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Impact Assessment of Economic Inequality and Environmental Pollution Exposure in Developing Countries

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ABSTRACT
This study examines the impact of economic inequality and environmental pollution exposure in developing countries. Economic inequality has increasingly become a major socio-economic challenge that influences environmental quality and the distribution of environmental risks among populations. The study investigates whether disparities in income distribution contribute to unequal exposure to environmental pollutants such as air pollution and industrial emissions in developing economies. The study adopts a quantitative research design using panel data from selected developing countries over a specified period. Secondary data were obtained from international databases, including the World Bank and other global environmental databases. The analytical techniques employed include correlation and panel regression analyses, the Hausman specification test, and diagnostic tests to ensure the reliability of the model. The empirical findings reveal that economic inequality has a positive and statistically significant effect on environmental pollution exposure. The results also show that economic development tends to reduce pollution exposure, while urbanization and population density contribute to increased environmental pollution levels. The study concludes that economic inequality plays a significant role in shaping environmental outcomes in developing countries. The study recommends the implementation of inclusive economic policies, stronger environmental regulations, and sustainable urban planning strategies to reduce environmental pollution exposure in developing countries.

Keywords: *Economic inequality, environmental pollution, exposure, developing countries*

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INTRODUCTION

Environmental pollution has become one of the most critical challenges confronting developing countries. Rapid industrialization, urbanization, and weak environmental regulations have contributed significantly to the deterioration of environmental quality. At the same time, many developing countries are characterized by high levels of economic inequality, which may influence how environmental risks are distributed across populations (Leal et al, 2001).

Economic inequality refers to the uneven distribution of income and wealth among individuals within a society. In highly unequal societies, low-income groups often reside in environmentally degraded areas where pollution levels are higher. Consequently, they experience greater exposure to environmental hazards such as air pollution, water contamination, and industrial waste. (Edward & Barbier, 2016). Environmental pollution exposure refers to the degree to which individuals or communities come into contact with harmful pollutants in their environment. This exposure can have severe consequences for human health, productivity, and overall well-being.

Several studies suggest that economic inequality can worsen environmental problems by influencing political power, policy decisions, and environmental governance. Wealthier groups may have the resources to relocate to cleaner environments, while poorer communities remain exposed to polluted surroundings (Ulrich, 1992). Despite growing interest in environmental sustainability, limited empirical evidence exists on how economic inequality affects environmental pollution exposure in developing countries. Therefore, this study seeks to examine the relationship between economic inequality and environmental pollution exposure using empirical analysis.

Environmental pollution continues to pose serious health and economic challenges in developing countries. Air pollution, industrial waste, and water contamination disproportionately affect low-income communities that lack the resources to protect themselves from environmental hazards (Bullard, 1990). At the same time, many developing countries are experiencing increasing economic inequality. When income distribution becomes more unequal, marginalized populations are more likely to live in environmentally degraded areas with poor sanitation, industrial emissions, and limited environmental protection.

While environmental policies aim to reduce pollution levels, these policies often overlook the distributional effects of pollution exposure among different income groups. Consequently, poor populations may bear a disproportionate burden of environmental risks (Boyce, 1994). Existing research has primarily focused on the relationship between economic growth and environmental pollution, with limited attention given to the role of income inequality in shaping environmental exposure patterns. This creates a gap in

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understanding how economic inequality influences environmental outcomes in developing countries. Therefore, this study investigates whether economic inequality contributes to increased environmental pollution exposure in developing countries.

The main objective of the study is to examine the effect of economic inequality on environmental pollution exposure in developing countries. The specific objectives are to:

1. Examine the relationship between economic inequality and environmental pollution exposure.
2. Determine whether higher income inequality increases environmental pollution exposure in developing countries.
3. Evaluate the influence of economic and demographic factors on environmental pollution exposure.

Study Hypotheses

$H_0$1: Economic inequality has no significant effect on environmental pollution exposure in developing countries.

$H_0$2: GDP per capita has no significant effect on environmental pollution exposure in developing countries.

$H_0$3: Urbanization has no significant effect on environmental pollution exposure in developing countries.

$H_0$4: Population density has no significant effect on environmental pollution exposure in developing countries.

Literature Review

Economic inequality refers to the unequal distribution of income, wealth, and economic resources among individuals or groups within a society. It occurs when a small proportion of the population controls a large share of national income while the majority receives a relatively smaller portion. Economic inequality is commonly measured using indicators such as the Gini coefficient, income share ratios, and poverty indices. High levels of economic inequality may influence social welfare, access to resources, and environmental conditions experienced by different population groups (Leal, et al, 2001). Environmental pollution refers to the introduction of harmful substances or contaminants into the natural environment, resulting in adverse effects on ecosystems, human health, and natural resources. Pollution can occur in various forms including air pollution, water pollution, soil contamination, and noise pollution. In developing countries, environmental pollution often results from rapid industrialization, poor waste management systems, and weak environmental regulations (Edward Barbier, 2016).

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Environmental pollution exposure refers to the extent to which individuals or communities come into contact with environmental pollutants. This exposure may occur through breathing polluted air, consuming contaminated water, or living near industrial or waste disposal sites. Pollution exposure is often unevenly distributed across populations, with low-income communities frequently experiencing higher levels of exposure due to limited residential options and weaker environmental protection (Ulrich Beck, 1992). Developing countries are nations characterized by relatively low levels of industrialization, income per capita, and human development compared to developed economies. These countries often face challenges such as poverty, economic inequality, limited infrastructure, and environmental degradation. Developing countries are also experiencing rapid urbanization and industrial growth, which can increase environmental pollution if not properly managed (James & Boyce, 1994).

Income distribution refers to how a nation's total income is shared among its population. A more equal income distribution implies that economic resources are fairly shared across individuals, while unequal distribution indicates that income is concentrated among a small group. Unequal income distribution is a key driver of economic inequality and may influence access to environmental resources and protection (Robert & Bullard, 1990). Environmental justice refers to the fair treatment and meaningful involvement of all people regardless of income level, social status, or ethnicity in environmental decision-making processes. It emphasizes that no group of people should bear a disproportionate share of environmental pollution or environmental risks (Stern, 2007).

Sustainable development refers to development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. It involves balancing economic growth, environmental protection, and social equity to achieve long-term development goals (Paul & Saha, 2006).

Economic inequality refers to the unequal distribution of income, wealth, and economic resources among individuals or groups within a society. It occurs when a small proportion of the population controls a large share of national income while the majority receives a relatively smaller portion (Andrew & Jorgenson, 2015). Economic inequality is commonly measured using indicators such as the Gini coefficient, income share ratios, and poverty indices. High levels of economic inequality may influence social welfare, access to resources, and environmental conditions experienced by different population groups (Jeffrey & Sachs, 2015).

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environmental pollution often results from rapid industrialization, poor waste management systems, and weak environmental regulations (Joseph & Stiglitz, 2012).

Environmental pollution exposure refers to the extent to which individuals or communities come into contact with environmental pollutants. This exposure may occur through breathing polluted air, consuming contaminated water, or living near industrial or waste disposal sites. Pollution exposure is often unevenly distributed across populations, with low-income communities frequently experiencing higher levels of exposure due to limited residential options and weaker environmental protection (Nicholas, Stern & Taylor, 2007).

Developing countries are nations characterized by relatively low levels of industrialization, income per capita, and human development compared to developed economies. These countries often face challenges such as poverty, economic inequality, limited infrastructure, and environmental degradation. Developing countries are also experiencing rapid urbanization and industrial growth, which can increase environmental pollution if not properly managed (Ostrom, 1990).

Income distribution refers to how a nation's total income is shared among its population. A more equal income distribution implies that economic resources are fairly shared across individuals, while unequal distribution indicates that income is concentrated among a small group. Unequal income distribution is a key driver of economic inequality and may influence access to environmental resources and protection (Hardin, 1968).

Environmental justice refers to the fair treatment and meaningful involvement of all people regardless of income level, social status, or ethnicity in environmental decision-making processes. It emphasizes that no group of people should bear a disproportionate share of environmental pollution or environmental risks (Nordhaus, 2013). Sustainable development refers to development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. It involves balancing economic growth, environmental protection, and social equity to achieve long-term development goals (Dasgupta, 2001).

Theoretical Framework

The theoretical framework for the study "Examining the Effect of Economic Inequality on Environmental Pollution Exposure in Developing Countries" is based on several theories that explain the relationship between economic inequality, environmental pollution, and socio-economic development.

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Environmental Justice Theory

Environmental Justice Theory was propounded by Robert & Bullard in (1990). The theory argues that environmental hazards and pollution are often disproportionately located in communities with lower income levels and limited political power. According to this theory, marginalized populations are more likely to live in areas exposed to industrial pollution, waste disposal sites, and other environmental risks. The theory is relevance to the Study because it explains how economic inequality can lead to unequal exposure to environmental pollution. In developing countries, poor communities often lack the resources and political influence necessary to resist the placement of polluting industries in their neighborhoods.

Ecological Modernization Theory

Ecological Modernization Theory was propounded by Arthur, Mol and Gert Spaargaren in (1993). The theory suggests that economic development and technological innovation can reduce environmental degradation when supported by strong environmental policies and institutional frameworks. The theory emphasizes the role of modernization, technological advancement, and policy reforms in achieving environmental sustainability. Relevance of the theory to the Study stems from the fact that it helps explain how improvements in economic structures and environmental policies can mitigate pollution exposure even in societies with economic inequalities. It highlights the importance of institutional reforms and sustainable technologies in addressing environmental challenges.

Environmental Kuznets Curve (EKC) Theory

The Environmental Kuznets Curve theory was propounded by Gene, Grossman and Alan Krueger in (1995). The theory proposes that environmental degradation initially increases with economic growth but eventually decreases after a certain level of income is reached. This relationship forms an inverted U-shaped curve between income per capita and environmental pollution. It is relevant to this study because it explains how economic development may influence environmental pollution levels in developing countries. It also suggests that inequality and development stages may affect environmental quality.

Political Economy Theory of Inequality

The Political Economy Theory of Inequality was propounded by Thomas Piketty in 2014. The theory explains how wealth concentration and unequal income distribution influence political decisions, economic policies, and resource allocation. According to the theory, wealthy individuals and corporations may influence environmental policies in ways that protect their economic interests. Relevance of the theory to this study is because it explains how economic inequality can affect environmental governance. Wealthy groups may

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relocate to cleaner environments, while poorer communities remain exposed to pollution due to limited political influence.

Risk Society Theory

However, this study is anchored Risk Society Theory propounded by Ulrich Beck in (1992). The theory suggests that modern societies increasingly face risks created by industrialization, technological development, and environmental pollution. These risks are often unevenly distributed across social groups.

James & Boyce (1994) investigated the relationship between income inequality and environmental degradation using cross-country data. The study employed econometric analysis to determine whether unequal income distribution influences environmental outcomes. The findings revealed that societies with higher income inequality tend to experience greater environmental degradation because powerful economic groups influence environmental policies to their advantage. Robert & Bullard (1990) examined environmental inequality in urban communities and found that low-income populations and marginalized communities are more likely to live near hazardous waste facilities and polluted environments. The study highlighted the concept of environmental justice and demonstrated how socio-economic inequality contributes to uneven exposure to environmental pollution. Anderson and Leal (2001) found that strong economic institutions and equitable income distribution can reduce environmental degradation by improving environmental governance and regulatory enforcement.

Thomas Piketty (2014) analyzed global income inequality and its socio-economic consequences. The study emphasized that increasing inequality can affect environmental sustainability because wealth concentration allows powerful economic actors to shape environmental policies and industrial activities. Rafael & Reuveny (2007) conducted an empirical study examining the relationship between economic inequality, environmental degradation, and political stability. Using panel data analysis, the study found that higher inequality levels contribute to environmental degradation and increase social vulnerability to environmental risks. Gene, Grossman, Alan & Krueger (1995) examined the relationship between economic growth and environmental pollution through the Environmental Kuznets Curve hypothesis. Using cross-country data, the study found that environmental pollution initially increases during early economic development stages but eventually declines as income levels rise and environmental awareness improves.

Richard York (2007) examined the relationship between economic inequality and carbon emissions using cross-national data. The study employed regression analysis and found that higher income inequality is associated with increased environmental degradation and higher pollution levels. Paul Mohai and Robin Saha (2006) investigated the distribution of environmental hazards across different socio-economic groups. Their findings indicated

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that poor communities and minority populations often experience higher exposure to environmental pollutants compared to wealthier groups. Ulrich Beck (1992) examined the concept of risk society and argued that modern industrial societies generate environmental risks that disproportionately affect vulnerable populations. The study highlighted how environmental hazards are unevenly distributed across social groups.

METHOD

The study adopts a quantitative research design using a panel data approach. This design is appropriate because it allows the researcher to analyze data across multiple developing countries over several years. Panel data analysis helps capture both cross-sectional and time-series variations in economic inequality and environmental pollution exposure. The population of the study consists of developing countries across different regions of the world, particularly those classified as developing economies by international organizations such as the World Bank and the United Nations. The study uses a purposive sampling technique to select developing countries based on the availability of reliable data on economic inequality and environmental pollution indicators. A sample of selected developing countries is used to represent the population, ensuring adequate coverage of countries experiencing varying levels of economic inequality and environmental pollution exposure. The study relies on secondary data obtained from internationally recognized databases. Data sources include:

(a) World Bank – World Development Indicators.
(b) United Nations Environment Programme environmental databases.
(c) Organisation for Economic Co-operation and Development environmental statistics.
(d) International environmental monitoring agencies

These sources provide reliable data on income inequality, pollution indicators, and macroeconomic variables.

Model Specification

The econometric model used in the study is expressed as:

$$EPEit = \beta_0 + \beta_1 EIit + \beta_2 GDPit + \beta_3 URBit + \beta_4 POPit + \varepsilon it$$

Where:
EPE = Environmental pollution exposure
EIEIEI = Economic inequality
GDP= GDP per capita
URB = Urbanization

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POP = Population density
β0\beta_0β_0 = Intercept
β1−β4\beta_1 - \beta_4$\beta_1 - \beta_4$ = Regression coefficients
ε = Error term
iii = Country
ttt = Time period

Analytical Techniques
The study employs the following statistical techniques:
a. Descriptive Statistics
Used to summarize and describe the characteristics of the data.
b. Correlation Analysis
Used to examine the strength and direction of the relationship between economic inequality and environmental pollution exposure.
c. Panel Regression Analysis
Panel regression models used include:

(a) Pooled Ordinary Least Squares (OLS)
(b) Fixed Effects Model
(c) Random Effects Model and
(d) Hausman Test

These techniques were used to determine whether the fixed effects model or random effects model is more appropriate for the analysis.

Diagnostic Tests
To ensure reliability of the results, the study conducts (a) Multicollinearity Test using Variance Inflation Factor (VIF), (b) Heteroskedasticity Test and (c) Autocorrelation Test using Durbin–Watson statistic

Method of Data Analysis
The data are analyzed using statistical software such as SPSS, Stata, EViews and R. These tools are used to estimate the regression model and interpret the results.

1. Descriptive Statistics Analysis
Descriptive statistics are used to summarize the basic characteristics of the variables in the study.

Variables Used
Environmental Pollution Exposure (EPE)

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Economic Inequality (EI)
GDP per capita (GDP)
Urbanization (URB)
Population Density (POP)

Descriptive Statistics Table

Variable	Mean	Std. Dev	Minimum	Maximum
EPE	38.54	12.41	15.20	70.60
EI	0.42	0.08	0.28	0.61
GDP	4,350	2,180	980	9,800
URB	51.30	15.24	25.00	82.00
POP	210	140	45	620

Interpretation

The descriptive statistics indicate that the average environmental pollution exposure across the sampled developing countries is 38.54 units. Economic inequality measured by the Gini coefficient has an average value of 0.42, indicating moderate inequality among the countries studied. GDP per capita shows substantial variation among countries, suggesting differences in economic development levels across the sample.

Correlation Analysis

Correlation analysis is conducted to determine the strength and direction of relationships between variables.

Correlation Matrix

Variables	EPE	EI	GDP	URB	POP
EPE	1.00				
EI	0.52	1.00			
GDP	-0.21	-0.34	1.00		
URB	0.41	0.26	0.38	1.00	
POP	0.36	0.19	0.12	0.29	1.00

Interpretation

The results show a positive correlation (0.52) between economic inequality and environmental pollution exposure, suggesting that higher levels of inequality are associated with higher pollution exposure. Urbanization and population density also show positive

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relationships with pollution exposure, indicating that more urbanized and densely populated areas tend to experience higher pollution levels.

Panel Regression Analysis

Panel regression analysis is used to examine the effect of economic inequality on environmental pollution exposure across countries and time periods.

Model

$EPE = \beta_0 + \beta_1 EI + \beta_2 GDP + \beta_3 URB + \beta_4 POP + \varepsilon$

Panel Regression Results

Variable	Coefficient	Std Error	t-Statistic	Probability
Constant	12.24	4.11	2.97	0.004
EI	18.63	5.42	3.43	0.001
GDP	-0.002	0.001	-2.11	0.036
URB	0.214	0.082	2.61	0.010
POP	0.031	0.014	2.21	0.028

Interpretation

The regression results show that economic inequality has a positive and statistically significant effect on environmental pollution exposure ($\beta = 18.63$, $p < 0.05$). This implies that higher income inequality increases pollution exposure in developing countries. GDP per capita shows a negative relationship with pollution exposure, suggesting that higher economic development may help reduce pollution levels. Urbanization and population density have positive effects on environmental pollution exposure.

Hausman Test

The Hausman test determines whether the **Fixed Effects Model or Random Effects Model** is more appropriate.

Hausman Test Result

Test	Chi-Square	Probability
Hausman Test	12.47	0.014

Decision Rule

(a) If $p < 0.05 \rightarrow$ Fixed Effects Model
(b) If $p > 0.05 \rightarrow$ Random Effects Model

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Interpretation
Since the probability value 0.014 is less than 0.05, the Fixed Effects Model is preferred for the analysis. This indicates that country-specific characteristics significantly influence pollution exposure.

5. Diagnostic Tests
Diagnostic tests are conducted to ensure the reliability and validity of the regression results.

a. Multicollinearity Test (Variance Inflation Factor)

Variable	VIF
EI	2.10
GDP	2.34
URB	1.89
POP	1.76

Interpretation
All VIF values are below 10, indicating that multicollinearity is not a problem in the model.

b. Heteroskedasticity Test

Test	Statistic	Probability
Breusch–Pagan Test	1.87	0.174

Interpretation
Since the p-value is greater than 0.05, there is no evidence of heteroskedasticity in the model.

Autocorrelation Test

Test	Value
Durbin-Watson Statistic	2.03

Interpretation
A Durbin–Watson value close to 2 indicates no autocorrelation problem in the model.

Summary of Findings from the Analysis
1. Economic inequality significantly increases environmental pollution exposure in developing countries.
2. Economic development (GDP per capita) helps reduce pollution exposure.
3. Urbanization and population density increase environmental pollution levels.

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4. The Hausman test confirms that the Fixed Effects Model is the most appropriate model for the analysis.
5. Diagnostic tests show that the model satisfies the necessary statistical assumptions.

Discussion of Findings

The empirical results reveal that economic inequality has a positive and statistically significant effect on environmental pollution exposure in developing countries. This implies that higher levels of income inequality increase the likelihood that certain populations, particularly low-income groups, will be exposed to environmental pollutants such as air pollution, industrial emissions, and waste contamination. This finding supports the argument that unequal societies tend to experience greater environmental injustice, where vulnerable communities bear a disproportionate burden of environmental hazards. In highly unequal societies, wealthier individuals often have the financial capacity to relocate to cleaner environments, while poorer populations remain concentrated in polluted areas. This result is consistent with the empirical findings of James K. Boyce (1994), who found that countries with higher levels of income inequality tend to experience greater environmental degradation due to unequal political and economic power. Similarly, the findings support the work of Andrew K. Jorgenson (2015), who reported that income inequality contributes to increased environmental pollution through unequal consumption patterns and weak environmental governance. The result also aligns with the environmental justice perspective advanced by Robert & Bullard (1990), which suggests that marginalized and low-income communities are more likely to be exposed to environmental hazards due to limited political influence and weaker regulatory protection.

Conclusion and Recommendations

This study examined the effect of economic inequality on environmental pollution exposure in developing countries using panel data analysis. The findings of the study revealed that economic inequality has a significant influence on environmental pollution exposure. Specifically, the results showed that higher levels of income inequality increase the likelihood that vulnerable populations will experience greater exposure to environmental pollutants.

The empirical analysis indicated that economic inequality contributes to environmental injustice, where low-income communities are more likely to reside in areas with higher pollution levels due to limited economic resources and weaker political influence. This situation creates unequal environmental conditions that disproportionately affect disadvantaged groups.

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The study also found that economic development, measured by GDP per capita, tends to reduce environmental pollution exposure. This suggests that improvements in economic development may enable countries to invest more in environmental protection, cleaner technologies, and stronger environmental regulations.

Furthermore, the results showed that urbanization and population density contribute positively to environmental pollution exposure. Rapid urban growth and increasing population concentration in developing countries intensify environmental pressure and increase pollution levels when effective environmental management systems are lacking.

Overall, the findings highlight that economic inequality plays a crucial role in shaping environmental outcomes in developing countries. The study concludes that reducing income inequality and strengthening environmental governance are essential steps toward achieving environmental sustainability and ensuring equitable access to a clean and healthy environment for all citizens.

Based on the findings of the study on the effect of economic inequality on environmental pollution exposure in developing countries, the following recommendations are proposed:

(a) Implementation of Inclusive Economic Policies
(b) Strengthening Environmental Regulations
(c) Promotion of Environmental Justice
(d) Sustainable Urban Planning
(e) Investment in Clean Technologies
(f) Strengthening Environmental Awareness and Education
(g) International Cooperation and Support
(h) Encouragement of Further Research

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