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Economic Growth, Transport Energy Consuption and Environmental Quality Nexus: Assessing the Evidence from Nepal

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Abstract
This paper intends to determine the influence of economic growth and energy use in the transport sector on the degradation of the environment or rise in CO 2 emissions. It is based on secondary data gathered from numerous financial reviews of Nepal and reports from the World Bank. The exploratory and descriptive research designs are applied to investigate the relationship and effect of GDP and transportation energy consumption on the deterioration of environmental quality. The descriptive statistics, correlation analysis, and ordinary least square (OLS) method are used in the study. It has been discovered that the GDP and transportation energy use each have a substantial role in determining environmental quality. The worsening of environmental quality is also observed to increase by 0.2796 and 0.6699 percent for every one percent increase in GDP and transportation energy consumption, respectively. Policymakers may increase spending on energy-efficient transportation, production methods, and renewable energy sources to decrease carbon emissions.

Keywords
descriptive research, economic growth, GDP, carbon emission

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1 Introduction

The conflict between the green economy and energy consumption is a foremost international matter [1]. The trend of urbanization, population development, rapid economic growth, and increasing specialization have increased the demand for transportation facilities. The growth of transport infrastructure has pressured the government to preserve oil and gas. Oil-related products account for over 90 percent of transportation energy use [2]. Outdoor air pollution, primarily from transportation emissions, causes millions of premature deaths yearly and is linked to various respiratory and cardiovascular diseases [WHO 2021].

The connection between Nepal's economic growth, transport energy consumption, and environmental quality can be complex and multifaceted. While economic growth is often associated with high energy consumption, especially in the transport sector, the impact on environmental quality depends on various factors, including the efficiency of energy use, technological advancements, policy frameworks, and the integration of sustainable practices [3]. Economic growth generally refers to the increased production of goods and services within a country over time. In the context of Nepal, economic growth can lead to an improvement in living standards, increased employment opportunities, and poverty reduction. As an economy grows, transportation activities usually increase to support trade, tourism, and infrastructure development. This often leads to higher energy consumption in the transport sector, which predominantly relies on fossil fuels such as petrol, diesel, and coal [UNFCCC, 2020]..The quality of the environment may be negatively impacted by Nepal's rapidly increasing energy consumption for transportation, especially when it comes to fossil fuel-powered automobiles. These consequences include the deterioration of ecosystems, air pollution, greenhouse gas emissions, and noise pollution.

When fossil fuels are burned in automobiles, emissions of particulate matter (PM), carbon dioxide (CO_2), nitrogen oxides (NO_x), and volatile organic compounds (VOCs) are released. These pollutants damage the environment and public health by adding to air pollution. The transportation industry substantially impacts greenhouse gas emissions, specifically carbon dioxide emissions, which are the primary driver of climate change. Using more energy for transportation can result in more emissions, exacerbating the global climate change problem. According to estimates, the transport industry is responsible for more than 25 percent of worldwide CO_2 emissions [4].

This study pursues to determine how energy use for transportation and economic extension affect environmental degradation in Nepal. The continuing causal relationship between economic growth, transportation energy use, and environmental quality is also explored.

The residue of the paper is prepared as follows: The second segment contains theoretical and empirical literature review. Third segment discusses the different types of research designs, data sources, and data processing procedures. Fourth part presents the data presentation and analysis, and finally segment 5 concludes with some policy implications.

2 Literature Review

The literature review covers theoretical and empirical research to show how Gross Domestic Product (GDP) and transport energy consumption harm the environment. This section reviews essential theoretical and empirical literature.

According to According to Costantini & Martini [1] and Adams et al. [4] , the energy used for transportation either degrades the state of the environment or increases CO_2 emissions. The direct impact of transport fuel consumption on long-term CO_2 emissions was noted by Johansson. In the ASEAN-5 countries, Chandran & Tang [5] studied the effects of income, foreign direct investment (FDI), transport energy consumption, and CO_2 emissions. They discovered that while FDI does not affect CO_2 emissions, revenue and transportation energy consumption do.

In 18 Asian nations, Nasreen et al. [6] examined the connection between environmental degradation and transport energy usage and GDP. They discovered that in Asian countries, there is a 0.57 percent and 0.46 percent decline in environmental quality for every one percent increase in transport energy use and economic growth, respectively. Chang [7] and Rehman [8] found that transportation energy use either lowers environmental quality or raises CO_2 emissions.

According to the verdicts of Xiangzhoa and Ji [9], Zhang et al. [10], and Chang et al. [11], a country's economic expansion destroys the quality of its environment by increasing CO2 emissions. Economic expansion is a long-term cause of environmental degradation in high- and upper-middle-income nations [12]. Nonetheless, every country in the economic category has a significant correlation between ecological deterioration and energy use.

Consumption of clean energy favors economic growth [13]. Use of fossil fuels and GDP expansion contribute to the decline in environmental quality. Numerous published studies have been done that show how ecological regulations directly affect economic growth. However, views on the impact of environmental rules on economic growth vary. Chintrakarn [14], and Costa-Campi et al. [15] found the negative link between environmental quality and economic development. According to Husaini and Zhang et al. (2021) there is an inverse U-shaped relationship between economic growth and environmental quality.

Raihan and Tuspekova [16] found a correlation between economic progress, energy use, agricultural productivity, and CO_2 emissions in Nepal. They discovered that a one percent increase in economic growth and energy consumption from fossil fuels would result in 0.61 and 0.67 percent increase in CO_2 emissions, respectively. Dahal et al. [17] observed Nepal's CO_2 emissions, industrial output and economic growth. They found that a one percent increase in GDP results in a 0.314 percent increase in CO_2 emissions in Nepal.

All these studies are associated to the causes of CO_2 emissions. Most studies focus on GDP growth, energy use, fossil fuel consumption, use of running machinery, and transport energy consumption in many countries. However, this study searches for the individual or joint impact of economic growth and transport energy consumption on Nepal's environmental quality deterioration. The present study is distinct than previous ones on the basis on variables, country, data points, objectives, data processing tools, techniques, result estimation software, and methods of the study. Regional disparities and temporal variations in the relationship between CO2 emissions and economic growth may exist. Transport energy consumption and CO2 emissions are also affected by the quality of vehicles, such as whether they are efficient, well-maintained, or old. So, it is the conclusion from a Nepalese perspective.

3 Materials and Methods

Research Design
A systematic framework for planning and carrying out the research process is provided by research design. Analytical and exploratory research designs are employed in this study. The relationship and effect of GDP and transport energy consumption on the decline in environmental quality are investigated using the exploratory research design, and the findings are described using the analytical research methodology.

Data and Result Estimation
Secondary data gathered from Nepalese economic surveys and several World Bank reports served as the investigation's foundation. The number of data points is 33 from F/Y 1988/89 to 2021/22. Descriptive statistics, correlation analysis, unit root testing, ordinary least square method, serial correlation LM (Lagrange Multiplier) test, heteroscedasticity test, Jarque-Bera (J-B) normality test, CUSUM, and CUSUM square test are a few of the statistical and econometric methods employed. Both EViews12 and SPSS 27 are used to analyze the secondary data.

Variables and Model Specification
Three variables, GDP, transport energy consumption, and environmental degradation through CO_2 emissions are included in this study. Deterioration of environmental quality is taken as the outcome variable and GDP and transport energy consumption are taken as predictor variables. It is assumed that the deterioration of Nepal's environmental quality (DEQL) depends upon gross domestic product (GDPN) and transport energy consumption (TECM) as mentioned below:

$$\text{DEQL} = f(\text{GDPN}, \text{TECM}) \quad (1)$$

The functional relation between the response and predictor variable after converting the logarithmic form is:

$$\text{LDEQL} = f(\text{LGDP}, \text{LTECM}) \quad (2)$$

A linear regression model's parameter can be estimated statistically using the Ordinary Least Squares (OLS) approach. Using this popular technique, a straight line can be fitted through a group of data points, which minimizes the sum of the squared discrepancies between the observed and anticipated values. Simply put, OLS seeks to minimize the sum of the squared vertical distances between the observed data and the bar to choose the line that best matches the provided data points. The following equation (3) defines the line:

$$Z = \alpha + \beta_1 Y_1 + \beta_2 Y_2 + \ldots + \beta_n Y_n + \mu \quad (3)$$

Where Z is the response variable. $Y_1, Y_2, \ldots, Y_n$ are the explanatory variables. $\beta_1, \beta_2, \ldots, \beta_n$ are the coefficients (parameters) to be projected, α shows the intercept of the regression line. μ represents the error term. The Ordinary Least Square (OLS) model, after introducing the variables of this study, is specified as under:

$$\text{LDEQL} = \alpha + \beta_1 \text{LGDPN} + \beta_2 \text{LTECM} \quad (4)$$

The fundamental presumptions of the ordinary least squares approach are linearity, independency, homoscedasticity, normalcy of errors, lack of perfect multicollinearity, and lack of endogeneity. OLS measures association rather than cause. It takes more evidence and the analysis of potential confounding factors to establish causation. OLS assumes that independent factors exist before dependent variables. The understanding of causality depends on this premise.

4 Materials and Procedures

Descriptive Statistics
The standard summary statistics summarize the dataset and help to understand its key features and characteristics. The summary statistics of the variables GDP, transport energy consumption, and deterioration of environmental quality with particular reference to CO_2 emissions are presented in Table 1.

Table 1: Key statistics of variables

Variables	N	Min.	Max.	Mean	Std Deviation	C. V.	Skewness	Kurtosis
Transport energy consumption	33	216159	4494500	1409155.45	1271384.36	90.22%	1.4185	3.6198
GDP	33	3401	37450	14634.82	11489.432	78.51%	0.7124	2.0324
CO_2 emissions	33	1098	15224	5589.39	4519.060	80.86%	1.0949	2.7036

Source: Calculated by Researcher using SPSS 27, 2023. Note: Transport energy use is presented in kilogram oil equivalent (KOE). GDP is placed in 10 million American Dollars and CO_2 emissions are calculated in Kilotons (KT).

Table 1 provides summary statistics for three variables, transport energy consumption, GDP, and CO_2 emissions, that indicate environmental quality deterioration. The maximum and minimum values of variables show the range of the data. The largest and smallest values of GDP range from 37450 to 3401 ten million USD, transport energy consumption from 4494500 to 216159, and CO_2 emissions from 15225 to 1098 kilotons, respectively. The standard deviation calculates the data's dispersion or spread. It expresses the degree to which the data differ from the mean. A more significant standard deviation indicates more considerable variability in the data. A relative indicator of variability is the coefficient of variation. It makes it possible to compare the variability of variables with various scales. Compared to other variables, the GDP has a lower coefficient of variance. Thus, GDP data is more consistent than other indicators. The two other variables are platykurtic, the transport energy consumption data is leptokurtic, and all the data are positively skewed.

Correlation Analysis

The correlation coefficients show the degree to which the values of the variables are related to one another. Statistics known as correlation coefficients describe the magnitude and direction of the linear link between two variables. The relationship between GDP and transportation energy consumption (TECM), GDP and deterioration in environmental quality (DEQL), transportation energy consumption (TECM), and ecological quality condition is measured in Table 2.

Table 2: Association between pairs of variables

Variables	GDPN	TECM	DEQL
GDPN	1.00	0.932**	0.961**
Significance (Two-tailed)		0.000*	0.000*
TECM	0.932**	1.00	0.972**
Significance (Two-tailed)	0.000*		0.000*
DEQL	0.961**	0.972**	1.00
Significance (Two-tailed)	0.000*	0.000*	

**. Association is significant at the 0.01 level. Source: Calculated by the researcher using SPSS 27, 2023. Note: GDPN shows the GDP of Nepal. TECM shows the condition of transport energy consumption in Nepal and DEQL shows a decrease in environmental quality depending upon the condition of CO_2 emissions.

The Pearson correlation coefficient between Gross Domestic Product (GDP) and transport energy consumption (TECM) is 0.932. The correlation is highly significant (P-value < 0.01). It is significant at a 1 percent level of significance. This indicates a strong positive relationship between GDPN and TECM, suggesting that as Nepal's gross domestic product increases, there is a corresponding increase in transport energy consumption. The Pearson correlation coefficient between GDPN and environmental deterioration is 0.961. The correlation is also highly significant at a 1 percent significance level (p-value < 0.01). It suggests a strong positive relationship between GDPN and environmental deterioration, indicating that as Nepal's gross domestic product increases, there is a corresponding decrease in environmental quality. The Pearson correlation coefficient between TECM and DEQL is 0.972. The correlation is highly significant (P-value < 0.01). This implies a strong positive relationship between TECM and DEQL, indicating that as transport energy consumption in Nepal increases, there is a corresponding decrease in environmental quality, likely due to increased CO_2 emissions from transportation. It is concluded that a strong positive relationship exists between GDPN, TECM, and DEQL. Additionally, there is a robust positive connection between TECM and DEQL. More transport energy consumption leads to improved GDP and decreased environmental quality.

Unit Root Test

The stationarity of a time series refers to its statistical properties remaining constant over time. Non-stationary series often exhibit trends, changing means, or varying variances, which can complicate the analysis. The stationarity testing was conducted using the Augmented Dickey-Fuller (ADF) test, a commonly used test for determining stationarity. The ADF test produces a test statistic, a p-value, and a critical value. The stationarity decision is based on comparing the test statistic and the critical value. The upshots of the stationary test are displayed in Table 3.

Table 3: Fallouts of stationarity test

Variable	Criteria	Level (L)	First intercept (D)	Decision
LDEQL	ADF test	-0.463	-2.968	Data is stationary
	P-value	0.885	0.219	after the first
	t-value	-2.769	-3.588	difference.
LGDPN	ADF test	-0.351	-2.957	Data is stationary
	P-value	0.977	0.445	after the first
	t-value	-2.255	-3.558	difference.
LTECM	ADF test	-0.537	-2.957	Data is stationary
	P-value	0.871	0.849	after the first
	t-value	-1.375	-3.558	difference.

Source: Calculated by the investigator using EViews12.

The results indicate that the outcomes of stationarity testing for three variables: LDEQL, LGDPN, and LTECM. All variables, gross domestic product, the quantity of transport energy consumption, and environmental quality, are stationary after the first difference because the P-value of the Augmented Dickey-Fuller (ADF) test of all variables is less than 0.05.

Odinary Least Square (OLS) Method

A statistical method for estimating a linear regression model's parameter is the Ordinary Least Squares (OLS) method. By minimizing the sum of the squared differences between the values predicted by the linear regression model and the observed values of the dependent variable, the objective of OLS is to determine which line best fits the data points. The upshots of the Ordinary Least Squares (OLS) method are shown in Table 4.

Table 4: Upshots of OLS regression examination

Response Variable: LDEQL				
Variables	Coefficient	Std. Error	t-Statistic	Probability
LGDPN	0.2796	0.0593	4.7137	0.0001
LTECM	0.6669	0.0609	10.955	0.000
C	-3.4766	0.4054	-8.575	0.000
R-Squared	0.9797	Average dependent variable: 8.336		
Adjusted R-Squared	0.9784	S.D. dependent variable: 0.767		
Std. Error of regression	0.1127	Akaike info criterion: -1.4408		
F-statistic	726.987	D-W statistics: 1.5600		
Prob(F-statistic)	0.000			

Source: Calculated by the investigator using EViews12.

Table 4 displays the Ordinary Least Squares (OLS) models and their results. The GDP plays a crucial role in worsening Nepal's environmental quality. It means that economic expansion is responsible for Nepal's CO_2 emissions. That is, a one percent increase in GDP is projected to result in a 0.2796 percent increase in environmental degradation. Alam [18], Nepal et al. [19], Sharma et al. [20], and Khan et al. [21] all demonstrated a positive relationship between economic growth and a decline in environmental quality using CO_2 emissions. Similarly, transportation energy use is statistically significant in determining Nepal's environmental quality. In Nepal, a one percent increase in transport energy consumption translates into a 0.6669 percent rise in CO_2 emissions. The increase in CO_2 emissions indicates that the nation's environmental condition is deteriorating. The following relation (5) is an estimation of the ordinary least squares regression equation:

$$\begin{aligned} \text{LDEQL} = -3.4776 + 0.2796 \cdot \text{LGDPN} \\ +0.6669 \cdot \text{LTECM} \\ (0.000) \quad (0.0001) \quad (0.000) \end{aligned} \tag{5}$$

The R-squared value is 0.9797. It exceeds sixty percent. More than sixty percent, precisely 97.97 percent, of the variation in environmental quality depends on the gross domestic product and transportation energy consumption. The adjusted R-squared value is also high. Therefore, independent variables are neatly fitted to explain the dependent variable. The regression standard error (S.E.) is 0.1127, quantifying the average deviation between observed and predicted values. The lower value of S.E. indicates that there is no longer a disparity between detected and projected values. Durbin-Watson (D-W) statistics have a value of 1.56, which is near to 2. Therefore, no significant autocorrelation exists. The F-statistic is 726.987, and the corresponding P-value is 0.00, indicating that the model is statistically significant. It suggests that the independent variables GDP and transport energy consumption significantly impact Nepal's ecological quality.

Residual and Stability Diagnostic Checking

Residual diagnostic checking focuses on analyzing the residuals of a model to detect potential problems or violations of assumptions. In contrast, stability diagnostic checking examines the consistency and robustness of a model across different subsets of data or over time. Both techniques are crucial for model validation and ensuring the reliability of statistical analyses. Residual and stability diagnostic checking are essential techniques used to assess the quality and reliability of statistical models. The outcomes of serial correlation, heteroscedasticity, and normality tests are presented in Table 5.

Table 5: Outcomes of residual and stability tests

Approaches	Null hypothesis	Observed R-squared
Serial Correlation LM Test	No serial correlation	2.1769 (0.3367)
	Decision: No problem with serial correlation	
Heteroskedasticity Test	Homoscedasticity	0.6259 (0.7313)
	Decision: No heteroscedasticity	
Normality test (Jarque-Bera)	Residuals are normally distributed	1.0443 (0.593)
	Model residuals follow a normal distribution.	

Source: Calculated by the researcher using Eviews12.

The model's diagnostic examination indicates no heteroscedasticity, serial correlation is not a problem, and the residuals are normally distributed, as shown in Table 5. It attests to the dependability and clarity of the OLS in use. The critical limits of the CUSUM and CUSUMSQ plots are at 5 percent, which shows that the OLS parameters are reliable and precise enough to evaluate the relationship between the explanatory and response variables. The CUSUM and CUSUM squared tests are displayed in Figure 1.

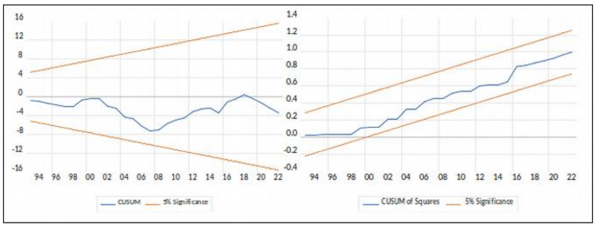

Figure 1: CUSUM and CUSUMSQ test for stability diagnostic.

Conclusions, Policy Implications, and Limitations

The long-term causal relationship between Nepal's economic growth, transportation energy consumption, and environmental quality has been explained in this research. The GDP is more reliable than transportation energy use in predicting environmental quality. There is a high degree of positive (0.961) connection between GDP and declining environmental quality. As a result, there is a strong positive association between environmental degradation and economic growth. Likewise, a strong positive correlation exists between the amount of energy used for transportation and the decline in environmental quality. Moreover, the country's economic expansion, coupled with transportation energy use, is responsible for the decrease in environmental quality. Increased energy use for transportation can either improve the economy or worsen the environment by raising CO_2 emissions. Both GDP and energy used for transport have a considerable impact on the rise in CO_2 emissions and environmental degradation. This study indicates that a one percent rise in GDP leads to a 0.2796 percent increase in the decline of environmental quality. Similarly, a one percent rise in transportation energy use is accompanied by a 0.6699 percent increase in CO_2 emissions.

The increase in GDP and transport energy consumption contributes to the decline in environmental quality. Policymakers may increase investment in renewable energy resources such as solar, wind, hydro, and geothermal. Incentives and subsidies can be provided to make renewable energy more economically viable and attractive for the business and household sectors. Energy efficiency technologies and practices could be promoted through tax incentives, rebates, and public awareness campaigns. Policymakers can implement policies and regulations supporting energy-efficient transportation, building, and industrial sectors. Stakeholders can support public transport, cycling, and walking by upgrading infrastructure and providing incentives for public and electric vehicles. Policymakers can implement a carbon-pricing mechanism to encourage businesses to minimize carbon emissions. The income generated from emissions can be reinvested in renewable energy projects, energy efficiency programs, and low-carbon technology research and development.

This article was based on secondary data covering 33 years, from fiscal year 1988/89 to fiscal year 2021/22. Environmental quality is influenced by limited independent variables, namely transport energy consumption and GDP. Descriptive statistics, correlation analysis, and ordinary least squares regression were implemented using straightforward statistical methods. Subsequently, further investigation is necessary, encompassing more countries, data points, factors, instruments, and approaches.

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