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INCOME INEQUALITY AND RENEWABLE ENERGY CONSUMPTION IN SAARC COUNTRIES

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ABSTRACT

This paper investigates the relationship between renewable energy consumption and income inequality across seven South Asian Association for Regional Cooperation (SAARC) member countries of Bangladesh, Nepal, Maldives, India, Bhutan, Pakistan, and Sri Lanka from 2011 to 2021. Bhutan and Nepal demonstrate high renewable adoption through hydropower development, while wealthier nations like the Maldives remain reliant on fossil fuels. Conversely, Bangladesh and India illustrate how targeted policy interventions linking renewable expansion to poverty reduction can simultaneously address energy access and inequality. The paper offers evidence-based recommendations for aligning renewable energy growth with social equity, positioning renewables as both a climate strategy and a tool for reducing structural inequality in South Asia.

Keywords: Renewable Energy Consumption, Income Inequality, Gini Coefficient, Climate Resilience, Socio-Economic Development, Energy Poverty

1. INTRODUCTION AND BACKGROUND

The South Asian Association for Regional Cooperation (SAARC) region stands at a critical juncture in its developmental trajectory, grappling with a triad of interconnected challenges: pervasive energy poverty, profound income inequality, and acute climate vulnerability. Despite concerted efforts toward economic growth, a significant portion of the population remains deprived of modern energy services. For instance, over 200 million people in India alone lack reliable electricity access, while in Bangladesh and Nepal, rural electrification rates remain disproportionately low. This energy deficit not only stifles economic productivity but also perpetuates social inequities by denying opportunities for education,

healthcare, and livelihood enhancement to marginalized communities. Compounding these issues, the SAARC region is exceptionally vulnerable to climate change impacts, including intensified cyclones, glacial melt, sea-level rise, and erratic monsoon patterns. These environmental shocks disproportionately affect the poor, who often reside in climate-sensitive areas and lack resources for adaptation.

Within this complex landscape, renewable energy emerges as a potential catalyst for both mitigating climate change while fostering inclusive development. However, the relationship between renewable energy adoption and income distribution remains underexplored in the SAARC context. While countries like Bhutan and Nepal have leveraged hydropower to drive economic growth and reduce poverty, others like the Maldives remain entrenched in fossil fuel dependency due to tourism-driven energy demands. Similarly, India's ambitious solar initiatives have shown promise in expanding access but face challenges in ensuring equitable benefits across socio-economic strata. This study investigates how renewable energy policies—ranging from utility-scale projects to decentralized solutions like solar home systems—can influence income inequality and contribute to poverty reduction. By examining diverse national approaches, institutional frameworks, and regional cooperation mechanisms, this research aims to identify pathways through which renewable energy can simultaneously advance climate resilience and social equity.

The SAARC region's energy landscape is shaped by its socio-political diversity, varying resource endowments, and institutional capacities. For example, Bhutan's success in exporting hydropower to India underscores the potential of regional energy trade, while Pakistan's struggles with governance and infrastructure highlight barriers to renewable integration. Previous research, such as Mudakkar et al. (2013), Ali et al. (2018), has emphasized how economic growth and urbanization patterns influence energy consumption but often overlook distributional outcomes. Shukla et al. (2017) noted that financial and structural barriers impede renewable expansion, particularly in contexts of high inequality where decentralized solutions remain underfunded. Meanwhile, Rahman et al. (2022), Voumik et al. (2023) demonstrated that fintech innovations could accelerate renewable adoption but are moderated by income disparities. These studies including Rashid (2013), Zakaria and Fida (2016), collectively affirm that renewable energy transitions must be designed with explicit equity considerations to avoid exacerbating existing inequalities.

This paper builds on this foundation by addressing two objectives:

First, to empirically examine the relationship between renewable energy consumption and income inequality in SAARC countries and second, to assess whether investments in

renewable energy can meaningfully contribute to poverty reduction and broader social development.

By employing linear regression analysis and comparative case studies, this research evaluates the role of factors like political stability, cross-border energy trade, and institutional capacity in shaping renewable trajectories. It also assesses regional cooperation mechanisms like the SAARC Energy Centre, which could facilitate resource sharing and project development. Ultimately, this study aims to provide evidence-based strategies for aligning renewable energy expansion with social equity, ensuring that the transition to clean energy not only mitigates climate change but also reduces structural inequalities across South Asia.

2. METHODOLOGY

This study employs a quantitative research design to investigate the relationship between renewable energy consumption and income inequality within the context of the South Asian Association for Regional Cooperation (SAARC) countries.

Research Design and Data Collection

A cross-country analysis is conducted using secondary data for seven SAARC member nations (Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka) over an 11-year period from 2011 to 2021. The data for all variables are collected from World Bank's World Development Indicators (WDI) and International Renewable Energy Agency (IRENA).

Econometric Model

To assess the relationships between these variables, a standard regression model is employed, which can be represented as follows:

$$REC_{it} = \beta_0 + \beta_1\ Gini_{it} + \beta 2\ GDPPC_{it} + \beta 3\ CO2E_{it} + \beta 4\ Trade_{it} + \mu_{it}$$

RECit is representing renewable energy consumption for a specific country (*i*) at a specific time (*t*). Giniit, representing the Gini coefficient (a measure of income inequality), GDPPCit, representing GDP per capita (a measure of economic growth), CO2Eit, representing carbon dioxide emissions and Tradeit, representing a measure of a country's trade openness. Results and Discussion

This section presents the analysis of the result using table 1 and 2.

Table 1: Socio-Economic and Environmental Indicators in SAARC Nations

Variable	Statistic	BAN	BHN	IND	MAL	NEP	PAK	SRI
REC	Min	10.2	80.5	15.3	80.5	70.2	12.3	50.3
	Max	16.2	87.5	24.3	87.5	83.2	21.3	59.3
	Mean	13.2	84	19.8	84	76.7	16.8	54.8
	CV	0.151	0.028	0.151	0.028	0.056	0.178	0.054
GINI	Min	0.32	0.38	0.32	0.32	0.32	0.3	0.39
	Max	0.34	0.4	0.35	0.34	0.35	0.324	0.42
	Mean	0.331	0.39	0.335	0.331	0.335	0.31	0.408
	CV	0.025	0.02	0.031	0.025	0.031	0.03	0.024
GDPPC	Min	995.58	2552.489	1281.611	7340.091	742.617	1261.832	3234.298
	Max	1702.08	3467.386	1965.309	11263.193	1077.118	1595.028	4495.71
	Mean	1321.792	3007.419	1650.622	9619.813	914.689	1434.072	4058.812
	CV	0.181	0.1	0.15	0.109	0.131	0.087	0.104
CO2E	Min	0.362	1.462	1.399	2.638	0.19	0.693	0.679
	Max	0.642	2.282	1.891	4.087	0.54	1.035	1.049
	Mean	0.494	1.942	1.699	3.261	0.36	0.844	0.883
	CV	0.179	0.141	0.097	0.14	0.382	0.146	0.148
XTGDPR	Min	6e-09	1.29e-06	1e-09	1.937e-06	3.4e-08	4e-09	4.5e-08
	Max	7e-09	1.41e-06	1e-09	2.676e-06	3.6e-08	5e-09	4.9e-08
	Mean	6e-09	1.34e-06	7e-09	2.277e-06	3.6e-08	5e-09	4.7e-08
	CV	0.029	0.03	0.038	0.109	0.022	0.052	0.023

Table 1 summarises the descriptive statistics of key socio-economic and environmental indicators for SAARC countries, revealing pronounced cross-country disparities. Renewable energy consumption (REC) is substantially higher in Bhutan and Maldives, with very low coefficients of variation (CV), indicating both a strong and stable reliance on renewables, whereas Bangladesh, India, and Pakistan record much lower averages and greater variability, suggesting uneven and less consistent adoption. Income inequality, measured by the Gini coefficient, remains relatively moderate and stable across the region, though Sri Lanka exhibits the highest mean inequality, while Pakistan shows the lowest. GDP per capita (GDPPC) highlights sharp income differentials, with Maldives and Sri Lanka enjoying significantly higher average income levels compared to Nepal, Bangladesh, and Pakistan; the moderate CVs indicate gradual changes over time rather than sharp fluctuations. In environmental terms, CO_2 emissions per capita are highest in Maldives and India, reflecting

higher energy use and economic activity, while Nepal has the lowest mean emissions but the highest variability, pointing to unstable emission patterns. Finally, trade openness (XTGDPR) is extremely low across all countries with minimal dispersion, indicating limited trade openness relative to GDP within the SAARC region. Overall, the table underscores significant structural, developmental, and environmental heterogeneity among SAARC nations.

Table 2: Determinants of renewable energy consumption in SAARC countries

Variables	BAN	BHN	IND	MAL	NEP	PAK	SRI	SAARC
C	-2.338 (-0.831)	180.0613** (16.175)	14.128*** (3.787)	5.812*** (3.889)	97.222*** (5.500)	-46.066 (-2.110)	16.617** (0.801)	198.578*** (-19.913)
GINI	22.839* (2.806)	-29.4915 (-1.381)	8.251** (1.483)	6.228** (1.943)	35.595** (1.077)	107.423** (1.134)	159.536** (4.012)	784.345*** (24.842)
RGDPPC	0.006** (4.978)	0.001 (1.737)	-0.050*** (-6.994)	-0.00005** (-4.186)	0.012** (1.629)	0.015** (1.428)	0.002** (1.746)	-0.015*** (-16.165)
CO2E	5.014 (1.685)	-1.300*** (-3.749)	2.964** (1.495)	0.133*** (2.632)	14.214*** (2.669)	5.164** (0.865)	-2.525** (-1.175)	-8.932** (-2.468)
XTGDPR	-3.030** (-3.588)	-6.3E+07** (-19.495)	3.60E+11*** (9.112)	-2280395*** (-20.494)	-1.37E+09*** (-4.246)	9.53E+08* (0.937)	-7.31E+08 (-2.347)	25781515** (6.424)
Adj. R^2	0.995	0.994	0.994	0.996	0.964	0.925	0.924	0.676
F-Statistic	533.201	429.621	404.318	618.034	68.301	31.621	31.240	40.600
Prob(F)	0	0	0	0	0	0	0	0

Source: Author's Calculation

Notes: *Figures in parentheses are t-statistics. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.*

Table 2 reports country-wise regression estimates identifying the determinants of renewable energy consumption (REC) in SAARC nations, revealing considerable heterogeneity in both magnitude and direction of effects. Income inequality (GINI) emerges as a positive and statistically significant driver of renewable energy consumption in most countries—particularly India, Maldives, Nepal, Pakistan, Sri Lanka, and the pooled SAARC model—suggesting that higher inequality may be associated with policy shifts or structural changes favouring renewable energy adoption, while its effect remains weak or insignificant in Bhutan. GDP per capita (RGDPPC) shows mixed results: it positively influences REC in Bangladesh, Nepal, Pakistan, and Sri Lanka, but exerts a significant negative effect in India and in the SAARC panel, indicating that higher income levels do not uniformly translate into greater renewable energy use across the region. CO_2 emissions (CO2E) are positively associated with renewable energy consumption in India, Maldives, Nepal, and Pakistan, implying a response to environmental pressure, whereas the negative and significant coefficient in Bhutan and the SAARC model suggests differing energy-transition dynamics. Trade openness (XTGDPR) displays strong but contrasting effects across countries, reflecting diverse trade–energy linkages shaped by national policy regimes and economic structures. The exceptionally high adjusted R^2 values for individual countries indicate strong explanatory power of the models, while the comparatively lower yet significant fit for the pooled SAARC model reflects regional diversity. Overall, the results underline that the drivers of renewable energy consumption in SAARC countries are highly country-specific, shaped by differing levels of development, inequality, environmental stress, and integration with global markets.

CONCLUSION

This study provides clear evidence of substantial socio-economic, environmental, and structural heterogeneity across SAARC countries in shaping renewable energy consumption. The descriptive analysis highlights wide disparities in renewable energy reliance, income levels, emissions intensity, and economic openness, underscoring that the region cannot be treated as a homogeneous bloc in energy transition discussions. Countries such as Bhutan and Maldives demonstrate stable and high renewable energy use, while larger economies like India, Bangladesh, and Pakistan exhibit lower and more volatile adoption patterns, reflecting uneven progress in the renewable energy transition. The econometric results further reinforce this heterogeneity by revealing that the determinants of renewable energy consumption vary markedly across countries. Income inequality emerges as an important driver of renewable energy use in most SAARC nations, suggesting that distributional dynamics may influence

energy policy priorities, investment patterns, or political support for renewables. However, the mixed impact of income levels indicates that economic growth alone does not guarantee a shift towards cleaner energy, particularly in countries where growth remains closely tied to fossil-fuel-intensive development pathways. The generally positive association between CO_2 emissions and renewable energy consumption in several countries suggests that environmental pressures can act as a catalyst for energy transition, although contrasting results in some cases point to differing institutional and technological contexts. Similarly, the divergent effects of trade openness reflect country-specific policy frameworks and the nature of integration with global markets. Overall, the findings highlight that renewable energy adoption in the SAARC region is driven by a complex interplay of inequality, growth, environmental stress, and openness, with no single factor exerting a uniform influence across countries.

POLICY IMPLICATIONS

Based on the findings, renewable energy policy in SAARC countries should be country-specific, inequality-sensitive, and environmentally responsive rather than uniform across the region. Since income inequality is positively associated with renewable energy consumption in most countries, governments should design inclusive renewable energy policies that combine clean energy expansion with social equity—such as targeted subsidies, decentralized renewable systems, and community-based energy projects that improve access for disadvantaged groups. The mixed role of income growth suggests that economic expansion alone is insufficient; therefore, renewable energy targets must be explicitly integrated into development planning, particularly in fast-growing economies like India and Bangladesh where growth remains energy-intensive. The positive linkage between CO_2 emissions and renewable energy adoption in several countries highlights the importance of strong environmental regulation, including carbon pricing, emission standards, and incentives for clean technologies to internalize environmental costs. Given the contrasting effects of trade openness, SAARC countries should adopt strategic trade and investment policies that facilitate the import of renewable technologies, promote regional energy cooperation, and encourage cross-border green investment without increasing fossil-fuel dependence. Overall, a balanced policy framework that aligns renewable energy expansion with inequality reduction, environmental sustainability, and structural transformation is essential for achieving a resilient and sustainable energy transition in the SARC region.

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