Climate Change and Environment Kuznets Curve in Developing Economies (D-8 Nations)

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Abstract*—The main goal of the current study is to determine the relationships between CO_2 emissions and the inflow of foreign investment for developing economies (D-8 countries) to determine whether or not the environmental Kuznets curve hypothesis is validated or otherwise for the study areas. The dependent variable in the current study is carbon dioxide emissions. The population was used as the control variable in this study, while the independent variables were population growth, per capita Gross Domestic Product (GDP), inflow of foreign investment, inflation, and open trade for D-8 countries from 1999 to 2023. The Fixed Effect (FE) and Random Effect (RE) model techniques were used for empirical analysis, and the Hausman test was used to choose the best-fitting model for this study. Empirical findings validate the existence of the Environmental Kuznets curve (EKC) hypothesis in D-8 countries over the study period. Additionally, there is a strong positive correlation between the inflow of foreign investment and carbon emissions, supporting the pollution heaven hypothesis, which holds that developed countries transfer their obsolete technology to developing nations. This paper explains how Foreign Direct Investment (FDI) and GDP per capita impact carbon dioxide emissions in developing countries and assists policymakers in proposing policies to draw in higher-quality FDI. Developing countries need to take a comprehensive and varied approach to achieve green economic growth. By utilizing renewable energy and promoting environmentally friendly transportation it is currently crucial to turn the transportation sector green and promote environmentally friendly transportation to lessen environmental effects and make the environment more environmentally friendly. This may be done by using renewable energy and encouraging environmentally friendly transportation. The need to coordinate global policies with the Sustainable Development Goals (SDG) is the main subject of this study, especially when it comes to achieving sustainable economic growth with the fewest possible environmental risks. Government and policymakers may achieve a sustainable future for developing nations by balancing economic development and environmental sustainability by focusing on green economic growth.

***Keywords*—carbon dioxide emissions, gross domestic product per capita, foreign direct investment, inflation, trade openness and population growth; developing economies**

I. Introduction

Carbon Dioxide (CO_2) emissions have significantly increased as a result of anthropogenic activities, especially the industrialization and economic expansion of nations, which contribute to the acceleration of climate change [1, 2]. As economic activity raises carbon emissions, economic development and carbon emissions continue to be tightly related. Thus, it was demonstrated that the primary factor influencing carbon emissions is economic growth. The two main determinants of economic and social development that involve carbon emissions from the production and consumption sides, respectively, are industrialization and urbanization [3, 4]. Numerous activities are expected to have an impact on carbon emissions [5]. Encompassing industrial structure (Shahid *et al*., 2024), foreign investment (Esso), energy consumption, trade, and urbanization [6]. The "Environment Kuznets Curve" states that the relationship between environmental quality and economic growth is an inverted U-shaped curve. Dinda [7] reports a thorough examination of this concept (2004). Renowned economist Simon Kuznets first put forth this theory in the 1950s and 1960s. Finding a relationship with an inverted U-shaped curve is crucial to achieving sustainable development. According to that curve, environmental conditions tend to improve as per capita income rises during the early stages of economic expansion. However, after a certain amount of time, additional increases in per capita income result in better environmental quality because of the availability of renewable resources and cutting-edge technology.

According to [8] the quantity or number of pollutants and discharges is either close to or beyond the ecological conveying limit's upper limit. Additionally, some recent studies have revealed that an increase in natural pollution can be a major cause of illnesses, especially respiratory conditions, as well as cardiovascular or mental infections [9]. The trash attack trend, suggests that the area surrounding the city is implicated, and is frequently observed in some large cities including Beijing, Shanghai, and Guangzhou. Including many other countries, China's waste output has increased at an annual pace of 5–8% over the past few decades. China's natural conditions are generally harsh [10]. According to Dangerman [11], excessive energy use is harming the ecosystem by contaminating the air, especially in China's eastern and focal areas [12]. Additionally, the "Middle Income Trap" now includes health problems and inequality-related problems brought on by natural

contamination [13]. Numerous studies have noted this issue; for example, ecological contamination in China accounts for 8–10% of the impact of real GDP and alternatives on the well-being of monetary development [14]. Home livelihood had a significant impact, which generally lowered the level. According to [15], air pollution provides serious health risks to people in agricultural countries where levels of contamination are often higher than in non-industrial countries. There is a connection between pollution and economic progress. There was a detrimental impact on the growth of several economic sectors in the area. However, the substance eventually stopped contributing to pollution. The government takes measures to protect the climate after the economy has grown as needed. Up to a certain point, there is a positive correlation between public income and climate protection spending. Climate change knowledge and awareness are additional factors that impact people's desire to safeguard the environment. However, it is not scientifically changing as a result of industrial progress [16]. The current analysis supports policymakers' recommendations for policies that encourage carbon emission reduction, particularly with regard to developing countries. Additionally, it supports the plan maker's recommendations for the final amount and quality of FDI that might not adversely impact the environmental quality of developing countries while taking economic growth into account. There are several studies on the mentioned subject, however, more research is still required to address the problem statement. First, the primary environmental influence component in this study was the inflow of Foreign Investment. Second, this study tested hypotheses for D-8 Nations using the Environmental Kuznets Curve (EKC). The rest of this research is as follows: The second section examines earlier empirical research. The third section of the current study covers the description of the data and the creation of the study's variables. The study's theoretical framework and econometric technique are covered in the fourth section. The findings from empirical research are covered in the fifth section. The results are concluded and policy implications are provided in the final section.

II. Literature Review

One of the main causes of the rise in atmospheric carbon emissions is economic expansion. Growing economies result in more industrial activity, which raises carbon emissions. It is determined that environmental quality is declining in tandem with economic prosperity. The intricate and multifaceted relationship between economic growth and carbon emissions presents difficulties for policymakers who are trying to strike a balance between environmental sustainability and economic development. Designing successful policies that can support sustainable economic growth while reducing environmental impact requires an understanding of this relationship. Economic growth and environmental quality have been seen to be closely and strongly related. Yang [17] states that the relationship between trade openness, energy consumption, carbon emissions, and economic growth was examined over the years 1971–2009 in the case of Pakistan. They assert that there is a long-term association between the variables, supporting the environmental Kuznets curve hypothesis for this nation. The findings also indicate that there is a unidirectional causal relationship between environmental quality and economic development. In order to determine whether policies that substitute renewable energy sources for conventional ones could be implemented to reduce greenhouse gas emissions, this study looks at the effects of environmental pollution, economic development, and the use of renewable energy in Tunisia [18]. They concluded that economic progress and carbon emissions are causally related in both directions.

On the same note, Kahouli [19] investigated the connection between economic development in the Mediterranean region and energy consumption, carbon emissions, and R&D stocks. According to the author, there is a strong two-way causal relationship between carbon emissions and economic development in industrialized nations. Riti [20] examined the relationship between China's economic development, energy consumption, and carbon dioxide emissions. The study's findings showed irregularities in the environmental kuznet curve, which could be the result of various data sources and factors used in the analysis. Cherni and Jouini [21] investigated the relationship between Tunisia's carbon dioxide emissions, renewable energy, and economic growth. In order to reach zero carbon emissions in the nation, the study attempted to quantify the extent to which renewable energy sources may be utilized as a substitute for non-renewable energy sources. The study's conclusions demonstrated a reciprocal causal relationship between Tunisia's economic expansion and carbon dioxide emissions. In Pakistan, Mirza and Kanwal [22] found a dynamic causal relationship between carbon dioxide emissions, economic growth, and energy consumption. The study's findings supported the notion that, in the instance of Pakistan, there is a direct correlation between energy consumption and economic growth. In the United Arab Emirates, Shahbaz [23] discovered an inverted U-shaped EKC between energy use and economic development. Ahmed [24] used time series data from 1980 to 2013 to examine the effects of EKC in Pakistan. Energy consumption, economic growth, population, and trade openness were the dependent variables, while deforestation was used as a proxy for environmental deterioration. The ARDL model was used in the study, and the findings indicated that there was cointegration between the variables in the short term as well. The impact of FDI on environmental quality in 123 countries between 1996 and 2018 is examined by [25]. The outcome suggests that foreign direct investment has a detrimental and substantial effect on the environment for the worldwide sample. Dong *et al.* [26] discuss the Environmental Kuznets Curve hypothesis's legality for D-8 nations from 1972 to 2014. The main idea of this study is to determine how carbon emissions, GDP, and energy consumption are related in D-8 nations. The outcome demonstrates that an inverted N-shape relationship exists. Dasgupta *et al.* [25] looks at how ICT affects carbon emissions for 91 countries using data from 1990 to 2017.

Dangerman and Schellnhuber [27] used China's large information test to examine how air pollution and its spatial overflow affect social well-being. The impacts of air pollution and its geographical overflow on social well-being in 116 Chinese cities between 2006 and 2012 are investigated in this study using a geographical Durbin Model (SDM).

Their main findings are an absolute increase of 0.217 and 1.543 per 10,000 people in the mortality rates of all its neighbors from a cellular breakdown in the lungs and respiratory illness separately. They also used public health statistics data on built-up discharges of sulfur dioxide and ash from related urban communities to measure air contamination. They did this by using overview information on death censorship locations at 161 locations in China. Elliott *et al.* [28] investigated the impact of PM_2 on social welfare. Five contaminations are serious. 2015 saw Pm_2 pollution commitments of 40.3, 33.1, and 26.8%, respectively, which added up to hit expiries, severe lower respiratory contamination expiries, and ischemic coronary sickness expiries. Therefore, these two poisons are chosen as indicators of ecological quality in this study due to the remarkable negative effects of SO_2 and resident outflows on social well-being.

FDI has both beneficial and bad effects on the environment. FDI undoubtedly has an impact on the environment in host nations. Foreign direct investment has the potential to improve environmental quality in host countries by introducing clear technologies and good management practices. The relationship between foreign direct investment and the environment is estimated by certain authors. According to their estimates, pollution will rise by 4% for every 1% increase in foreign direct investment. It indicates that, in comparison to home nations, the environment and foreign direct investment are favorably correlated in host countries. Although there are many studies on the subject at hand, this study intends to close the research gap by adding to the body of knowledge in three key ways: First, the primary environmental influence component in this study was the inflow of foreign investment. Second, the EKC was employed in this study to test the hypothesis for the D-8 organization for economic cooperation.

III. Methodology and Data

A. Data and Variables

The dependent variables in the current study are CO_2 emissions, while the independent variables are GDP per capita, Foreign Direct Investment (FDI), open trade, and population growth (POP). These studies used panel data for D-8 countries from 1999 to 2023; the World Development Indicators (WDI) provided the pertinent data. The variables are listed in Table 1.

Table 1. List of variables

Regressors	Abbreviation	Dimension	Source
CO_2	CO_2	Metric ton per capita	World Development Indicator (WDI)
GDP	GDP	Per capita constant 2010 US $	World Development Indicator (WDI)
FDI	FDI	Net inflow percentage (%) of GDP	World Development Indicator (WDI)
Inflation	INF	GDP deflator annual (%)	World Development Indicator (WDI)
Open trade	TO	Percentage (%) of GDP	World Development Indicator (WDI)
Population growth	POP	Annual percentage (%)	World Development Indicator (WDI)

B. Dependent Variables

1) Carbon dioxide emissions

Emissions of carbon dioxide are employed as the dependent variable. It is created both naturally and by human activity, such as when coal, oil, gasoline, and wood are burned. About 20% of the earth's greenhouse effect is impacted, compared to 0% for water vapor and 25% for clouds.

C. Independent Variables

1) FDI

FDI is defined as the net inflow percentage (%) of GDP, which is taken from the World Development Indicators (WDI).

2) GDP Per Capita (GDP)

GDP is used as an independent variable in the current study. Gross Domestic Product per capita is calculated by dividing a nation's GDP by its total population. It is also occasionally used to determine population standards of living; a greater GDP is associated with a higher standard of life. There is a positive correlation between carbon dioxide emissions and GDP per capita. It means that rising carbon dioxide emissions are a direct result of rising gross domestic output.

3) Inflation (INF)

Inflation is used as an independent variable in the current study. A broad increase in the cost of goods and a decline in the purchasing power of money is known as inflation. Things become less productive when inflation occurs. Inflation prevents industries from making money. Uncertainty is a result of inflation.

4) Trade Openness (TO)

Open Trade is another important indicator of the current study. The ratio of a nation's imports and exports to its gross domestic product is known as trade openness. Countries and socioeconomic levels have different relationships with regard to trade openness and carbon dioxide. The main argument is that trade openness lowers emissions of carbon dioxide.

5) Population Growth (POP)

The term "population growth" describes an annual increase in the number of people. The positive correlation between Carbon Dioxide (CO_2) emissions and Population increase (POP). Several articles demonstrate that carbon dioxide emissions have a favorable effect on population growth. If population growth increases by 1%, carbon dioxide emissions will increase by 1.8%.

D. Model Specification

The regression equation to assess the impact of FDI on CO_2 emission is shown below:

$$CO_{2_{it}} = \beta_0 + \beta_1 Econ_{it} + \beta_2 FDI_{it} + \beta_3 C_{it} + \varepsilon_t \quad (1)$$

In the above equation, CO_2 emissions are denoted by CO_2,

economic variables are denoted by $ECON_{it}$, FDI is denoted by FDI_{it} controlled variables that confirm a nation's particular facial appearance are denoted by C_{it} and μ_{it} represents error term. We simplified Equation (1) and rewritten in Eq. (2) as follows:

$$LnCO_{2_{it}} = \beta_0 + \beta_1 LnGDP_{it} + \beta_2 LnGDP^2{}_{it} + \beta_3 LnFDI_{it} + \beta_4 Lnopentrade_{it} + \beta_5 Lnpop_{it} + \varepsilon_t \quad (2)$$

where i represents a nation at time t, and m represents the number of nations, β_1 , β_2, β_3 , β_4 , and β_5 are scalar parameters, CO_2 denotes Carbon Dioxide Emissions that is used to determine the environmental degradation. The GDP_{it} is a gross domestic product while ${GDP_{it}}^2$ shows the square of gross domestic products. According to the EKC hypothesis, environmental degradation is determined by the Level of GDP, which shows a reversed U-shaped pattern. The FDI_{it} inflow of FDI in the nation i at times t, $opentrade_{it}$ is trade openness and ε_t is the random error term.

E. Econometric Technique

Before we began our investigation, the data was processed for normalized factors to reduce information problems and make the model's results more consistent. We attempted to show the criterion divergence for a variable to adjust the factors. We then deducted the specification and distribution by the criterion variation for each observed value of the variable. We start our investigation by unit root test to check the stationarity of every factor. We have applied the panel unit root test on each variable to test the level of stationarity.

The FE model and RE model will be applied to the provided model after the Panel Unit Root Test (IPS) and Levin, Lin, Chu (LLC) have been completed. The best-fitting model for the current investigation will be determined by the Hausman test.

IV. Empirical Results and Discussion

Current research aims to determine whether the environmental Kuznets curve hypothesis is true across D-8 countries and to find a relationship between Carbon Dioxide (CO_2) emissions and foreign direct investment. The CO2 emissions have been used as the dependent variable in recent studies. The population was used as the control variable in this study, while the independent variables were GDP per capita, FDI, INF, open trade (TO), and population growth (POP). The D-8 countries were studied from 1999 to 2023 using the Fixed Effect and Random Effect Model technique for empirical analysis, and the Hausman test was used to select the best-fitting model for the current study. Before the start of the inquiry, the data was treated using normalized factors to reduce information-related problems. Current research aims to determine whether the environmental Kuznets curve hypothesis is true across D-8 countries and to find a relationship between carbon dioxide (Co_2) emissions and foreign direct investment. CO_2 emissions have been used as the dependent variable in this study. Population is the control variable in this study, while GDP per capita, FDI, INF, open trade (TO), and population growth (POP) are the independent variables. The study covers the years 1999–2023 for D-8 countries and employs the Fixed Effect and Random Effect Model techniques for empirical analysis. The Hausman test is also used to select the best-fitting model for this study.

Before the research started, the data was treated using normalized factors to reduce information problems and make the model's results more consistent. To verify the stationarity of the variables, we start our research with a unit root test. The Root Tests for the Panel Unit were utilized to analyze the variables' order of integration for the degradation examination. The IPS unit root test statistic in Table 2 indicates that population growth, inflation, and foreign direct investment are all stationary at the same level. At the first difference, GDP per capita and trade openness remain constant. At the second difference, the carbon dioxide (CO_2) emissions variable is stationary. The LLC unit root test [29], which is presented in Table 4, has produced similar findings. The classification of the combination of variables to be used in the degradation evaluation is examined using the Unit Root Test. The LLC unit root test statistic in Table 3 indicates that the population growth, foreign direct investment, and carbon dioxide (CO_2) emissions are all stationary at the same level. At the first difference, both trade openness and inflation are stagnant. At the second difference, the GDP per capita variable is stationary. We use fixed and random effect models for the current investigation because the ARDL approach does not fulfill the permutation of level stationary and first difference stationary variables.

Table 2. Panel Unit Root Testing (IPS)

Variables	Level	1st difference
CO_2	0.03 (0.527)	0.50 (0.629)
FDI	–2.60 (0.004***)	–
GDP	1.930 (0.960)	–4.28 (0.000***)
INF	–2.46 (0.006***)	–
TO	0.631 (0.26)	–6.271 (0.000***)
POP	–3.64 (0.0001***)	–

The __*** indicate at 1%, ___** indicate significance at 5% and ___* indicates significance at 10%

The mean, median, and mode are examples of central tendency metrics that are provided by descriptive statistics. Mean displays the series' average value as displayed in Table 3.

We used a regressed fixed effect model in Table 4, with FDI, GDP per capita, inflation, trade openness, and population growth as independent variables and carbon dioxide (CO_2) emissions as the dependent variable. According to Model 1's findings, foreign direct investment is substantial and positively correlated with carbon emissions. It indicates the strong correlation between foreign direct investment (an independent variable) and carbon dioxide (CO_2) emissions (a dependent variable) for the emission of carbon. One possible explanation for the positive correlation could be that less developed countries import foreign direct investment (FDI), which is unnecessary for developed countries and not environmentally beneficial. The rationale is that the entry of foreign direct investment leads to the adoption of cleaner construction technology and environmentally friendly industrial methods, which immediately demonstrate the decrease in ecological emissions in the host countries. Furthermore, residential countries that have historically achieved higher levels of output typically have given more attention to ecological supremacy through strict environmental policies and foreign direct investment entrance requirements. This rise in

pollution is a result of economies that rely heavily on fossil fuels. The necessity for investments in renewable energy and the energy sector's usage of inefficient technology, which results in excessive carbon emissions, exacerbate this even further. The results also support the idea that energy use has continued to be a major contributor to the rising trend of energy-related emissions, which could have been prevented had alternative sources been used sooner. The findings of [30–32] for their separate studies on France, Central America, and Turkey are fairly comparable to this one.

Table 3. Descriptive statistics of the variables

	CO_2	FDI	GDP	INF	POP	TO
Mean	11.771	6.056	26.141	12.452	3.869	3.314
Median	11.853	6.067	26.186	12.465	3.856	3.338
Maximum	12.199	6.134	26.618	12.485	3.972	3.391
Minimum	11.323	5.996	25.654	12.344	3.740	3.147
S.D	0.268	0.034	0.311	0.040	0.061	0.061

Table 4. Panel Unit Root Testing
Levin Lin Chu (LLC)

Variables	Level	1st difference
CO_2	–2.69 (0.003***)	–
FDI	–2.21 (0.01***)	–
GDP	–0.23 (0.407)	–0.30 (0.50)
Inf	1.21 (0.2)	–5.24 (0.000***)
TO	0.08 (0.46)	–5.64 (0.000***)
Pop	–6.38 (0.000***)	–

The __*** indicate at 1%, ___** indicate significance at 5% and ___* indicates significance at 10%

They are built to maximize their foreign direct investment inflow and to encourage cleaner foreign direct investment that results in humanizing efficiency and environmental superiority through the strict ecological strategy and foreign direct investment eligible principles. According to the contamination radiance hypothesis, foreign direct investment inflows can contribute positively to ecological superiority and restore the location's superiority by transferring environmentally friendly technologies to the host country. The results of Model 2 show that FDI and GDP per capita have a strong positive correlation with carbon dioxide emissions, supporting the Environmental Kuznets Curve (EKC) theory. The findings of Model 3 to Model 6 further support the Environmental Kuznets Curve (EKC) hypothesis by showing a negative and substantial relationship between the square of GDP per capita and carbon emissions. (Naqvi *et al.* 2025). According to this N-shaped model, pollution levels approach a negative peak before beginning to increase again with additional economic progress, while environmental deterioration brought on by economic growth reverses with economic advancement after reaching a positive peak.

The results also indicate that the financial system emits lower CO_2 later than achieving a verge level of GDP per capita, with the coefficient of square term of GDP per capita being significantly negative for all countries except D-8 countries [33, 34]. It could be as a result of cleaner construction methods and the promotion of eco-friendly technologies to direct better manufacturing with reduced CO_2 emissions. Furthermore, at higher development rates, the economy tends to shift toward the service sector, which produces a somewhat lower level of contamination than the industrial sector which is heavily centered on power [35]. The results of Model 3 show a positive and significant relationship between carbon emissions and FDI, GDP per capita, and inflation. In Model 4, carbon emissions are positively correlated with FDI, GDP per capita, inflation, and trade openness. Table 5 also demonstrates that TO has a negative impact on CO_2 emissions for emerging countries, but it unquestionably and significantly affects CO_2 production in growth. It might be the result of the adoption of unclean building methods in developing nations, which could lead to ecological degradation.

Table 5. FE Model, dependent variables is CO_2

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
FDI	0.113 (8.001***)	0.069 (5.854***)	0.069 (5.828***)	0.075 (6.129***)	0.053 (3.841***)	0.034 (3.12***)
GDP		0.246 (10.868***)	0.059 (0.290)	0.087 (0.435)	0.168 (0.845)	0.338 (2.18**)
GDP²			–0.012 (–0.926)	–0.023 (–1.758)	–0.029 (–2.244**)	–0.035 (–3.440***)
INF				0.045 (3.348***)	0.040 (3.014***)	0.035 (3.415***)
TO					0.219 (3.023***)	0.187 (3.336***)
POP						0.753 (–11.238***)
R-SQUARE	0.965	0.978	0.978	0.980	0.980	0.988

The __*** indicate at 1%, ___** indicate significance at 5% and ___* indicates significance at 10% or above.

Table 6. RE Model, Dependent Variables is CO_2

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
FDI	0.114 (8.012***)	0.068 (5.764***)	0.067 (5.659***)	0.072 (5.976***)	0.049 (3.544***)	0.011 (1.079)
GDP		0.255(11.276***)	0.076 (0.374)	0.084 (0.419)	0.176 (0.888)	0.362 (2.360**)
GDP ²			–0.012 (–0.919)	–0.024 (–1.816)	–0.031 (–2.341**)	–0.041 (–4.072***)
INF				0.049 (3.615***)	0.041 (3.126***)	0.044 (4.328***)
TO					0.251 (3.529***)	0.378 (7.542***)
POP						0.691 (–10.774***)
chi- square statistic	0.135	15.353	33.990	29.149	16.004	197.222
chi-square degree of freedom	1	2	3	4	5	6
Hausman test probability	0.712	0.0005	0.0000	0.0000	0.0068	0.0000

The __*** indicate at 1%, ___** indicate significance at 5% and ___* indicates significance at 10% or above.

Additionally, the favorable impact of trade openness on ecological emissions is caused by dirty construction methods coupled with lax ecological principles and policies in developing countries. However, because the residential economy has strict regulations and authoritarian support for ecological standards, trade openness results in lower ecological emissions in industrialized nations. Additionally, residential nations are using more advanced and complex technology, which directly reduces Carbon Dioxide (CO_2) emissions and improves ecological quality. The results of Model 5 show that while population increase has a considerably negative relationship with carbon dioxide (CO_2) emissions, all other variables have a significant positive relationship with CO emissions. The results are comparable to those of the Fixed Effect Model and have both positive and negative indications as expected. Carbon dioxide emissions are the dependent variable in Table 6's regress Random Effect (RE) model, while GDP per capita, inflation, trade openness, population growth, and FDI are the independent variables. Model 1 to Model 5 shows a strong and positive correlation between carbon emissions and FDI. This may be because residential countries have strict enough policies on ecological values to protect the environment; as a result, energy-intensive activities lead to fewer ecological emissions in residential countries. In contrast, outdated or broken-down building methods are still in use in poor countries, requiring more energy and labor during the manufacturing process, which leads to environmental degradation. The results of models two through six demonstrate a positive and significant correlation between GDP per capita and carbon emissions, which lends additional credence to the Environmental Kuznets Curve (EKC) theory. By demonstrating a positive and significant correlation between the square of GDP per capita and carbon emissions, the results of the current study in models 3 through 6 further support the Environmental Kuznets Curve (EKC) theory [36]. This N-shaped model states that while environmental degradation caused by economic expansion reverses with economic advancement after reaching a positive high, pollution levels approach a negative peak before starting to rise again with further economic advancement.

In Model 3, GDP per capita, and inflation have a significant and positive relationship with carbon emissions. Loose ecological principles are typically accepted by developing countries as a means of attracting foreign direct investment (FDI), which is closely linked to higher levels of pollution emissions. Foreign Direct Investment (FDI) inflows may thereby degrade the atmosphere of developing countries. Nevertheless, developing countries adapt their innovation methods, increase their productivity, and regain their ecological supremacy by welcoming FDI inflows that need sophisticated skills, cleaner building methods, and improved administrative procedures. With the exception of GDP per capita square, foreign direct investment, GDP per capita, inflation, and trade openness all exhibit substantial and positive relationships in Model 4. Companies in residential areas throughout the world constantly seek out asset opportunities in emerging nations, appropriating the low cost in conditions of workers and excess assets, according to [37] easily accessible universal image of contaminated sanctuary hypothesis. Emergent nations typically have loose ecological dictatorship structures because they contribute to lower development costs and provide a relative advantage mostly through exhausting conduct that causes contamination. Therefore, since loose trade policies offer a relative benefit primarily to contamination-concentrated behavior, they may lead to better foreign direct investment inflow in developing countries. In Model 5, population growth shows a strong positive correlation with Carbon Dioxide (CO_2) emissions, while foreign direct investment, GDP per capita, inflation, and trade openness have significant and positive correlations. Last but not least, the observed finding also demonstrates a positive and significant correlation between population and CO_2 emissions for developing countries. These effects might be appropriate given that a larger population may lead to higher claims because of people's fundamental needs and better financial mobility, which in turn may lead to increased energy consumption and environmental degradation. Table 6 contains the Hausman Test Statistic for the example nation. The P-value indicates that the fixed effect model is superior for the sample nation. We reject the null hypothesis, which reflects the consistency of the fixed effect model because the Hausman test statistic is extremely small. The greater the evidence indicating the null hypothesis should be rejected, the smaller the value.

V. Conclusion and Policy Recommendation

The findings of this investigation offer compelling proof of the existence of the EKC hypothesis in the context of developing economies. The nation's reliance on fossil fuels is replicated by the initial increase in pollution that follows the upward trend in economic expansion. We find that controlling the parameters that indicate the initial increase and subsequent decline in pollution levels, respectively, requires significant work in developing or undeveloped nations. We find that controlling the parameters that indicate the initial increase and subsequent decline in pollution levels, respectively, requires significant work in developing or undeveloped nations. Stricter environmental laws, more funding for green technologies, and public awareness campaigns to encourage sustainable practices are a few ideas for future initiatives. A balance between environmental sustainability and economic growth can be reached by addressing these crucial factors, which would ultimately support the Environmental Kuznets Curve concept. Finding the relationship between CO_2 and FDI among D-8 countries and determining whether or not the environmental Kuznets curve hypothesis is correct among D-8 countries are the main goals of this study. Carbon dioxide emissions have been used as the dependent variable in the current study. Using the population as the control variable and the GDP per capita, foreign direct investment, inflation, trade openness, and population growth as independent variables, the current study examined D-8 countries from 1999 to 2023. The FE and RE models were used for empirical analysis, and the Hausman test was used to choose the best-fitting model for the study. The Hausman test statistic indicates that the FE model is more appropriate for the given investigation. The following is obtained from the current studies: Initially, the results verified that the environmental Kuznets curve was experimentally supported in D-8 countries between 1999 and 2023; however, the results differ for the majority of D-8

countries. Carbon emissions and GDP per capita have a strong positive correlation, supporting the environmental Kuznets curve theory. At first, carbon emissions rise in tandem with GDP per capita. Additionally, the data indicate that the coefficient of square term of GDP per capita is notably negative for all D-8 countries, suggesting that a financial system emits less CO_2 after reaching an entrance level of GDP per capita. It might be cleaner construction technology and the use of environmentally friendly technology, which could lead to better construction with lower CO_2 emissions.

Second, there is a strong positive correlation between FDI and carbon emissions, supporting the pollution heaven hypothesis, which holds that developed countries transfer their obsolete technology to developing nations. Thirdly, the practical findings likewise demonstrate a positive and noteworthy relationship between population and CO_2 emissions for emerging countries. This result may be due to the fact that a larger population may result in a greater need for people's basic needs and better financial management, which ultimately leads to greater usage of electricity and the erosion of ecological superiority.

Lastly, there is a strong positive correlation between trade openness and carbon emissions. Open trade may make it easier for developing nations to affordably import carbon-efficient expertise.

A. Policy Implications

This paper explains how FDI and GDP per capita impact carbon dioxide emissions in developing countries and may assist policymakers in proposing policies to draw in higher-quality FDI. Policymakers can suggest investing funds in R&D projects that will advance the technology needed for effective essential mineral extraction, recycling, and substitution of raw materials. This can reduce supply chain vulnerabilities, stimulate innovation, and enhance the effectiveness of resource utilization. According to the current study, nations with strict policies and a limited framework for ecological values might anticipate more favorable ecological consequences from foreign direct investment than those without such frameworks.

In addition, adopting cleaner invention techniques and encouraging the industrial sector's tiny carbon revolution may improve the location of FDI in technical modernization and business transformation.

The policymakers in the energy-consuming economies should also improve the benefits of ICT and Prioritize smart infrastructure investments, such as efficient public transportation, smart energy grids, localized renewable energy, and digital connectivity. This includes funding for research and development of novel solutions to urban concerns. Policymakers in energy-consuming economies should progressively exploit ICT's promise for future energy conservation while addressing current energy availability and sustainability issues. These technologies have the potential to improve economic growth and energy poverty. Tailored policy measures may guarantee that the good effect of reduction of energy poverty benefits energy-consuming nations by acknowledging the inequalities in development and infrastructure.

Developing countries need to take a comprehensive and varied approach to achieve green economic growth. By utilizing renewable energy and promoting environmentally friendly transportation it is currently crucial to turn the transportation sector green and promote environmentally friendly transportation to lessen environmental effects and make the environment more environmentally friendly. This may be done by using renewable energy and encouraging environmentally friendly transportation.

In order to control growth and safeguard the environment, sustainable farming practices are necessary. Pakistan needs to take a comprehensive and varied approach to achieve green economic growth. Promotion of environmentally friendly Sustainable agricultural methods is required to manage expansion and protect the environment. As part of the CPEC Green Corridor Initiative, China has already been assisting Pakistan in modernizing its agriculture sector by promoting agricultural research, sharing advanced farming and irrigation system technologies, storage facilities, and market access to boost agricultural product growth and marketability. Agriculture is the lifeblood of low-income economies. This collaboration will eventually help to improve their economic situation and alleviate poverty.

In addition to fostering economic growth in Pakistan, more focus is required on the investment in renewable energy sources like wind and solar power as it lessens the country's dependency on fossil fuels, hence minimizing environmental damage and climate change.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Conceptualization, Methodology, and Formal analysis and investigation: Asma Arif, Umaima Arif, and Sania Shaheen; original draft writing review, Muhammad Danish Habib; Funding acquisition: Festus Victor Bekun, and Murat Ismet Haseki; all authors had approved the final version.

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