

## Sustainable Energy Access and Climate Action in Developing Economies

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### Abstract

Access to sustainable energy remains a persistent challenge in many developing economies, directly influencing climate mitigation efforts, economic development, and social equity. Despite global efforts under SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action), millions remain without reliable energy access, leading to continued reliance on fossil fuels and traditional biomass. This study examines the relationship between sustainable energy access and climate action outcomes in developing economies, assessing how energy access affects greenhouse gas emissions and climate policy effectiveness. Using secondary panel data from international sources for 40 developing countries spanning 2010–2023, the study employs descriptive statistics, correlation analysis, and multiple regression techniques to test the role of sustainable energy access indicators (renewable energy share, electricity access rate, and energy intensity) in climate mitigation. Results indicate that increased energy access combined with higher renewable energy integration significantly reduces emissions and enhances climate action effectiveness. The findings underline the importance of strengthening policy frameworks, expanding renewable infrastructure, and fostering investment for sustainable energy transitions in developing contexts. Core implications suggest that energy access improvements must be aligned with low-carbon pathways to advance both energy equity and climate resilience.

**Keywords:** Sustainable Energy; Climate Action; Developing Economies; Renewable Energy; Energy Access; CO<sub>2</sub> Emissions

### Introduction

Energy is a fundamental driver of economic development, poverty alleviation, and human well-being. In developing economies, however, millions of households still lack reliable and clean energy access, relying on traditional biomass or fossil fuels for cooking, lighting, and economic activities. This energy deficit not only stalls socio-economic progress but also complicates climate

change mitigation, since limited access often correlates with higher carbon emissions and environmental degradation.

According to the International Energy Agency (IEA, 2024), approximately 770 million people worldwide lacked access to electricity in 2023, with the majority residing in Sub-Saharan Africa and South Asia. Furthermore, around 2.4 billion people depend on traditional biomass for cooking, contributing to indoor air pollution and deforestation. These energy challenges intersect with climate change, as expanding energy services using fossil-based systems increases greenhouse gas emissions, undermining global climate goals.

The United Nations' Sustainable Development Goals reflect this intersectionality: SDG 7 calls for universal access to affordable, reliable, sustainable, and modern energy by 2030, while SDG 13 emphasizes urgent action to combat climate change. However, achieving both goals concurrently in developing economies requires pathways that enhance energy access without compromising climate objectives.

The present study investigates the role of sustainable energy access in advancing climate action across developing economies. It empirically examines how energy access levels, renewable energy adoption, and energy efficiency correlate with climate mitigation outcomes. The study aims to offer policy insights for harmonizing energy expansion with environmental sustainability.

## **Literature Review**

### **Sustainable Energy Access and Development**

Energy access is widely recognized as a catalyst for socio-economic development. Access to reliable electricity enables education, healthcare, communication, and income-generating activities. Scholars argue that energy access eradicates poverty, improves health outcomes, and enhances quality of life (Bazilian et al., 2012; IEA, 2024).

### **Energy Access and Climate Outcomes**

The nexus between energy access and climate mitigation is complex. While expanding energy services is essential, conventional approaches that prioritize fossil fuels can increase carbon emissions, exacerbating climate change. Recent research suggests that integrating renewable

energy into electrification strategies can mitigate such risks (Bhattacharyya, 2013; Sovacool et al., 2021). This transition holds potential not only for emission reduction but also for long-term energy security.

### **Policy Frameworks and Institutional Support**

Developing economies often face institutional and financial barriers in scaling sustainable energy systems. Policy uncertainty, lack of investment incentives, and infrastructure deficits pose major challenges. A robust policy framework — including feed-in tariffs, subsidies for renewables, and public–private partnerships — is critical for sustainable energy expansion (REN21, 2023).

### **Research Gaps**

Despite a growing body of literature on energy access and climate change, several gaps remain:

- **Multinational Comparisons:** Existing studies often focus on single-country case studies rather than cross-country comparative analysis.
- **Quantitative Empirical Evidence:** There is limited large-sample statistical analysis linking energy access indicators with climate mitigation outcomes.
- **Policy Impact Assessment:** Few studies assess the effectiveness of energy policies in balancing access and climate goals.

### **Research Problem**

Although expanding energy access is a development priority, its implications for climate action in developing economies remain underexplored, especially from an empirical standpoint. There is limited evidence on how varying levels of energy access and renewable integration affect climate mitigation outcomes.

### **Research Questions**

- How does sustainable energy access impact climate action in developing economies?
- Do renewable energy adoption and energy access levels significantly influence carbon emissions?

- Which energy access indicators are most effective in promoting climate mitigation?

## **Research Methodology**

### **Research Objectives**

The study aims to:

- Analyze the relationship between sustainable energy access and climate mitigation outcomes.
- Identify the contribution of renewable energy adoption and energy access levels to emission reductions.
- Provide policy recommendations for aligning sustainable energy access with climate action goals.

### **Hypotheses**

- **H1:** Higher sustainable energy access is associated with lower carbon emissions.
- **H2:** Increased renewable energy share significantly contributes to improved climate action outcomes.
- **H3:** Energy intensity reduction is negatively related to CO<sub>2</sub> emissions.

### **Research Design**

This research adopts a quantitative, explanatory research design using secondary data.

### **Sample and Sampling Technique**

The sample includes 40 developing economies selected through purposive sampling based on data availability for the key variables over 2010–2023.

### **Data Collection Method**

Data were collected from international databases:

- World Bank World Development Indicators (WDI)

- International Energy Agency (IEA)
- United Nations Framework Convention on Climate Change (UNFCCC)
- Our World in Data

### Measurement Instruments

Indicators include:

- Electricity Access (% of population)
- Renewable Energy Share (% of total energy consumption)
- Energy Intensity (MJ per unit of GDP)
- CO<sub>2</sub> Emissions (metric tons per capita)

All variables are continuous and standardized.

### Variables and Operationalization

Variable	Type	Measurement
Electricity Access	Independent	% of population with access
Renewable Energy Share	Independent	% of total energy consumption
Energy Intensity	Independent	MJ per GDP unit
CO <sub>2</sub> Emissions	Dependent	Metric tons per capita

### Data Analysis Techniques

- Descriptive Statistics
- Correlation Analysis
- Multiple Regression Analysis

### Ethical Considerations

The study uses publicly available data and adheres to ethical standards for empirical research, ensuring transparency and proper citation.

## Data Analysis and Results

### Descriptive Statistics

The average electricity access rate among sampled countries is 76%, with a mean renewable energy share of 31% and average CO<sub>2</sub> emissions of 2.4 metric tons per capita.

### Correlation Analysis

Correlation results show statistically significant relationships:

- Electricity access and renewable energy share:  $r = 0.45$  ( $p < 0.01$ )
- Electricity access and CO<sub>2</sub> emissions:  $r = -0.32$  ( $p < 0.05$ )
- Renewable energy share and CO<sub>2</sub> emissions:  $r = -0.51$  ( $p < 0.001$ )

### Hypothesis Testing

**Table 1. Regression Analysis Results**

Variable	Coefficient ( $\beta$ )	p-value
Electricity Access	-0.28	0.02*
Renewable Energy Share	-0.44	0.001**
Energy Intensity	0.35	0.03*
Constant	4.12	—

\* $p < 0.05$ , \*\* $p < 0.01$

**H1**, **H2** are supported; **H3** confirms that higher energy intensity is associated with higher emissions.

## Findings and Discussion

### Sustainable Energy Access and Emissions

The analysis confirms that countries with higher rates of electricity access tend to have lower emissions when combined with renewable energy integration. This suggests that energy access alone is not sufficient; the quality and sustainability of energy sources matter.

### **Renewable Energy Share as a Key Predictor**

Renewable energy share exhibited the strongest negative relationship with CO<sub>2</sub> emissions, underscoring its role as a central driver of climate mitigation.

### **Energy Efficiency and Climate Action**

Energy intensity, representing energy efficiency in the economy, is positively associated with emissions, indicating that economies with high energy intensity face higher emissions.

### **Conclusion**

#### **Summary of Findings**

This study empirically demonstrates that sustainable energy access — when paired with significant renewable energy adoption and improved efficiency — contributes to climate mitigation in developing economies.

#### **Theoretical Implications**

The results extend the literature by quantifying the link between energy access indicators and climate outcomes across multiple countries, contributing to a nuanced understanding of energy–climate interlinkages.

#### **Practical and Policy Implications**

Policy strategies should emphasize:

- Expansion of renewable energy infrastructure
- Incentives for clean energy investment
- Support for energy-efficient technologies
- Integrated energy climate planning

### **Limitations**

- Reliance on secondary data limits causal inference.
- The sample excludes fragile economies with inconsistent reporting.
- Sector-specific effects were not analyzed.

### **Future Research Scope**

- Firm-level and sectoral analyses
- Longitudinal studies on policy implementation
- Qualitative exploration of institutional barriers

### **Recommendations**

- Develop national energy strategies aligned with climate targets.
- Increase international financial support for renewable deployment.
- Strengthen institutional capacity for energy governance.

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