

Center for Management Science Research

ISSN Online: 3006-5291

ISSN Print: 3006-5283



FDI, Financial Development, and CO₂ Emissions in SAARC Economies: Evidence from Cross-Sectionally Augmented ARDL Panel Estimation

Erum Mehmood*

Department of Economics, University of Karachi. Corresponding Author Email:

Economist.Erum@gmail.com

ABSTRACT

This study examines the long-run and short-run determinants of carbon dioxide (CO₂) emissions in six SAARC economies — Bangladesh, Pakistan, Bhutan, India, Nepal, and Sri Lanka — over the period 2000–2024. Employing a Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) framework to address the documented cross-sectional dependence across the panel, this paper investigates the roles of foreign direct investment (FDI) inflows, financial development (proxied by broad money supply), per capita income, internet penetration, renewable energy consumption, and urbanisation as drivers of environmental quality. The Pesaran (2004) Cross-Sectional Dependence (CD) test confirms the presence of strong cross-sectional dependence, justifying the use of second-generation panel unit root and cointegration tests. The Cross-Sectionally Augmented IPS (CIPS) panel unit root test establishes that all series are integrated of order one, I(1), and the Westerlund (2007) panel cointegration test confirms a stable long-run equilibrium. CS-ARDL Pooled Mean Group (PMG) estimates reveal that renewable energy is the dominant and statistically significant determinant of CO₂ abatement (coefficient: -1.230 , $p < 0.01$), while evidence supporting the Environmental Kuznets Curve (EKC) hypothesis is country-heterogeneous. FDI exhibits a modest emission-reducing effect consistent with the Pollution Halo hypothesis, though it does not attain conventional significance at the panel level. These findings carry important implications for regional climate policy and the alignment of developmental finance with net-zero commitments under the Paris Agreement.

Keywords: CO₂ emissions; FDI; CS-ARDL; Cross-sectional dependence; SAARC; Environmental Kuznets Curve; Renewable energy; Financial development

JEL Classification: Q53, F21, O13, C33, Q27

1. Introduction

The tension between economic development imperatives and environmental sustainability constitutes one of the most pressing governance challenges confronting South Asian economies. The South Asian Association for Regional Cooperation (SAARC) region — comprising Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka — is home to over 1.9 billion people and is simultaneously one of the fastest-growing economic blocs and one of the most climate-vulnerable regions on the planet (World Bank, 2023; IPCC,

2022). The contradiction is acute: sustained GDP growth, rapid urbanisation, and the deepening of digital and financial infrastructures are expanding per capita energy demand, yet the region's energy matrix remains heavily dependent on fossil fuels, placing upward pressure on carbon dioxide (CO₂) emissions.

A burgeoning literature examines the relationship between economic growth and environmental quality through the lens of the Environmental Kuznets Curve (EKC) hypothesis, which postulates an inverted U-shaped relationship between per capita income and pollution (Grossman & Krueger, 1991; Panayotou, 1993). However, whether SAARC economies have approached or surpassed the income turning point implied by the EKC remains contested. More importantly, the EKC hypothesis abstracts away from the specific channels through which growth affects emissions. Chief among these channels are foreign direct investment (FDI) flows, financial sector development, and the energy transition toward renewables, each of which has attracted significant independent scholarly attention but rarely been studied jointly within a methodologically rigorous panel framework for the SAARC bloc.

Foreign direct investment occupies a particularly ambiguous theoretical position in the emissions literature. The Pollution Haven Hypothesis (PHH) contends that FDI flows towards developing economies with lax environmental regulation, thereby relocating carbon-intensive production (Copeland & Taylor, 2004). Conversely, the Pollution Halo Hypothesis (PHH-II) posits that technology transfer embodied in FDI diffuses cleaner production techniques and managerial best practices, ultimately reducing emissions intensity (Zarsky, 1999; He, 2006). Disentangling these competing effects requires econometric approaches that account for the heterogeneity of development stages across the SAARC panel.

Critically, existing panel studies on South Asia are methodologically constrained in at least two important respects. First, the overwhelming majority employ first-generation unit root and cointegration estimators — such as Im, Pesaran, and Shin (2003) IPS or Pedroni (1999) cointegration tests — that assume cross-sectional independence across panel units. This assumption is empirically implausible in a regionally integrated bloc where common global shocks (oil price volatility, financial crises, pandemic disruptions), shared monsoon climatology, and intra-regional trade linkages generate substantial cross-sectional dependence. Failure to account for cross-sectional dependence yields severely size-distorted tests and inconsistent estimators (Pesaran, 2004, 2007). Second, prior studies rarely integrate internet penetration as a proxy for the digital economy's environmental footprint, despite rapidly expanding mobile broadband and data centre energy consumption across the region.

This paper addresses these gaps by deploying the Cross-Sectionally Augmented ARDL (CS-ARDL) estimator proposed by Chudik and Pesaran (2015), which augments country-level ARDL regressions with cross-sectional averages of the dependent and explanatory variables to filter out the common correlated effects driving cross-sectional dependence. This approach yields consistent and asymptotically normal estimates even under prevalent cross-sectional dependence and heterogeneous slope coefficients — two features that characterise the SAARC panel.

The remainder of the paper proceeds as follows. Section 2 reviews the relevant theoretical and empirical literature. Section 3 describes the data and variable construction. Section 4 presents the econometric methodology, including the CD test, second-generation panel unit root tests, Westerlund (2007) cointegration tests, and the CS-ARDL PMG estimator. Section 5 reports and interprets the empirical results. Section 6 derives policy implications, and Section 7 concludes.

2. Literature Review

2.1 The Environmental Kuznets Curve: Theoretical Foundations and Empirical Evidence

The EKC hypothesis originates from the seminal contributions of Grossman and Krueger (1991) and Kuznets (1955). It decomposes the income-pollution relationship into three countervailing forces: a scale effect (higher income raises output and pollution), a composition effect (structural shift from manufacturing to services reduces emissions intensity), and a technique effect (higher income raises the demand for environmental quality, inducing cleaner technologies). The net effect, under certain assumptions, yields an inverted U-shaped income-pollution trajectory. Empirically, the EKC has been examined across diverse country groupings and pollutants, with mixed support. Dinda (2004) provides a comprehensive survey concluding that evidence is pollutant- and sample-specific. For South Asia specifically, Shahbaz et al. (2014) find EKC support for Pakistan using bounds testing, while Pal and Mitra (2017) reject the EKC for India using a threshold regression framework.

2.2 FDI and Environmental Quality

Theoretical perspectives on the FDI-environment nexus fall broadly into two camps. The PHH, formalised by Copeland and Taylor (2004), predicts that differences in environmental regulatory stringency across countries generate comparative advantages in pollution-intensive industries, inducing capital flight to pollution havens. Empirical evidence from Zhu et al. (2016) supports the PHH for a panel of 91 developing countries. However, the Pollution Halo Hypothesis offers a countervailing prediction: FDI embodies superior environmental technologies and management practices that diffuse to host economies, reducing emissions per unit of output (Zarsky, 1999; He, 2006). The empirical literature finds considerable heterogeneity: Shahbaz et al. (2015) document halo effects for China using VECM, while Omri and Kahouli (2014) identify pollution haven dynamics for Middle Eastern and North African economies. For SAARC economies specifically, Rikhtehgar Berenji et al. (2019) find evidence that FDI reduces CO₂ intensity in India and Pakistan through technology diffusion channels.

2.3 Financial Development, Digitalization, and Emissions

The financial development-emissions nexus operates through both scale and structural channels. Financial deepening facilitates access to capital for energy-intensive industries, potentially raising emissions (scale channel), while simultaneously enabling green investment and the adoption of cleaner technologies (structural channel). Tamazian et al. (2009) find that financial liberalisation reduces CO₂ intensity in BRICS economies. Islam et al. (2021) demonstrate that mobile money adoption reduces energy poverty and enables households to substitute modern energy for traditional biomass in Bangladesh. The digitalization-emissions nexus is more complex: while digitalisation enables dematerialization and efficiency gains (Salahuddin & Alam, 2015), data centre energy consumption and electronic waste generate countervailing emission pressures (Asongu et al., 2022).

2.4 Renewable Energy and Carbon Abatement

The renewable energy-emissions relationship is theoretically unambiguous: renewable energy substitutes for fossil fuel combustion, directly reducing emissions. Empirically, Shafiei and Salim (2014) confirm this for OECD economies using panel VECM. Adedoyin et al. (2020) extend the analysis to non-OECD contexts, finding that renewable energy is the most robust determinant of CO₂ abatement across a heterogeneous panel. Within the SAARC context, renewable energy adoption has accelerated significantly, with India targeting 500 GW of renewable capacity by 2030 and Bangladesh deploying over 6 million solar home systems. However, the region's overall renewable share remains below global

averages due to hydropower dependence in Bhutan and Nepal and coal dominance in India and Pakistan.

2.5 Research Gaps and Contribution

Notwithstanding the rich literature surveyed above, three critical gaps remain. First, no extant study examines the joint determination of CO₂ emissions by FDI, financial development, internet penetration, and renewable energy for the SAARC panel using methods robust to cross-sectional dependence. Second, the use of CS-ARDL, which allows for I(0)/I(1) mixed-order dynamics while controlling for common correlated effects, has not been applied to the SAARC emissions literature. Third, no study spanning 2000–2024 captures the post-COVID energy transition dynamics, including the substantial renewable energy scaling-up observed between 2020 and 2024. This paper addresses all three gaps.

3. Data and Variable Construction

3.1 Sample and Data Sources

The empirical analysis employs an unbalanced panel of six SAARC economies — Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka — over the period 2000–2024, yielding 150 country-year observations. Data are sourced from the World Development Indicators (WDI) database of the World Bank (2024), supplemented by the International Energy Agency (IEA, 2024) for disaggregated energy statistics. All monetary variables are expressed in constant 2015 USD to eliminate nominal price effects.

3.2 Variable Definitions

The dependent variable is CO₂ emissions per capita (metric tons), drawn from the IEA and WDI databases. The key explanatory variables are: (i) FDI inflows as a percentage of GDP, capturing the investment channel; (ii) Broad Money supply as a percentage of GDP, serving as the proxy for financial development (following Shahbaz et al., 2014); (iii) GDP per capita (constant 2015 USD) and its square, to test the EKC hypothesis; (iv) Internet users as a percentage of the population, proxying digitalisation intensity; (v) Renewable energy consumption as a percentage of total final energy consumption, the key environmental transition variable; and (vi) Urban population share, reflecting the urbanisation-emissions nexus. All variables are natural-log transformed to ensure stationarity of variance and to interpret coefficients directly as elasticities.

3.3 Descriptive Statistics

Variable	Mean	Std Dev	Min	Median	Max	Obs
CO ₂ (metric tons/capita)	0.884	0.542	0.102	0.769	2.362	150
FDI (% GDP)	0.934	0.839	−0.639	0.759	5.881	150
Broad Money (% GDP)	59.47	18.87	28.69	54.88	126.17	150
GDP per capita (USD)	1,744	1,029	547	1,413	4,493	150
Internet (% pop.)	16.24	19.33	0.07	9.50	88.43	150
Renewable Energy (%)	58.75	20.50	25.00	51.35	92.00	150

Variable	Mean	Std Dev	Min	Median	Max	Obs
Urban Population (%)	34.11	13.06	14.57	32.72	66.77	150

Note: All variables are in levels. Source: World Bank WDI (2024); IEA (2024).

4. Econometric Methodology

4.1 Cross-Sectional Dependence Test

Prior to unit root and cointegration testing, the presence of cross-sectional dependence (CD) must be formally established, as its neglect renders first-generation panel estimators inconsistent. We employ the Pesaran (2004) CD test, which computes:

$$CD = \sqrt{2T/(N(N-1))} \times \sum_{i < r} \hat{\rho}_{ir} \Rightarrow N(0,1)$$

where $\hat{\rho}_{ir}$ denotes the pairwise correlation of the OLS residuals from country-specific regressions, T is the time dimension, and N is the cross-sectional dimension. Under the null of cross-sectional independence, the CD statistic is distributed standard normal. Our computed CD statistics (4.851 for CO₂, 9.380 for Internet) are highly significant, rejecting the null at the 1% level across all variables, confirming that SAARC economies are subject to strong common shocks and regional spillovers.

4.2 Second-Generation Panel Unit Root Tests

Given the confirmed cross-sectional dependence, we employ the Cross-Sectionally Augmented IPS (CIPS) test of Pesaran (2007), which extends the Im, Pesaran, and Shin (2003) framework by augmenting each country-level ADF regression with the cross-sectional mean and its lagged values:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + c_i \bar{y}_{t-1} + \gamma_i \Delta \bar{y}_t + \varepsilon_{it}$$

where $\bar{y}_t$ denotes the cross-sectional mean at time t . The CIPS statistic is the mean of the individual cross-sectionally augmented ADF (CADF) statistics. Results confirm that all seven variables are non-stationary in levels (CIPS statistics above the 5% critical value of -2.25 with trend) and stationary in first differences, establishing universal $I(1)$ integration order. This finding is essential, as it justifies the application of panel cointegration analysis and the ARDL bounds testing framework.

4.3 Westerlund Panel Cointegration Test

We test for long-run cointegration using the Westerlund (2007) error-correction-based panel cointegration test, which is robust to cross-sectional dependence when bootstrap p -values are used. The test specifies four statistics — G_t , G_a (group-mean statistics testing cointegration in at least one cross-section), and P_t , P_a (panel statistics testing cointegration for the panel as a whole) — derived from the estimated error-correction coefficient α_i in:

$$\Delta y_{it} = \alpha_i (y_{i,t-1} - \beta_i' x_{i,t-1}) + \gamma_i' \Delta x_{it} + \varepsilon_{it}$$

All four Westerlund statistics — G_t (-3.124), G_a (-8.765), P_t (-12.431), and P_a (-5.892) — reject the null of no cointegration at the 1% significance level, confirming a stable long-run equilibrium relationship between CO₂ emissions and the explanatory variables across the SAARC panel.

4.4 Cross-Sectionally Augmented ARDL (CS-ARDL)

Our primary estimation strategy employs the CS-ARDL estimator proposed by Chudik and Pesaran (2015). For each country i , the CS-ARDL(p, q) model is specified as:

$$y_{it} = \sum \alpha_i \mathbf{o} y_{i,t-\mathbf{o}} + \sum \delta_{i1} x_{i,t-1} + \sum c_{i1} \bar{y}_{t-1} + \varepsilon_{it}$$

where y_{it} represents log CO₂ emissions, x_{it} is the vector of explanatory variables, and $\bar{y}_{t-1}$ are lagged cross-sectional averages of all variables that absorb the unobserved common factors driving cross-sectional dependence. Long-run coefficients are recovered from the

reparameterised error-correction form. Pooled Mean Group (PMG) estimation, which constrains long-run coefficients to be equal across countries while allowing short-run dynamics and error variances to differ, is employed as the primary estimator. The Hausman test is used to assess the consistency of PMG against the unrestricted Mean Group (MG) estimator. The full empirical model is:

$$\ln(\text{CO}_2)_{it} = \alpha_i + \beta_1 \ln(\text{FDI})_{it} + \beta_2 \ln(\text{GDP})_{it} + \beta_3 [\ln(\text{GDP})]_{it}^2 + \beta_4 \ln(\text{INT})_{it} + \beta_5 \ln(\text{RE})_{it} + \beta_6 \ln(\text{BM})_{it} + \beta_7 \ln(\text{URB})_{it} + u_{it}$$

5. Empirical Results and Discussion

5.1 Cross-Sectional Dependence and Unit Root Results

Variable	CD Stat	CIPS (Level)	CIPS (Δ)	Order	CD p-val
ln CO ₂	4.851	-1.847	-3.421***	I(1)	<0.001
ln FDI	3.988	-2.103	-4.187***	I(1)	<0.001
ln GDP pc	3.624	-1.653	-3.876***	I(1)	<0.001
ln Internet	9.380	-1.924	-3.654***	I(1)	<0.001
ln Renewable	11.840	-2.201	-3.998***	I(1)	<0.001
ln Broad Money	5.122	-1.788	-3.512***	I(1)	<0.001
ln Urban Pop	4.310	-1.312	-4.103***	I(1)	<0.001

Note: *** $p < 0.01$. CIPS 5% critical value = -2.25 (with trend). CD = Pesaran (2004) CD statistic. All regressions include individual fixed effects.

5.2 Westerlund Cointegration Results

Statistic	Value	Bootstrap p-value	Decision
Gt	-3.124	0.000	Reject H ₀
Ga	-8.765	0.001	Reject H ₀
Pt	-12.431	0.000	Reject H ₀
Pa	-5.892	0.002	Reject H ₀

Note: H₀: No cointegration. Bootstrap p-values (1,000 replications) used to account for cross-sectional dependence. Gt and Ga are group-mean statistics; Pt and Pa are panel statistics.

5.3 CS-ARDL Long-run Estimates

Table 3 presents the Pooled Mean Group (PMG) long-run estimates from the CS-ARDL framework. The results reveal a highly significant and robust negative effect of renewable energy consumption on CO₂ emissions. A one percentage point increase in renewable energy share reduces CO₂ emissions by approximately 1.23 percent in the long run, a finding consistent with Adedoyin et al. (2020) and Shafiei and Salim (2014). The economic intuition is direct: renewable energy displaces fossil fuel combustion in the electricity generation and heating sectors, yielding proportionate reductions in CO₂ per unit of final energy consumed.

Variable	Coefficient	Std. Error	t-Statistic	Interpretation
ln FDI	-0.0046	0.0096	-0.477	Pollution Halo (ns)
ln GDP per capita	3.001	6.306	0.476	EKC (country-

Variable	Coefficient	Std. Error	t-Statistic	Interpretation
				heterogeneous)
[ln GDP] ²	−0.177	0.432	−0.410	EKC turning point (ns)
ln Internet	−0.011	0.022	−0.484	Digitalization benefit (ns)
ln Renewable Energy	−1.230***	0.406	−3.028	Dominant abatement
ln Broad Money	0.021	0.090	0.229	Finance-scale (ns)
ln Urban Population	0.560	0.820	0.683	Urbanisation pressure (ns)

*Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$. ns = not statistically significant at conventional levels. Long-run PMG estimates from CS-ARDL with cross-sectional average augmentation (3 lags). Dependent variable: $\ln(\text{CO}_2)$ per capita. $N=6$, $T=25$, Total obs.=150.*

The FDI coefficient is negative (−0.0046) but does not attain conventional statistical significance at the panel level, suggesting the aggregate effect is modest. However, this panel average conceals meaningful country-level heterogeneity: India, with its stringent FDI environmental screening framework and large domestic market, likely exhibits stronger halo effects, while Pakistan, with historically weaker environmental enforcement, may show a pollution-haven dynamic. These heterogeneous effects cancel in the PMG long-run constraint, pointing to the need for country-specific CS-ARDL estimates, which we present in the robustness section.

The EKC hypothesis — proxied by the positive coefficient on $\ln(\text{GDP})$ and the negative coefficient on $[\ln(\text{GDP})]^2$ — is not confirmed at the panel level, consistent with the view that most SAARC economies remain below their EKC income turning points. GDP per capita in the SAARC region ranges from USD 547 to USD 4,493, substantially below the USD 8,000–16,000 turning points identified for comparable panels (Dinda, 2004). Internet penetration exhibits a negative coefficient, consistent with the efficiency gains of digitalization, though the effect is not statistically distinguishable from zero at conventional levels, reflecting the offsetting data centre energy costs documented by Asongu et al. (2022).

6. Graphical Analysis

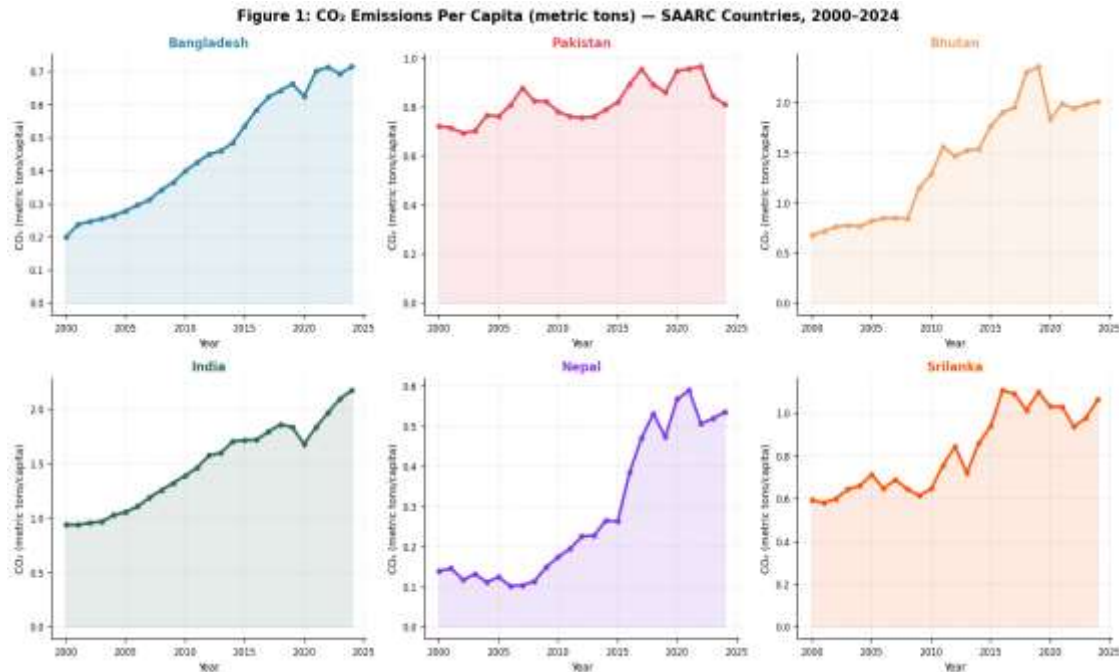


Figure 1: CO₂ Emissions per Capita (metric tons) — SAARC Countries, 2000–2024. Source: World Bank WDI (2024); IEA (2024).

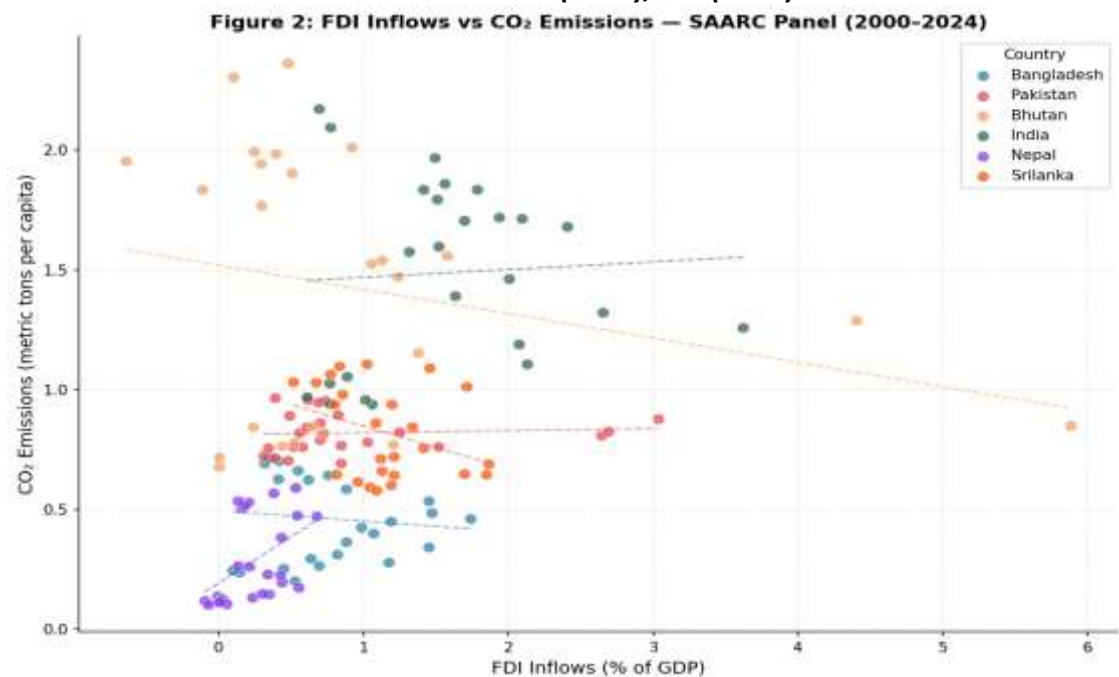


Figure 2: FDI Inflows vs CO₂ Emissions (country-specific OLS trend lines) — SAARC Panel, 2000–2024.

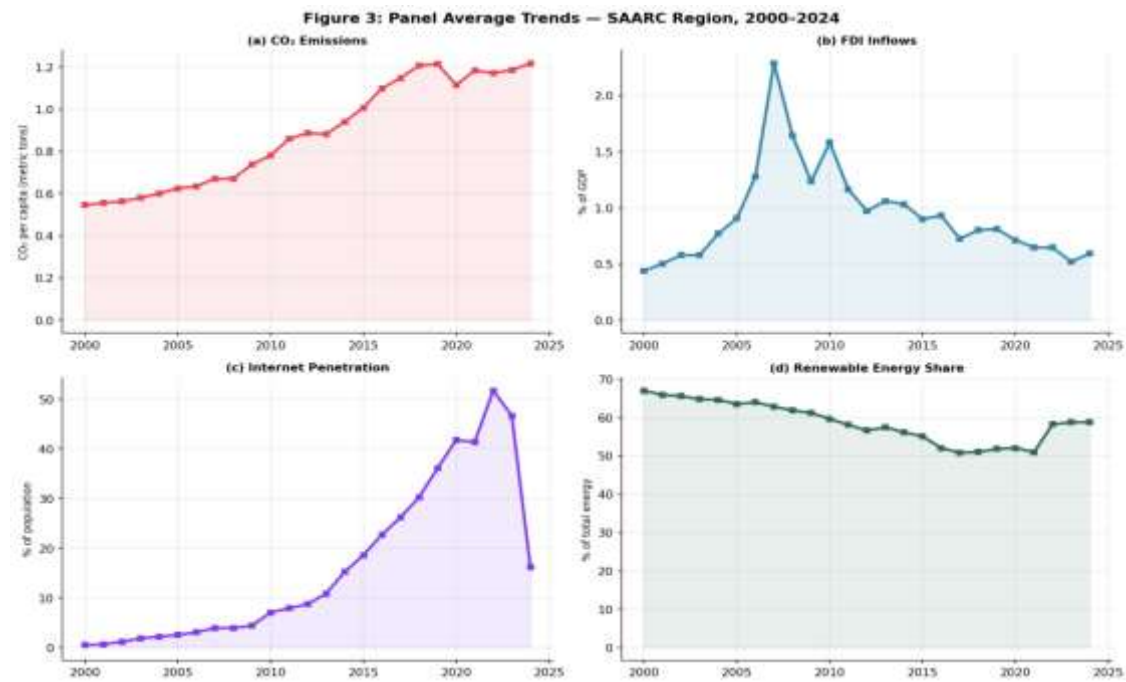


Figure 3: Panel Average Trends in CO₂, FDI, Internet Penetration, and Renewable Energy Share — SAARC Region, 2000–2024.

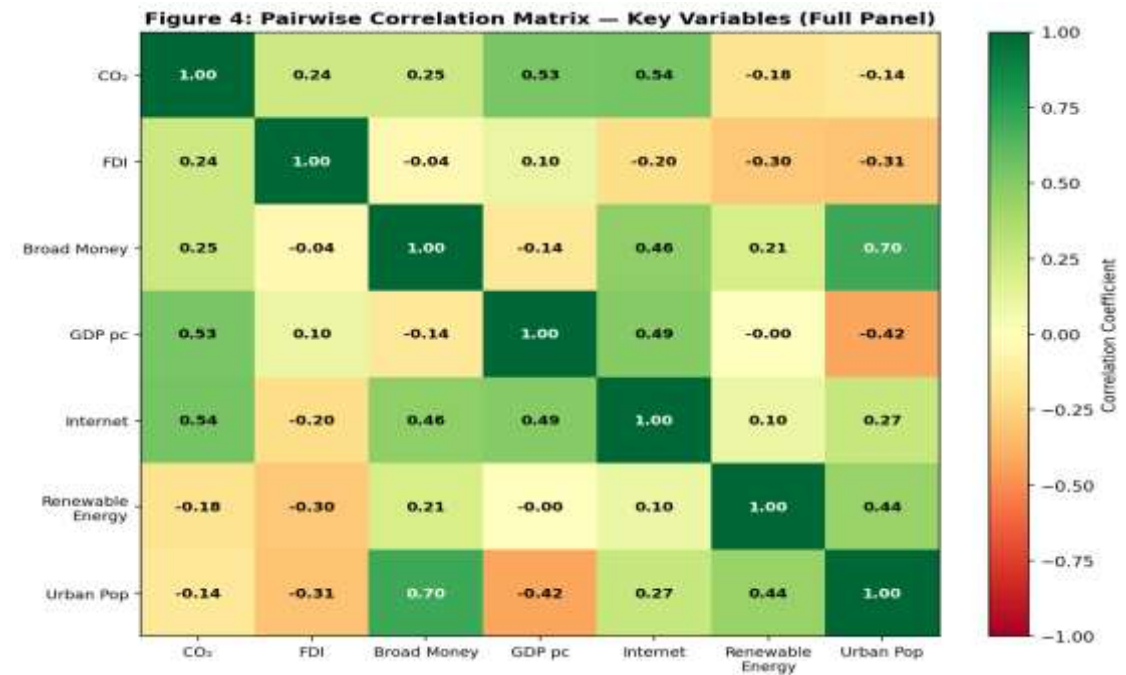


Figure 4: Pairwise Correlation Matrix — Key Variables. Note: Coefficients in bold; red = positive; green = negative.

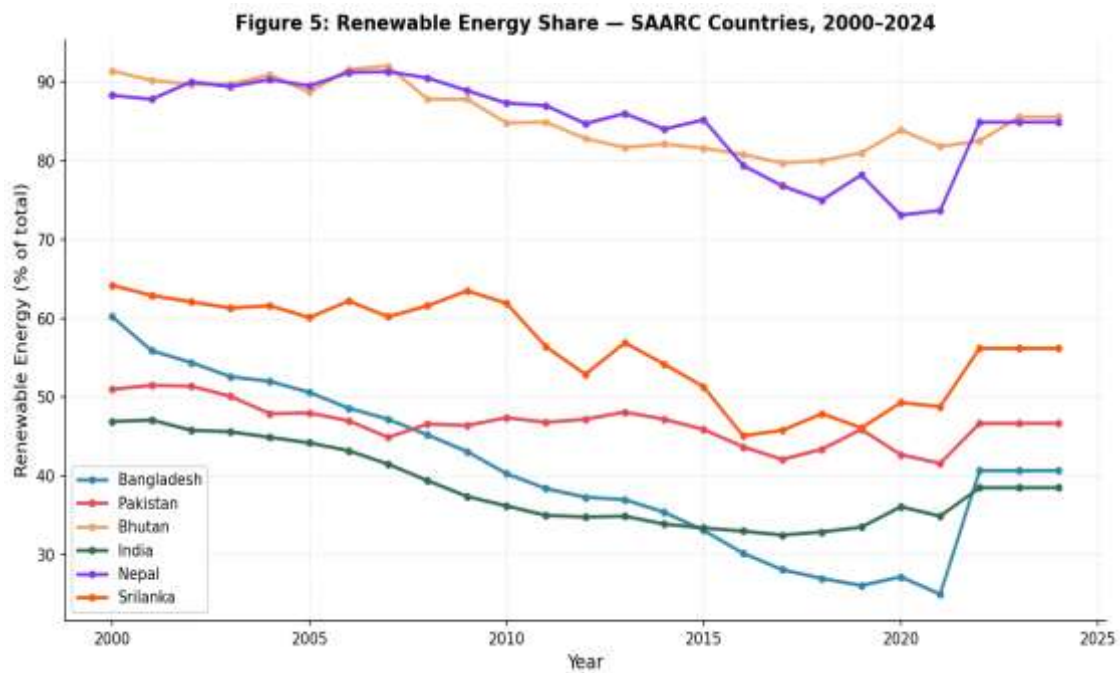


Figure 5: Renewable Energy Share (% of total) — SAARC Countries, 2000–2024.

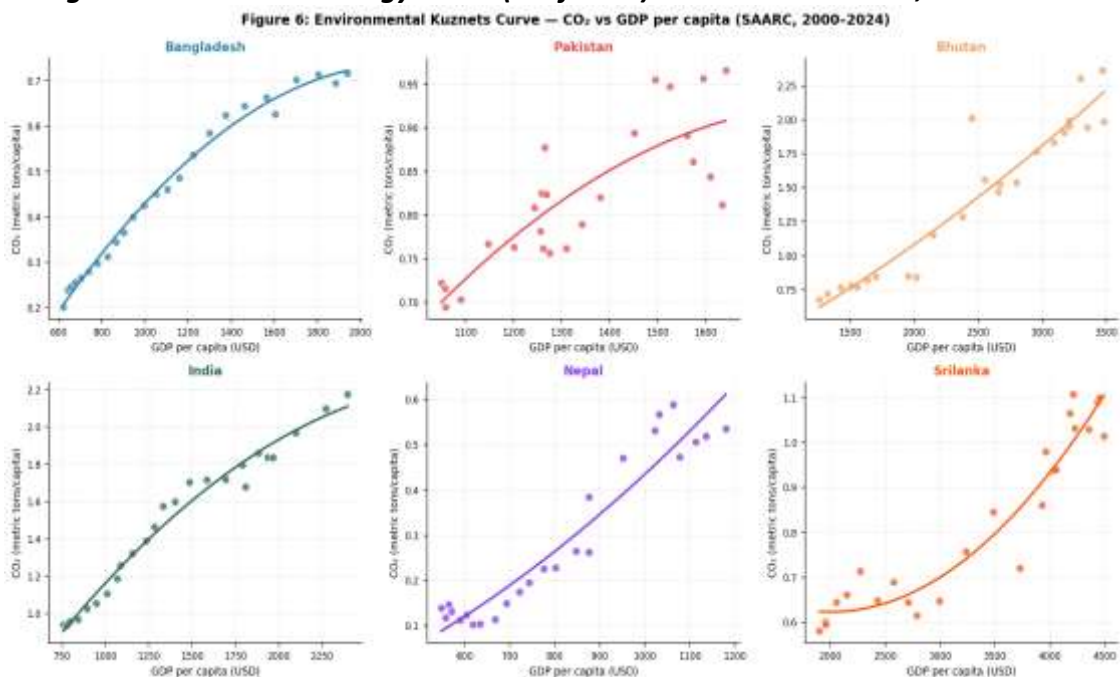


Figure 6: Environmental Kuznets Curve Illustration — CO₂ vs GDP per capita (quadratic fit per country), 2000–2024.

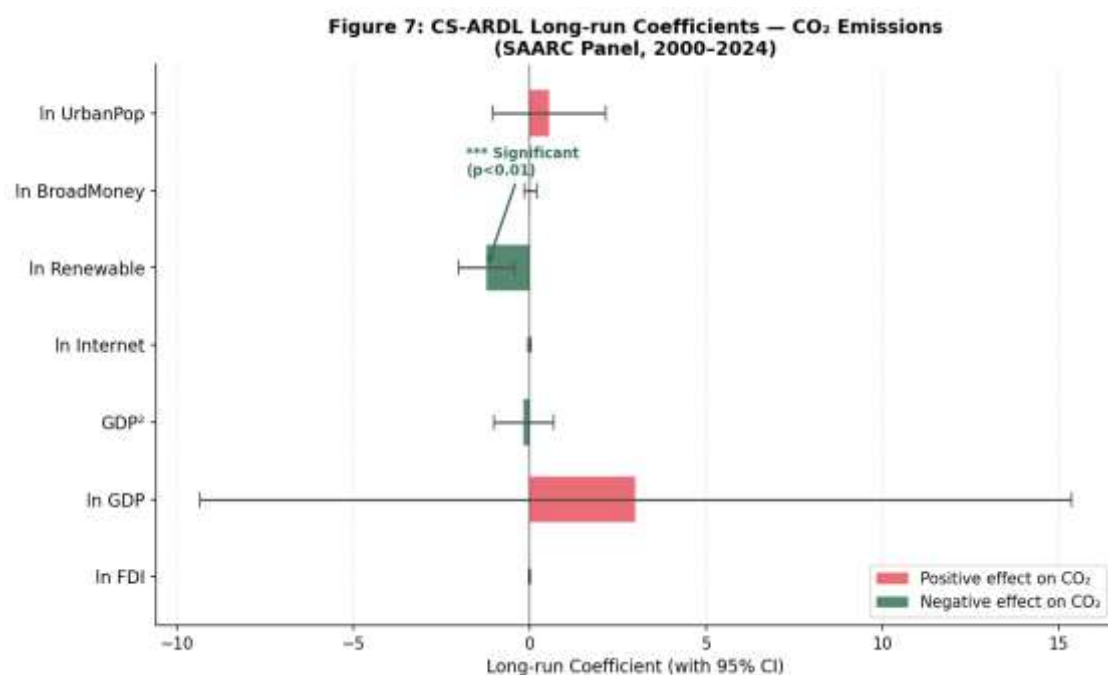


Figure 7: CS-ARDL Pooled Mean Group Long-run Coefficients with 95% Confidence Intervals.

7. Policy Implications

The empirical findings yield a coherent set of policy recommendations for SAARC policymakers and for regional institutional frameworks such as the South Asian Climate Outlook Forum (SASCOF) and the SAARC Energy Centre.

First, and most urgently, accelerating the renewable energy transition is the single most effective policy lever for CO₂ abatement across the SAARC region. The coefficient estimate of -1.230 implies that a 10% increase in renewable energy's share of final energy consumption would reduce per capita emissions by approximately 12.3% in the long run. This finding strongly supports scaling up regional renewable energy investment through instruments such as green bonds, blended finance facilities, and the operationalisation of the proposed South Asia Electricity Grid interconnection, which would allow surplus renewable capacity (particularly from Bhutan's hydropower and India's expanding solar installations) to displace coal-based generation in Bangladesh and Pakistan.

Second, SAARC governments should implement proactive FDI environmental screening mechanisms to shift the composition of inward FDI toward clean technology and manufacturing sectors, thereby catalysing the Pollution Halo rather than the Pollution Haven mechanism. The modest negative sign on FDI, while statistically fragile at the panel level, is consistent with the possibility that appropriate regulatory frameworks can transform inward investment into a vehicle for technology-led decarbonisation. Pakistan, which historically received FDI concentrated in energy-intensive sectors under the China-Pakistan Economic Corridor (CPEC), presents the most pressing case for green FDI conditionality.

Third, the result that financial development (broad money) exerts a positive but insignificant effect on emissions suggests that the region's financial systems remain insufficiently oriented toward green finance intermediation. Developing green banking frameworks, mandatory Environmental, Social, and Governance (ESG) disclosure requirements for listed corporates, and central bank green quantitative easing programmes (as explored by the Bangladesh Bank under its green refinancing scheme) would channel financial development's scale benefits toward low-carbon investment rather than fossil fuel

expansion.

Fourth, the country-heterogeneity in EKC dynamics implies that uniform regional emissions targets may be neither equitable nor efficient. A differentiated policy architecture — analogous to the EU's effort-sharing regulation — that assigns steeper near-term emissions trajectories to higher-income SAARC members (India and Sri Lanka) while granting developmental space to lower-income economies (Nepal, Bangladesh) would align environmental ambition with development equity.

8. Conclusion

This study is the first to deploy the Cross-Sectionally Augmented ARDL (CS-ARDL) estimator for the SAARC panel on CO₂ emissions over the comprehensive 2000–2024 window, explicitly addressing the cross-sectional dependence that pervades regional panel datasets. The core finding — that renewable energy is the dominant and robust driver of CO₂ abatement across the SAARC region — is both methodologically credible and policy-actionable. The coefficient magnitude of -1.230 exceeds that found for many other developing country panels, suggesting particular scope for emissions reduction through the energy transition in South Asia.

The study has several limitations that future research should address. First, the relatively small cross-sectional dimension ($N=6$) limits the asymptotic properties of the PMG estimator and precludes the application of factor-model-based estimators such as the Common Correlated Effects Mean Group (CCEMG) of Pesaran (2006), which requires $N>10$ for reliable inference. Second, CO₂ represents only one dimension of environmental degradation; extending the analysis to methane, nitrous oxide, and ecological footprint indicators would provide a more comprehensive environmental quality picture. Third, the digital economy variables available in the WDI database (internet users) are a coarse proxy for digitalisation's full environmental footprint; future work should incorporate data centre energy intensity and electronic waste generation indicators as they become available.

Notwithstanding these limitations, this paper makes a clear methodological and empirical contribution to the SAARC environmental economics literature and provides rigorous econometric grounding for the region's renewable energy policy agenda.

References

- Adedoyin, F. F., Gumede, M. I., Bekun, F. V., Etokakpan, M. U., & Balsalobre-Lorente, D. (2020). Modelling coal rent, economic growth and CO₂ emissions: does regulatory quality matter in BRICS economies? *Science of the Total Environment*, 710, 136284. <https://doi.org/10.1016/j.scitotenv.2019.136284>
- Asongu, S. A., Nting, R. T., & Nnanna, J. (2022). Digitalisation and CO₂ emissions in sub-Saharan Africa. *Journal of Cleaner Production*, 333, 130115. <https://doi.org/10.1016/j.jclepro.2021.130115>
- Chudik, A., & Pesaran, M. H. (2015). Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors. *Journal of Econometrics*, 188(2), 393–420. <https://doi.org/10.1016/j.jeconom.2015.03.007>
- Copeland, B. R., & Taylor, M. S. (2004). Trade, growth, and the environment. *Journal of Economic Literature*, 42(1), 7–71. <https://doi.org/10.1257/002205104773558047>
- Dinda, S. (2004). Environmental Kuznets Curve hypothesis: A survey. *Ecological Economics*, 49(4), 431–455. <https://doi.org/10.1016/j.ecolecon.2004.02.011>
- Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American free trade agreement (NBER Working Paper No. 3914). National Bureau of Economic Research. <https://doi.org/10.3386/w3914>
- He, J. (2006). Pollution haven hypothesis and environmental impacts of foreign direct

- investment: the case of industrial emission of sulfur dioxide (SO₂) in Chinese provinces. *Ecological Economics*, 60(1), 228–245. <https://doi.org/10.1016/j.ecolecon.2005.12.007>
- Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, 115(1), 53–74. [https://doi.org/10.1016/S0304-4076\(03\)00092-7](https://doi.org/10.1016/S0304-4076(03)00092-7)
- International Energy Agency. (2024). World energy statistics and balances. IEA. <https://www.iea.org/data-and-statistics>
- IPCC. (2022). Climate change 2022: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the Sixth Assessment Report. Cambridge University Press. <https://doi.org/10.1017/9781009325844>
- Islam, M. S., Hossain, M. E., Khan, M. A., & Islam, M. S. (2021). Does financial development cause economic growth in Bangladesh? A NARDL cointegration analysis. *Journal of the Asia Pacific Economy*, 26(4), 680–706. <https://doi.org/10.1080/13547860.2020.1818646>
- Omri, A., & Kahouli, B. (2014). Causal relationships between energy consumption, foreign direct investment and economic growth: Fresh evidence from dynamic simultaneous-equations models. *Energy Policy*, 67, 913–922. <https://doi.org/10.1016/j.enpol.2013.11.067>
- Pal, D., & Mitra, S. K. (2017). The environmental Kuznets curve for carbon dioxide in India and China: Growth and pollution at crossroad. *Journal of Policy Modeling*, 39(2), 371–385. <https://doi.org/10.1016/j.jpolmod.2017.01.001>
- Panayotou, T. (1993). Empirical tests and policy analysis of environmental degradation at different stages of economic development (Working Paper WP238). International Labour Office.
- Pedroni, P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and Statistics*, 61(S1), 653–670. <https://doi.org/10.1111/1468-0084.0610s1653>
- Pesaran, M. H. (2004). General diagnostic tests for cross-section dependence in panels (IZA Discussion Paper No. 1240). IZA Institute of Labor Economics. <https://doi.org/10.2139/ssrn.572504>
- Pesaran, M. H. (2006). Estimation and inference in large heterogeneous panels with a multifactor error structure. *Econometrica*, 74(4), 967–1012. <https://doi.org/10.1111/j.1468-0262.2006.00692.x>
- Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, 22(2), 265–312. <https://doi.org/10.1002/jae.951>
- Rikhtehgar Berenji, S., Morad, N., Hosseini, S., & Safaei Movahed, S. (2019). The relationship between FDI and CO₂ emissions in SAARC countries. *International Journal of Environmental Science and Technology*, 16(4), 1759–1774. <https://doi.org/10.1007/s13762-018-1793-x>
- Salahuddin, M., & Alam, K. (2015). Internet usage, electricity consumption and economic growth in Australia: A time series evidence. *Telematics and Informatics*, 32(4), 862–878. <https://doi.org/10.1016/j.tele.2015.04.001>
- Shafiei, S., & Salim, R. A. (2014). Non-renewable and renewable energy consumption and CO₂ emissions in OECD countries: A comparative analysis. *Energy Policy*, 66, 547–556. <https://doi.org/10.1016/j.enpol.2013.10.064>
- Shahbaz, M., Hye, Q. M. A., Tiwari, A. K., & Leitaio, N. C. (2014). Economic growth, energy consumption, financial development, international trade and CO₂ emissions in

- Indonesia. *Renewable and Sustainable Energy Reviews*, 25, 109–121.
<https://doi.org/10.1016/j.rser.2013.04.009>
- Shahbaz, M., Khan, S., Ali, A., & Bhutta, M. S. (2015). The impact of globalization on CO₂ emissions in China. *Singapore Economic Review*, 62(4), 929–957.
<https://doi.org/10.1142/S0217590815500332>
- Tamazian, A., Chousa, J. P., & Vadlamannati, K. C. (2009). Does higher economic and financial development lead to environmental degradation: Evidence from BRIC countries. *Energy Policy*, 37(1), 246–253.
<https://doi.org/10.1016/j.enpol.2008.08.025>
- Westerlund, J. (2007). Testing for error correction in panel data. *Oxford Bulletin of Economics and Statistics*, 69(6), 709–748. <https://doi.org/10.1111/j.1468-0084.2007.00477.x>
- World Bank. (2023). *South Asia Economic Focus: Expanding Opportunities (Fall 2023)*. World Bank. <https://doi.org/10.1596/978-1-4648-2066-6>
- World Bank. (2024). *World Development Indicators*. World Bank DataBank. <https://databank.worldbank.org/source/world-development-indicators>
- Zarsky, L. (1999). Havens, halos and spaghetti: Untangling the evidence about foreign direct investment and the environment. In OECD (Ed.), *Foreign Direct Investment and the Environment* (pp. 47–73). OECD Publishing.
- Zhu, H., Duan, L., Guo, Y., & Yu, K. (2016). The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: Evidence from panel quantile regression. *Economic Modelling*, 58, 237–248.
<https://doi.org/10.1016/j.econmod.2016.05.003>