental impact. Specifically, the following variables were selected for investigation:

1. Carbon dioxide damage (% of GNI) and current US\$: These variables provide insights into the economic cost associated with carbon dioxide emissions, both as a percentage of Gross National Income (GNI) and in absolute US dollar terms.
2. Gross Domestic Product (GDP): GDP serves as a key indicator of economic activity and overall economic performance, while GDP per capita offers a measure of economic output per person, aiding in the assessment of living standards and economic well-being.

3. Urban Population Growth (% annual): Urbanization rates reflect the pace at which populations are shifting from rural to urban areas, influencing infrastructure demands, resource consumption patterns, and environmental pressures.
4. Trade (% of GDP): Trade as a percentage of GDP indicates the extent of a country's integration into the global economy, with implications for economic growth, industrial structure, and environmental impact.
5. Inflation, consumer prices (annual %): Inflation rates measure the annual percentage change in consumer prices, affecting purchasing power, investment decisions, and overall economic stability.
6. Current account balance (% of GDP): The current account balance reflects a country's net income from international trade in goods, services, and transfers, influencing its overall economic health and external vulnerabilities.

#### **Data Processing:**

Upon collection, the raw data underwent meticulous cleaning and preprocessing procedures to ensure its integrity and reliability for subsequent analysis. This involved addressing missing values, duplicates, and inconsistencies, while also normalizing the dataset to account for variations in scale across variables. Additionally, feature engineering techniques were applied to capture complex relationships within the data effectively, enhancing the richness of the analytical insights derived from the dataset.

#### **Data Analysis:**

The analysis commenced with descriptive statistics to summarize the dataset, providing an overview of key trends, distributions, and central tendencies across the selected variables. Exploratory data analysis (EDA) techniques, including visualization and correlation analysis, were then employed to uncover underlying patterns and relationships within the data. Regression models were subsequently constructed to explore the impact of factors such as GDP, urban population growth, and trade on carbon dioxide damage, utilizing advanced statistical techniques to control for potential confounding variables and model complexity. Model performance was rigorously evaluated using key metrics, including R-squared and mean squared error, to assess predictive accuracy and reliability. It's worth noting that this

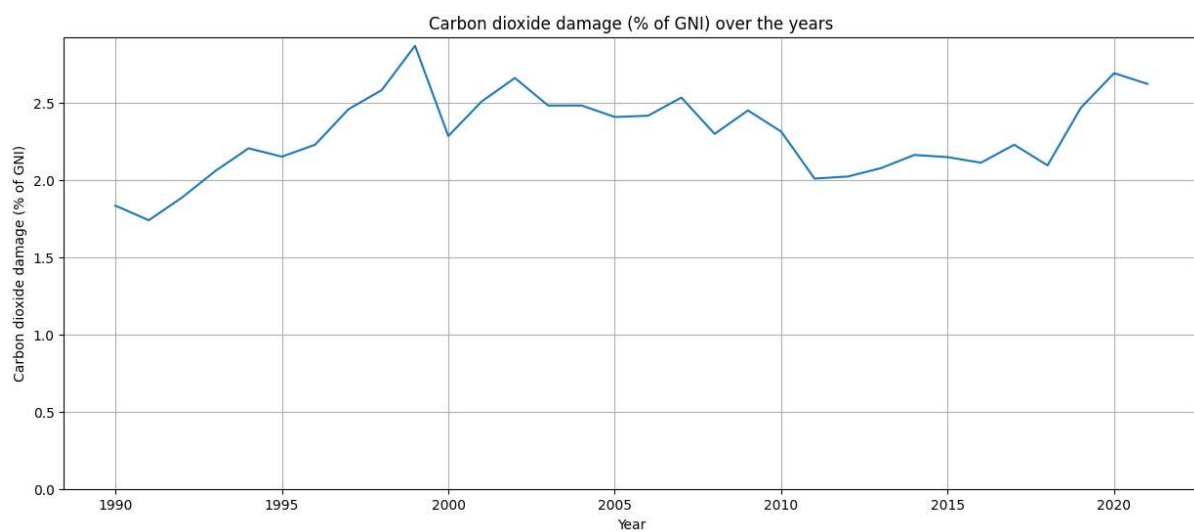
study focused specifically on data pertaining to Pakistan, offering insights tailored to its unique socio-economic context and environmental challenges.

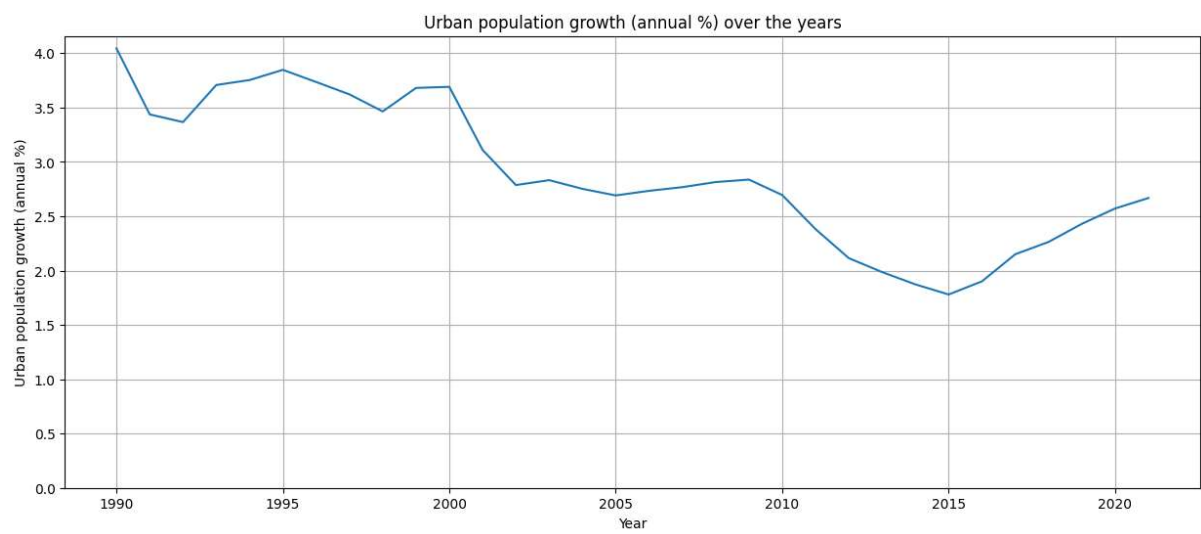
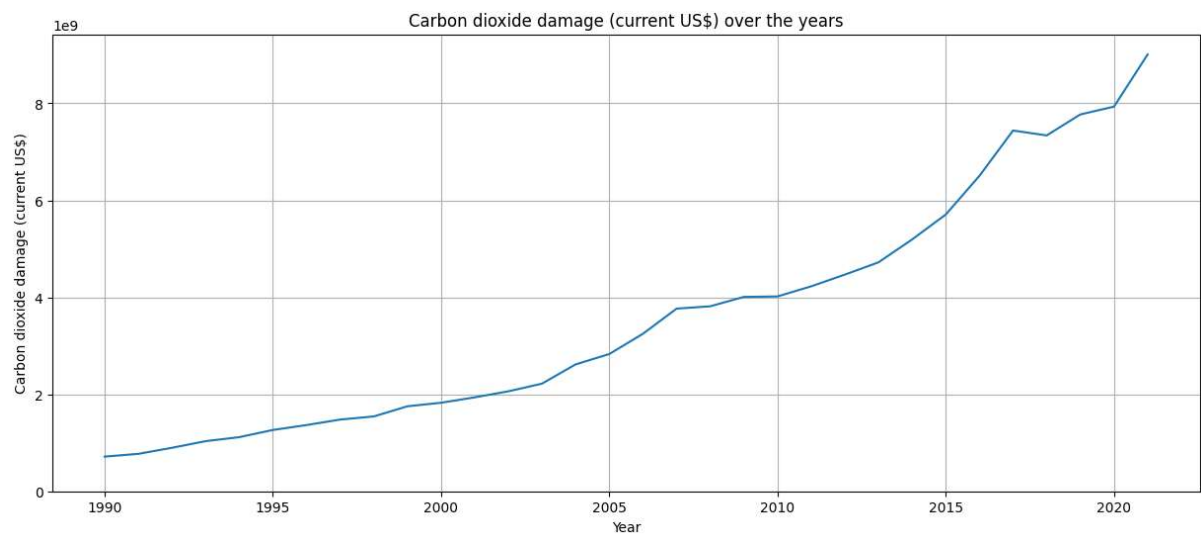
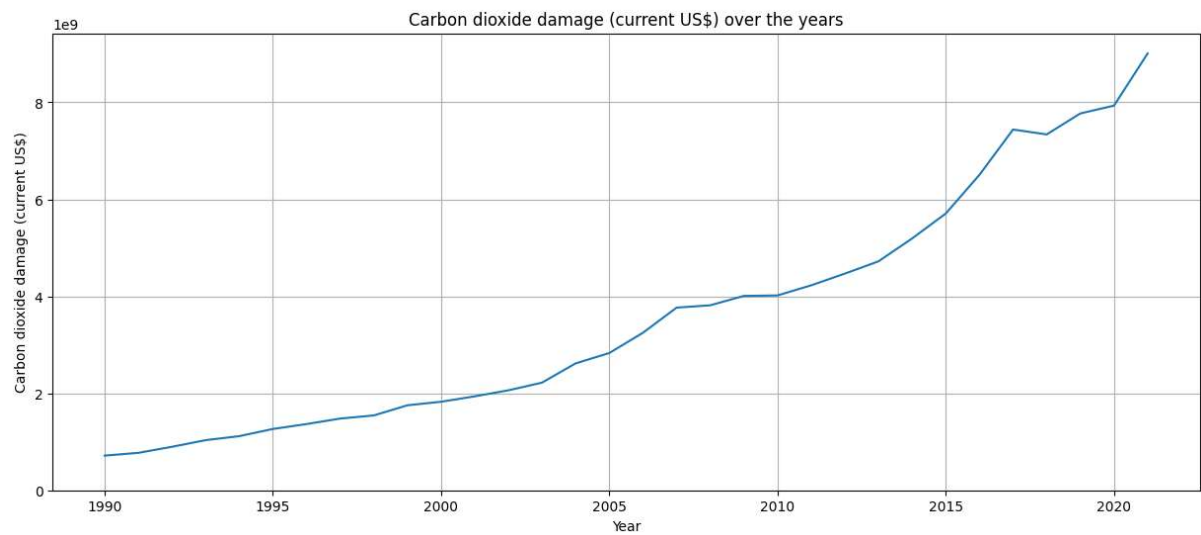
### Statistical Software:

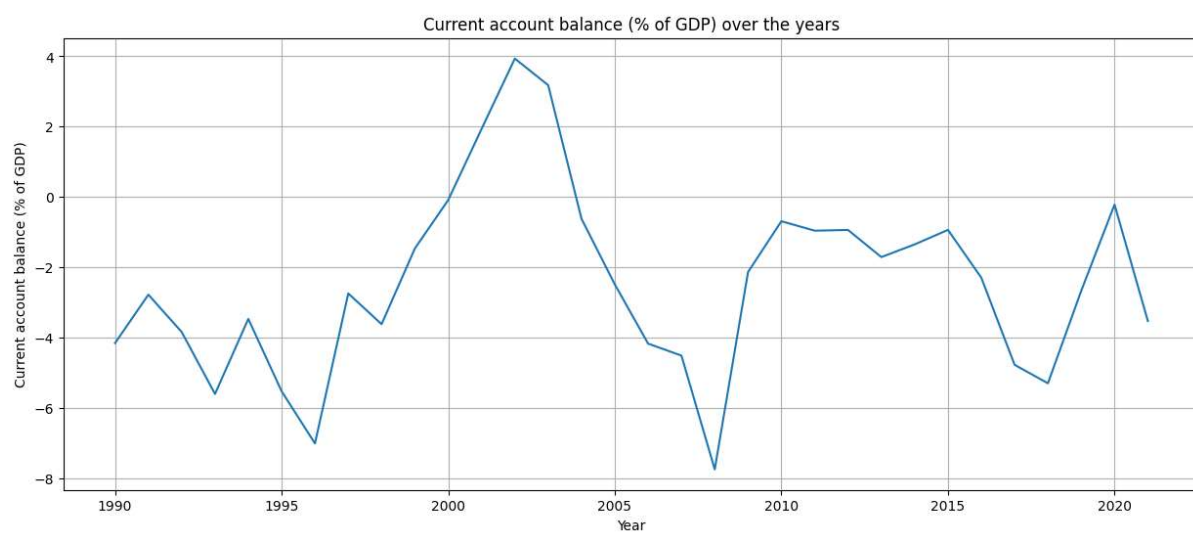
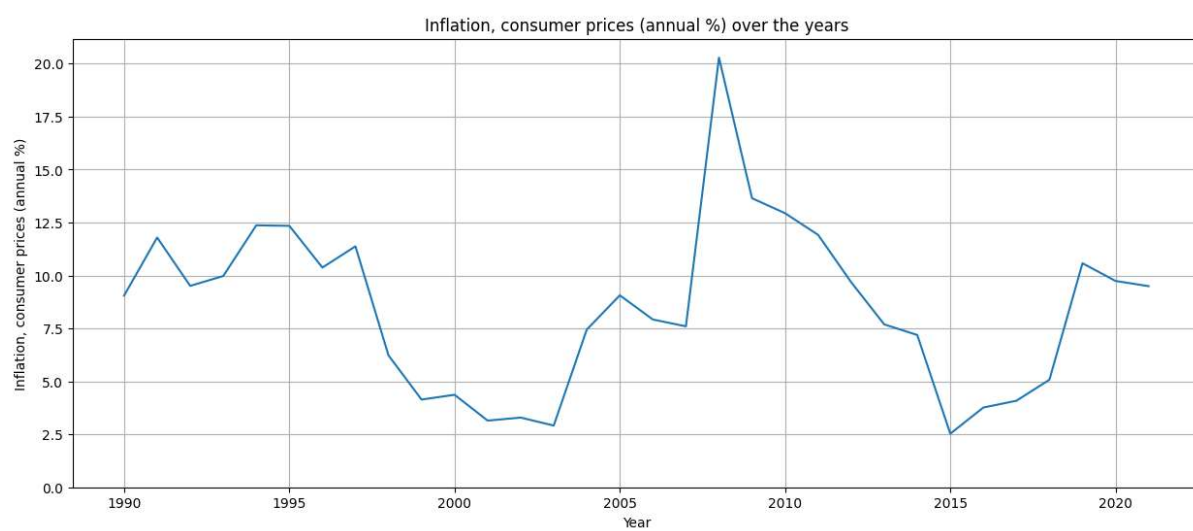
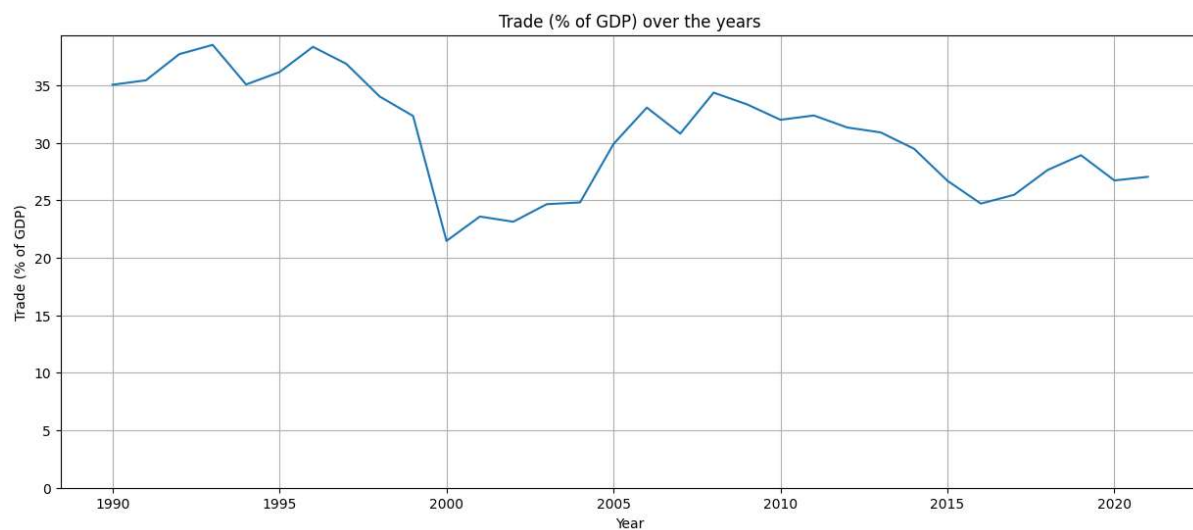
All data processing and regression analyses were conducted using the Python programming language (version 3.10.3) along with relevant libraries, including pandas, NumPy, scikit-learn, and statsmodels. Leveraging the capabilities of these tools ensured efficient data handling, analysis, and interpretation, contributing to the robustness and reliability of the study's findings.

## Data Analysis

### Univariate Analysis of the variables:







### Summary of the Regression Model:

Intercept	-10.600230124821532
GDP (current US\$)	1.2293467735851822
Urban population growth (annual %)	0.22286606489769542
Trade (% of GDP)	0.008796760916531421
Inflation, consumer prices (annual %)	-0.009590961228099146
Current account balance (% of GDP)	0.006509127445395856
R-squared	0.9363890461090549
Mean Squared Error	0.02399706612602185

## Results

**GDP Impact:** A one-unit increase in the natural logarithm of GDP corresponds to an estimated increase of approximately 1.23 units in the natural logarithm of carbon dioxide damage. This suggests a positive relationship between GDP and carbon dioxide damage, indicating that higher economic activity is associated with increased carbon emissions.

**Urbanization Influence:** Urban population growth is associated with higher levels of carbon dioxide damage, with a one-unit increase in annual urban population growth corresponding to an estimated increase of approximately 0.22 units in the natural logarithm of carbon dioxide damage.

**Trade Impact:** While positive, the impact of trade on carbon dioxide damage is relatively small, with a one-unit increase in trade as a percentage of GDP leading to an estimated increase of approximately 0.009 units in the natural logarithm of carbon dioxide damage.

**Inflation Effects:** Surprisingly, higher inflation rates are associated with slightly lower levels of carbon dioxide damage, with a one-unit increase in inflation resulting in an estimated decrease of approximately 0.009 units in the natural logarithm of carbon dioxide damage.

**Current Account Balance Influence:** A higher current account balance as a percentage of GDP is associated with increased carbon dioxide damage, with a one-unit increase corresponding



to an estimated increase of approximately 0.0065 units in the natural logarithm of carbon dioxide damage.

The high R-squared value (approximately 0.94) indicates that the model explains a significant portion of the variability in carbon dioxide damage based on the selected independent variables. The low mean squared error further supports the model's predictive performance.

## **Discussion**

The regression analysis reveals several key insights into the relationship between economic factors and carbon dioxide damage. Firstly, the positive association between GDP and carbon dioxide damage underscores the environmental impact of economic growth. As economies expand, so do industrial activities and energy consumption, resulting in increased carbon emissions. Urbanization emerges as another significant driver, with higher urban population growth rates correlating with heightened carbon dioxide damage. This highlights the environmental challenges associated with rapid urban development and the need for sustainable urban planning strategies. While trade exhibits a positive relationship with carbon dioxide damage, its influence appears relatively minor compared to GDP and urbanization.

However, policies promoting sustainable trade practices remain crucial for mitigating emissions within global supply chains. The unexpected negative relationship between inflation and carbon dioxide damage is intriguing and suggests potential shifts in consumption patterns or improvements in energy efficiency with higher inflation rates. Finally, the positive association between the current account balance and carbon dioxide damage underscores the environmental implications of trade imbalances. Addressing these challenges requires integrated policy approaches that balance economic growth with environmental sustainability, emphasizing the importance of long-term environmental stewardship in achieving sustainable development goals.

## **Conclusion**

The regression analysis sheds light on the complex interplay between economic activity and carbon dioxide damage in Pakistan. These findings highlight the critical need to address environmental sustainability concerns alongside economic growth initiatives. For Pakistan, this translates to formulating policies that curb carbon emissions while fostering economic development. Policymakers should prioritize factors like GDP and urbanization, which significantly influence carbon dioxide damage. Promoting sustainable trade practices and addressing trade imbalances are also crucial considerations. The intriguing negative relationship between inflation and carbon dioxide damage warrants further investigation within the Pakistani context. Understanding this association could potentially unlock opportunities to leverage inflationary pressures for environmental improvements. Ultimately, achieving sustainable development in Pakistan requires holistic policy approaches that seamlessly integrate environmental considerations into economic decision-making processes. This will ensure a healthier and more resilient future for Pakistan.

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