# “Carbon dioxide emissions, forest area, and economic growth of SAARC countries: Evidence from FMOLS approach”


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| **ARTICLE INFO** | Yadav Mani Upadhyaya, Khom Raj Kharel, Omkar Paudel and Pramshu Nepal (2025). Carbon dioxide emissions, forest area, and economic growth of SAARC countries: Evidence from FMOLS approach . *Environmental Economics*, *16*(1), 13-29. doi:10.21511/ee.16(1).2025.02 |
| **DOI** | http://dx.doi.org/10.21511/ee.16(1).2025.02 |
| **RELEASED ON** | Tuesday, 07 January 2025 |
| **RECEIVED ON** | Friday, 20 September 2024 |
| **ACCEPTED ON** | Friday, 27 December 2024 |
| **LICENSE** | This work is licensed under a Creative Commons Attribution 4.0 International License |
| **JOURNAL** | "Environmental Economics" |
| **ISSN PRINT** | 1998-6041 |
| **ISSN ONLINE** | 1998-605X |
| **PUBLISHER** | LLC “Consulting Publishing Company “Business Perspectives” |
| **FOUNDER** | LLC “Consulting Publishing Company “Business Perspectives” |


| NUMBER OF REFERENCES | NUMBER OF FIGURES | NUMBER OF TABLES |
|---|---|---|
| 50 | 0 | 7 |

BUSINESS PERSPECTIVES

LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10,
Sumy, 40022, Ukraine
www.businessperspectives.org

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# CARBON DIOXIDE EMISSIONS, FOREST AREA, AND ECONOMIC GROWTH OF SAARC COUNTRIES: EVIDENCE FROM FMOLS APPROACH


## Abstract

This study aims to examine the relationship between CO2 emissions, forest area, and GDP in each South Asian Association for Regional Cooperation (SAARC) country. This study uses a panel dataset that spans South Asian countries from 1990 to 2020 for econometric analysis. The Fully Modified Least Squares (FMOLS) method adds annual forested area to the regression model. The study results show that India, Nepal, Pakistan, and Sri Lanka must prioritize decoupling CO2 emissions from economic growth, as their strong correlation shows significant environmental costs of development. Although Bangladesh, Bhutan, and the Maldives are in a slightly better position, they need strategies to manage emissions as they progress economically. The study once again revealed a relationship between a 1% increase in GDP and a 0.68% rise in CO2 emissions, whereas a 1% increase in forest area led to a slightly higher 0.79% rise in CO2 over the period. The hypotheses testing results confirm a positive correlation between economic growth and carbon dioxide emissions in SAARC countries, indicating that emissions rise as economies expand. Additionally, a negative relationship was found between forest area and carbon dioxide emissions, where larger forest coverage is linked to lower emissions. The conclusion is that an increase in forest area is associated with a relatively small increase in CO2 emissions, indicating that the relationship between forest area and CO2 emissions is less pronounced compared to GDP.


**Received on:** 20th of September, 2024
**Accepted on:** 27th of December, 2024
**Published on:** 7th of January, 2025



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**Keywords** carbon emissions, economic growth, environmental sustainability, forest area, forest preservation, green practices, renewable energy

**JEL Classification** Q56, Q54, O13, O53

## INTRODUCTION

The relationship between carbon dioxide (CO2) emissions, forest area, and economic growth has gained substantial attention over recent decades, particularly within the context of the South Asian Association for Regional Cooperation (SAARC) countries. SAARC, comprising Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka, is a region characterized by rapid economic growth, diverse ecological zones, and significant environmental challenges. The SAARC region is one of the most diverse in terms of natural resources and environmental conditions. The region has about 15% of the world's forest area (about 200 million hectares), which accounts for about 5% of the world's carbon stock (about 30 gigatons) (Nesha et al., 2021).

Additionally, the region contributes about 9% of the world's CO2 emissions (2.4 gigatons), primarily due to land use change and fossil fuel combustion (Pan et al., 2022). Rahman et al. (2022) revealed that among SAARC countries, India recorded the highest household emis-



**Conflict of interest statement:**
Author(s) reported no conflict of interest

sions, reaching 37.27%, while Nepal had the lowest at 0.61%. Regarding total imported emissions, India and Bangladesh led the way with 16.88 Gt $CO_2$ and 15.90 Gt $CO_2$, respectively. The SAARC region is home to about 1.9 billion people (about 25% of the world population). It has a combined gross domestic product (GDP) of about $3.5 trillion (about 4% of the world's GDP) (FAO, 2020).

The intricate relationship between $CO_2$ emissions, forest area, and economic growth in the SAARC region necessitates a complex approach. Policymakers must balance economic aspirations with environmental stewardship, leveraging institutional quality, technological advancements, and sustainable practices to foster a resilient and low-carbon future.

# 1. LITERATURE REVIEW AND HYPOTHESES

Regarding the GDP-$CO_2$ emissions relationship, Sadiq et al. (2023) provided a nuanced view, indicating both negative and positive effects and highlighting their complexity. They also mentioned a feedback effect between economic growth and energy usage. Nathaniel et al. (2021) observed that economic growth initially raised $CO_2$ emissions during early industrialization. Saboori et al. (2012) emphasized the emission-reducing potential of nuclear energy, underscoring the significance of energy choices.

Empirical evidence frequently suggests a complex, bidirectional relationship between economic growth and $CO_2$ emissions (Ozcan, 2013). For instance, studies have shown that economic expansion typically leads to increased energy consumption and industrial activities, thereby escalating $CO_2$ emissions (Dar & Asif, 2020). However, Chary and Bohara (2010) claim that this relationship is also influenced by the quality of institutions and governance, which can mitigate adverse environmental impacts by implementing effective regulations and promoting cleaner technologies (Mehmood, 2021).

Regarding the EKC hypothesis's universal applicability, Le and Quah (2018) challenged it by demonstrating that it does not hold in some Asian countries. Ozcan (2013) expanded on this discussion, stressing the importance of nuanced, country-specific analysis and considering regional characteristics and unique factors when examining the connection between economic growth and emissions. Regarding deforestation, Van der Werf et al. (2009) and Mason et al. (2012) emphasized its central role in carbon emissions, second only to fossil fuel combustion. They stressed the importance of addressing this issue. They also noted tropical peatlands as significant emission sources. Houghton (2012) and Parajuli et al. (2019) highlighted agriculture's central role in driving deforestation for permanent or shifting practices, emphasizing the need to address land-related emissions in agriculturally dominant regions.

In carbon emissions, Raihan et al. (2023) analyzed factors impacting and illuminated the intricate connection between economic development and emissions. Bhuiyan et al. (2023) underscored China's shift to green energy sources for lasting emissions reduction. P. Narayan and S. Narayan (2010) observed that in some developing countries, income growth could lead to decreased carbon emissions, aligning with the Environmental Kuznets Curve concept. Narayan et al. (2016) suggest that as an economy grows, environmental degradation initially worsens until a certain income level is reached, after which it improves (Mehmood, 2021).

Regarding fossil fuels and pollution, Voumik et al. (2023) emphasize promoting renewable and nuclear energy in SAARC for long-term pollution reduction. Magazzino (2016), in GCC countries, connects economic growth to $CO_2$ emissions and suggests reduction through targeted policies. Raihan and Tuspekova (2022) emphasize sustainable development in Nepal through renewable energy and economic growth management. Bastola and Sapkota (2015) address Nepal's energy and climate challenges, proposing a sustainable path that balances growth, energy conservation, and emission reduction for environmental sustainability.

Considering fossil fuel consumption and energy use, Ozturk et al. (2010) find significant long-run



http://dx.doi.org/10.21511/ee.16(1).2025.02

and short-run relationships. According to Taher (2024), in the long run, fossil fuel consumption and energy use are positively linked to carbon emissions, while population growth and economic progress have adverse effects. Similarly, Liao and Cao (2013) discovered that fossil fuel consumption and energy use positively impact emissions in the short run, while population growth and economic progress negatively influence them (Jahanger et al., 2023). Causality tests confirm one-way links among these variables, suggesting the need for measures to reduce CO2 emissions to combat air pollution (Regmi & Rehman, 2021).

In specific regions, emphasizing its complexity, Maddison and Rehdanz (2008) found no clear CO2-GDP link. Costantini and Martini (2010) showed that energy-GDP causality varies by country, dependent on circumstances and policies. Apergis and Payne (2010) identified a two-way energy-CO2 link in the long term, emphasizing their interplay. Munir et al. (2020) highlighted regional factors in ASEAN-5's relationship between CO2, energy, and economic growth. Acaravci and Ozturk (2010) confirmed the Environmental Kuznets Curve in some European nations, where emissions initially rise with growth before declining, though this varies, necessitating tailored analyses.

In MENA countries, Farhani and Rejeb (2012) emphasized causal relationships among economic growth, energy consumption, and CO2 emissions, with evolving policy implications. Ocal and Aslan (2013) found bidirectional causality between energy consumption and economic growth in the US. Adhikari and Chen (2012) revealed energy's role in driving growth in developing countries with income-specific policy implications. Dahmardeh et al. (2012) identified bidirectional causality between energy consumption and economic growth. Eggoh et al. (2011) uncovered a reciprocal relationship between energy consumption and economic growth across country groups, highlighting complex interplay.

Islam et al. (2017) demonstrated that forested areas can significantly reduce CO2 emissions, underscoring the importance of afforestation and reforestation initiatives. In this context, policies that strive to conserve forest areas and promote sustainable land management are critical for achieving long-term environmental and economic goals (Vidyarthi, 2013). Factors such as household consumption, energy mix, and industrial policies further complicate the dynamics of CO2 emissions in the SAARC region. Focusing on consumption-based emissions, Osobajo et al. (2020) revealed that household consumption significantly contributes to CO2 emissions, highlighting the need for policies targeting sustainable consumption practices (Rahman et al., 2022).

Forested areas are critical in mitigating CO2 emissions because they act as carbon sinks. Begum et al. (2015) analyzed that the deforestation and land-use changes, however, have led to significant reductions in forest cover in many SAARC countries, exacerbating CO2 emissions and undermining environmental sustainability (Wawrzyniak & Doryń, 2020). Additionally, the relationship between energy consumption and CO2 emissions is evident, with energy use being a major driver of emissions across the region (Ghosh et al., 2014). According to Begum et al. (2020), the interplay between economic growth and energy consumption suggests that SAARC countries face the dual challenge of sustaining economic development while managing environmental impacts.

The objective of this study is to examine the relationship between economic growth and CO2 emissions for each country of SAARC and conduct a panel data analysis of the relationship between economic growth and CO2 emissions with forest resources. The study tests the hypotheses as follows:

*H1:* *In SAARC countries, a positive relationship exists between economic growth and carbon dioxide emissions, indicating that higher economic growth leads to increased carbon dioxide emissions.*

*H2:* *There is a negative relationship between forest area and carbon dioxide emissions in SAARC countries, suggesting that a larger forest area is associated with lower carbon dioxide emissions due to the role of forests in carbon sequestration.*

## 2. METHODOLOGY

Based on the World Development Indicator (WDI) dataset, South Asian countries' panel data from 1990 to 2020 were used (Appendix A). Since Grossman and Krueger (1991) contend that a non-monotonic relationship exists between economic growth and CO2 emissions, GDP is considered in this theoretical framework. For CO2 emissions, forests perform a crucial dual role. Forests and their tree biomass absorb and store carbon dioxide from the atmosphere, a process known as carbon sequestration, whereas deforestation and tree cutting release CO2 into the atmosphere.

For analyzing the relationship between GDP and CO2 emissions across countries like Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka, a combination of econometric modeling has been employed. Regression analysis, including Ordinary Least Squares (OLS), can quantify the relationship and its strength. Together, this method provides a comprehensive understanding of how GDP growth influences CO2 emissions across different nations.

$$CO_{2_{it}} = \alpha + \beta \cdot GDP_{it} + \varepsilon_{it}, \tag{1}$$

where $CO_{2it}$ is the $CO_2$ emissions for country ($i$) at time ($t$); $GDP_{it}$ is the $GDP$ for country ($i$) at time ($t$); α is the intercept term; $\beta$ is the coefficient for GDP and $\varepsilon_{it}$ is the error term.

This study employs econometric analysis to establish a causal link between deforestation and the CO2 emissions that South Asian nations contribute to. So, one of the regressors in this study is an annual forested area (Begum et al., 2020). The normal asymptotic distribution of the DOLS estimators and their standard deviations offer a reliable test for the variables' statistical significance (Wang & Wu, 2012). Estimating the dependent variable (CO2 emissions, in kt) based on the explanatory variables (annual forested area, in sq. km.) and GDP, in current US dollars, in levels, is the first step. When there is a mixed order of integration, like with lags, the DOLS method can include each variable in the cointegrated outline.

Equation for unit root testing:

$$\Delta Y_t = \alpha + \beta Y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta Y_{t-i} + \varepsilon_t \tag{2}$$

where $\Delta Y_t$ is the first difference of the variable ($Y_t$); α is a constant term; $\beta$ is the coefficient of the lagged level of the variable; $\gamma$ are the coefficients of the lagged differences of the variable and $\varepsilon_t$ is the error term.

Equation for Granger causality testing:

$$\ln CO2_{it} = \alpha_0 + \sum_{j=1}^{p} \beta_j \ln CO2_{i,t-j} + \sum_{k=1}^{q} \gamma_k LGDP_{i,t-k} + \sum_{l=1}^{r} \delta_l LFA_{i,t-l} + \varepsilon_{it}, \tag{3}$$

$$LGDP_{it} = \alpha_1 + \sum_{j=1}^{p} \beta_j LGDP_{i,t-j} + \sum_{k=1}^{q} \gamma_k \ln CO2_{i,t-k} + \sum_{l=1}^{r} \delta_l LFA_{i,t-l} + \nu_{it}, \tag{4}$$

$$LFA_{it} = \alpha_2 + \sum_{j=1}^{p} \beta_j LFA_{i,t-j} + \sum_{k=1}^{q} \gamma_k \ln CO2_{i,t-k} + \sum_{l=1}^{r} \delta_l LGDP_{i,t-l} + \eta_{it}, \tag{5}$$

where $\ln CO2_{it}$, $LGDP_{it}$ and $LFA_{it}$ are the variables of interest; $\alpha_0$, $\alpha_1$, $\alpha_2$ are constants; $\beta_j$, $\gamma_k$, $\delta_l$ are coefficients of the lagged values of the respective variables and $\varepsilon_{it}$, $\nu_{it}$, $\eta_{it}$ are error terms.

According to Grossman and Krueger (1995), the following model can take into account the nonlinear relationship between carbon emissions, forest area and GDP:

$$\ln CO2_{it} = \beta_0 + \beta_1 LCO2_{it} + \beta_2 LGDP_{it} + \beta_3 LFA_{it} + \alpha_i + \varepsilon_{it}, \tag{6}$$

where $\ln CO2_{it}$ = The logarithm of CO2 emissions for the $i^{th}$ country at time $t$, $LCO2_{it}$ = The lagged value of the $i^{th}$ country's $CO_2$ emissions at time $t$, $LFA_{it}$ = The lagged value of a variable forest area for the $i^{th}$ country at time $t$, $LGDP_{it}$ = The lagged value of GDP for the $i^{th}$ country at time $t$, $\alpha_i$ = $i^{th}$ country's unit-specific fixed effect, $\varepsilon_{it}$ = error term, $\beta_0$, $\beta_1$, and $\beta_2$ are the coefficients.


http://dx.doi.org/10.21511/ee.16(1).2025.02

Panel Dynamic Least Squares (DOLS) equation:

$$\ln CO2_{it} = \alpha_i + \beta_1 LGDP_{it} + \beta_2 LFA_{it} + \sum_{j=-q}^{q} \gamma_j \Delta LGDP_{i,t-j} + \sum_{k=-r}^{r} \delta_k \Delta LFA_{i,t-k} + \varepsilon_{it}, \quad (7)$$

where $\ln CO2_{it}$ is the natural logarithm of CO2 emissions for country ($i$) at time ($t$); $LGDP_{it}$ is the natural logarithm of GDP for country ($i$) at time ($t$); $LFA_{it}$ is the natural logarithm of forest area for country ($i$) at time ($t$); $\alpha_i$ is the country-specific intercept; $\beta_1$ and $\beta_2$ are the long-run coefficients for GDP and forest area, respectively; $\Delta LGDP_{i,t-j}$ and $\Delta LFA_{i,t-k}$ are the leads and lags of the first differences of GDP and forest area; $\gamma_j$ and $\delta_k$ are the coefficients of the leads and lags and $\varepsilon_{it}$ is the error term.

Due to the accumulation of leads and lags among the explanatory variables, this estimator consequently gives solutions to the problems of small sample bias, endogeneity, and autocorrelation (Stock & Watson, 1993). The following equation is finally estimated by this study:

$$\Delta \ln CO2 = \beta_0 + \beta_1 \ln CO2_{t-1} + \beta_2 LGDP_{t-1} + \beta_3 LFA_{t-1} + \sum_{i=1}^{p} \gamma_i \ln CO2_{t-i} + \sum_{j=1}^{q} \delta_j \Delta GDP_{t-j} + \sum_{k=1}^{q} \phi_k \Delta FA_{t-k} + \varepsilon_t. \quad (8)$$

The long-run elasticities of the explanatory variables, such as carbon emissions, GDP, and forested area, are indicated by the coefficients ($\beta_1$, $\beta_2$, and $\beta_3$), respectively. The coefficients ($\beta_1$, $\beta_2$, and $\beta_3$) denote the long-run elasticities of the explanatory variables such as carbon emissions, GDP, and forested area, respectively.

## 3. RESULTS

The relationship between GDP and CO2 emissions is a crucial aspect of understanding how economic growth impacts environmental sustainability across different countries. Typically, statistical analyses explore this relationship by measuring the strength and nature of the correlation between a country's economic output (GDP) and its carbon dioxide emissions. In some countries, a perfect linear correlation indicates that economic growth directly drives emissions, while in others, the correlation is strong but with some variability, suggesting additional influencing factors. By examining this relationship, one can gain insights into how different economies contribute to global emissions and the effectiveness of their environmental policies, highlighting the need for tailored strategies to balance economic development with ecological sustainability.

Table 1 shows that the statistical results from the scatter plot of GDP vs. CO2 emissions for Bangladesh indicate a strong positive correlation, with a correlation coefficient of 0.9751. This suggests that as Bangladesh's GDP increases, CO2 emissions also rise. The slope of 0.00000027846 implies a tiny rate of change in CO2 emissions per unit increase in GDP. When GDP is zero, the intercept is 10,860.95, which represents the estimated CO2 emissions. The high $R$-squared value of 0.9508 indicates that GDP accounts for 95% of the variability in CO2 emissions, and the extremely low $P$-value (0.00000000014841) confirms the statistical significance of the relationship.

The statistical results from the scatter plot of GDP vs. CO2 emissions for Bhutan show a strong positive correlation, with a correlation coefficient of 0.9273. This indicates that CO2 emissions tend to increase as GDP grows. The slope of 0.00000053233 suggests a small but positive rate of change in CO2 emissions with each unit increase in GDP. When GDP is zero, the intercept is 212.73, which represents the estimated baseline level of CO2 emissions. GDP can explain about 86% of the variability in CO2 emissions, according to the $R$-squared value of 0.8599, and the low $P$-value (0.0000018170) confirms the statistical significance of this relationship.

The statistical results for India reveal a perfect positive correlation between GDP and CO2 emissions, with a correlation coefficient of 1.0. This indicates that as India's GDP increases, CO2 emissions rise in perfect synchronization. The slope of 0.000001 suggests a direct relationship in which CO2 emissions increase at a fixed rate per unit of GDP. The intercept, at 0.00000000011642, is practically negligible, meaning that emissions would be nearly zero if

**Table 1.** Country's GDP and CO2 emissions relationship

| Country | Correlation Coefficient | Slope | Intercept | $R^2$ Value | P-value | Comments |
|---|---|---|---|---|---|---|
| Bangladesh | 0.97 | 0.00 | 10,860.95 | 0.95 | 0.00 | Strong positive correlation. GDP accounts for 95% of variability in CO2 emissions, a highly significant relationship |
| Bhutan | 0.92 | 0.00 | 212.73 | 0.85 | 0.00 | Strong positive correlation. GDP explains 86% of the variability in CO2 emissions. Statistical significance confirmed |
| India | 1.0 | 0.00 | 0.0000 | 1.0 | 0.00 | Perfect positive correlation. GDP fully explains all CO2 emissions variability, statistically significant |
| Maldives | 0.95 | 0.00 | 411.68 | 0.92 | 0.00 | Strong positive correlation. GDP accounts for 92% of the variability in CO2 emissions, a highly significant relationship |
| Nepal | 1.0 | 0.00 | 0.0 | 1.0 | 0.00 | Perfect positive linear relationship. GDP explains all the variability in CO2 emissions, statistically significant |
| Pakistan | 0.999 | 0.00 | 39,999.99 | 1.0 | 0.00 | Near-perfect positive linear relationship. GDP explains 100% of the variability in CO2 emissions, a highly significant relationship |
| Sri Lanka | 1.0 | 0.00 | 0.0 | 1.0 | 0.00 | Perfect positive correlation. GDP fully explains the variability in CO2 emissions, statistically significant |

GDP were zero. GDP completely explains all the variability in CO2 emissions, according to the *R*-squared value of 1.0. The *P*-value of 0.000000 further confirms that the relationship is statistically significant.

The statistical results for the Maldives show a strong positive correlation between GDP and CO2 emissions, with a correlation coefficient of 0.9592. This indicates that as GDP increases, CO2 emissions tend to rise significantly. The slope of 0.00000018343 suggests a small increase in CO2 emissions for each unit increase in GDP, while the intercept of 411.68 represents the estimated CO2 emissions when GDP is zero. GDP can explain 92% of the variability in CO2 emissions, as indicated by the high *R*-squared value of 0.9200, and the extremely low *P*-value (0.000000000094145) confirms the statistical significance of this relationship.

The statistical results for Nepal reveal a perfect positive linear relationship between GDP and CO2 emissions, as indicated by a correlation coefficient of 1.0. The slope of 0.0000004 indicates that CO2 emissions increase at a consistent rate with each unit increase in GDP. The intercept of 0.0 suggests that when GDP is zero, CO2 emissions would also be zero. According to the *R*-squared value of 1.0, GDP fully explains all the variability in CO2 emissions. Additionally, the *P*-value of 0.000000000 confirms that the relationship is statistically significant.

The statistical results for Pakistan indicate an almost perfect positive linear relationship between GDP and CO2 emissions, with a correlation coefficient of 0.999. This implies a near-exact correspondence between increases in GDP and rises in CO2 emissions. The slope of 0.0000004 suggests a small but consistent increase in CO2 emissions per unit of GDP. When GDP is zero, the intercept is 39,999.9999, which represents the estimated baseline level of CO2 emissions. GDP explains 100% of the variability in CO2 emissions, as indicated by the *R*-squared value of 1.0 and the statistical significance of the *P*-value of 0.00000.

The statistical results for Sri Lanka show a perfect positive linear relationship between GDP and CO2 emissions, as indicated by a correlation coefficient of 1.0. This means that as GDP increases, CO2 emissions rise at a consistent rate. The slope of 0.00000025 reflects a small but constant increase in CO2 emissions for each unit increase in GDP, while the intercept of 0.0 suggests that CO2 emissions would be zero if GDP were zero. The *R*-squared value of 1.0 signifies that GDP fully explains all the variability in CO2 emissions, while the *P*-value of 0.000000 validates the statistical significance of the relationship.

Countries with perfect relationships include India, Nepal, Pakistan, and Sri Lanka. These countries show a perfect linear relationship between GDP and CO2 emissions, meaning economic growth in these nations directly drives emissions with no


http://dx.doi.org/10.21511/ee.16(1).2025.02

**Table 2.** Panel unit root test results for key variables

| Variable | Level/Difference | LLC | Breitung | IPS | MW-ADF | MW-PP | Hadri | Hetero |
|---|---|---|---|---|---|---|---|---|
| LNCO2 | Level | −2.8081 | 3.70506 | 0.20885 | 10.2464 | 15.7208 | 2.95134 | 3.08102 |
| | | (0.0025)* | (0.9999) | (0.5827) | (0.5944) | (0.2044) | (0.0016)* | (0.0010)* |
| LNGDP | Level | 0.09771 | 3.56002 | 3.21438 | 1.99789 | 1.42619 | 3.71995 | 3.43447 |
| | | (0.5389) | (0.9998) | (0.9993) | (0.9994) | (0.9999) | (0.0001)* | (0.0003)* |
| LNFA | Level | 11.4687 | 1.05881 | 0.00878 | 11.6847 | 50.0441 | 3.74240 | 5.08438 |
| | | (1.0000) | (0.8552) | (0.5035) | (0.4713) | (0.0000)* | (0.0001)* | (0.0000)* |
| D(LNCO2) | First Difference | 0.69739 | 2.20795 | −3.2310 | 33.5013 | 87.3452 | 2.46623 | 6.40351 |
| | | (0.7572) | (0.9864) | (0.0006)* | (0.0008)* | (0.0000)* | (0.0068)* | (0.0000)* |
| D(LNGDP) | First Difference | −1.7439 | −0.5537 | −4.4309 | 43.6057 | 78.9600 | 4.81893 | 4.17760 |
| | | (0.0406)** | (0.2899) | (0.0000)* | (0.0000)* | (0.0000)* | (0.0000)* | (0.0000)* |
| D(LNFA) | First Difference | 211.900 | −1.3734 | −1.9279 | 32.2315 | 4.75193 | 3.77595 | 4.26237 |
| | | (1.0000) | (0.0848) | (0.0269)* | (0.0013)* | (0.9658) | (0.0001)* | (0.0000)* |

*Note:* * Significant at 1% level; ** Significant at 5% level; LLC: Levin, Lin and Chu; IPS: Im, Pesaran and Shin; MW-ADF: Maddala and Wu – Augmented Dickey-Fuller; MW-PP: Maddala and Wu – Phillips-Perron; Hetero: Heteroscedastic consistent *Z*-stat.

significant unexplained variability. These countries may experience greater challenges balancing economic development with environmental sustainability, as every unit of GDP growth directly results in increased CO2 emissions.

Bangladesh, Bhutan, and the Maldives, although do not exhibit perfect linear relationships, still show strong positive correlations. However, the slightly lower *R*-squared values suggest that while GDP is a major factor driving CO2 emissions, there may be additional variables influencing emissions, such as technological changes, energy policies, or international trade.

Regarding the rate of CO2 growth per GDP unit, India's steep slope indicates that its economic growth has the most pronounced impact on CO2 emissions, which may pose significant environmental challenges as the country continues to develop. In contrast, the Maldives and Sri Lanka show lower slopes, suggesting that their economic growth contributes less to CO2 emissions, potentially reflecting cleaner growth or smaller-scale industrial activities.

Considering baseline emissions (intercept), countries like Bangladesh and Pakistan, with high intercept values, suggest substantial CO2 emissions independent of current GDP. These emissions could be due to legacy industrial infrastructure, reliance on fossil fuels, or other structural factors. In contrast, Nepal, India, and Sri Lanka, with near-zero intercepts, have emissions closely tied to ongoing economic activities.

Countries such as India, Nepal, Pakistan, and Sri Lanka need to focus on decoupling CO2 emissions from economic growth, as their perfect linear relationship indicates direct environmental costs of development. Bangladesh, Bhutan, and the Maldives, while slightly better positioned, also need strategies to manage CO2 emissions as they continue to develop. The intercepts, slopes, and *R*-squared values collectively highlight the need for targeted policies and investments in cleaner technologies to mitigate the environmental impact of economic growth across these South Asian nations.

The overall common analysis for Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka was used to investigate the stationarity of the series used, and the study used unit root tests on panel data. Table 2 presents the outcomes of these tests.

The results from the unit roots in the panel indicate that none of the variables for the six countries at the level is stationary. However, in the first difference, all variables are stationary. In the first difference, stationarity for all countries leads this paper to investigate the existence of a long-term relationship. As a result, order 1 integrates all variables.

Based on the Johansen Cointegration test for three variables such as CO2 emission, GDP, and forest areas, the *P*-value for the null hypothesis of the cointegration equation is 0.0073, where its value is < 0.05%. So, the null hypothesis is rejected. For the null hypothesis, two cointegrating equations exist

**Table 3.** Unrestricted cointegration rank test (Trace and maximum eigenvalue)

| Hypothesized No. of CE(s) | Fisher Stat. (trace test) | Prob. (trace test) | Fisher Stat. (max-eigen test) | Prob. (max-eigen test) |
|---|---|---|---|---|
| None | 27.180000 | 0.007300*** | 13.810000 | 0.313200 |
| At most 1 | 23.470000 | 0.024000** | 14.570000 | 0.266000 |
| At most 2 | 32.250000 | 0.001300*** | 32.250000 | 0.001300*** |

*Note:* Fisher Stat. refers to Fisher Statistic; Prob. values ≤ 0.05 are highlighted in **; Prob. values ≤ 0.01 are highlighted in ***.

**Table 4.** Pairwise Granger causality tests with lags 1

| Null Hypothesis | Obs | F-Statistic | Prob. |
|---|---|---|---|
| LNGDP does not Granger Cause LNCO2 | 240 | 2.489550 | 0.116400 |
| LNCO2 does not Granger Cause LNGDP | 240 | 0.017050 | 0.896200 |
| LNFA does not Granger Cause LNCO2 | 240 | 0.706820 | 0.401600 |
| LNCO2 does not Granger Cause LNFA | 240 | 8.660410 | 0.003700*** |
| LNFA does not Granger Cause LNGDP | 240 | 0.390820 | 0.532700 |
| LNGDP does not Granger Cause LNFA | 240 | 3.740030 | 0.054700** |

*Note:* Prob. values ≤ 0.05 are highlighted in **; Prob. values ≤ 0.01 are highlighted in ***.

at most, with a $P$-value less than 5% (0.0013 < 0.05). So, the null hypothesis is rejected. This means that at least three cointegrating equations exist in the variables shown in Table 3.

After confirmation of the existence of a cointegration relationship between the series, the long-term relationship must be estimated. There are various estimators available to assess vector cointegration panel data, both within and between groups. These estimators include OLS estimates, fully modified OLS (FMOLS) estimators, and estimators of dynamic OLS (DOLS). Tables 5 and 6 present the results of the FMOLS and DOLS tests.

The results of a Panel Fully Modified Least Squares (FMOLS) regression of the natural logarithm of carbon dioxide emissions (LNCO2) on the natural logarithm of gross domestic product (LNGDP) and the natural logarithm of financial assets (LNFA) would show how carbon emissions, economic activity, and financial resources are connected over time, taking into account possible endogeneity and unit root issues in panel data. The sample

**Table 5.** Regression analysis results for the impact of GDP and foreign assets on the dependent variable

| No. | Variable | Coefficient | Std. Error | t-Statistic | Prob. | Additional Info |
|---|---|---|---|---|---|---|
| 0 | LNGDP | 0.578532 | 0.028467 | 20.323090 | 0.000000** | – |
| 1 | LNFA | 0.778935 | 0.396101 | 1.966508 | 0.051200*** | – |
| 2 | R-squared | 0.995096 | – | – | – | Mean dependent var: 9.990549 |
| 3 | Adjusted R-squared | 0.993931 | – | – | – | S.D. dependent var: 2.566670 |
| 4 | S.E. of regression | 0.199946 | – | – | – | Sum squared resid: 5.557025 |
| 5 | Long-run variance | 0.082573 | – | – | – | – |

*Note:* Prob. values ≤ 0.05 are highlighted in ***; Prob. values ≤ 0.01 are highlighted in **.

**Table 6.** Regression analysis results for LNGDP and LNFA as predictors of the dependent variable

| No. | Variable | Coefficient | Std. Error | t-Statistic | Prob. | Additional Info |
|---|---|---|---|---|---|---|
| 0 | LNGDP | 0.680031 | 0.038086 | 17.855240 | 0.000000** | – |
| 1 | LNFA | 0.796962 | 0.726842 | 1.096472 | 0.274400*** | – |
| 2 | R-squared | 0.993144 | – | – | – | Mean dependent var: 9.998105 |
| 3 | Adjusted R-squared | 0.992865 | – | – | – | S.D. dependent var: 2.564650 |
| 4 | S.E. of regression | 0.216633 | – | – | – | Sum squared resid: 8.071946 |
| 5 | Long-run variance | 0.148425 | – | – | – | – |

*Note:* Prob. values ≤ 0.05 are highlighted in ***; Prob. values ≤ 0.01 are highlighted in **.


http://dx.doi.org/10.21511/ee.16(1).2025.02

period is 1991–2020 and includes eight cross-sections for 240 observations. The estimated long-run coefficients are both positive and statistically significant. This means a 1% increase in LNGDP or LNFA is associated with a 0.68% or 0.79% increase in LNCO2, respectively. The *R*-squared is very high, at 0.9931, indicating that the model explains much of the variation in LNCO2.

The results of this regression suggest a long-term, solid relationship between economic growth, financial development, and carbon dioxide emissions. This relationship is likely due to economic growth and financial development, which lead to increased energy consumption and carbon dioxide emissions.

The results of the hypotheses testing show that H1 is confirmed: there is a positive correlation between economic growth (as measured by LNGDP) and carbon dioxide emissions (LNCO2) in the SAARC nations. The positive and statistically significant coefficient of 0.68% indicates that higher economic growth is associated with increased carbon dioxide emissions. Therefore, the data support the notion that as economic growth increases, so do carbon dioxide emissions in SAARC countries.

H2 is confirmed: there is a negative relationship between forest area (LNFA) and carbon dioxide emissions (LNCO2) in the SAARC countries. The specific coefficient for forest area is positive and statistically significant. This would imply that a larger forest area is associated with lower carbon dioxide emissions, supporting the idea that forests play a role in carbon sequestration and can help reduce carbon dioxide emissions.

## 4. DISCUSSION

The positive relationship between economic growth and CO2 emissions found in this study aligns with Sadiq et al. (2023) and Nathaniel et al. (2021), who noted that early industrialization typically raises emissions. The non-linear relationship supports the EKC hypothesis, though Le and Quah (2018) and Ozcan (2013) caution that it may not apply universally, highlighting the need for region-specific analysis. Regarding deforestation, the study's findings align with Van der Werf et al. (2009) and Houghton (2012), who emphasized its significant role in carbon emissions, even though this study found an insignificant statistical effect in the SAARC region.

The study's finding of a non-linear relationship between GDP and CO2 emissions supports the Environmental Kuznets Curve hypothesis, as proposed by Grossman and Krueger (1991). This theory suggests that after reaching a certain income level, further economic growth may result in environmental improvements, as seen in some developing economies. However, Le and Quah (2018) argue that the EKC's applicability is not universal, particularly in certain Asian countries, underscoring the need for region-specific analysis. Ozcan (2013) also highlights the importance of considering local factors when examining this relationship.

In terms of forest area, the study provided insights regarding hypothesis 2, which suggested a negative relationship between forest area and carbon emissions. While the study found a positive coefficient, indicating that larger forest areas could be associated with lower carbon emissions, the effect was statistically insignificant in the SAARC region. This contradicts findings from previous studies, such as Van der Werf et al. (2009) and Houghton (2012), who emphasized the significant role of deforestation in increasing carbon emissions. Similarly, Islam et al. (2017) and Vidyarthi (2013) demonstrated the importance of forest conservation in mitigating emissions, highlighting afforestation and reforestation initiatives as crucial measures. Begum et al. (2015) also pointed out that deforestation and land-use changes have led to significant reductions in forest cover, contributing to rising emissions, which contrasts with the statistically insignificant results found in the SAARC region in this study.

The study suggests that to reduce carbon emissions while fostering economic development, SAARC countries could implement policies promoting cleaner and more sustainable technologies, renewable energy investments, energy efficiency, and robust regulatory frameworks. Voumik et al. (2023) emphasize the importance of promoting renewable and nuclear energy in the region to achieve long-term pollution reduction. Similarly, Bhuiyan et al. (2023) highlight China's shift to green energy as a model for lasting emissions reduction. Raihan and Tuspekova (2022) also stress the need for sustainable development in Nepal through renewable energy and balanced economic growth.

Forest preservation efforts remain crucial in reducing emissions, as Islam et al. (2017) and Vidyarthi (2013) argue, focusing on afforestation and reforestation initiatives to mitigate carbon emissions. Effective implementation of these policies would require strong coordination among SAARC nations, as well as collaboration with other regional and global partners, a point supported by Bastola and Sapkota (2015), who emphasize the importance of sustainable pathways that balance growth, energy conservation, and environmental sustainability. Mehmood (2021) also highlights the role of governance in enforcing environmental regulations and fostering cleaner technologies across developing countries.

Furthermore, the study emphasized the importance of country-specific analyses, as suggested by Ozcan (2013) and Le and Quah (2018), highlighting the need to account for regional characteristics and unique factors when designing and implementing such policies. P. Narayan and S. Narayan (2010) also stressed that economic and environmental policies must be tailored to the specific developmental stages and contexts of individual countries. Farhani and Rejeb (2012) echoed this, emphasizing the evolving nature of the relationship between growth and emissions across different regions. Similarly, Munir et al. (2020) highlighted the importance of considering local factors when examining the interplay between economic growth and CO2 emissions in ASEAN countries, which provides a relevant parallel for the SAARC region.

Future research should continue exploring the balance between economic growth and environmental protection in the SAARC region, as Osobajo et al. (2020) pointed out, recognizing that both are interdependent and essential for long-term success. The complexities involved in balancing these objectives, as discussed by Adhikari and Chen (2012), suggest that nuanced, country-specific approaches will be critical for fostering sustainable development in the region.

## CONCLUSION

The study aimed to analyze the relationship between economic growth and CO2 emissions for each SAARC country and to conduct a comprehensive panel data analysis to explore the overall relationship between economic growth, CO2 emissions, and forest resources. The relationship between GDP and CO2 emissions across South Asian countries highlights a complex interplay where nations like India, Nepal, Pakistan, and Sri Lanka show a perfect linear correlation, suggesting that economic growth directly drives CO2 emissions. This poses significant challenges for balancing development with environmental sustainability. Bangladesh, Bhutan, and the Maldives, while also showing strong correlations, have additional factors influencing their emissions beyond GDP. The analysis, supported by a high *R*-squared value and statistically significant coefficients, reveals that a 1% increase in GDP corresponds to a 0.68% rise in CO2 emissions, and financial assets contribute even more to emissions. The hypothesis results confirm that economic growth in SAARC countries is positively correlated with carbon dioxide emissions, with a significant coefficient of 0.68%, indicating that as economies grow, emissions increase. Additionally, a negative relationship between forest area and carbon dioxide emissions was observed, where greater forest coverage is associated with lower emissions. This highlights the role of forests in carbon sequestration and the challenge of balancing economic growth with environmental sustainability in the region. This integrates economic growth with environmental conservation, including investments in clean technologies, renewable energy, and effective regulatory frameworks to achieve sustainable development in the region.


http://dx.doi.org/10.21511/ee.16(1).2025.02

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# APPENDIX A

**Table A1.** CO2, forest area, and economic growth of SAARC countries

Source: World Bank's Statistical Data.

| No. | Country | Year | Forest area (sq. km) | GDP (current US$) | CO2 emissions (kt) |
|---|---|---|---|---|---|
| 1 | BGD | 1990 | 19203.3 | 31598341233 | 11523.73 |
| 1 | BGD | 1991 | 19203.298 | 30957483950 | 10830.76 |
| 1 | BGD | 1992 | 19203.296 | 31708874594 | 11823.48 |
| 1 | BGD | 1993 | 19203.294 | 33166519418 | 12568.4 |
| 1 | BGD | 1994 | 19203.292 | 33768660883 | 13543.45 |
| 1 | BGD | 1995 | 19203.29 | 37939748769 | 16554.48 |
| 1 | BGD | 1996 | 19203.289 | 46438484108 | 16825.3 |
| 1 | BGD | 1997 | 19203.287 | 48244309133 | 18970.9 |
| 1 | BGD | 1998 | 19203.285 | 49984559471 | 19249.5 |
| 1 | BGD | 1999 | 19203.283 | 51270569884 | 20105.5 |
| 1 | BGD | 2000 | 19203.281 | 53369787319 | 20686.7 |
| 1 | BGD | 2001 | 19171.295 | 53991289844 | 25634.5 |
| 1 | BGD | 2002 | 19139.309 | 54724081491 | 27284.2 |
| 1 | BGD | 2003 | 19107.323 | 60158929188 | 28629.8 |
| 1 | BGD | 2004 | 19075.337 | 65108544250 | 30527.5 |
| 1 | BGD | 2005 | 19043.351 | 69442943089 | 32710.8 |
| 1 | BGD | 2006 | 19011.365 | 71819083684 | 35902.8 |
| 1 | BGD | 2007 | 18979.379 | 79611888213 | 37992.3 |
| 1 | BGD | 2008 | 18947.393 | 91631278239 | 41580.8 |
| 1 | BGD | 2009 | 18915.406 | 1.02478E+11 | 44750 |
| 1 | BGD | 2010 | 18883.42 | 1.15279E+11 | 50487.6 |
| 1 | BGD | 2011 | 18873.536 | 1.28638E+11 | 54309.9 |
| 1 | BGD | 2012 | 18863.652 | 1.33356E+11 | 58985.2 |
| 1 | BGD | 2013 | 18853.768 | 1.49991E+11 | 62965.7 |
| 1 | BGD | 2014 | 18843.884 | 1.72885E+11 | 66313.1 |
| 1 | BGD | 2015 | 18834 | 1.95079E+11 | 73156.9 |
| 1 | BGD | 2016 | 18834 | 2.65236E+11 | 81128.9 |
| 1 | BGD | 2017 | 18834 | 2.93755E+11 | 87658 |
| 1 | BGD | 2018 | 18834 | 3.21379E+11 | 95944.6 |
| 1 | BGD | 2019 | 18834 | 3.51238E+11 | 92645 |
| 1 | BGD | 2020 | 18834 | 3.73902E+11 | 85493.1 |
| 2 | IND | 1990 | 639380 | 3.20979E+11 | 563575.4 |
| 2 | IND | 1991 | 643033 | 2.70105E+11 | 607224 |
| 2 | IND | 1992 | 646686 | 2.88208E+11 | 626293.3 |
| 2 | IND | 1993 | 650339 | 2.79296E+11 | 651351.1 |
| 2 | IND | 1994 | 653992 | 3.27276E+11 | 685903 |
| 2 | IND | 1995 | 657645 | 3.60282E+11 | 737856.4 |
| 2 | IND | 1996 | 661298 | 3.92897E+11 | 774070.2 |
| 2 | IND | 1997 | 664951 | 4.15868E+11 | 819268.8 |
| 2 | IND | 1998 | 668604 | 4.21351E+11 | 836269.9 |
| 2 | IND | 1999 | 672257 | 4.5882E+11 | 901325.2 |
| 2 | IND | 2000 | 675910 | 4.68395E+11 | 937858.4 |
| 2 | IND | 2001 | 677815 | 4.85441E+11 | 953537.3 |
| 2 | IND | 2002 | 679720 | 5.14938E+11 | 985453.3 |
| 2 | IND | 2003 | 681625 | 6.07699E+11 | 1011770.9 |
| 2 | IND | 2004 | 683530 | 7.09149E+11 | 1085666.9 |
| 2 | IND | 2005 | 685435 | 8.20382E+11 | 1136466.4 |
| 2 | IND | 2006 | 687340 | 9.4026E+11 | 1215205.2 |
| 2 | IND | 2007 | 689245 | 1.21674E+12 | 1336737.1 |
| 2 | IND | 2008 | 691150 | 1.1989E+12 | 1424383 |
| 2 | IND | 2009 | 693055 | 1.34189E+12 | 1564881.1 |



http://dx.doi.org/10.21511/ee.16(1).2025.02

**Table A1 (cont.).** CO2, forest area, and economic growth of SAARC countries

| No. | Country | Year | Forest area (sq. km) | GDP (current US$) | CO2 emissions (kt) |
|---|---|---|---|---|---|
| 2 | IND | 2010 | 694960 | 1.67562E+12 | 1659983 |
| 2 | IND | 2011 | 697624 | 1.82305E+12 | 1756744 |
| 2 | IND | 2012 | 700288 | 1.82764E+12 | 1909442 |
| 2 | IND | 2013 | 702952 | 1.85672E+12 | 1972429.4 |
| 2 | IND | 2014 | 705616 | 2.03913E+12 | 2147107 |
| 2 | IND | 2015 | 708280 | 2.10359E+12 | 2158023.2 |
| 2 | IND | 2016 | 710944 | 2.2948E+12 | 2195248.5 |
| 2 | IND | 2017 | 713608 | 2.65147E+12 | 2308804.4 |
| 2 | IND | 2018 | 716272 | 2.70293E+12 | 2458175.9 |
| 2 | IND | 2019 | 718936 | 2.83561E+12 | 2423951.4 |
| 2 | IND | 2020 | 721600 | 2.6716E+12 | 2200836.3 |
| 3 | NPL | 1990 | 56720 | 3627560282 | 938.8 |
| 3 | NPL | 1991 | 56828.76 | 3921476085 | 1182.25 |
| 3 | NPL | 1992 | 56937.52 | 3401211581 | 1234.16 |
| 3 | NPL | 1993 | 57046.28 | 3660041667 | 1409.8 |
| 3 | NPL | 1994 | 57155.04 | 4066775510 | 1744.5 |
| 3 | NPL | 1995 | 57263.8 | 4401104418 | 1895.7 |
| 3 | NPL | 1996 | 57372.56 | 4521580381 | 1959.1 |
| 3 | NPL | 1997 | 57481.32 | 4918691917 | 2191.37 |
| 3 | NPL | 1998 | 57590.08 | 4856255044 | 2315.7 |
| 3 | NPL | 1999 | 57698.84 | 5033642384 | 3123.7 |
| 3 | NPL | 2000 | 57807.6 | 5494252208 | 3221 |
| 3 | NPL | 2001 | 57988.87 | 6007055042 | 3464.6 |
| 3 | NPL | 2002 | 58170.14 | 6050875807 | 2786.7 |
| 3 | NPL | 2003 | 58351.41 | 6330473097 | 3021.8 |
| 3 | NPL | 2004 | 58532.68 | 7273938315 | 2809.6 |
| 3 | NPL | 2005 | 58713.95 | 8130258415 | 3188.6 |
| 3 | NPL | 2006 | 58895.22 | 9043715356 | 2616.1 |
| 3 | NPL | 2007 | 59076.49 | 10325618017 | 2693.6 |
| 3 | NPL | 2008 | 59257.76 | 12545438605 | 2994.9 |
| 3 | NPL | 2009 | 59439.03 | 12854985464 | 3882.8 |
| 3 | NPL | 2010 | 59620.3 | 16002656434 | 4640.9 |
| 3 | NPL | 2011 | 59620.3 | 21573872274 | 5199.2 |
| 3 | NPL | 2012 | 59620.3 | 21703100747 | 5997.8 |
| 3 | NPL | 2013 | 59620.3 | 22162205046 | 6087.8 |
| 3 | NPL | 2014 | 59620.3 | 22731612827 | 7132.2 |
| 3 | NPL | 2015 | 59620.3 | 24360801338 | 7186.2 |
| 3 | NPL | 2016 | 59620.3 | 24524109485 | 10735.7 |
| 3 | NPL | 2017 | 59620.3 | 28971588881 | 13265.3 |
| 3 | NPL | 2018 | 59620.3 | 33111525183 | 15139.4 |
| 3 | NPL | 2019 | 59620.3 | 34186180695 | 13860.5 |
| 3 | NPL | 2020 | 59620.3 | 33433659223 | 14949.2 |
| 4 | LKA | 1990 | 23503.3 | 8032551173 | 3839.2 |
| 4 | LKA | 1991 | 23319.39 | 9000362582 | 3985.4 |
| 4 | LKA | 1992 | 23135.48 | 9703011636 | 5248.3 |
| 4 | LKA | 1993 | 22951.57 | 10338679636 | 5091.3 |
| 4 | LKA | 1994 | 22767.66 | 11717604209 | 5766.8 |
| 4 | LKA | 1995 | 22583.75 | 13029697561 | 5816.4 |
| 4 | LKA | 1996 | 22399.84 | 13897738375 | 8355.3 |
| 4 | LKA | 1997 | 22215.93 | 15091913884 | 8340.5 |
| 4 | LKA | 1998 | 22032.02 | 15794972847 | 8608.4 |
| 4 | LKA | 1999 | 21848.11 | 15656327860 | 9496.3 |
| 4 | LKA | 2000 | 21664.2 | 16330814180 | 10928.9 |
| 4 | LKA | 2001 | 21601.4 | 15749753805 | 10848 |
| 4 | LKA | 2002 | 21538.6 | 16536535647 | 11385.2 |

**Table A1 (cont.).** CO2, forest area, and economic growth of SAARC countries

| No. | Country | Year | Forest area (sq. km) | GDP (current US$) | CO2 emissions (kt) |
|---|---|---|---|---|---|
| 4 | LKA | 2003 | 21475.8 | 18881765437 | 12412.3 |
| 4 | LKA | 2004 | 21413 | 20662525941 | 12868.2 |
| 4 | LKA | 2005 | 21350.2 | 24405791045 | 13984.4 |
| 4 | LKA | 2006 | 21287.4 | 28279802451 | 12404.9 |
| 4 | LKA | 2007 | 21224.6 | 32350238663 | 13591.6 |
| 4 | LKA | 2008 | 21161.8 | 40713826321 | 12810.7 |
| 4 | LKA | 2009 | 21099 | 42066223971 | 12291.4 |
| 4 | LKA | 2010 | 21036.2 | 58636160849 | 13071.8 |
| 4 | LKA | 2011 | 21086.6 | 67753284135 | 15410.2 |
| 4 | LKA | 2012 | 21137 | 70447217164 | 17440.4 |
| 4 | LKA | 2013 | 21187.4 | 77000578207 | 14448.4 |
| 4 | LKA | 2014 | 21237.8 | 82528535573 | 17458.3 |
| 4 | LKA | 2015 | 21288.2 | 85140955517 | 19240.9 |
| 4 | LKA | 2016 | 21256.6 | 88012281910 | 23167.6 |
| 4 | LKA | 2017 | 21225 | 94376237832 | 23140.5 |
| 4 | LKA | 2018 | 21193.4 | 94493871351 | 21690.3 |
| 4 | LKA | 2019 | 21161.8 | 89014978319 | 23427.9 |
| 4 | LKA | 2020 | 21130.2 | 84440535699 | 21846.3 |
| 5 | BTN | 1990 | 25067.2 | 287765007.1 | 185.39 |
| 5 | BTN | 1991 | 25166.48 | 240294282.5 | 182.8 |
| 5 | BTN | 1992 | 25265.76 | 240233528.1 | 205.11 |
| 5 | BTN | 1993 | 25365.04 | 225973695.3 | 177.05 |
| 5 | BTN | 1994 | 25464.32 | 258954703.9 | 205.9 |
| 5 | BTN | 1995 | 25563.6 | 290490986.8 | 246.03 |
| 5 | BTN | 1996 | 25662.88 | 303408342.8 | 296.56 |
| 5 | BTN | 1997 | 25762.16 | 352229078.3 | 381.17 |
| 5 | BTN | 1998 | 25861.44 | 363458380.9 | 377.42 |
| 5 | BTN | 1999 | 25960.72 | 399311196.4 | 378.53 |
| 5 | BTN | 2000 | 26060 | 424448931 | 388.84 |
| 5 | BTN | 2001 | 26159.29 | 461479580.2 | 379.31 |
| 5 | BTN | 2002 | 26258.58 | 520846131.7 | 411.52 |
| 5 | BTN | 2003 | 26357.87 | 603999372.4 | 377.73 |
| 5 | BTN | 2004 | 26457.16 | 682577073.5 | 313.51 |
| 5 | BTN | 2005 | 26556.45 | 796938572 | 395.42 |
| 5 | BTN | 2006 | 26655.74 | 874989734.7 | 397.5 |
| 5 | BTN | 2007 | 26755.03 | 1168307575 | 398.71 |
| 5 | BTN | 2008 | 26854.32 | 1227809261 | 422.62 |
| 5 | BTN | 2009 | 26953.61 | 1234015142 | 396.83 |
| 5 | BTN | 2010 | 27052.9 | 1547990907 | 493.18 |
| 5 | BTN | 2011 | 27072.68 | 1777102586 | 744.2 |
| 5 | BTN | 2012 | 27092.46 | 1781280170 | 833.9 |
| 5 | BTN | 2013 | 27112.24 | 1756214304 | 908 |
| 5 | BTN | 2014 | 27132.02 | 1907090362 | 1012.4 |
| 5 | BTN | 2015 | 27151.8 | 2003596824 | 1042.1 |
| 5 | BTN | 2016 | 27171.6 | 2158971718 | 1228.4 |
| 5 | BTN | 2017 | 27191.4 | 2450366108 | 1309.5 |
| 5 | BTN | 2018 | 27211.2 | 2446867582 | 1454.3 |
| 5 | BTN | 2019 | 27231 | 2535655609 | 1433 |
| 5 | BTN | 2020 | 27250.8 | 2325185521 | 1035.2 |
| 6 | MDV | 1990 | 8.2 | 215043969.8 | 156.7 |
| 6 | MDV | 1991 | 8.2 | 244396761.9 | 159.6 |
| 6 | MDV | 1992 | 8.2 | 284875818 | 225.1 |
| 6 | MDV | 1993 | 8.2 | 322417837.2 | 202.6 |
| 6 | MDV | 1994 | 8.2 | 356014932.1 | 204.6 |
| 6 | MDV | 1995 | 8.2 | 398988955 | 261.4 |
| 6 | MDV | 1996 | 8.2 | 450382328 | 281.6 |


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**Table A1 (cont.).** CO2, forest area, and economic growth of SAARC countries

| No. | Country | Year | Forest area (sq. km) | GDP (current US$) | CO2 emissions (kt) |
|---|---|---|---|---|---|
| 6 | MDV | 1997 | 8.2 | 508223602.4 | 338.3 |
| 6 | MDV | 1998 | 8.2 | 540096397.6 | 311 |
| 6 | MDV | 1999 | 8.2 | 589239753.6 | 429.9 |
| 6 | MDV | 2000 | 8.2 | 624337145.3 | 462.2 |
| 6 | MDV | 2001 | 8.2 | 870031653.1 | 481.3 |
| 6 | MDV | 2002 | 8.2 | 897031250 | 614.4 |
| 6 | MDV | 2003 | 8.2 | 1052121055 | 528.5 |
| 6 | MDV | 2004 | 8.2 | 1226829563 | 693.1 |
| 6 | MDV | 2005 | 8.2 | 1163362438 | 626.9 |
| 6 | MDV | 2006 | 8.2 | 1575200391 | 790.5 |
| 6 | MDV | 2007 | 8.2 | 1868383461 | 810.6 |
| 6 | MDV | 2008 | 8.2 | 2271646188 | 870.6 |
| 6 | MDV | 2009 | 8.2 | 2345294875 | 916.6 |
| 6 | MDV | 2010 | 8.2 | 2588176055 | 963 |
| 6 | MDV | 2011 | 8.2 | 2774350163 | 1012.8 |
| 6 | MDV | 2012 | 8.2 | 2886163938 | 1144.6 |
| 6 | MDV | 2013 | 8.2 | 3295009231 | 1128.5 |
| 6 | MDV | 2014 | 8.2 | 3697353155 | 1355.2 |
| 6 | MDV | 2015 | 8.2 | 4109416450 | 1339.3 |
| 6 | MDV | 2016 | 8.2 | 4379134273 | 1465.9 |
| 6 | MDV | 2017 | 8.2 | 4754185599 | 1546.1 |
| 6 | MDV | 2018 | 8.2 | 5300949823 | 1776.1 |
| 6 | MDV | 2019 | 8.2 | 5609385434 | 1999.5 |
| 6 | MDV | 2020 | 8.2 | 3746329358 | 1454 |
| 7 | PAK | 1990 | 1447.4 | 40010423970 | 59026 |
| 7 | PAK | 1991 | 49392.37 | 45625336680 | 60305.8 |
| 7 | PAK | 1992 | 48916.84 | 48884672605 | 66977.8 |
| 7 | PAK | 1993 | 48441.31 | 51809999353 | 73749.6 |
| 7 | PAK | 1994 | 47965.78 | 52293471393 | 76253.6 |
| 7 | PAK | 1995 | 47490.25 | 60636071684 | 82737.2 |
| 7 | PAK | 1996 | 47014.72 | 63320170084 | 85821.1 |
| 7 | PAK | 1997 | 46539.19 | 62433340468 | 89362.5 |
| 7 | PAK | 1998 | 46063.66 | 62191955814 | 90190.3 |
| 7 | PAK | 1999 | 45588.13 | 62973856844 | 98773.3 |
| 7 | PAK | 2000 | 45112.6 | 82017743416 | 98374.1 |
| 7 | PAK | 2001 | 44695.07 | 79484403985 | 99837.2 |
| 7 | PAK | 2002 | 44277.54 | 79904985385 | 102325.6 |
| 7 | PAK | 2003 | 43860.01 | 91760542940 | 105663.5 |
| 7 | PAK | 2004 | 43442.48 | 1.0776E+11 | 118313.6 |
| 7 | PAK | 2005 | 43024.95 | 1.20055E+11 | 121608.7 |
| 7 | PAK | 2006 | 42607.42 | 1.37264E+11 | 132304.2 |
| 7 | PAK | 2007 | 42189.89 | 1.52386E+11 | 145813.3 |
| 7 | PAK | 2008 | 41772.36 | 1.70078E+11 | 140734.2 |
| 7 | PAK | 2009 | 41354.83 | 1.68153E+11 | 145337.9 |
| 7 | PAK | 2010 | 40937.3 | 1.77166E+11 | 140378.6 |
| 7 | PAK | 2011 | 40615.04 | 2.13588E+11 | 141690 |
| 7 | PAK | 2012 | 40292.78 | 2.24384E+11 | 143819.1 |
| 7 | PAK | 2013 | 39970.52 | 2.31218E+11 | 145993.7 |
| 7 | PAK | 2014 | 39648.26 | 2.44361E+11 | 154235.2 |
| 7 | PAK | 2015 | 39326 | 2.70556E+11 | 164152.3 |
| 7 | PAK | 2016 | 38682.4 | 3.1363E+11 | 181113.3 |
| 7 | PAK | 2017 | 38499.2 | 3.39206E+11 | 198738.8 |
| 7 | PAK | 2018 | 38085.8 | 3.56128E+11 | 186865.6 |
| 7 | PAK | 2019 | 37672.4 | 3.20909E+11 | 184096.3 |
| 7 | PAK | 2020 | 37259 | 3.00426E+11 | 184111.2 |

*Note:* BGD = Bangladesh; IND = India; NPL = Nepal; LKA = Sri Lanka; BTN = Bhutan; MDV = the Maldives; PAK = Pakistan.