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RESEARCH ARTICLE

Urbanization in a Globalized World: Reviewing Environmental Sustainability in Developing Countries

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Abstract

Climate change remains a critical issue worldwide, and balancing economic growth with sustainable development is of paramount importance. Our study explores the complex relationship between globalization, environmental sustainability, and urbanization in selected developing countries. By utilizing a simple panel regression technique and data from 40 developing countries from 1994 to 2018, the study examines how these factors influence environmental stability. We find that with a strong focus on environmental sustainability, economic growth can be enhanced. Additionally, we find that globalization, along with GDP per capita and access to electricity, significantly impacts environmental sustainability. Conversely, the effect of urbanization on environmental stability appears to be minimal.

Keywords

CO2 emission, Urban population, Economic globalization, GDP per capita, Access to electricity

JEL codes: Q56, O44, F64

Introduction

The rapid pace of globalization, urbanization, and environmental degradation has significantly impacted developing countries, altering their economic, social, and environmental landscapes (Fan et al. 2019). While globalization has increased trade and investment, it has also widened economic disparities, leading to social and political unrest. Urbanization has created new opportunities for economic growth and development, but it has also brought challenges such as overcrowding, pollution, and inadequate infrastructure. Environmental degradation threatens the livelihoods and well-being of millions (Yuan et al. 2018). Our study explores how these interconnected issues shape the development trajectory of developing countries.

The responsibility to conserve natural resources and protect the global ecosystem depends heavily on international cooperation and sustainable practices. The Sustainable Development Goals (SDGs), adopted by the United Nations in 2015, are closely linked to the pressing challenges of globalization, environmental sustainability, and urbanization in developing countries. The SDGs aim to eradicate poverty, promote sustainable development, and address climate change along with other environmental concerns. They emphasize the importance of inclusive and equitable growth that balances economic, social, and environmental dimensions. For instance, SDG-11 focuses on making cities and human settlements inclusive, safe, resilient, and sustainable, addressing many challenges associated with urbanization. Similarly, SDG-13 calls for urgent action to combat climate change and its impacts, while SDG-8 seeks to promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all. By addressing these issues through the SDGs, developing countries can build a more sustainable, resilient, and prosperous future (UN 2015). A clean and sustainable environment positively impacts public health and overall well-being (Azam et al. 2021).

The world is currently experiencing unprecedented rates of urbanization, with more than half of the global population now living in urban areas (figure 1). According to the United Nations, by 2050, the urban population is projected to increase by 2.5 billion people, reach-

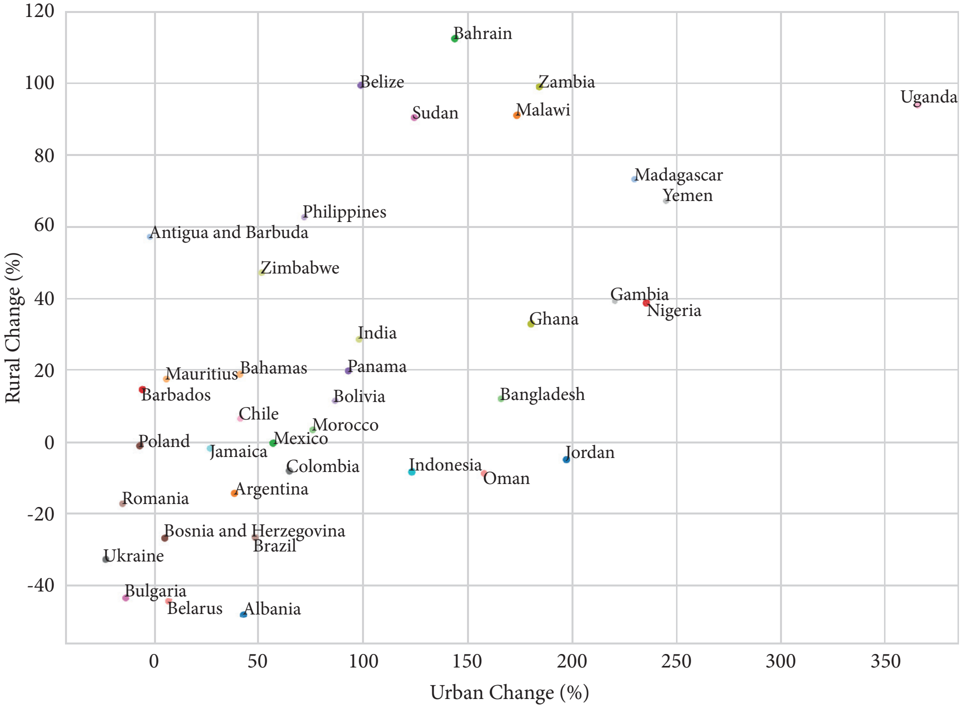

Figure 1. Percentage Change in Urban and Rural Populations (1995-2022). *Source:* Authors' Plot using data from WDI

ing 68% of the world's total population. This trend is particularly prevalent in developing countries, where population growth is high, and cities are expanding rapidly. For example, in Africa, the urban population is expected to triple by 2050, reaching 1.3 billion people. Similarly, in Asia, the urban population is projected to reach 2.7 billion by 2050, accounting for 56% of the continent's total population. Rapid urbanization poses significant challenges, including inadequate housing, infrastructure, and basic services such as water and sanitation. These issues often lead to overcrowding, pollution, and social inequality (Kuddus et al. 2020).

Urbanization is one of the most profound social transformations of modern times, driven by a variety of social, economic, and environmental factors. It is widely recognized as a key condition for development. As of 2022, the World Urban Forum reports that there are over 10,000 cities globally. People are increasingly migrating to cities in search of better opportunities and improved living standards, particularly in developing countries. According to the UN-Habitat World Cities Report 2022, it is estimated that between 2020 and 2070, the number of cities in low-income countries will increase by 76%, in higher-income and lower-middle-income countries by 20%, and in upper-middle-income countries by 6% (UN-Habitat 2022). Globally, urbanization surged by approximately 50% in the twenty-first century (Mohan & Dasgupta, 2004), with projections estimating that urban populations will reach 4.6 billion by 2030. In most countries, urbanization is typically accompanied by rapid economic expansion, population movement from rural areas to cities and towns, the agglomeration of tertiary and secondary industries in urban areas, as well as a rise in the number of towns and the continued expansion of urban areas.

The year 2010 marked a milestone in urbanization, as global urbanization surpassed 50% for the first time. While urbanization in developed countries continues to rise, developing countries are expected to experience the most significant surge. Countries in the Global South are urbanizing rapidly, with much of the future growth projected in Asia and Africa (Gu et al. 2021). This growth could have substantial implications for sustainable development. As metropolises expand and populations continue to grow, cities are increasingly becoming concentrations of poverty and inequality. This shift underscores the need for scholars to reconsider the relationship between globalization and urbanization within the framework of sustainability (Watson 2009; Hochstenbach & Musterd 2018).

The term "urbanization" can seem contradictory, as villages are typically associated with rural (non-urban) spaces. Scholars have used this phenomenon to explore the connections between urban and rural areas, challenge existing concepts of urban and rural, and question the notion of 'complete' urbanization (Roy 2016; Cowan 2018; Gururani 2023). However, the development and evolution of urban villages as an empirical phenomenon within the context of changing 'landscapes of accumulation' in rapidly urbanizing cities remains undertheorized. Over the past two decades, developing economies have undergone a dramatic transformation due to urbanization and globalization, with growth occurring at a faster pace in developing countries compared to developed ones (Sadorsky 2014; Salahuddin et al. 2019). In this environment, every developing country is striving to become more urbanized and globalized in order to compete on the global stage.

Globalization has accelerated significantly in recent decades, driven by advancements in technology, communication, and transportation. The volume of global trade has increased more than tenfold since 1970, reaching K19.48 trillion in 2019, according to the World Trade Organization. Meanwhile, foreign direct investment (FDI) has also surged, with total FDI inflows reaching K1.54 trillion in 2020, despite the impact of the COVID-19 pandemic. Globalization has also led to increased migration and cultural exchange, shaping the economic and social landscapes of countries worldwide. However, the benefits of globalization have not been distributed equally, leading to widening economic disparities both within and among countries. Additionally, globalization has given rise to new challenges, including environmental degradation and the erosion of social and cultural values (WTO 2020).

Both globalization and urbanization have adverse impacts on environmental sustainability. Since the 1960s, the negative ecological and environmental consequences of urbanization have been a central focus of global economic and social development. Urbanization and globalization influence not only economic growth, population health, education, and socialization, but also have significant implications for environmental protection, remediation, and natural resource exploitation. It is widely recognized that long-term economic development cannot be sustained without a continuous supply of inputs such as energy. Consequently, global energy demand has surged (Dellink et al. 2017; Adebayo & Kirikkaleli 2021).

In the Chinese context, scholars conceptualize globalized urbanization as a "special phenomenon emerging in China's political and economic transition" (Liu et al. 2010). Urbanization in China is characterized by unregulated assets and transitional neighborhoods that are under threat from state regulation. Studies in the Chinese context particularly emphasize the informality of inter-globalization in urban villages (Wu 2016). Similarly, in India, scholars examine the movement of migrant labor into urban villages (Cowan 2015) and focus on the role of pre-existing regimes of land and property in creating new forms of differentiation and fragmentation (Cowan 2018; Gururani 2023). Additionally, they explore the state of service and infrastructural provision in these settlements (Kumar 2015).

Both urbanization and globalization contribute to increased energy consumption in the economy. In the past, transitions between different environmental conditions occurred more gradually and over longer periods compared to today. Growing concerns about the quality of rapidly expanding urban environments, long-term predictions regarding the global environment, the cost and security of energy supplies, and the environmental impact of energy production have heightened interest in understanding energy demand behavior and its environmental costs (Abbass et al. 2022). The expansion of global trade, the acceleration of capital flows across nations, and the rise in industrial energy use have all played a role in the globalization of environmental concerns.

Urbanization is driving more people into cities, increasing the demand for energy, water, and other natural resources, which are supplied through both natural and artificial means. This rapid urbanization can lead to various problems, such as the creation of slums and the reduction of agricultural land. Slums often develop along roadways due to urban expansion (Ray 2017), and they can exacerbate environmental degradation. Additionally, as residential areas expand, agricultural lands are being converted for urban use, which can negatively impact agricultural output in developing countries that heavily rely on agriculture. Many developing countries have experienced urban sprawl, with private developers acquiring green lands for new projects. For instance, Lahore, Pakistan's second-largest city by population, has seen its eastern and southwestern peripheries transformed into gated communities with residential developments.

Previous literature has emphasized the significant impact of globalization and urbanization on economic development but often overlooks their environmental consequences. Environmental degradation has become a pressing issue due to the expansion of new cities to accommodate growing urban populations and meet production demands. Both urbanization and globalization place pressure on the consumption and production sectors, respectively.

Additionally, increased electricity usage driven by these trends further strains environmental sustainability. Urbanization leads to the proliferation of slums, which contributes to greater pollution, water contamination, and deteriorating air quality. This study explores the impact of globalization and urbanization on environmental sustainability, seeking viable solutions. It examines the relationship between a sustainable environment, globalization, and urbanization in developing countries from 1994 to 2018.

Review of the Literature

Since the early 1990s, concerns about environmental quality have intensified, prompting increased efforts to explore the relationship between the environment, urbanization, and globalization. This has led to a substantial body of research examining both theoretical and empirical links. For example, Al-Mulali et al. (2015) investigated how economic growth, urbanization, trade openness, economic development, and renewable energy affect pollution in Europe. Their findings indicate that GDP growth, urbanization, and economic development contribute to higher CO2 emissions in the long run, while trade openness reduces CO2 emissions. Similarly, Rafiq et al. (2016) examined the interplay between urbanization, trade openness, CO2 emissions, and energy intensity. They found that both CO2 emissions and energy intensity increase with population density and affluence. Increasing trade openness has a negative impact on pollution, whereas decreasing trade openness has a positive effect. Furthermore, Caglayan Akay and Oskonbaeva (2021) found that negative trade shocks have a more significant impact on environmental quality in the long run compared to the positive effects of trade openness.

Li and Haneklaus (2021) explored the relationship between GDP, trade openness, clean energy consumption, urbanization, and CO2 emissions. Their findings reveal the presence of the environmental Kuznets curve (EKC) in the long run among G7 economies, indicating that CO2 emissions initially increase with economic growth but eventually decrease as economies develop. Additionally, their study found that increased clean energy consumption leads to a reduction in CO2 emissions. Conversely, Li et al. (2022) discovered that in E7 countries, energy consumption and urbanization are significant contributors to CO2 emissions. Foreign Direct Investment (FDI) helps mitigate CO2 emissions, while economic and population growth contribute to higher CO2 emissions. Their research also indicates a complex relationship where increased energy consumption and environmental degradation drive economic growth, and greater energy consumption exacerbates environmental degradation. In the short term, energy consumption, urbanization, and trade promote economic growth, whereas industrialization and urbanization drive increased energy consumption (Kahouli et al. 2022).

Rehman et al. (2021) found that globalization, energy use, trade, and GDP growth positively impact ecological footprints in the long run. Conversely, fuel importation has an adverse impact on the ecological footprint in Pakistan. Similarly, Rehman and Rehman (2022) analyzed the effects of urbanization, energy consumption, economic development, and population growth on CO2 emissions, using data from 2001 to 2014 for five of the most populous Asian countries: China, India, Indonesia, Pakistan, and Bangladesh. Their results indicated that India is a major contributor to CO2 emissions due to population growth and economic development. In contrast, China and Pakistan also contribute to CO_2 emissions through energy consumption and urbanization. Using the gray technique, the study found a direct causal relationship between CO_2 emissions and the unsustainable growth of the population, leading to environmental damage.

The existing literature on the relationship between the environment, urbanization, and globalization often remains unclear, as many studies focus on a limited number of countries and influencing factors. This study aims to clarify this nexus by examining the interactions among the environment, globalization, and urbanization, along with other variables such as gross domestic product per capita (GDPPC) and energy poverty in developing countries. Using panel data from 1994 to 2018 for 40 developing nations, this study differentiates itself from previous research, which frequently emphasizes the industrial sector, globalization, and renewable energy in relation to energy consumption. Instead, our study explores the combined effects of economic globalization, energy poverty, urbanization, and GDPPC on environmental sustainability.

Methodology & Econometric Model

CO_2 emissions are a key environmental indicator due to their widespread availability and use in global environmental evaluations. Their relevance stems from their critical role in environmental sustainability, particularly concerning climate change and global warming. This makes CO_2 emissions essential for assessing the environmental impacts of variables such as globalization and urbanization. Additionally, the standardized nature of CO_2 emissions as a metric facilitates comparison across different countries, reinforcing its status as a widely recognized indicator of environmental impact. This focus on CO_2 emissions aligns with the global imperative to combat climate change by reducing greenhouse gas emissions.

In current research, CO_2 emissions are commonly used as a proxy for environmental sustainability, consistent with numerous previous studies (Poumanyvong & Kaneko 2010; Zhang & Lin 2012; Sadorsky 2014; Bano et al. 2018; Yao et al. 2020; Huang et al. 2021; Khan et al. 2022; Safi et al. 2022). In light of theoretical literature and empirical studies, CO_2 emissions (measured in metric tons per capita) are used as the dependent variable. Independent variables include urban population (% of total population), access to electricity (% of population), GDP per capita (constant 2015 USK), and economic globalization, as measured by the KOF index 2021.

While most literature considers economic indicators as proxies for globalization, our study employs the latest version of the KOF index 2021, focusing specifically on the general index of economic globalization[1].

The functional form of the model is written as follows:

$$\ln CO2t = \ln GLOt + \ln URBt + \ln GDPPCt + \ln ENPOVt + \varepsilon t$$

The countries included in the study were selected based on the IMF definition, which considers criteria such as population, GDP per capita, the Human Development Index (HDI), and the Human Asset Index (HAI). We utilized a panel data set covering the period from 1994 to 2018. Data were collected from the World Development Indicators, based on the availability of information for the selected countries (table 1).

1 By the time, the article was written KOF data for 2022-23 was not available.

Table 1. Description of the Variables

Variable		Definition	Source
CO_2 emissions	CO2	Carbon dioxide (CO_2) emissions are primarily produced from the use of fossil fuels and the production of cement. They include CO_2 released from the combustion of solid, liquid, and gas fuels, as well as from the flaring of gas.	WDI
Urban population	URB	The term "urban population" refers to individuals living in cities, as defined by national statistical agencies. The percentage of urban population represents the proportion of people residing in urban areas out of the total population, expressed per 100 people.	WDI
Access to electricity	ENPOV	Access to electricity refers to the percentage of the population with reliable electricity service. Ensuring that a majority of the global population has access to electricity is a key objective of the sustainable development goals.	WDI
GDP per capita	GDPPC	GDP represents the total value of goods and services produced within an economy. It is calculated by summing the gross value added by all resident producers, adding product taxes, and subtracting subsidies that are not included in the final value of products.	WDI
Economic Globalization	GLO	Economic globalization refers to the growing integration and interdependence of national economies across the globe. It encompasses the expansion of international trade, the cross-border movement of capital and labor, and the rise of multinational corporations that operate in multiple countries.	WDI

Source: compiled by the authors

In previous research, panel estimations have been employed using various techniques. Khalid et al. (2021), Sikder et al. (2022), and Shekhawat et al. (2022) utilized techniques such as the Autoregressive Distributed Lag (ARDL) model to examine both long-run and short-run relationships among variables, as well as cointegration techniques and simple panel models like Pooled OLS, Fixed Effects, and Random Effects. Similarly, this study uses a straightforward panel regression approach to investigate the relationship between globalization, environmental sustainability, and urbanization in developing countries.

There are three primary types of regression models used in panel data analysis: Pooled OLS, Fixed Effects, and Random Effects. Pooled OLS is the simplest model, treating each observation as independent and disregarding both the panel and time dimensions. Fixed Effects models account for individual-specific variations by controlling for omitted variables that are constant over time but vary across units. This model is effective in managing unobserved heterogeneity or fixed effects, and it provides consistent results even in the presence of correlations between regressors. Random Effects models, also known as variance components models, treat the unobserved effects as random variables drawn from a distribution. This approach is suitable when cross-sectional units are randomly selected from a larger population. The random effects model accounts for the impact of the error term on the regression results (The Econometrics… 2024).

Three panel data models are employed and evaluated for their suitability based on diagnostic tests. Various diagnostic tests, including the Variance Inflation Factor (VIF) test for multicollinearity and White's test for heteroskedasticity, are utilized to ensure model accuracy.

Descriptive statistics for all variables are summarized in table 2. Notably, there is a significant discrepancy between the natural logarithm of GDP per capita (lnGDPPC) and the natural logarithm of energy poverty (lnENPOV) in terms of their mean, standard deviation, and range. The descriptive statistics reveal variations among other variables as well, evident from their standard deviations and mean values. For instance, the natural logarithm of energy poverty (lnENPOV) ranges from a minimum value of -0.6275 to a maximum value of 4.6052.

Table 2. Descriptive Statistics

Variables	lnCO2	lnURB	lnGLO	lnGDPPC	lnENPOV
Mean	.5636312	3.909117	3.8429	8.214774	4.202559
Std. Dev.	1.442581	.4494669	.3244808	1.178463	.6987737
Minimum	-3.300066	2.524528	2.772589	5.472911	-.6275495
Maximum	3.229739	4.520375	4.430817	10.50608	4.60517
Observations N = 1000 n=40 T= 25					

Source: Authors' calculations

Table 3 indicates that the p-values for all independent variables are less than 0.05, suggesting that these variables have a significant impact on the dependent variable, lnCO2. The R-squared value of 0.8739 shows that the model explains 87% of the variation in the dependent variable. Additionally, the F-statistic confirms that the model is a good fit. However, it is important to note that while the Pooled OLS model provides an ideal fit under these conditions, it assumes no differences among countries and that the error term is uncorrelated. These assumptions could lead to biased and inconsistent results. Therefore, we have also checked the normality of the data and performed diagnostic tests for multicollinearity and heteroskedasticity to ensure robustness[2].

The results of both the Fixed Effects and Random Effects models show that all independent variables have p-values less than 0.05, indicating a significant impact on the dependent variable, lnCO2. The R-squared value for the Fixed Effects model is 0.8492, meaning that the model explains 84.92% of the variation in the dependent variable. Similarly, the R-squared value for the Random Effects model is 0.8437, indicating that this model explains 84.37% of the variation, which is very close to the Fixed Effects model. Additionally, the F-statistics for both models suggest that they are a good fit. To determine which model is more appropriate for further analysis, we perform the Hausman test to choose between the Fixed Effects and Random Effects models.

In the Fixed Effects model, we encountered issues of autocorrelation, cross-sectional dependency, and heteroscedasticity in our panel data. To address these problems and obtain unbiased and consistent results, we conducted a robustness check using the Newey-West Standard Errors technique. This method is well-suited for macro panel data estimation

2 Results of diagnostic tests are available in the Appendix (tables A1-A6).

as it provides robust results by correcting for heteroscedasticity and autocorrelation, often referred to as robust standard errors or heteroscedasticity and autocorrelation corrected (HAC) standard errors. We determined the number of lags for the Newey-West Standard Errors based on the Stock and Watson thumb rule. The robust results obtained using this technique are presented in the following tables.

Table 3. Pooled OLS, Fixed-Effect Model & Random Effect Model

Variables	Pooled OLS		Fixed Effects		Random Effects	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
lnURB	.2306164	.0564474	.2126472	.1144474	.3210045	.1063725
lnGLO	.784701	.0556163	.1625839	.0451857	.1216414	.0446155
lnGDPPC	.646841	.0216122	.507021	.0348946	.5640785	.0332077
lnENPOV	.6479092	.0402066	.1795215	.0375212	.1818268	.0372085
Cons	11.38993	.2151323	5.811938	.3285674	6.556584	.3109084

Source: Authors' calculations

Table 4. Adjusted Fixed-Effect Model

Variables	Coefficient	t-statistics	p-value
lnURB	.2306164 (.0789273)***	2.92	0.004
lnGLO	.784701 (.087481)***	8.97	0.000
lnGDPPC	.646841 (.0377636)***	17.13	0.000
lnENPOV	.6479092 (.0770924)***	8.40	0.000
Const	-11.38993 (.0789273)***	-32.40	0.000

Source: Authors' calculations

*** Newey-West Standard Error

Table 4 presents the robust results using Newey-West standard errors, where the t-statistics have been corrected and the probability values are reliable. The results reveal a significant and positive relationship between urbanization and CO2 emissions, indicating that increased urbanization adversely impacts environmental sustainability in developing countries. Similarly, the analysis of the economic globalization KOF index shows a significant and positive relationship with CO2 emissions. This suggests that an increase in the economic aspect of globalization is associated with higher CO2 emissions, further exacerbating the negative effects on environmental sustainability.

A 1% increase in the economic globalization index (lnGLO) is associated with a 0.78% increase in CO2 emissions. In developing countries, both urbanization and globalization contribute to increased energy consumption, which exacerbates energy poverty. This is due to the growth in residential areas, public utility services, and industrial expansion. In our model, access to electricity (as a percentage of the population) is used as a proxy for energy poverty. The results indicate that increased access to electricity is significantly and positively related to CO2 emissions, suggesting that as more people gain access to electricity, CO2 emissions also rise, impacting environmental sustainability. Similarly, economic growth, represented by GDP per capita (GDPPC), shows a significant and positive relationship with CO2 emissions. An increase in GDPPC leads to higher CO2 emissions, which negatively affects environmental sustainability. These findings align with previous studies, including those by (Salahuddin et al. 2019; Shekhawat et al. 2022; Sikder et al. 2022).

We employed the Granger causality test (1969) to investigate the extent to which each variable can predict the others. Table 5 indicates a unidirectional causality running from CO2 emissions to economic globalization (GLO). This means that CO2 emissions Granger-cause economic globalization, but economic globalization does not Granger-cause CO2 emissions. Therefore, efforts to control CO2 emissions could influence economic globalization, which, in our case, affects the trade sector. Similarly, the test reveals unidirectional causality from GDP per capita (GDPPC) to both economic globalization (GLO) and urbanization (URB). This indicates that GDP per capita Granger-causes both economic globalization and urbanization, but the reverse is not true.

Table 5. Granger Causality test

Variables	z- stats	P-value	Null hypothesis
lnCO2 to lnGLO	1.98	0.048	rejected
lnCO2 to lnURB	-9.38	0.000	rejected
lnCO2 to lnGDPPC	-2.63	0.009	rejected
lnCO2 to lnENPOV	0.46	0.644	accepted
lnURB to lnCO2	2.68	0.007	rejected
lnURB to lnGLO	9.69	0.000	rejected
lnURB to lnGDPPC	11.74	0.000	rejected
lnURB to lnENPOV	4.38	0.000	rejected
lnGLO to lnCO2	0.52	0.601	accepted
lnGLO to lnURB	-2.46	0.014	rejected
lnGLO to lnGDPPC	1.86	0.064	accepted
lnGLO to lnENPOV	4.02	0.000	rejected
lnGDPPC to lnCO2	-4.29	0.000	rejected
lnGDPPC to lnURB	-0.99	0.324	accepted
lnGDPPC to lnGLO	3.66	0.000	rejected
lnGDPPC to lnENPOV	-1.25	0.209	accepted

Source: Authors' calculations

The results indicate that there is no Granger causality between GDP per capita (GDP-PC) and urbanization (URB). This suggests that changes in economic development do not impact urbanization, as the urbanization rate continues to increase annually regardless of economic development. Conversely, urbanization (URB) Granger-causes GDP per capita (GDPPC), meaning that changes in urbanization have an effect on economic development.

Similarly, GDP per capita (GDPPC) Granger-causes economic globalization (GLO), indicating that changes in economic development influence globalization. However, economic globalization (GLO) does not Granger-cause GDPPC. This lack of causality might be due to our study's focus on globalization primarily within the trade sector, which impacts economic growth but may not directly reflect overall economic development.

On the other hand, the results reveal a bidirectional causality between CO2 emissions and both urbanization (URB) and GDP per capita (GDPPC). Specifically, CO2 emissions Granger-cause both URB and GDPPC, indicating that efforts to control CO2 emissions will affect urbanization and economic development. Conversely, changes in URB and GDPPC will also impact CO2 emissions. Additionally, there is bidirectional causality between economic globalization (GLO) and urbanization (URB). This means that changes in GLO will influence URB, and changes in URB will, in turn, affect GLO. Lastly, CO2 emissions and GDPPC do not Granger-cause energy poverty (ENPOV). Therefore, changes in CO2 emissions or GDPPC will not directly affect energy poverty. However, both URB and GLO Granger-cause ENPOV, suggesting that changes in urbanization and globalization will impact energy poverty.

Conclusion

Environmental sustainability is a critical global issue that affects both current and future generations. This study investigates the complex relationships between globalization, urbanization, and environmental sustainability in developing countries. By employing panel regression models, including pooled OLS, fixed effects, and random effects, the study thoroughly examines these connections. The robustness of the results is confirmed through a series of diagnostic tests.

Our empirical findings reveal that globalization has a significant and positive impact on environmental sustainability, followed by electricity consumption and income per capita. In contrast, urbanization does not show a significant effect on environmental sustainability in the developing countries examined. The high levels of carbon emissions, largely due to traditional fuel and energy production methods, contribute substantially to environmental degradation.

Given the increasing environmental concerns affecting both current well-being and future prospects, this research underscores the importance of well-crafted economic strategies. By examining the interactions among globalization, environmental sustainability, and urban growth in developing countries, the study suggests that prioritizing and promoting sustainable policies is essential. Additionally, raising public awareness about environmental care and improving environmental quality should be a key focus.

Developing countries should take necessary measures to control the excessive emission of CO2 during the process of urbanization and globalization by adopting the right set of policies. Basic living necessities such as clean water, electricity, and gas should be provided. Improving facilities in rural areas can help reduce the extent of migration towards urban areas, which, in turn, can help reduce CO2 emissions. It is important to reduce the use of fossil fuels, coal, and oil and replace them with renewable resources such as solar and wind energy. As globalization drives industrialization, adopting environmentally friendly production practices will be crucial for achieving sustainable economic growth. By embracing these strategies, developing countries can advance towards a more sustainable and resilient future.

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Appendix

Table A1. VIF test results

Variable	VIF	1/VIF
lnENPOV	2.99	0.334051
lnURB	2.44	0.409636
lnGLO	1.24	0.809654
lnGDPPC	2.46	0.406493
Mean VIF	2.28	

Source: authors' calculations

Table A2. White test results

Test	Chi2-Value	P-value
White's test	201.44	0.0000

Source: authors' calculations

Table A3. Hausman test results

Chi-Square Statistics	P-value	Test Summary
58.74	0.0000	Fixed Effect

Source: authors' calculations

Table A4. Free's test results

Test	Critical values from Frees' Q distribution			Test summary
Frees test for cross-sectional dependency	alpha = 0.10	alpha = 0.05	alpha = 0.01	All the three values are greater than the alpha critical values
	0.1035	0.1350	0.1947	
Frees' test of cross-sectional independence = 9.469				
Average absolute value of the off-diagonal elements = 0.461				

Source: authors' calculations

Table A5. Wald test results

Test	Chi2-value	P-value	Test Summary
Wald test for group-wise Heteroscedasticity	38663.16	0.0000	Data is Heteroscedastic

Source: authors' calculations

Table A6. Autocorrelation test results

Test	F-value	P-value	Test Summary
Wooldridge test for autocorrelation	9.411	0.0039	First order autocorrelation exists

Source: authors' calculations

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