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The Impact of Carbon Dioxide Emissions on the Economic Growth of India

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ABSTRACT- This study aimed to analyze the impact of CO_2 emissions on the economic growth of India. The preliminary analysis of the data showed that CO_2 emissions are on the rise in India. Further, the analysis showed that carbon emissions are lower from the gaseous fuel consumption than electricity and heat production, and manufacturing industries, and construction. Similarly, the carbon emissions from liquid fuel consumption are lower than those from electricity and heat production but higher than those from manufacturing and construction. The analysis of the data proves that there is a connection between these variables. Results of correlation analysis and regression analysis showed that carbon emissions have a negative and significant impact on India's economic growth. Based on these results, we conclude that reducing carbon emissions is critical for the country's well-being. As a result, the government should devise strategies to reduce carbon emissions that are environmentally benign. Environmental protection is a long process requiring ongoing planning, government regulations, and public and industrial participation.

KEYWORDS- Economic growth, Carbon Dioxide Emissions, Carbon Intensity, Regression Analysis**.**

I. INTRODUCTION

Over the last few decades, researchers have focused their efforts on the relationship between economic growth and carbon dioxide emissions. Many countries are confronted with significant issues, like ensuring stable economic growth while also protecting the environment. Rising carbon dioxide emissions are exacerbating the threat of climate change. Developed countries consume a lot of energy, which results in carbon dioxide emissions; hence pollution is inextricably tied to economic development and growth. Environmental degradation has been identified as a significant issue in the process of economic development and growth. Because pollution has a direct impact on human life and the environment. Pollution clearly has a heinous impact on human health, resource depletion, and natural disasters. The major forms of pollution include air pollution, land degradation, soil contamination, water pollution, and noise pollution, whereas the source of pollution in the atmosphere involves the burning of fuels that generate house and industrial energy, depletion of vehicle consumption of petrol, diesel oil, waste gas, dirt, and heat. The main environmental pollutants are sulphur dioxide, nitrogen dioxide, and particulate matter.

Carbon dioxide and methane are the most significant contributors to greenhouse gas emissions, and global warming has emerged as a major source of concern because carbon dioxide emissions are causing the earth's temperature to rise. As a result, it is apparent that carbon dioxide emissions, in addition to having a direct impact on human life and the environment, have a significant impact on the economic growth and development process. In this context, this study aims to look into the impact of carbon dioxide emissions on India's economic growth.

A. An Over View of Carbon Emissions and Climate Change in India

India was the fourth most affected country by climate change from 1996 to 2015 [1]. India produces about three gigatonnes (Gt) of CO2eq per year, or about two and a half tonnes per person, less than half the global average. The United States Agency for International Development (USAID) published a report in 2018 that stated 7 percent of global emissions are attributed to the country [2]. As temperatures rise on the Tibetan Plateau, Himalayan glaciers retreat, affecting the Ganges, Brahmaputra, Yamuna, and other major rivers. According to a study published in 2007 by the World Wide Fund for Nature (WWF), the Indus River may run dry for the same reason. India's heatwaves are becoming more frequent and powerful as a result of climate change. Severe landslides and floods are expected to become more common in places like Assam [3]. If the Intergovernmental Panel on Climate Change's predictions about global warming come true, climate-related issues might cause India's GDP to drop by up to 9%, according to the Indira Gandhi Institute of Development Research. This would be aided by shifting growing seasons for major crops like rice, which may experience a 40% fall in production.

As of 2019, estimates for greenhouse gas emissions are unknown; nevertheless, a comprehensive greenhouse gas inventory is possible. Reducing greenhouse gas emissions, and hence air pollution, in India would yield health benefits worth four to five times the cost, making it the most cost-effective country on the planet. In 2014, India's carbon intensity as a percentage of GDP was twice that of the rest of the world. According to the Paris Agreement's commitments, its intensity was to be lowered by 33-35 percent by 2030. In 2014, India produced 2,600 metric tonnes of CO2 equivalent (2,300 metric tonnes with LULUCF) [4]. According to the

UNEP, India's annual emissions per person are anticipated to reach between 3 and 4 tonnes by 2030. In 2019, China was estimated to have emitted 27% of global greenhouse gas emissions.

India has the highest social cost of carbon in the world [5]. Climate change might cost India between 3 and 10% of its GDP every year by 2100, according to a report by the London-based global think tank Overseas Development Institute, and its poverty rate could rise by 3.5 percent by 2040. Furthermore, India's poor, who number over 400 million, would be disproportionately affected by climate change. This is an issue because so many people rely on natural resources for food, shelter, and money. Agriculture employs almost 56 percent of India's population, with coastal parts employing many more.

B. An Overview of Economic Growth in India

The economy of India was in shambles at the time of its independence. It was in charge of the growth of a foreign country rather than her own as a colony. The government, which is in charge of agricultural and industrial accomplishments in general, refused to play even a minor role in this. On the other hand, thanks to the states' active participation, the world saw remarkable progress and expansion in agriculture and manufacturing in the half-century leading up to India's independence. The British government never made any significant changes to improve the social sector, which hampered the economy's ability to produce.

In terms of systematic economic organisation, the administration of the time had a significant problem after India became independent. The need for expansion and development was in high demand among the political elite as the country rode on promises and feelings of national fervour. India had made a number of critical and strategic decisions by 1956, which have continued to impact the country's economic destiny.

The Indian economy is in the process of transitioning to a market economy [6]. India's economy is ranked third in terms of purchasing power parity (PPP) and fifth in terms of nominal GDP. In terms of per capita income, India ranked 119th in terms of GDP (PPP) and 142nd in terms of GDP (nominal) in 2018. India's average annual growth rate has been between 6.0 percent and 7.0 percent since the beginning of the twenty-first century [7]. From 2014 to 2018, India's economy and market were the world's largest and fastest-growing. India's economy's long-term and future growth scenarios are favourable and auspicious due to its favourable and auspicious demographic dividend, as well as its healthy and high-income people. After the shock and tremor of demonetization in 2016 and the adoption of the Goods and Services Tax (GST) in 2017, the Indian economy stagnated and slowed [8]. Domestic private expenditure/consumption is responsible for more than half of India's growth. As a result, India has surpassed China to become the world's sixth-largest consumer market. India's GDP is fueled by investment, government spending, and exports. As a result of its strong democracy and alliances, India has emerged as the world's fastest-growing major economy, and it is expected to become one of the world's top three economic powers in the next 10-15 years. However, the devastating COVID-19 has had a negative impact on India's growth potential, causing it to decelerate.

C. Rationale of the Study

Carbon emissions have become a serious global issue in recent years. The global societal cost of carbon emissions is rising over time. Climate change is expected to cost India between 3 and 10% of its GDP each year by 2100, according to studies, and the country's poverty rate might rise by 3.5 percent by 2040. Furthermore, India's poor, who number over 400 million, would be disproportionately affected by climate change. This is an issue because so many people rely on natural resources for food, shelter, and money Agriculture employs almost 56 percent of India's population, with coastal parts employing many more. With this in mind, this study examines the nature and trajectory of the relationship between economic growth and carbon emissions because a well-established, well-directed, and well-understood relationship between economic growth and carbon emissions could aid Indian policymakers in framing appropriate policies that will accelerate the pace of development over time.

D. Objectives of the Study

The objectives of the study are as follows:

- To analyze the trends in CO_2 emissions in India.
- To analyze the impact of CO_2 emissions on the economic growth of India.

E. Hypothesis of the Study

The hypothesis of the study is as follows:

- There is no impact of CO_2 emissions on the economic growth of India.

II. REVIEW OF LITERATURE

Alam [9] looked on the impact of economic development on environmental quality in India. Economic development and environmental degradation were measured using GDP per capita and CO2 emissions, respectively. The researchers looked at the long-term link between CO2 emissions, per capita GDP, and industrial value-added. CO2 emissions rise when GDP per capita rises, even if industrial value-added remains constant.

Misra, K [10] examined the relationship between India's economic growth and carbon emissions for the period 1970-2012. Granger causality was used to determine whether or not there are unidirectional and bidirectional causal relationships between variables. The findings show that there is one-way causation between energy use and GDP and carbon emissions. The ARDL showed that the variables have a long-run link but that there is no such association in the short run. According to the findings, any endeavour to reduce carbon emissions without improving energy efficiency will have a negative impact on the country's economic growth.

Xiongling [11] showed that in the long run, economic growth and CO2 emissions are balanced. The findings revealed that long-term economic development could help to decrease environmental degradation.

Kasperowicz [12] using ECM estimate, found a negative relationship between CO2 emissions and GDP, implying that the development of new low-carbon technologies will allow for the same level of production with reduced CO2 emissions in the long run. The negative association is undoubtedly caused by EU countries' energy conservation and low-carbon technological progress.

Heidari, Turan Katircioğlu,and Saeidpour [13] investigated the relationship between economic growth, CO2 emissions, and energy consumption in five ASEAN (Association of Southeast Asian Nations) countries for the period 980-2008. The first regime (with GDP per capita below $4,686) demonstrated that environmental deterioration rises in tandem with economic expansion, whereas the second regime reversed the tendency (GDP per capita above 4,686 USD). Energy usage increased CO2 in both regimes, according to the findings. In the ASEAN countries, these findings confirm the EKC concept.

Ghosh, Alam, and Md. Osmani [14] examined the causal relationship between GDP, CO2 emissions, and energy consumption for Bangladesh. The study made use of time series data from 1972 to 2011. The study found that CO2 emissions have a detrimental impact on economic growth, whereas energy use has a favourable impact.

Farhani and Rejeb [15] looked at the link between energy consumption, GDP, and CO2 emissions in 15 MENA nations using data from 1973 to 2008. In the short run, there is no causal link between GDP and energy consumption, or between CO2 emissions and energy consumption, according to the findings of this study. In the long run, however, there is a one-way causality from GDP and CO2 emissions to energy consumption.

Even some researchers utilizing a similar methodology, the outcomes are mixed. This could be due to differences in the variables used, the transformations used, the sample period, and/or the panel of nations examined. However, it will be interesting to analyze the relationship between economic growth and carbon emissions with recent datasets.

III. RESEARCH METHODOLOGY AND DATA SOURCES

A. Sources of Data

Secondary sources have been used for collecting the data for the present study. The secondary data have been utilized to examine the trends in CO2 emissions in India and to investigate the impact of CO2 emissions on the economic growth of India. The data for the present study have been extracted from the following sources:

- Books and journals
- World Development Indicators, World Bank.

B. Coverage of Study

To achieve the objectives of the present study, secondary sources of data have been obtained for the period 1990-1991 to 2017-2018.

C. Methods Used for Analyzing and Interpreting Data

After gathering the necessary data from various sources, correlation analysis and linear regression analysis were used to examine it, in addition to generating annual growth rates and percentages.

- **Correlation Analysis:** Karl Pearson's coefficient of correlation was used to determine the association between CO2 emissions and economic growth (GDP) in India. The coefficient of correlation was calculated using the formulae below:

$$r = \frac{n\left(\sum xy\right) - \left(\sum \mathbf{x}\right)\left(\sum \mathbf{y}\right)}{\sqrt{\mathrm{n} \sum \mathbf{x}\ \mathbf{2} - \left(\sum \mathbf{x}\right)\ \mathbf{2}\ \mathrm{n} \sum \mathbf{y}\ \mathbf{2} - \left(\sum \mathbf{y}\right)\ \mathbf{2}}} \quad (1)$$

- Regression analysis; to know the effect of CO2 emissions on the economic growth of India, a regression equation of the following form will be used;

$$LGDP = \alpha + \beta CO_2 \quad (2)$$

Where,
LGDP = log of GDP (economic growth)
CO2 = CO2emmissions
α = intercept
β = slope (change)

D. Independent and Dependent Variables

In this study, the independent variable used is carbon dioxide emissions and the dependent variable is economic growth (GDP).

E. Limitation of the Study

The study's drawback is that it only looks at one major greenhouse gas, carbon dioxide emissions, and it ignores other greenhouse gases like sulphur dioxide, nitrogen dioxide, and others.

IV. DATA ANALYSIS AND RESULTS

A. Trends in CO2 Emissions (kg per 2010 US$ of GDP)

Table 1 and figure 1 show that between 1990 and 2006, CO2 emissions in India showed a declining trend. However, during the next three years, CO2 emissions showed an upward trend. From 2010 onwards, CO2 emissions at large showed a declining tendency. This was largely due to the ratification of Kyoto Protocol commitments- as Kyoto Protocol commits countries to contain the emission of greenhouse gases, affirming its stand on climate action.

Table 1: Trends in CO2 Emissions (kg per 2010 US$ of GDP)

Year	CO2 emissions (kg per 2010 US$ of GDP)	Average Annual Growth (AGR)
1990	1.10819303	
1991	1.184062256	6.846210345
1992	1.164883279	-1.619760878
1993	1.151240248	-1.171192963
1994	1.138059826	-1.14488888
1995	1.139661108	0.140702807
1996	1.110592963	-2.550595559
1997	1.128875602	1.646205197
1998	1.086875238	-3.720548444
1999	1.074950528	-1.097155353
2000	1.076500848	0.144222406
2001	1.041936236	-3.210829995
2002	1.039163086	-0.266153504
2003	0.99110153	-4.62502535
2004	0.982795493	-0.838061149
2005	0.952982646	-3.033474137
2006	0.941200544	-1.236339547
2007	0.961956333	2.205246136
2008	0.994459624	3.378873832
2009	1.015637139	2.129550014
2010	0.99384982	-2.145187278
2011	0.998503145	0.468212061
2012	1.026300653	2.783917948
2013	0.99413189	-3.134438531
2014	1.005574063	1.15097128
2015	0.93693652	-6.825707363
2016	0.878786759	-6.206371425
2017	0.867403652	-1.295320804
2018	0.861292813	-0.704497629

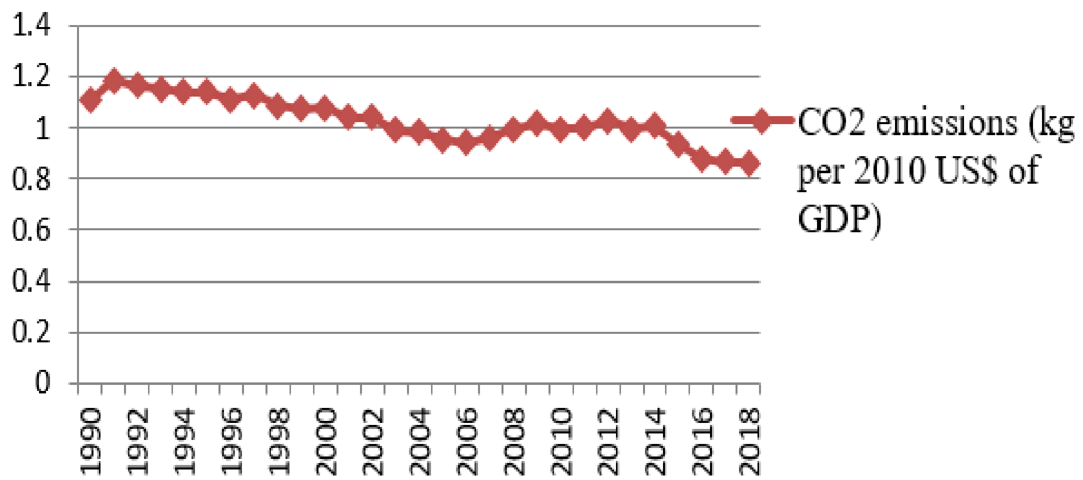

Figure 1: Trends in CO2 Emissions (kg per 2010 US$ of GDP)

B. Trends in CO2 emissions (metric tons per capita)

Table 2 and Figure 2 show trends in CO2 emissions (metric tons per capita). Table 2 and Figure 2 shows that between 1990 and 1999, CO2 emissions (metric tons per capita) were in the range of one and five. From the year 2000 to 2009, there were wide fluctuations in CO2 emissions (metric tons per capita). CO2 emissions (metric tons per capita) were highest in the year 2009. Thereafter, the pace of increase in CO2 emissions (metric tons per capita) somewhat slowed down, and these emissions remained in the range of about 1.64 metric tons per capita to 1.65 metric tons per capita in 2014, 2015, and 2016. However, during the next two years, CO2 emissions per capita again showed an upward trend.

Table 2: Trends in CO_2 Emissions (metric tons per capita)

Year	CO2 emissions (metric tons per capita)	Average Annual Growth (AGR)
1990	0.644102026	
1991	0.681429666	5.795299131
1992	0.693121231	1.715740647
1993	0.703544619	1.503833332
1994	0.727526089	3.408663674
1995	0.768837675	5.678364854
1996	0.790663149	2.838762218
1997	0.82074131	3.804168862
1998	0.823779815	0.370214738
1999	0.870943498	5.725277826
2000	0.88982752	2.168225864
2001	0.887330155	-0.280657249
2002	0.903241998	1.793226855
2003	0.913962074	1.186844344
2004	0.962435743	5.303684953
2005	0.991399583	3.009431014
2006	1.041839796	5.087778354
2007	1.129216789	8.386797413
2008	1.185904772	5.02011508
2009	1.288080997	8.615887886
2010	1.349214466	4.746088846
2011	1.408315593	4.38041012
2012	1.507820975	7.06555992
2013	1.535560059	1.839680221
2014	1.649327519	7.408857697
2015	1.641198393	-0.492875183
2016	1.648359053	0.436306809
2017	1.7191902	4.297070303
2018	1.799825446	4.69030392

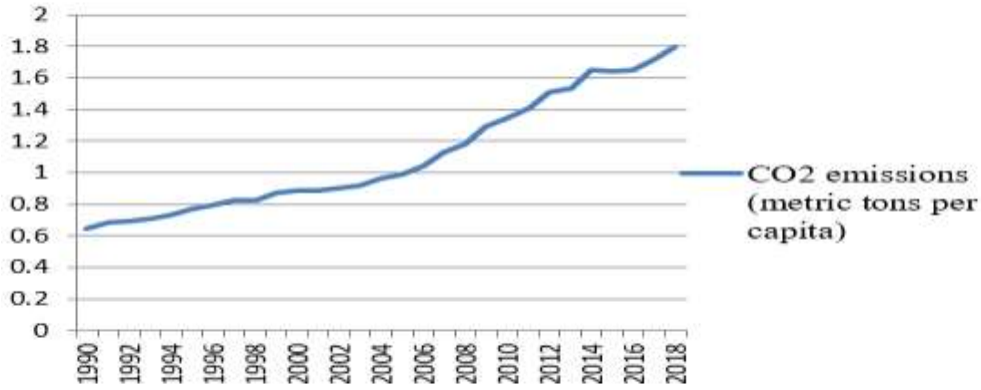

Figure 2: Trends in CO2 Emissions (metric tons per capita)

C. CO2 Emissions from various Sectors

Table 3 and figure 3 show trends in CO_2 emissions electricity and heat production, from gaseous fuel consumption and from manufacturing industries and construction. Table 3 and figure 3 show that carbon emissions from electricity and heat production are highest, followed by carbon emissions from manufacturing industries and construction. Carbon emissions from electricity and heat production ranged between 50% in 1993 to about 57% in 2004. The carbon emissions from electricity and heat production started declining from 2005 and came down to 54.60% in 2014. On the other hand, the carbon emissions from manufacturing industries and construction declined from 27.90% in 1990 to about 22% in 1997. From 1998 to 2007, the carbon emissions from manufacturing industries and construction remained in the 19%-22% range. However, the CO_2 emissions from manufacturing industries and construction slowly started increasing from 2008 and increased up to 26.40 in 2016.

The CO_2 emissions from gaseous fuel consumption, as compared to CO_2 emissions from gaseous fuel consumption and from manufacturing industries and construction, were substantially low during the 1990-2016 period. In general, The CO_2 emissions from gaseous fuel consumption ranged between 3% to 5% over the given period. This analysis shows that gaseous fuel consumption contributes less to greenhouse gases as compared to electricity and heat production, and manufacturing industries and construction.

Table 3: Trends in CO2 Emissions from various Sectors

Year	CO2 emissions from electricity and heat production (% of total)	CO2 emissions from gaseous fuel consumption (% of total)	CO2 emissions from manufacturing industries and construction (% of total fuel combustion)
1990	43.74728983	3.753837648	27.90294301
1991	45.28882286	3.882911878	26.5769466
1992	46.79111618	4.328184083	26.02024543
1993	49.40466613	4.140949929	24.56476267
1994	48.78320101	4.218955593	24.73523003
1995	51.61796292	5.273631899	21.99440425
1996	52.46165064	5.12148728	20.97331749
1997	51.53463001	5.607097799	21.74475332
1998	52.72557811	5.671901456	22.39155625
1999	53.73852515	4.6842884	21.50498704
2000	55.21427609	4.670289203	21.04914424
2001	55.86708204	4.571256028	20.80820132
2002	54.92646116	4.776795439	21.61486169
2003	56.26402197	4.92463564	19.86979221
2004	56.88778239	4.564566543	19.6631235
2005	55.56049575	4.436859212	21.43518776
2006	55.53305756	4.075149104	22.39641268
2007	55.45391293	3.94721907	22.92256361
2008	53.62066787	4.431417605	23.47209525
2009	52.29103743	5.817291413	24.28175828
2010	51.50289162	6.023990668	25.97380603
2011	51.76420685	5.193320025	26.86397744
2012	53.44267238	4.094746538	25.18483772
2013	52.31799877	5.180161175	26.9695432
2014	53.60529195	4.33785986	26.40827462
2015	NA*	4.603916436	NA
2016	NA	4.389254287	NA

NA implies data not available for the given year(Source: World Bank, Development Indicators 2018)

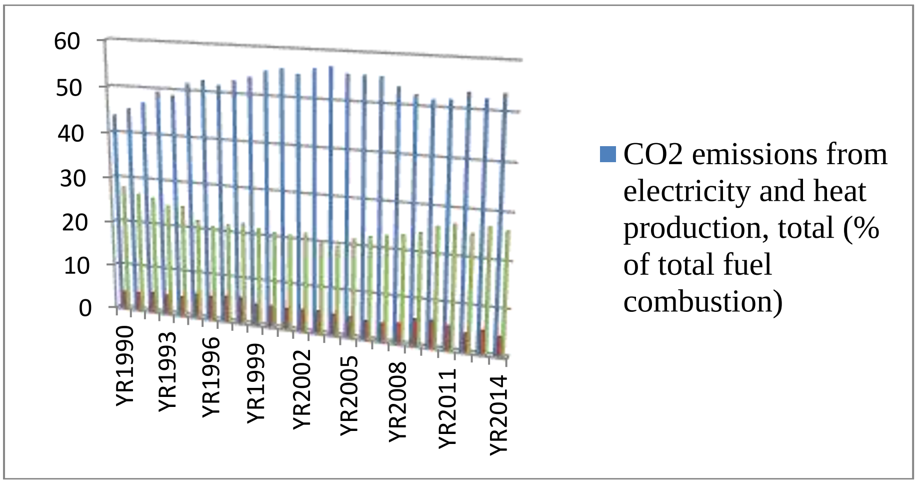

Figure 3: Trends in CO2 Emissions from various Sectors

D. CO2 Emissions from Liquid Fuel Consumption (% of total)

Figure 4 shows trends in CO2 emissions from liquid fuel consumption. Table 3 and figure 3 show that the carbon emissions from liquid fuel consumption initially showed an upward trend up to 2001. Thereafter, the carbon emissions from liquid fuel consumption show a declining tendency, and the carbon emissions from liquid fuel consumption were lowest in the year 2012. From 2012, the carbon emissions from liquid fuel consumption again started increasing and to about 30% of the total. Thus, we can say that the carbon emissions from liquid fuel consumption are lower than those from electricity and heat production but higher than those from manufacturing and construction.

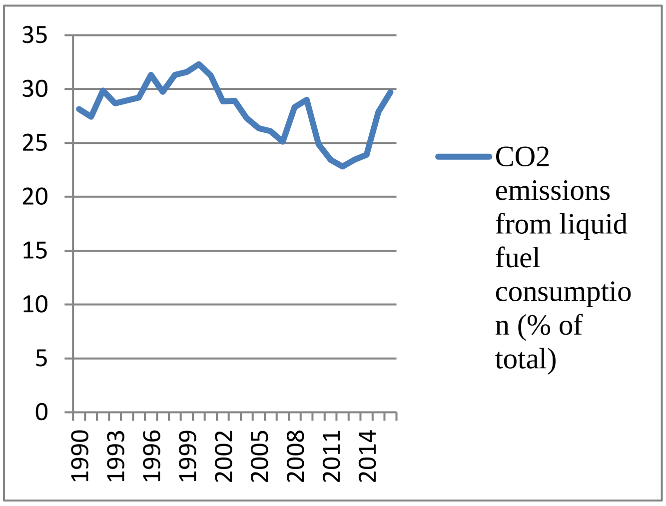

Figure 4: CO2 emissions from liquid fuel consumption

E. CO2 Intensity (kg per kg of Oil Equivalent Energy Use)

Carbon intensity, as noted before, is the ratio of carbon dioxide per unit of energy, or the amount of carbon dioxide emitted as a result of using one unit of energy in production. Emission intensities are also used to compare the environmental impact of different fuels or activities. The related terms - emission factor and carbon intensity - are often used interchangeably. Carbon dioxide emissions, largely by-products of energy production and use, account for the largest share of greenhouse gases, which are associated with global warming. Figure 5 shows that the CO2 intensity (kg per kg of oil equivalent energy use) increased from 1.84 in 1990 to about 2.60 (kg per kg of oil equivalent energy use) in 2014, indicating that CO2 intensity increased by more than half times from 1990 to 2014.

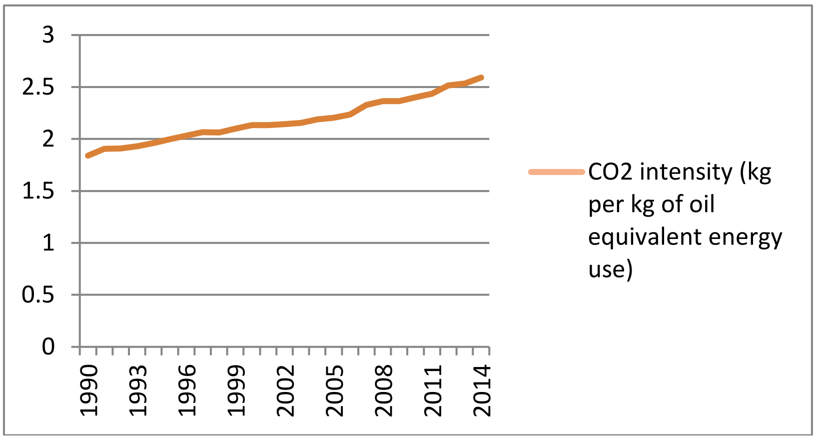

Figure 5: Trends in Carbon Intensity

F. Correlation Analysis

To work out the relationship between CO2 emissions and economic growth (GDP) in India, results based on Karl Pearson's coefficient of correlation have been reported in this section. The results in Table 4 show that CO2 emissions have a negative and statistically significant relationship with economic growth.

Table 4: Results of Karl Pearson's Coefficient of Correlation

Variable	LGDP	LCO_2
LGDP	1.0000	-
LCO_2	-0.9414*	1.0000

* indicates significance at 1% level of significance, L signifies log of the variable.

G. Results of Regression Analysis

Regression analysis applied on our dependent variable and independent variable produces results as shown in Table 6.

Table 6: Results of Correlation Analysis

LGDP	Coef.	Std.err.	P > t	P-Value
Cons.	26.24	0. 121	10.44	0.000*
LCO_2	-.440	0.421	-216.66	0.000*
R^2 = 0.58, Adj R-squared= 0.578, F = 109.03, Prob. > F = 0.000*				

* indicates significance at 1% level of significance, L signifies log of the variable.

Table 6 shows that in this model, R2 = 0.58. Adj.R2 = 0.5781, F = 109.03 and p-value for this model is (0.000) **. The R2 value of 0.58 implies that 58% of the dependent variable (economic growth) variation is explained by the independent variable (CO1 emissions) alone. The F statistic is statistically significant (at 0.01 level of significance), which implies that the model is statistically significant.

Table 6 also shows that the model equation for our model can be written as:

LGDP = 26.24 - 0.440CO2 emissions

The beta coefficient value for the independent variable (CO2 emissions) in this model equation is -0.440. This beta coefficient value shows that a unit change in CO2 emissions brings about a 44% change in economic growth. Further, this value of the beta coefficient is statistically significant at a 1% level of significance. Thus, we reject the null hypothesis H0 – there is no impact of CO2 emissions on the economic growth of India and conclude that CO2 emissions have a significant influence on the economic growth of India.

V. CONCLUSION

This research aimed to look into the impact of CO2 emissions on India's economic growth. The data analysis clearly demonstrates that there is a link between these variables. Based on these data, we believe that reducing carbon emissions is critical for the country's and people's well-being. As a result, the government should devise environmentally favourable methods for reducing carbon emissions. Environmental protection is a long-term process that necessitates ongoing planning, government policy, and industrial and public participation.

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