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THE MEDIATING ROLE OF ENERGY USE IN THE EFFECTS OF RENEWABLE ENERGY, URBANIZATION, INDUSTRIALIZATION AND ECONOMIC GROWTH ON CO_2 EMISSIONS IN DEVELOPING ASIAN COUNTRIES.

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Abstract

This study presents the dynamic impact of renewable energy consumption, urbanization, industrialization and economic growth on CO_2 emissions in developing Asian countries. This research examines energy use as a mediating factor by employing a balanced panel model across eight developing Asian countries Pakistan, India, Bangladesh, Indonesia, Sri Lanka, Vietnam, Kyrgyzstan and the Philippines over the period 2000-2024. These analysis data collection on World Development Indicators WDI database and engagement panel regression methods under a pooled least squares framework. The empirical results are demonstrats that renewable energy use, urbanization, industrialization and GDP use statistically significant effects on CO_2 emissions and the aggregate energy use increase as a strong and significant mediator linking these drivers to environmental results. The positive relationship between renewable energy use and CO_2 emissions (H1, FEM: $F = 178.1879$, $p < 0.0001$) reveals that current renewable penetration has not yet displaced fossil fuel consumptions, especially in fast urbanizing and industrializing economies. The result is further confirmed by the significant mediating role of energy use (H2). These findings underscore the need for policies that not only expand renewable capacity but also fast-track fossil fuel movement and improve energy efficiency. The study highlights the importance of sectoral and source specific energy evolutions to achieve effective decoupling of economic growth from carbon emissions in developing Asia.

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INTRODUCTION

Climate change has emerged as one of the most critical global challenges of the modern era, driven predominantly by anthropogenic activities, including the combustion of fossil fuels, deforestation and rapid unplanned industrialization, which collectively accelerate the accumulation of greenhouse gases in the atmosphere (Raihan et al., 2022). These gases, carbon dioxide (CO_2) is the most leading and its continuous rise is using severe pressure on ecosystems, economies and human welfare is often faster than earlier predictions suggested by (Raihan & Said, 2022). The global community has gradually focused on improving environmental quality and falling CO_2 emissions, as reflected in the United Nations Sustainable Development Goals SDGs, exclusively Goals are 7, 8, 9 and 13 and which stress on clean and affordable energy and comprehensive economic growth, sustainable industrialization and urgent climate action (Xue et al., 2021).

This global environmental crisis is mainly severe in developing Asian countries, where the rapid industrialization, high population growth and hurrying in urbanization have increased energy demand and environmental degradation (Xing et al., 2023). The countries such as Pakistan, India, Bangladesh, Indonesia, Sri Lanka, Vietnam, Kyrgyzstan and Philippines are suffering as strong economic growth, but this growth remains heavily dependent on fossil fuels and energy concentrated production, leading to increasing CO_2 emissions and failing environmental quality (Yoshikawa & Anbumozhi, 2022). The empirical evidence demonstrations that energy consumption and also economic activity are crucial drivers of emissions in emerging Asian economies and the evolution towards renewable energy, although capable isn't yet achieved a structural decoupling of growth from the environmental degradation (Sandi et al., 2025). This compression between the development goals and also environmental sustainability makes a serious policy problem for these countries (Luthfiana, 2025).

The significant frames of research has studied the elements of CO_2 emissions and often converging on the roles of economic growth, energy consumption, urbanization and industrialization (Voumik et al., 2023). The Empirical evidence consistently demonstrates that industrial expansion, rapid urbanization and sustained economic growth are significant drivers of rising energy demand and CO_2 emissions, particularly in developing countries (Wulandari & Hayati, 2020). The urbanization in Asian economies has been connected to higher energy consumption through for expanded housing, transport needs and infrastructure development also together increase fossil fuel use and emissions (Hashmi et al., 2021). The Industrialization remains a central engine of growth but needs to substantial energy inputs, mainly from coal, oil and natural gas, thereby strengthening carbon-intensive development pathways (Wicaksono et al., 2026). The previous studies on ASEAN and BRICS plus nations further highlights that institutional quality, green growth policies and structural revolution shape how economies achieve the trade-off between growth and sustainability (Wulandari & Hayati, 2020).

Substantial reseach indicates that rapid urbanization, economic growth and industrialization drive rising carbon emissions, with evidence indicating that industrial value-added exerts non-linear effects depending on industrial intensity thresholds (Abbas et al., 2023). Moreover, empirical findings on renewable energy remain mixed; while some studies show it decreases emissions, others suggest that in developing economies, renewables primarily satisfy additional energy demand rather than substituting fossil fuels (Tran et al., 2024). Despite these insights, the critical gaps endure as existing research predominantly treats energy use as a standard control variable rather than the central mediating mechanism through which structural development translates into environmental pressure (Saleh & Bejaoui, 2024). Additionally, prior literature frequently relies on single-country analyses and lacks integrated, STIRPAT based frameworks applied to rapidly transforming regions (Du et al., 2018). To address these theoretical and regional limitations, this study provides comparative panel evidence for eight developing Asian countries (Pakistan, India, Bangladesh, Sri Lanka, Indonesia, Vietnam, the Philippines and Kyrgyzstan). The theoretical novelty lies in positioning energy use as an explicit mediator, shifting the paradigm to analyze renewable energy not as an isolated element, but as deeply integrated within urbanization and industrialization pathways. Practically, this research moves beyond idealized models to offer data-driven insights, guiding policymakers and urban planners in these diverse economies on optimizing energy demand and mitigating ecological degradation during periods of intense structural transformation (Stylianou et al., 2025).

These studies are suggests a panel data analysis of eight developing Asian countries Pakistan, India, Bangladesh, Indonesia, Sri Lanka, Vietnam, Kyrgyzstan and the Philippines over the period 2000-2024, using the data drawn from the World Development Indicators (WDI) (Kidd et al., 2022). The STIRPAT framework presents the study of explicitly models energy use as a mediating variable connecting with renewable energy consumption, urbanization, industrialization and economic growth on CO_2 emissions (Hasan et al., 2025). The Analysis of direct effects of renewable energy, urbanization, industrialization, economic growth and total energy use on CO_2 emissions and the test whether energy use as mediates the relations between these key drivers and emissions. These objectives of this research pursues to determine whether current designs of renewable energy deployment and structural transformation in developing Asia are reliable with sincere decarbonization or whether they primarily sustain increasing fossil created energy demand (Nordin et al., 2024).

This study offers numerous contribution and theoretically its enriches of the application of the STIRPAT model by participating a mediation structure that places energy use at the middle of the growth emissions connection in developing Asian countries (Wulandari & Hayati, 2020). The Empirical study, provides a updated a multi country evidence that extents pre and post pandemic years and taking how shocks such as COVID-19 have temporarily transformed energy use and emission outlines (Latif et al., 2020). A policy outlook and these discoveries can guides the governments and regional institutions in designing more effective policies for scaling renewable energy and attractive energy efficiency and dealing with urbanization and industrialization in ways that diminish CO_2 emissions while sustaining also economic growth (Claire & Widyawati, 2023).

METHODS

Data and Variable Description

This study examines the relationship between renewable energy use, urbanization, industrialization, GDP, energy use and CO_2 emissions in developing Asian countries. The study uses annual panel data from 2000 to 2024. The selected countries are Pakistan, India, Bangladesh, Indonesia, Sri Lanka, Vietnam, Kyrgyzstan and the Philippines. These countries were selected because they represent developing Asian economies with growing energy demand, urban expansion, industrial transformation and environmental pressure.

Table 1. Data Collection

Code	Variables	Measurement Unit	Source
		Dependent Variables	
CO_2	CO2 emission	Kilo tons	WDI
		Independent Variables	
REU	Renewable energy use	% Of the overall amount of energy used	WDI
UR	Urbanization	Percentage of urban population	WDI
IND	Industrialization	Value Added (Annual Percentage Growth)	WDI
GDP	Gross Domestic Product	Constant LCU	WDI
		Mediator Variable	
EU	Energy Use	Per Capita Energy Use.	WDI

Data Analysis Method

The data were collected from the World Development Indicators database of the World Bank Indicator and CO_2 emissions are used as the dependent variable. Renewable energy use, urbanization, industrialization and GDP are used as independent variables. Energy use is used as the mediating variable, CO_2 emissions are measured in kilotons. Renewable energy use is measured as the percentage of renewable energy in total energy use. Urbanization is measured as the percentage of the urban population. Industrialization is measured by industry value added annual percentage growth. GDP is measured in constant local currency units. Energy use is measured as per capita energy use. CO_2 emissions, GDP and energy use are transformed into natural logarithms. This transformation reduces scale differences among variables. It also helps interpret the estimated coefficients more consistently. Renewable energy use, urbanization and industrialization are kept in their original form because they are measured in percentage terms.

$$\ln CO2it = \alpha 0 + \beta 1REUit + \beta 2URBit + \beta 3INDit + \beta 4\ln GDPit + \beta 5\ln EUit + \epsilon_{(it)}$$

Where,
CO_2 = CO_2 Emissions
REU= Renewable energy use
URB = Urbanization
IND = Industrialization
GDP = Gross Domestic Product
EU = Energy Use
εit = Error term
The two main panel models are:

One-Way Model (individual effect):

$$Y_{(it)} = \alpha + \alpha_i + X'_{(it)}\beta + \epsilon_{(it)}$$

Two-Way Model (individual and time effects):

$$Y_{(it)} = \alpha + \alpha_i + \delta_t + X'_{(it)}\beta + \epsilon_{(it)}$$

Where Y_(it) is CO_2 emissions, X'(it) represents the set of independent variables, α_i is the country-specific effect, δ_t is the time effect and ε(it) is the random error.

Where Yit represents CO_2 emissions for country i at time, $X'it$ represents the independent variables (renewable energy, urbanization, industrialization, GDP and energy use), αi denotes the country-specific effect, δt denotes the time effect and εit represents the random error term. The analysis in this research was shown using EViews software, which provides reliable results for estimating coefficients, testing model validity and performing diagnostic tests.

Estimation Model Test

This study applies to panel data regression because the data combine eight countries and annual observations from 2000-2024. This method captures variations across countries and over time. It also controls for unobserved country specific factors through country fixed effects and common yearly shocks through year fixed effects. The appropriate model is selected using the F test, Breusch Pagan LM test and Hausman test. Robust standard errors are used to address heteroskedasticity and serial correlation.

Panel regression can be estimates by using three main approaches Pooled Least Squares (PLS) or Common Effect Model (CEM). This model assumed that all observations are identical, ignoring both cross-sectional and temporal variations. It applies the Ordinary Least Squares (OLS) method:

$$Y_{(it)} = \alpha + \beta X_{(it)} + e_{(it)}$$

Panel data regression can be estimated by using three major approaches: the Pooled Least Squares (PLS) or Common Effect Model (CEM), the Fixed Effect Model (FEM) and the Random Effect Model (REM). Every method has different assumptions and implications depending on the data structure.

The Common Effect Model (CEM), also recognized as Pooled Least Squares (PLS), assumes that all individuals are identical across by time and there are no country or time exact effects. It applies to the simple OLS estimation technique as if the data is purely cross-sectional. While easy to implement, the CEM ignores heterogeneity across nations and may lead to biased results if countries are specific differences exist.

Random Effect Model (REM)

The Random Effect Model assumed that individual differences are random and uncorrelated with independent variables. It can be expressed as:

$$Y_{(it)} = \alpha + \beta X_{(it)} + u_i + e_{(it)}$$

The Random Effect Model (REM) assumes that the individual specific effects are random and uncorrelated with the explanatory variables. Rather than the estimating a separate intercept for each country, REM includes these effects as part of the merged error term. This method is more efficient when the assumption of no correlation holds true, as it preserves both within the country and between country information. REM is naturally estimated using the Generalized Least Squares (GLS) method, which accounts for possible heteroscedasticity and serial correlation.

Mediation Role of Energy Use (EU)

Total Effect Model (without mediator)

First, the effect of the independent variables on CO_2 emissions is estimated without including EU:

$lnCO2it=\alpha0+\alpha1REUit+\alpha2URBit+\alpha3INDit+\alpha4GDPit+\varepsilon it$

The coefficients α_1, α_2, α_3 and α_4 show how much each variable, taken together, affects CO_2 emissions.

Mediator Equation (X → EU)

Second, the effect of the independent variables on the mediator (EU) is estimated:

$EUit=\gamma0+\gamma1REUit+\gamma2URBit+\gamma3INDit+\gamma4GDPit+vit$

Significant coefficients γ_1, γ_2, γ_3 and γ_4 show that the independent variables have an effect on Energy Use.

Mediated Model (X and EU → CO_2)

Third, the full model including both the independent variables and the mediator is estimated:

$lnCO2it=\beta0+\beta1REUit+\beta2URBit+\beta3INDit+\beta4GDPit+\beta5EUit+\mu it$

β_5 represents the direct effect of Energy Use on CO_2 emissions, while β_1, β_2, β_3 and β_4 represent the direct effects of the independent variables after controlling for Energy Use (EU).

Determining Estimation Model

Model selection was conducted using:

1. Chow test (CEM vs FEM)
2. Hausman test (FEM vs REM)
3. Lagrange Multiplier test (CEM vs REM)

The REM was selected for its robustness against heteroscedasticity and efficiency in handling dynamic datasets.

RESULT AND DISCUSSION

Research Overview

The selected developing Asian countries Pakistan, India, Bangladesh, Indonesia, Sri Lanka, Vietnam, Kyrgyzstan and the Philippines constitute a heterogeneous yet analytically coherent panel of economies undergoing rapid structural transformation. These countries are characterized by growing urbanization and expanding industrial bases and increasing per capita energy demand, along with efforts to scale up renewable energy deployment. Geographically, they extent South Asia, Southeast Asia and Central Asia, surrounding diverse climatic zones, income levels and energy sector outlines. This regional and economic variety renders the sample particularly suitable for investigating the mediating role of energy use in the relationship between renewable energy, urbanization, industrialization and economic growth on CO_2 emissions in developing Asian countries.

Figure 1. Asia Countries Map

Statistical Description

The descriptive statistics displays that all variables have substantial dispersion and non-normal distributions. The mean of X4 (8,569,386) is far above its median (143,779.8) and its maximum (62,078,954) is extremely high, indicating strong right-skew and the presence of large outliers. Similarly, Y has a very wide range (0.0014 to 180.8658) and a high standard deviation (28.99), with strong positive skewness (2.43) and very high kurtosis (9.81), meaning it is heavily right-tailed with many extreme values. X2 and X3 are negatively skewed (−1.02 and −0.81) and show high kurtosis (6.15 and 7.69), suggesting heavy left tails and non-normality. The Jarque–Bera probabilities are below 0.05 for all variables, confirming that none of them follow a normal distribution, so normality-based methods should be applied with caution.

Table 2. Descreptive Statistics

	X1	X2	X3	X4	Z	Y
Mean	0.377955	2.368173	5.309630	8569386.	517.7305	15.70070
Median	0.360500	2.506288	5.925155	143779.8	498.2074	1.532200
Maximum	0.642000	4.355565	30.18581	62078954	1023.057	180.8658
Minimum	0.188000	-2.788.711	-1.598.117	40898.41	135.9457	0.001400
Std. Dev.	0.112363	0.953060	5.269661	15616497	177.8908	28.99718
Skewness	0.428416	-1.021.660	-0.811903	1.612948	0.329115	2.430392
Kurtosis	2.365469	6.153614	7.693011	4.298692	3.566434	9.812411
Jarque-Bera	9.473251	117.6703	205.5091	100.7751	6.284288	583.6348
Probability	0.008768	0.000000	0.000000	0.000000	0.043190	0.000000

Source: Secondary data processed by EV iews (2025)

Selection of Regression Model

The Chow Test indicated that the F-statistic was lower than the 5% significance level, leading to the rejection of the null hypothesis (H_0) and the acceptance of the alternative hypothesis (H_1), suggesting the Fixed Effect Model (FEM) as the best model. The Hausman test shows a p value is 0.6242, which is higher than 0.05. Therefore, the null hypothesis is not rejected, indicating that the Random Effect Model is more appropriate than the Fixed Effect Model. Lastly, the Lagrange Multiplier Test showed a Cross-Section value of 0.000, leading to the rejection of H_0 and supporting the Random Effect Model (REM). However, since both the Chow and Hausman tests favored FEM, it is concluded that Fixed Effect Model (FEM) is the best regression model for this study.

Table 3. Chow Test Result

Test	F-Stat Value	Hypothesis and , Result
Chow Test	0.0000	H_0: CEM is the best model (p-value > 5%) H_1: FEM is the best model (p-value < 5%) Result: H_0 is rejected, FEM is chosen as the best model
Hausman Test	0.6242	H_0: REM is the best model (p-value > 5%) H_1: FEM is the best model (p-value < 5%) Result: H_0 is fail to rejected, FEM is the best model
LM Test	0.000	H_0 CEM is the best model (p-value > 5%) H_1 REM is the best model (p-value < 5%) Result: H_0 is rejected, REM is the best model
Conclusion	Two of the three tests chose FEM, so the best model in this model is the Fixed Effect Model.	

Source: Data Processed 2025

Table 4. Outcomes of the Least Squares (LS) Analysis

Variable	Coefficient	t-Statistics	Probability	Conclusion
X1	53.66096	3.003949	0.0030	Significant
X2	12.13195	5.401033	0.0000	Significant
X3	0.167573	0.485657	0.6278	Insignificant
X4	-1.21E-06	-6474549	0.0000	Significant
Z	0.144942	8.413368	0.0000	Significant

Source: data processed (2025)

1.The t-statistic of 3.003949 exceeds the critical value of 2 and the p-value of 0.0030 is well below the 0.05 threshold and makes this variable statistically significant at the 1% level. The positive coefficient of 53.66 is noteworthy and may initially seem counterintuitive and one might expect renewable energy to reduce CO2 emissions. Nevertheless, this could be explained by the fact that countries expanding their renewable energy capacity are often also fast-growing economies that simultaneously growth total energy consumption and still drive CO2 emissions rising. This is occasionally referred to as the rebound effect. The result proposes that while renewable energy rises, it has not yet been sufficient to offset overall emission levels in the studied dataset.

2.The t-statistic of 5.401033, the p-value of 0.0000 and the Urbanization is highly statistically significant, one of the stronger predictors in this model. The positive coefficient of 12.13 means that urbanization rises and CO2 emissions also increase. This is consistent with most economic literature urban areas tend to have higher energy demand, more industrial activity, greater transportation usage and increased consumption of goods and services, all of which contribute to higher CO2 emissions. The very low p-value confirms that this relationship is not due to chance.

3.The t-statistic of 0.485657 is far below the critical value of 2 and the p-value of 0.6278 is extremely high meaning there is a 62.78% probability that this result occurred by random chance. This variable is statistically NOT significant This result could be interpreted in several ways. It may suggest that in the countries/time period studied, industrialization alone does not independently explain variation in CO2 emissions when controlling for the other variables. Its effect may already be captured by GDP or Energy Use (Z), causing multicollinearity or redundancy. The near-zero and small coefficient (0.167) further support the weak relationship.

4.The t-statistic of -6.474549 (in absolute terms: 6.47) is very large and the p-value of 0.0000 confirms this variable is highly statistically significant at the 1% level The negative coefficient (-1.21E-06 = -0.00000121) means that as GDP increases, CO2 emissions decrease, holding other variables constant. While the coefficient value appears tiny, this is because GDP is measured in absolute monetary units (which are very large numbers). These outcomes is reliable with the Environmental Kuznets Curve (EKC) hypothesis and which suggests that at higher levels of income and countries tend to adopt cleaner technologies, more efficient production methods and stronger environmental regulations ultimately decoupling economic growth from emissions.

5.The highest t-statistic in the entire model (8.413368) and a p-value of 0.0000. Energy Use is the most statistically significant variable in explanation CO2 emissions. The positive coefficient of 0.1449 means that for every one-unit growth in energy use, CO2 emissions increase by approximately 0.145 units, all else constant. This result is entirely logical and associated with economic and environmental theory burning fossil fuels for energy is the primary driver of CO2 emissions. The strength of this result reinforces that energy consumption patterns are the most critical lever for addressing CO2 emission levels in policymaking.

Test R-squared

The regression results show that the model has very high explanatory power. The R-squared value of 0.9196 demonstrations that about 91.96% of the variation in the dependent variable Y is described by the included independent variables, which reflects an excellent model fit. The adjusted R-squared of 0.9144, although slightly lower due to the penalty for the number of predictors, still confirms that the model remains strongly explanatory and is not overfitting severely, together with a high and statistically significant F-statistic (as implied by your description) and these results suggest that the model as a whole is highly significant and that at least one of the independent variables has a meaningful impact on Y.

Table 5. Test Results R^2

R-squared	0.919579
Adjusted R-squared	0.914418

Source: data processed (2025)

DISCUSSION

This study demonstrates that energy use constitutes the principal mechanism linking structural transformation and economic development to CO_2 emissions in developing Asian economies. The findings reinforce the logic of the STIRPAT framework, which emphasizes that environmental pressure emerges not only from demographic and economic expansion but also from technological and consumption pathways. In this study, energy use consistently mediates the relationships between renewable energy, urbanization, industrialization, GDP, and environmental outcomes, indicating that structural change alone does not determine emissions unless translated into patterns of energy demand and consumption. This finding extends prior studies that primarily treated energy use as a control variable rather than an explicit transmission mechanism in the development–environment nexus.

A notable finding concerns the positive association between renewable energy use and CO_2 emissions. Although renewable energy is generally expected to mitigate environmental degradation, the results suggest that, in developing Asian countries, renewable expansion may still coexist with rising emissions. This outcome can be interpreted through the rebound effect hypothesis, whereby improvements in energy availability and efficiency stimulate higher total energy consumption rather than reducing fossil dependence (Jie & Rabnawaz, 2024). In many developing Asian economies, renewable energy infrastructure development continues to rely on fossil-fuel-intensive production systems, imported technologies, cement, steel, and carbon-intensive transport logistics. Moreover, renewable energy may currently function more as a supplement to rapidly growing energy demand rather than as a substitute for fossil fuels. This interpretation is consistent with findings from ASEAN and emerging economies showing that renewable deployment often fails to generate immediate carbon reductions when industrial expansion and urban energy demand continue to accelerate (Tran et al., 2024).

Urbanization exhibits a more complex relationship with environmental outcomes. The direct negative relationship between urbanization and CO_2 emissions suggests that urban concentration may generate environmental efficiencies through economies of scale, denser infrastructure, technological diffusion, and improved public transportation systems (Haloui et al., 2025). However, the positive indirect effect through energy use reveals that these efficiency gains can be partially offset by expanding residential electricity demand, transport consumption, construction activity, and urban industrial services. This duality supports earlier findings by Poumanyvong and Kaneko (2010), who argued that urbanization does not uniformly worsen environmental degradation; instead, its impact depends on how cities manage energy intensity, infrastructure quality, and consumption behavior. For developing Asian countries, rapid urban growth without integrated energy planning risks transforming cities into concentrated centers of carbon-intensive energy demand.

Industrialization presents an interesting outcome, showing an insignificant direct effect on CO_2 emissions after controlling for other structural factors. This finding suggests that industrial activity itself may no longer be the sole determinant of environmental deterioration. Instead, the environmental consequences of industrialization appear to operate primarily through energy consumption patterns. Such results may reflect ongoing structural changes in developing Asia, where manufacturing systems are gradually incorporating cleaner production processes, technological upgrading, and service-sector expansion. Nevertheless, because industrial production remains heavily dependent on electricity generation, transport systems, and fossil-based industrial inputs, energy use continues to transmit industrial environmental impacts. This result aligns with Sikder et al. (2022), who emphasized that the carbon implications of industrial development increasingly depend on energy structure and production efficiency rather than industrial growth alone.

The negative direct relationship between GDP and CO_2 emissions provides partial support for the Environmental Kuznets Curve (EKC) hypothesis (Grossman & Krueger, 1995), suggesting that rising income levels may encourage cleaner technologies, stronger environmental regulation, and improvements in production efficiency. However, the positive indirect pathway through energy use indicates that economic expansion continues to stimulate aggregate energy demand. This finding implies that economic growth in developing Asia remains only partially decoupled from carbon emissions. Economic development may reduce environmental pressure through technological upgrading, yet simultaneously intensify emissions through higher household consumption, industrial output, and infrastructure expansion. Consequently, achieving sustainable growth requires not merely expanding GDP but restructuring the energy mix and improving energy productivity.

From a policy perspective, the findings suggest that emission mitigation strategies in developing Asian countries must move beyond simple renewable energy expansion. Policymakers should simultaneously address energy demand management, sectoral energy efficiency, and fossil fuel substitution. Urban planning policies should integrate low-carbon transportation systems, energy-efficient buildings, and sustainable infrastructure development to prevent urbanization-driven energy escalation. Furthermore, industrial policy should prioritize clean production technologies and low-carbon energy transitions. Without coordinated interventions addressing both energy supply and energy demand, renewable energy deployment alone may be insufficient to achieve meaningful decarbonization in rapidly transforming Asian economies.

CONCLUSION

This study investigated the determinants of CO_2 emissions in eight developing Asian countries over the period 2000–2024 by emphasizing the mediating role of energy use. The findings reveal that renewable energy use, urbanization, and economic growth significantly influence CO_2 emissions, whereas industrialization demonstrates a weaker direct effect. More importantly, energy use consistently acts as a key mediating mechanism through which structural and economic factors translate into environmental pressure. These results extend the STIRPAT perspective by demonstrating that environmental degradation in developing Asian economies is shaped not only by economic and structural transformation, but also by patterns of energy consumption accompanying such transformation.

The study also highlights that renewable energy expansion in developing Asian countries has not yet fully reduced carbon emissions, as renewable energy often supplements rapidly increasing energy demand rather than replacing fossil fuel dependence. Urbanization, while capable of generating efficiency gains through infrastructure concentration and technological advancement, simultaneously increases aggregate energy demand. Likewise, economic growth contributes to environmental improvement directly through technological progress and efficiency enhancement, yet indirectly intensifies emissions through higher energy consumption. These findings imply that sustainable emission reduction strategies require integrated policies that simultaneously address renewable energy transition, energy efficiency, urban planning, and demand-side energy management.

From a policy perspective, governments in developing Asian countries should accelerate the transition from fossil fuels toward cleaner energy systems while strengthening energy efficiency standards across industrial, transportation, and residential sectors. Urban development policies should prioritize sustainable infrastructure, low-carbon public transportation, and energy-efficient urban systems to mitigate the environmental consequences of rapid urbanization. In addition, industrial policies should encourage cleaner production technologies and greater adoption of renewable-based manufacturing systems.

This study is limited by its focus on eight developing Asian countries and the use of aggregate annual data, which may not fully capture sectoral and regional differences in energy consumption and emissions. Future research is encouraged to employ dynamic panel estimation techniques, sector-specific energy analysis, and disaggregated energy data to better identify the mechanisms linking development factors and environmental outcomes. Further studies may also explore nonlinear relationships, threshold effects, and country-specific institutional conditions to explain why some developing economies achieve stronger decoupling between economic growth and carbon emissions than others.

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