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The Relationship between Climate-Responsive Public Expenditure, Economic Growth and Environmental Performance: Evidence from Nepal (2013–2022)

[1]Ayush Paudel and [2]Kamal Dhakal*
[1]Freelancer
[2]Department of Economics, Prithvi Narayan Campus, Pokhara, Nepal
**Corresponding Author: dhakalkamal45@gmail.com*

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Abstract

This paper investigates the relationship between CRPE, economic growth, and environmental performance proxy by per capita CO_2 emissions in Nepal from 2013 to 2022. Data sourced from the World Bank, EDGAR, and the Climate Budget Tagging at the Ministry of Finance are analyzed using Augmented Dickey–Fuller, Engle–Granger, OLS, and Unrestricted Distributed Lag models. Both CRPE and GDP have a positive effect on emissions, with elasticities being 0.63 and 1.40, respectively, indicating that Nepal remains in the rising phase of the EKC. At the same time, CRPE supports growth with elasticity 0.404, while environmental impacts may appear with a lag, which corresponds with the delayed effects of public investment according to the UDL model. The lack of a long-run equilibrium means that the dynamics of the model are dominated by the short run. Findings suggests Policy makers in developing countries to particularly focus on low-carbon investments and incorporate emission-reduction goals in fiscal policy frameworks to attain green, sustainable, and inclusive growth.

Keywords: *CO_2 emissions, economic growth, GDP, inclusive growth, sustainable*

Introduction

Recently emerged discourse on fiscal policy, environmental performance, and sustainable development often link climate-responsive public expenditure (CRPE), CO2 emissions, and economic growth (GDP). CRPE stands for government spending on initiatives to reduce the effects of climate change and help people adapt, is becoming increasingly accepted as a tool for both environmental and economic development. Research findings demonstrate that redirecting public funds toward climate-resistant industries creates enduring economic benefits which strengthen national resilience against climate-related disasters (Rehman et al., 2022; IFC, 2022). This is expected to reduce emissions, enhance resiliency, and raise productivity through sustainable agriculture and disaster risk management. UNDP (2021) addressed that initiatives like this help the contribution of national budgets to their climate targets. According to IFC (2022) it may also allow individuals to cope with climate shocks better, making them less vulnerable to such shocks and helping the economy prosper in the long term. Decreased CO2 emissions and economy stimulation are foreseen during the implementation of CRPE through its current or future operations since green infrastructure and adaptation projects take time to yield visible results.

Nepal is a landlocked and mountainous country in South Asia, wedged between India and China. Its unique topography shapes not only the settlement and economic activities of Nepal but also the country's climate vulnerability. Sustaining economic growth while addressing the risk of climate change remains critical in Nepal. This makes Nepal's growth path very sensitive to ecological shocks. According to ICIMOD (2023), the glaciers in the Hindu Kush Himalaya lost almost 65% of their volume. The hydropower sector in Nepal is clearly at stake, the country's hallmark for sustainable development. There are floods that have damaged or shut down power plants several times. According to the World Bank (2022), Nepal loses 1.5–2% of its GDP per year due to climate change.

Inclusion of climate issues in fiscal strategy becomes indispensable for Nepal and similar countries since the latter's economic growth is highly dependent on climate-sensitive sectors such as agriculture and water resources, and tourism. According to the UNDP (2021), the CPEIR system has increasingly popularized climate budgeting in Nepal, classifying governmental spending according to its climate-related importance. The Nepal Economic Forum (2025) reports that different ministries were now providing funds for various initiatives related to climate; among them, particular emphasis was placed on water management, agricultural development, and energy infrastructure. These fiscal policies are targeting a reduction of

environmental damage by means of sustainable economic growth due to increased resilience, higher productivity, and attraction of green investments.

The framework of this research study is postulated to understand the complex interlink between climate-responsive public spending and environmental performance and economic development in Nepal. The variables studied in this context are positioned within a broad socio-ecological and economic framework. It is imperative to use an integrative analytical model that can highlight how the intensification of climate change affects developing countries' dual obligations to balance environmental goals with economic growth. Therefore, by methodically examining the relationship between CRPE, GDP, and CO2 emissions in Nepal from 2013 to 2022, this study aims to close the gap in the body of existing literature.

Method of Data Collection and Analysis

The study employs a descriptive, correlational, and causal comparative research design to examine the relationship among CRPE, GDP, and CO_2 emissions. Annual secondary cross-sectional time series data from official government publications, Nepal's Ministry of Finance budget records, and international databases like the World Bank and World Development Indicators Data Bank are used in the analysis. These sources provide reliable annual data on CO2 emissions (metric tons per capita), GDP figures (in constant 2015 US dollars), and governmental budget allocated for climate change.

The analysis begins with descriptive statistics summarizing the trends, central tendencies, and dispersion. Natural logarithmic transformations were taken for empirical analysis. The method also applies correlation analysis to establish a relationship between the primary variables. Augmented Dickey-Fuller (ADF) tested stationarity and integration order of each variable. Then the co-integration test by Engle Granger was performed to choose if variables share a common long-term relationship. OLS linear regression models used to investigate the empirical relationship among key variables. Further, the Error Correction Term from the ECM model is used for the required pair. Complementing the above ECM to analyze the temporal effect, an Unrestricted Distributed Lag model was estimated. After successive assumptions regarding regression analysis were passed, OLS regression is applied, and then diagnostic tests. These tools enable us to study how fiscal elements and economic growth are related to influence Nepal's environmental outcomes and reversely how fiscal element influence growth trajectory.

Functional relationship between variables can be presented as:

CO_2 emission= f (GDP, CRPE)…….(1)

Converting functional relationship into linear form taking natural log on both sides:

OLS Model 1: $\ln CO_{2t} = \alpha_1 + \beta_1 \ln CRPE_t + \epsilon_t$ ……(2)

OLS Model 2: $\ln CO2t = \alpha_2 + \beta_2 \ln GDP_t + \epsilon_t$ ……(3)

OLS Model 3: $\ln GDP_t = \alpha_3 + \beta_3 \ln CRPE_t + \epsilon_t$……(4)

Where, CO_2= carbon emission, GDP=Gross domestic product and CRPE= climate-responsive expenditure

OLS Model 1 focuses on direct effect of CRPE on CO2 emissions, OLS Model 2 estimates scale effect of economic expansion on environmental performance and OLS Model 3 estimates effect of climate-responsive public expenditure on economic growth.

Table 1

Variable, their description, and measurement

Variables	Definition	Measurement
GDP	Gross Domestic product	In constant 2015 US dollars billion
CRPE	Climate Responsive Public Expenditure	% of total budget
CO_2 emission	Carbon emission	Per capita metric tons

The study focused basically on three variables, namely, climate-responsive public expenditure (CRPE), economic growth (GDP) as independent variables and CO_2 emissions per capita as dependent variable.

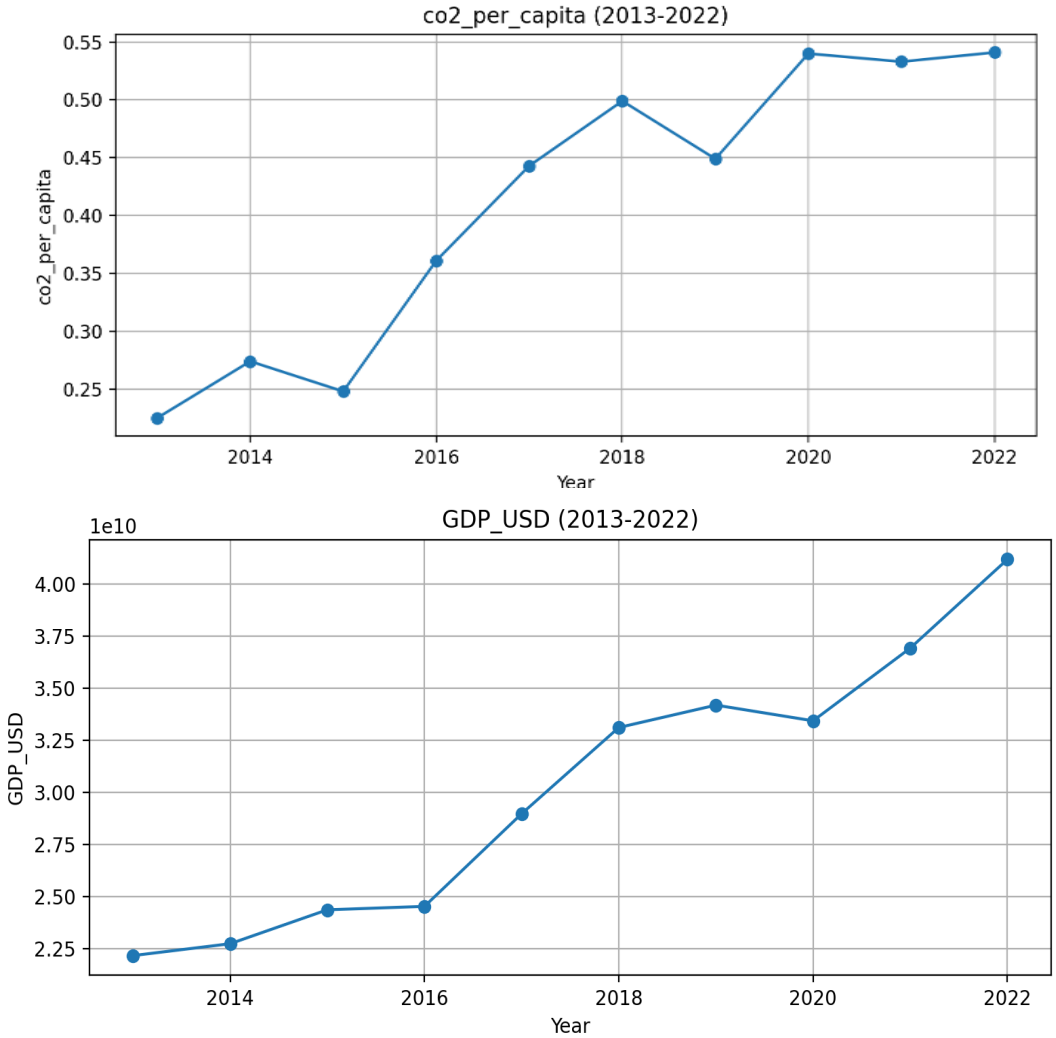
Environmental performance is measured by carbon dioxide emissions (CO2), expressed in metric tons, as reported in global databases like the World Development Indicators. This indicator represents the environmental impact of economic activity in Nepal and is log-transformed (ln CO2) for empirical analysis. All variables encompass the period 2013–2022, and their logarithmic transformations are utilized to attain normality, stationarity, enhance model fit, and facilitate the interpretation of coefficients as percentage elasticities. Gross Domestic Product (GDP) at constant US dollars, reported by World Bank is used as independent variable. It is expressed in billions of constant prices to eliminate the effect of inflation. The natural logarithm of GDP (lnGDP) is used to stabilize variance and allow for elasticity interpretation. The term Climate Responsive Public Expenditure (CRPE) refers to the budget that governments allocate for climate change programs and activities. The variable is expressed as percentage of total budget and is provided by Ministry of Finance of Nepal through its Climate Budget Tagging framework. To maintain consistency in regression analysis, this variable is translated into its natural logarithm (ln CRPE).

Results and Discussions

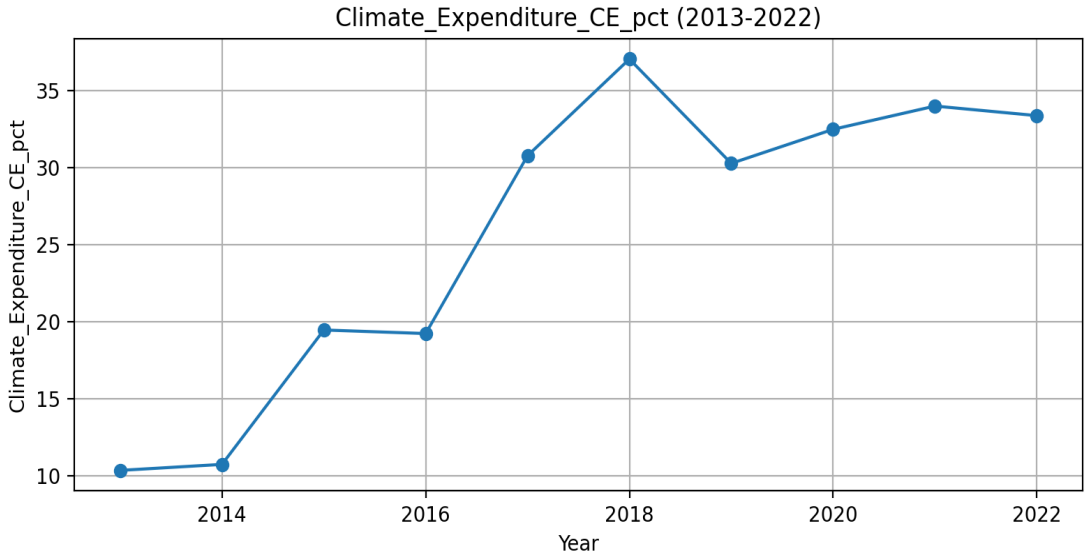
This section presents the empirical findings from the descriptive and econometric analysis. The results are organized into several subsections as: the trend analysis, descriptive statistics, correlation matrices, OLS and UDL output.

Figure 1

Trend of CO2 emissions per capita, gross domestic product (GDP) and climate-responsive public expenditure (CREP % of total budget) in Nepal



Source: World Bank World Development Indicators WDI and EDGAR (2023)



Source: Budget document of the respective fiscal year, Ministry of Finance

Figure 1 shows that the trend of CO2 emissions per capita rose from roughly 0.23 metric tons in 2013 to over 0.541 by 2022, economic shocks like the 2015 earthquake may have contributed to minor decreases in 2015 and 2018. The trend highlights the negative environmental effects of rising GDP. This supports the study's environmental component since increasing per-capita emissions highlight the scale implications of GDP expansion and provide context for examining whether climate-responsive spending lowers the environmental cost of growth. Real GDP increased from roughly USD 22.16 billion in 2013 to over USD 41 billion in 2022, expressed in constant 2015 USD. The summary statistics show steady economic growth, with only minor fluctuations during external shocks like the COVID-19 pandemic in 2019–2020. The climate expenditures following strong upward trend, rising from over 10.34% in 2013 to over 33% in 2022, with sharp increases following 2016 and a peak of almost 37% in 2018. This suggests that the government providing climate change investments more attention. The rise after 2016 aligns with Nepal's climate policy commitments under the Paris Agreement.

Descriptive statistics

These statistics show characteristics, trends, and variability of data which are essential for subsequent econometric analysis.

Table 1

Descriptive Statistics of Key Variables (2013–2022)

Variable	Mean	Median	Std. Dev	Min	Max	Range	Skewness	Kurtosis
CO_2	0.406	0.446	0.122	0.23	0.541	0.316	-0.40	-1.47
CRPE	25.76	30.51	9.94	10.34	37.03	26.69	-0.66	-1.25
GDP	30.16	31.04	6.57	22.16	41.18	19.02	0.23	-1.23

Source: Author's derivation using MS-Excel

Table 1 shows the descriptive statistics of the key variables: CO2 emissions per capita, climate-responsive public expenditure, and Gross Domestic Product, within the period of this study. The careful analysis of these descriptive statistics confirms that the three variables under consideration, are suitable for regression modeling.

Correlation between economic growth, environmental performance, and climate responsive expenditure

The correlation matrix summarizes the degree of association between each pair of variables based on data from 2013 to 2022.

Table 2

Correlation between GDP, CRPE and CO_2 emission

	lnCO_2	lnCRPE	lnGDP
lnCO_2	1		
lnCRPE	0.9151	1	
lnGDP	0.9171	0.8841	1

Source: Author's calculation from E-views 10

Table 2 shows there is a strong positive correlation (r=0.917) between lnGDP and lnCO2 emissions per capita. Government spending that responds to climate change lnCRPE and lnCO_2 have a strong positive correlation (r=0.915) implying that investments in climate change are associated with rising emissions. Furthermore, there is a strong correlation (r=0.884) between lnGDP and lnCRPE suggesting that government spending on climate-related issues tends to rise with economic growth.

Table 3

Stationarity test (Augmented Dickey-Fuller)

Variable	Test Statistic	*p*-value	Stationary
lnCO_2	-3.41	0.0446	Yes
ln CRPE	-5.37	0.0158	Yes

lnGDP	-3.13	0.0072	Yes

Source: Author's calculation from E-views 10

Table 3 shows ADF test results. All three variables are stationary, which is a prerequisite for valid time-series regression analysis. The finding that lnGDP is I (2) precludes the use of ARDL modeling, but the stationarity of the other variables at I (1) supports the validity of subsequent regression.

Table 4

Engle-Granger Cointegration Test

Test Pair	*t*-statistic	*p*-value	Cointegrated
$lnCO_2$ ~ lnCRPE	-3.308	0.0467	yes
$lnCO_2$ ~ lnGDP	-3.110	0.0618	No

Source: Author's calculation from E-views 10

Table 4 presents that no cointegration was found between CO2 emissions and GDP, indicating that the interactions among these variables are driven by short-term dynamics rather than stable long-term trends. As the pair $lnCO_2$ and ln CRPE found cointegrated, ECM is used to test whether long-run equilibrium adjustment mechanism exists or not.

Direct effect of climate-responsive public expenditure on CO2 emissions

Table 5

Diagnostic tests direct effect of CRPE on CO_2 emission

Test	Statistic	*p*-value	Interpretation
Jarque-Bera	2.2765	0.320	Normal residuals
Breusch-Pagan	0.1208	0.6997	Homoskedasticity
VIF	1.0000	—	No multicollinearity
Durbin-Watson	2.406	—	No autocorrelation

Source: Author's calculation from E-views 10

Table 6

Regression results direct effect of CRPE on CO_2 emission

Variable	Coefficient	Std. Error	*t*-value	*p*-value	95% CI
Intercept	-2.92	0.3417	-8.569	0.000	[-3.716, -2.140]
lnCRPE	0.627	0.107	5.856	0.000	[0.380, 0.873]
ecm_resid lag1	-0.8198	0.339	-2.41	0.0524	[-1.651, 0.011]

Source: Author's calculation from E-views 10

R-squared: 0.810, Adj. R-squared: 0.787, F-statistic: 34.29, Prob (F-statistic): 0.0004

Table 6 demonstrates that increases in CRPE are associated with higher CO2 emissions, as 1% increase in climate-responsive public spending corresponds to 0.63% increase in emissions. Similarly, ECM was also performed for completeness as pair $lnCO_2$~lnCRPE found co-integrated and found that error correction term as -0.8198 with p-value 0.0524 boarder line insignificant implying no significant speed adjustment towards equilibrium in a year. The short-run error correction model (ECM) explains approximately 51% of the short-run variation in economic growth ($R^2 = 0.5123$). Diagnostic tests indicate that model assumptions are satisfied, with no evidence of multicollinearity (VIF), heteroskedasticity (BPG test), non-normality (Jarque-Bera test), or serial correlation. However, the overall ECM model is not statistically significant at the 5% level (F-statistic p = 0.1159), and the error correction term (ECT) is marginally insignificant (coefficient = -0.8198, p = 0.052). The results indicate that there is no convincing evidence of a long-term equilibrium adjustment.

Scale effect of economic expansion on environmental performance

Table 7

Diagnostic tests scale effect of economy on CO_2 emission

Test	Statistic	*p*-value	Interpretation
Jarque-Bera	0.7777	0.6778	Normal residuals
Breusch-Pagan	1.1363	0.2647	Homoskedasticity
VIF	1.0000	—	No multicollinearity
Durbin-Watson	1.996	—	No autocorrelation

Source: Author's calculation from E-views 10

Table 8

Regression results scale effect of economy on CO_2 emission

Variable	Coefficient	Std. Error	*t*-value	*p*-value	95% CI
Intercept	-5.68	0.728	-7.804	0.000	[-7.361, -4.00]
lnGDP	1.398	0.214	6.515	0.000	[0.903, 1.893]

Source: Author's calculation from E-views 10

R-squared: 0.841, Adj. R-squared: 0.821, F-statistic: 42.45, Prob (F-statistic): 0.000185

Table 8 demonstrates a very strong association between economic growth and carbon emissions. The coefficient of lnGDP is highly significant implying 1% increase in GDP is associated with a 1.40% increase in CO2 emissions.

Effect of climate-responsive public expenditure on economic growth

Table 9

Diagnostic tests effect of climate-responsive public expenditure on economic growth

Test	Statistic	*p*-value	Interpretation
Jarque-Bera	0.433	0.805	Normal residuals
Breusch-Pagan	0.624	0.3950	Homoskedasticity
VIF	1.0000	—	No multicollinearity
Serial LM	—	0.1767	No autocorrelation

Source: Author's calculation from E-views 10

Table 10

Regression Coefficients effect of climate-responsive public expenditure on economic growth

Variable	Coef	Std. Err	*t*-value	*p*-value	95% CI
Intercept	2.11	0.242	8.737	0.000	[1.5535, 2.6676]
lnCRPE	0.403	0.075	5.33	0.000	[0.228, 0.577]

Source: Author's calculation from E-views 10

R-squared: 0.782, Adj. R-squared: 0.754, F-statistic: 32.24, Prob (F-statistic): 0.000

The model shows a statistically significant positive relationship between climate-responsive public expenditure and GDP. A 1% increase in CRPE is associated with a 0.404% increase in GDP.

The Unrestricted Distributed Lag (UDL) model

Table 11

UDL Model for lnCO2 = lnCRPE + lnCRPE(Lag1)

Variable	Coefficient	Std. Error	*t*-value	*p*-value	95% CI
Intercept	-2.83	0.33	-8.65	0.000	[-3.63, -2.03]
lnCRPE	0.19	0.19	0.99	0.36	[-0.28, 0.67]
lnCRPE_lag1	0.43	0.16	2.66	0.04	[0.04, 0.82]

Source: Author's calculation from R- Programming

R-squared: 0.89, Adj. R-squared: 0.85, F-statistic: 24.20, Prob (F-statistic): 0.0013, Durbin-Watson: 2.40

The coefficient of current lnCRPE is positive (0.19) but statistically insignificant (p = 0.36), suggesting that a 1% increase in current CRPE is only associated with a 0.19% increase in CO2 emissions, even though this influence is not very strong. In contrast, the lagged CRPE

is positive and statistically significant (0.43, p = 0.04). This elasticity states that for every 1% increase in CRPE in the previous year, current CO2 emissions increase by 0.43%.

Discussion

This research investigated relationship between CRPE, CO2 emissions per capita, and GDP in Nepal during the years between 2013 and 2022. Motivated by the question of how fiscal policy can move toward a perspective of sustainable development, this research was focused on whether climate-related public spending fosters economic growth and affects environmental outcomes. The EKC hypothesis, endogenous growth theory, and fiscal policy theory served as the foundation for analysis. The key variables, GDP, CO2 emissions per capita, and CRPE, were log-transformed for elasticity-based interpretation and to meet the assumptions of linear modeling.

The methods included ADF tests for stationarity, Engle-Granger co-integration for long-run relationships, OLS regressions, ECM and UDL model estimations to capture temporal dynamics, and Granger causality tests assessing predictive directional relationships among the variables. It follows from the statistics that there was considerable growth in both GDP and CRPE, with GDP leading. Consequently, the OLS regression analysis confirms that climate-responsive public expenditure and GDP are positively related to CO2 emissions. The direct impact of CRPE on CO2 emissions-a 1% rise in climate-responsive public spending-translates to a 0.63% increase in emissions. This is most probably because energy-intensive and infrastructure-related activities were the focus of climate-related initiatives, which initially raise emissions instead of lowering them. Similarly, GDP remains a strong predictor of emissions, hence underlining the environmental cost of economic growth. The coefficient of lnGDP stands at 1.398 and is highly significant ($p < 0.001$), which implies that a 1% increase in GDP is accompanied by a 1.40% increase in CO2 emissions. This implies that the economic growth of Nepal exerts a strong and more than proportionate effect on emissions, reflecting the scale effect of development. The positive elasticity lends support to the EKC hypothesis during its early stage, where emissions increase with the growth of income. No evidence of decoupling is found within the period of study, 2013–2022, which suggests that Nepal remains in the rising phase of the EKC. Similarly, the stimulating influence of CRPE on GDP supports the notion that environmental fiscal policy leads to growth as well.

These results for Nepal can be juxtaposed with evidence from the European Union. Georgieva (2022) noted that EU expenditure on environmental protection increased linearly

between the years 2008 and 2022, while GHG emissions continuously went down, especially in 2019–2020 due to COVID-19. It would thus appear that growth and emissions are decoupled, and the green policies invested in resulted in measurable environmental dividends. In contrast, both GDP and CRPE were seen to have increased significantly in the present study-from USD 22.16 to 41.18 billion and from 10.34% to over 33%, respectively. On the other hand, however, CO2 emissions per capita increased from 0.225 to 0.541 metric tons. Contrary to the European Union where increased spending on the climate was associated with decreased emissions, the very opposite was seen in Nepal: the country is therefore still in its initial stages of growth whereby emissions and growth walk together. Although the EU trend favors "green growth," the scale effect is reflected in the Nepalese scenario, stating economic expansion and fiscal growth raise emissions before institutional and technological changes can offset them.

It was found from the UDL model that the immediate effect of CRPE on resultant emissions was insignificant, but the lagged effect turned out to be significant, thus showing a delayed response of environmental degradation due to climate expenditure. Co-integration tests showed no evidence of a long-run equilibrium relationship among the variables studied; this implies that the dynamics are dominated by short-run effects. In general, the results lead to the twin imperative for increasing economic growth through climate-responsive public expenditure on the one hand and sustainability of the environment on the other. The results provided useful information to policymakers who seek balanced development with sustainability concerns in Nepal.

Conclusions

In conclusion, evidence shows that both GDP and CRPE positively impact emissions. The magnitudes detected suggest that a 1% rise in GDP and CRPE increases CO2 emissions by 1.40% and 0.63%, respectively. This infers that Nepal is still in an ascending phase of the Environmental Kuznets Curve, where growth and emission increase together. Although CRPE boosts economic growth, the environmental effect is not identified due to a time lag, as detected through the statistical significance of its lagged value. The absence of long-run co-integration means that short-run dynamics prevail. Unlike in the European Union's case, where economic growth is decoupled from emissions, fiscal and economic expansion in Nepal is still placing pressure on the environment. Policymakers must make climate-responsive spending more efficient by concentrating on low-carbon and renewable energy-based investment to achieve sustainable and inclusive growth.

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