A Report

On

Global Warming, Climate Change and Its impact on Economic Development

Development Economics(GS F234)

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ABSTRACT

The purpose of this report is to analyze the impacts of Global Warming and Climate Change on Economic Development of the Nation. Multiple Linear Regression model have been used to analyze the impact of global warming and climate change on economic development. The Human Development Index has been taken as a proxy for economic development and factors like Natural Resource Depletion, Carbon Dioxide Emissions, Forest Area, and Renewable Energy Consumption have been taken as a proxy for global warming and climate change. The hypothesis was that the HDI is negatively and linearly related to the above-mentioned factors and that this would imply a linear relation between Global Warming, Climate Change, and Disasters and Economic Development. To verify the data and apply linear regression, software like Stata and MS Excel were used. This report contributes formulating and factually testing the dependence of the above-mentioned factors. Although the study is subjected to certain limitations, it is observed that the limitations can be overcome by certain further testing. The results of the study may have valuable implications for policymakers and educators.

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INTRODUCTION

The life of more than half of the economically active population in the developing world directly depends on the environment through agriculture, farming, hunting, fishing, forestry, and foraging.

Environmental degradation can moreover degrade from the pace of economic development by imposing high costs on developing nations through health-related expenses and the decreased efficiency of resources. The poorest 20% of the poor in both rural and urban ranges will encounter the consequences of environmental ills most intensely. Extreme natural degradation, due to population pressures on minimal land, has driven to falling farm efficiency and per capita food production. Since the development of marginal land is largely the space of lower-income groups, the losses are endured by those who can least bear them.

In spite of the fact that the environmental costs related to different financial activities are disputed, development economists concur that environmental considerations ought to shape an integral part of policy initiatives. Harm to the soil, water supplies, and forests coming about from unsustainable strategies of production can greatly diminish long-term national efficiency but incomprehensibly can appear up as having a positive effect on current GNI figures. It is hence exceptionally important that the long-term implications of natural quality be considered in economic analysis. Rapid population growth and expanding financial movements in the creating world are likely to do broad natural harm unless steps are taken to relieve their negative results.

This brings us to the issue of developing countries and their role in the problem faced due to Global warming. The primary objective of the policymakers in these countries is to raise the standard of living of their respective societies, driving them to more happiness and satisfaction. Therefore, looking at the success of the developed countries in increasing their standard of living through the process of industrialization and technological advancement, the developing countries are following religiously in the footsteps of their industrialized competing countries. This implies that if the same process is followed by the developing countries, the future emissions of greenhouse gases can be expected to increase substantially. This, in turn, would imply a larger enhanced greenhouse effect and subsequently a more pronounced climate change in the future. This brings us to the objective of this study.

The direct correlation between economic growth and standard of living had prompted many of the current generation's developed countries to pursue a policy of accelerated economic development through the process of industrialization. One of the unique features of modern industrialization has been its demand for large amounts of energy. This demand for energy has been primarily met by the burning of fossil fuels which incidentally emit large amounts of greenhouse gas, carbon dioxide; consequently the enhanced greenhouse effect. However, a recent surge in public opinion over the environmental deterioration caused by these policies of accelerated growth has forced policymakers in these countries to reassess the economic growth policy. Nevertheless, policymakers contend that environmentally sensitive policies are costly and impose huge financial strains on the economy and argue that environmental goals can only be achieved at the expense of economic development.

The analysis of the impact of global warming and climate change on the economic development has been done by using efficient indicators such as rate of natural resource depletion, carbon dioxide emissions, forest area, renewable energy consumption, and Human Development Index(HDI) which gives a clear picture through a regression model about how Climate change and economic development are related.

LITERATURE REVIEW

1. **The impacts of global warming on farmers in Brazil and India** by Apurva Sanghi and Robert Mendelsohn (2008):

   This paper, namely "The Impact of Global Warming on Farmers in India and Brazil", endeavors to reveal insight on two important questions, namely, How great a threat global warming is to climate-sensitive and economically important sectors such as agriculture in developing countries and How well will agriculture workers be able to adjust to the threats of the global rise in temperature. A cross-sectional investigation is utilized to assess the atmosphere affectability of horticulture in Brazil and India. Utilizing board information from the two nations, the examination quantifies how net ranch salary or property estimations change with atmosphere, and therefore, how ranchers in India and Brazil respond and adjust to the atmosphere. The assessed connections are then used to foresee the outcome of elective atmosphere situations. An Earth-wide temperature boost before the finish of the following century could cause yearly harms in Brazil somewhere in the range of 1% and 39% and somewhere in the range of 4% and 26% in India, albeit a portion of this impact might be conceivably balanced via carbon preparation. However, these numbers don't factor into account the climate-induced outrageous weather occasions.

2. **Disasters, Climate Change and Economic Development in Sub-Saharan Africa: Lessons and Directions** by Ajay Chhibber and Rachid Laajaj (2008):

   In their paper "Disasters, Climate Change and Economic Development in Sub-Saharan Africa: Lessons and Directions", they deal with the link between natural disasters, weather variation, and financial development and hence outline a map for consideration. The connections among natural disaster events, environmental change and financial advancement plot a structure for thinking. This connects the constrained information on the long haul financial effect of cataclysmic events. Drawing joins among fiascos, asset the board, clashes, and other transmission channels is a fundamental condition to build up a proper reaction. The African government alongside their advancement accomplices needs to build up an increasingly hearty adjustment and reaction capacity to calamities as a major aspect of improvement arranging. The defense for more market-based financing components that have been utilized until now and accentuation on computed research.

3. **Implications of Climate Change for Economic Development in Northern Canada: Energy, Resource, and Transportation Sectors** by Terry D. Prouse, Chris Furgal, Rebecca Chouinard, Humfrey Melling, David Milburn and Sharon L. Smith (2009):

   The paper "Implications of Climate Change for Economic Development in Northern Canada: Energy, Resource, and Transportation Sectors" written by the above authors discusses how Northern Canada is anticipated to encounter significant changes to its atmosphere, which will have significant ramifications for northern financial advancement. A portion of these, for example, mining and oil and gas improvement, have encountered fast development as of late and are probably going to grow further, halfway as the aftereffect of circuitous impacts of the evolving atmosphere. Changing atmosphere influence a few financial parts including hydroelectric, oil and gas, and mining businesses just as foundation and transportation, both marine and freshwater. Of specific significance to all parts are anticipated changes in the cryosphere, which will make the two issues and openings. Potential adjustment systems that could be utilized to limit the negative effects made by an environmental change are likewise inspected.

4. **Are global warming and economic growth compatible? Evidence from five OPEC countries?** by Ramazan Sari and Ugur Soytas (2009):

   In their paper “Are Global Warming and Economic Growth Compatible? Evidence from Five OPEC Countries”, they use the connection between carbon discharges, income, energy and work in chosen OPEC nations for the time of 1971–2002, and therefore focus mainly on the connection between energy use and income. Utilizing the Autoregressive Distributed Lag (ARDL) approach, they find that there is a connection between the factors in Saudi Arabia as it were. Employment and energy are the longest-running variables for income in Saudi Arabia. In Indonesia, Algeria, Nigeria, and Venezuela, there is no cointegration among employment and vitality. Overall outcomes propose that none of the nations need to forfeit financial development to diminish their outflow levels. Indonesia and Nigeria may add to discharges decrease by means of vitality protection without negative long-run consequences for financial development and economic growth.

5. **Examining carbon emissions economic growth nexus for India: A multivariate cointegration approach** by Sajal Ghosh (2010):

   This paper “Examining Carbon Emissions Economic Growth Nexus for India”, tests cointegration and causality between carbon discharges and financial development for India utilizing ARDL limits testing approach supplemented by Johansen–Juselius most extreme probability system in a multivariate structure by consolidating vitality supply, venture and work for time range 1971–2006. The investigation neglects to build up since quite a while ago run harmony relationship and long haul causality between carbon emanations and financial development; in any case, there exists bi-directional short-run causality between the two. Subsequently, in the short-run, any push to diminish carbon discharges could prompt a fall in the national salary. This examination additionally sets up unidirectional short-run causality running from financial development to vitality supply and vitality supply to carbon discharges. The nonattendance of causality running from vitality supply to financial development infers that in India, vitality protection and vitality proficiency measures can be actualized to limit the wastage of vitality across the esteem chain. Such measures would limit vitality request supply holes. Non Appearance since quite a while ago run causality between carbon emanations and monetary development infers that over the long haul, spotlight ought to be given on saddling vitality from clean sources to control carbon outflows, which would not influence the nation's financial development.

6. **The Effects of Climate Change on GDP by Country and the Global Economic Gains From Complying With the Paris Climate Accord** by Tom Kompas, Van Ha Pham and Tuong Nhu Che (2018):

In their paper “Earth’s Future”, they used Computable general equilibrium(CGE) models which are a standard device for approach investigation and examples of financial development. This work expands an enormous dimensional intertemporal CGE exchange model to represent the different impacts of an Earth-wide temperature boost (e.g., misfortune in agrarian efficiency, ocean level ascent) Gross Domestic Product (GDP) development and levels for 139 nations, by decade and over the long haul, where makers look to advance and modify value desires and capital stocks to represent future atmosphere impacts. The potential financial increases from consenting to the Paris Accord are likewise assessed, indicating that even with a restricted arrangement of potential harms from a dangerous atmospheric deviation, these additions are significant. For instance, with the near instance of Representative Concentration Pathway 8.5 (4°C), the worldwide increases from consenting to the 2°C objective (Representative Concentration Pathway 4.5) are around US$17,489 billion every year over the long haul (the year 2100). The relative harms from not agreeing to Sub‑Saharan Africa, India, and Southeast Asia, overall temperature ranges, are particularly serious.

7. **The Economic Impacts of Climate Change** by Richard S J Tol (2018):

   In his paper "The Economic Impacts of Climate Change", experimental estimates demonstrate that environmental change will probably limitedly affect the economy and government assistance in the twenty-first century. Truth be told, the underlying effects of environmental change likely could be sure. Be that as it may, over the long haul the negative effects overwhelm the positive ones. Negative effects will be significantly more noteworthy in more unfortunate, more sultry, and lower-lying nations. Neediness decreases as supplements ozone harming substance outflows decreases as a way to lessen environmental change impacts. In spite of the fact that environmental change may influence the development pace of the worldwide economy and may trap more individuals in destitution, the measurement of these effects stays troublesome. The ideal carbon tax in the near future is somewhere close to a couple of tens and a couple of hundred dollars for every ton of carbon.

DATABASE AND METHODOLOGY

Period of Analysis: - Data have been collected for the period 2000,2005 and 2010 - 2015 for the analysis.

Method: - Linear Regression model has been used to analyze the impact of global warming and climate change on economic development. Human Development Index (HDI) has been taken as a proxy for economic development and Indicators like Natural resource depletion (% of GNI), Carbon dioxide emissions (kg per 2010 US$ of GDP), Carbon dioxide emissions, per capita (tones), Forest area (% of total land area), Renewable energy consumption (% of total final energy consumption) has been taken as a proxy for global warming and climate change. Software like Stata has been used for Linear Regression and MS Excel to calculate the Correlation Coefficient, Mean and Standard Deviation of these proxies.

Sources for the Data: - To analyze the model, secondary data have been collected from various sources like world bank, UNDP, etc.

EMPIRICAL INTERPRETATION

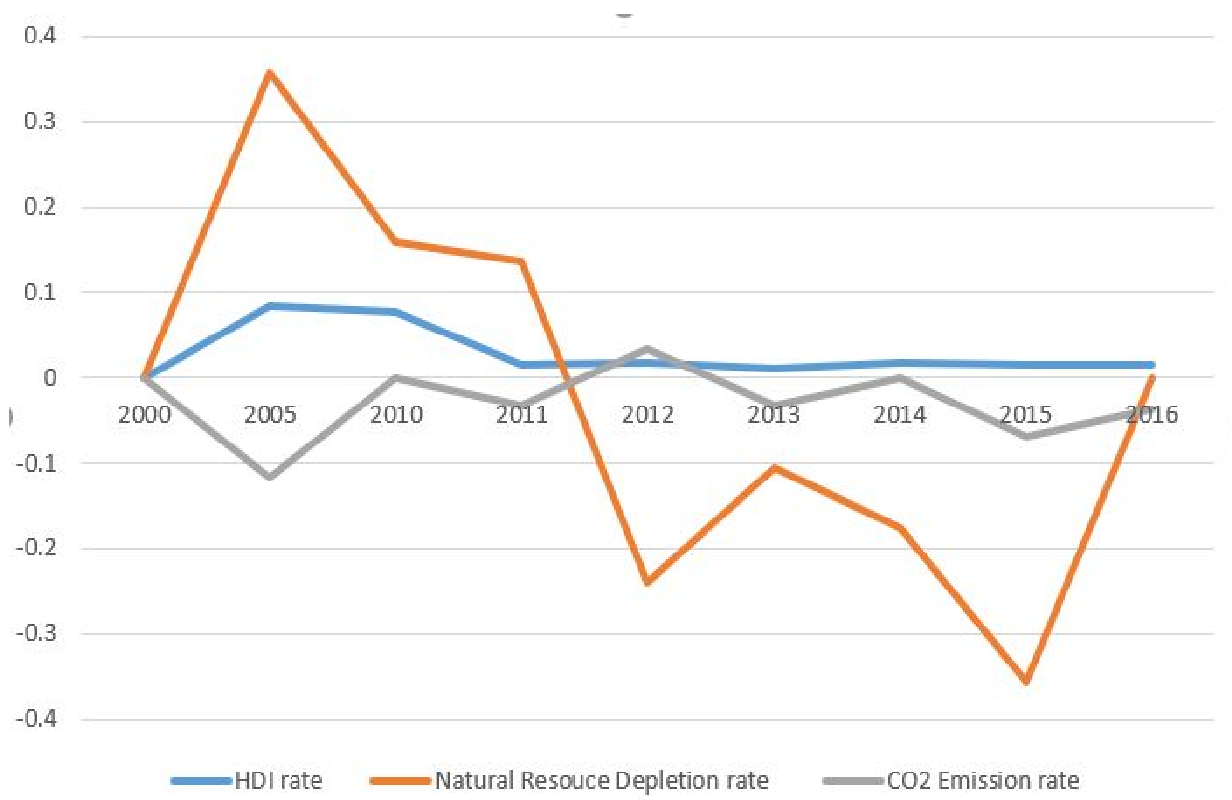
1. **HDI growth rate, Natural resource depletion (% of GNI) rate, Carbon dioxide emissions (kg per 2010 US$ of GDP) rate.**

YEAR	HDI	HDI rate (in %)	Natural Resource Depletion	Natural Resource Depletion rate (in %)	CO_2 Emissions	CO_2 Emissions rate (in %)
2000	0.5	-	1.4	-	0.34	-
2005	0.54	8.45	1.9	35.71	0.3	-11.76
2010	0.58	7.79	2.2	15.79	0.3	0
2011	0.59	1.55	2.5	13.64	0.29	-3.33
2012	0.6	1.69	1.9	-24	0.3	3.45
2013	0.61	1.17	1.7	-10.53	0.29	-3.33
2014	0.62	1.81	1.4	-17.65	0.29	0
2015	0.63	1.46	0.9	-35.71	0.27	-6.9
2016	0.64	1.59	0.9	0	0.26	-3.7

From the above table, we can observe that HDI increased from 0.5 in 2000 to 0.64 in 2016 increasing at a CAGR of 1.56% annually. HDI rate was maximum of 1.81% in 2014 and minimum of 1.46% in 2015. Average HDI from 2000 to 2016 is 0.565 and Dispersion of HDI from its mean is 4.46%.

Natural resource depletion calculated in the percentage of GNI has been fluctuating frequently from 2000 to 2016. It was maximum of 2.5 of GNI in 2011 and minimum of 0.9 of GNI in both 2015 and 2016. It kept decreasing at a CAGR of 2.72% annually. Its decreasing rate was maximum of 35.71% in 2015. Average natural resource depletion is 1.647 of GNI and its dispersion from mean is 43%.

CO_2 Emission calculated as kilograms per 2010 US$ of GDP has been generally decreasing from 2000 to 2016. It was maximum of 0.34 kg in 2000 and minimum of 0.26 kg in 2016. It kept decreasing at a CAGR of 1.66% annually. It decreased sharply in 2015 at 6.9%. Average CO_2 Emission is 0.306 kg and its dispersion from mean is 2.53%.



2. CO_2 emissions, per capita (tonnes) rate, Forest area (% of total land area) growth rate, Renewable energy consumption (% of total final energy consumption) rate.

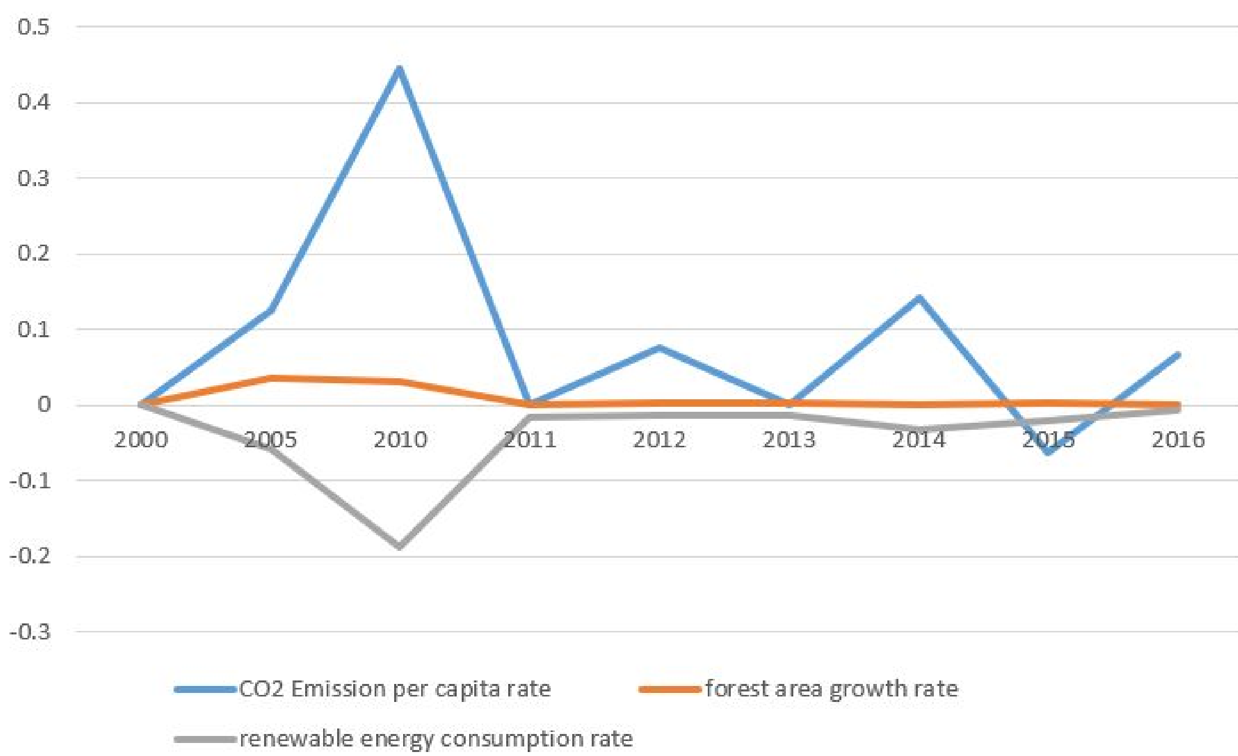
YEAR	CO_2 emissions, per capita	CO_2 emissions, per capita rate (in %)	Forest area	Forest area growth rate (in %)	Renewable energy consumption	Renewable energy consumption rate (in %)
2000	0.8	-	22	-	51.6	-
2005	0.9	12.50%	22.8	3.64%	48.6	-5.81%
2010	1.3	44.44%	23.5	3.07%	39.5	-18.72%
2011	1.3	0.00%	23.5	0.00%	38.9	-1.52%
2012	1.4	7.69%	23.6	0.43%	38.4	-1.29%
2013	1.4	0.00%	23.7	0.42%	37.9	-1.30%
2014	1.6	14.29%	23.7	0.00%	36.7	-3.17%
2015	1.5	-6.25%	23.8	0.42%	36	-1.91%
2016	1.6	6.67%	23.8	0.00%	35.8	-0.56%

From the above table, we can find out that CO_2 emissions per capita measured in tonnes generally kept increasing from 0.8 tonnes per capita in 2000 to 1.6 tonnes per capita in 2016. Emission rate increased drastically in 2014 by 14.29%

whereas it decreased by 6.25% in 2015. It is increasing at a CAGR of 4.43% annually. Average emission per capita is 1.31 tonnes and dispersion from this average value is approximately 28.5%.

Forest area measured in percentage of the total available area found out to be increasing from 22% of the total area in 2000 to 23.8% of the total area in 2016 at a CAGR of 0.5% annually. It can be clearly seen that the change in this forest area is not very significant. Average forest area is 23.4% of the total area.

Renewable energy consumption measured in the percentage of the total final energy consumption decreased from 51.6% in 2000 to 35.8% in 2016 at a CAGR of 2.26% annually. It decreased sharply by 3.17% in 2014. Average renewable energy consumption was 40.38% of total final consumption energy.



3. **Correlation Analysis**

	HDI	**Natural Resource Depletion**	**CO_2 Emissions**	**CO_2 emissions, per capita**	**Forest area**	**Renewable energy consumption**
HDI	**1**	**-0.31**	**-0.90**	**0.98**	**0.97**	**-0.98**
Natural Resource Depletion	**-0.31**	**1**	**0.36**	**-0.32**	**-0.1**	**0.18**
CO_2 Emissions	**-0.90**	**0.36**	**1**	**-0.81**	**-0.86**	**0.82**
CO_2 emissions, per capita	**0.98**	**-0.32**	**-0.81**	**1**	**0.94**	**-0.98**
Forest area	**0.97**	**-0.1**	**-0.86**	**0.94**	**1**	**-0.98**
Renewable energy consumption	**-0.98**	**0.18**	**0.82**	**-0.98**	**-0.98**	**1**

From the above correlation table, we can interpret that there is a strong positive correlation between HDI and CO_2 emissions, per capita and HDI and forest area. There is a strong negative correlation between HDI and Renewable energy consumption and HDI and CO_2 emissions. There is a weak negative correlation between HDI and Natural resource depletion. There is a strong positive correlation between CO_2 emissions and Natural resource depletion. There is a strong negative correlation between CO_2 emissions and CO_2 emissions, per capita and CO_2 emissions and forest area. There is a strong positive correlation between CO_2 emissions, per capita and forest area and a strong negative correlation between CO_2 emissions, per capita and natural resource depletion.

4. Stationarity Test.

The stationarity test has been done to make sure that the collected data doesn't change itself when shifted in time. Stationarity of data has been checked by performing the Dickey-Fuller Test in Stata. Variables on which this test is performed are HDI as a proxy of economic growth and Natural resource depletion, CO_2 emissions, forest area, CO_2 emissions per capita and natural resource depletion as proxies for global warming and climate change.

Null Hypothesis: Data is not stationary

Alternative Hypothesis: Data is stationary

```
. dfuller dHDI

Dickey-Fuller test for unit root                   Number of obs   =         6

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)           -20.442           -3.750            -3.000            -2.630
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

```
. dfuller dNR

Dickey-Fuller test for unit root                   Number of obs   =         6

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -2.273           -3.750            -3.000            -2.630
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.1808
```

```
. dfuller dco21

Dickey-Fuller test for unit root                   Number of obs   =         6

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -2.980           -3.750            -3.000            -2.630
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0368
```

```
. dfuller dco22

Dickey-Fuller test for unit root                   Number of obs   =         6

                               ---------- Interpolated Dickey-Fuller ----------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -6.102            -3.750            -3.000            -2.630
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

```
. dfuller dforest

Dickey-Fuller test for unit root                   Number of obs   =         6

                               ---------- Interpolated Dickey-Fuller ----------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -12.933            -3.750            -3.000            -2.630
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

```
. dfuller drenew

Dickey-Fuller test for unit root                   Number of obs   =         6

                               ---------- Interpolated Dickey-Fuller ----------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -20.844            -3.750            -3.000            -2.630
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

We performed an augmented Dickey-Fuller test in Stata to check stationarity. From the above result, we can see that the mod of test statistic for all the variables is more than the 10% critical value. As a result, we can reject the null hypothesis at the 10% significance level. Thus, Data of all variables is stationary. Thus, we can carry out the regression model.

5. Multiple Linear Regression Model.

We build a Multiple Linear Regression model of the HDI on the Natural resource depletion, forest area and Carbon dioxide emissions (kg per 2010 US$ of GDP) with the help of secondary data collected.

Independent Variable: Natural resource depletion(NRD), forest area (FA), CO_2 emissions (CE)

Dependent Variable: HDI

Regression line: HDI = $\beta_0 + \beta_1$*(NRD) + β_2*(FA) + β_3*(CE) + u_i

```
. regress HDI co21 NR forest
```

Source	SS	df	MS
Model	.015879122	3	.005293041
Residual	.000181101	5	.00003622
Total	.016060222	8	.002007528

Number of obs	= 9
F(3, 5)	= 146.14
Prob > F	= 0.0000
R-squared	= 0.9887
Adj R-squared	= 0.9820
Root MSE	= .00602

HDI	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
co21	-.1118492	.2228477	-0.50	0.637	-.6846975	.4609991
NR	-.0161936	.0046509	-3.48	0.018	-.0281491	-.0042381
forest	.0674552	.0077833	8.67	0.000	.0474476	.0874628
_cons	-.92907	.2383431	-3.90	0.011	-1.54175	-.3163895

Value of R-squared indicates variation in outcome due to variation in the predictor. Here R-squared is 0.9887 which means 98.87% variation in HDI is due to variation in Natural resource depletion(NRD), forest area (FA), CO_2 emissions (CE)

From the above table of the result of Linear regression run in Stata,

The estimated fitted line is

HDI = -0.929 - 0.016*(NRD) + 0.068*(FA) - 0.112*(CE)

Thus, we can interpret that one unit increase/decrease in natural resource depletion ceteris paribus will cause a decrease/increase by 0.016 units. Similarly, one unit increase/decrease in forest area ceteris paribus will lead to increase/decrease of 0.068 units in HDI and one unit decrease/increase in CO_2 emissions will cause 0.112 unit increase/decrease in HDI.

6. **Multiple Linear Regression Model.**

As we carried out multiple linear regression model, there can be a problem of multicollinearity. So to check multicollinearity, we carried out a variance inflation factor (VIF) test in STATA.

```
. vif
```

Variable	VIF	1/VIF
co21	5.48	0.182336
forest	4.81	0.207923
NR	1.43	0.697048
Mean VIF	3.91	

From the above result table, we can clearly see that VIF for each variable as well as overall is less than 10. So according to the rule of thumb, we can say that there is no problem of multicollinearity in this regression.

CONCLUSION

The literature review has enumerated the predominant role of global warming and climate change in the economic development of different nations. In this relation, the project has empirically analyzed and found the existence of a linear relationship between Human Development Index(proxy of Economic development) and Natural resource depletion (% of GNI), forest area, CO_2 emissions (in kg) (proxies of economic development). Hence, it is concluded that Natural resource depletion and CO_2 emissions have a significant and negative impact on the Human Development Index. Similarly, Forest area has a positive impact on the Human Development Index. As we already concluded that Natural resource depletion, CO_2 emissions are the cause of global warming and an increase in forest area has a negative impact on global warming and climate change. An increase in Human Development Index is a sign of economic development. Thus, Consequently, we can conclude that global warming and climate change have a significant negative impact on the economic development of India.

POLICY IMPLICATIONS

Strategies for mitigation of emissions like development of “carbon markets,” taxes on carbon, and subsidies to encourage faster technological progress should be implemented. As a policy Strategy, establishing a long-term quantity cap on greenhouse gases in the atmosphere to guard against environmental catastrophe. This would involve long-term limits on the number of greenhouse emissions equal to a quantity that the earth could absorb. In the short term, policies could be designed to limit the economic burden if abatement costs turned out initially to be unexpectedly high.

Adaptation to climate change is also critical for protecting livelihoods and continuing to make development gains. Policy adaptations can help make the “livelihood assets” of the poor more resilient to environmental stresses while providing other development benefits like Inventorying and tracking the ecological resources of the poor. Implementing early warning systems to anticipate environmental emergencies and to prevent disasters (preserving funds for development efforts). Restoring and expanding natural ecosystem barriers (such as reforestation and mangrove expansion) to extreme events such as flooding and water shortages. Constructing infrastructure to serve the poor while accounting for likely climate change (including storm shelters and flood barriers as well as protected roads and bridges, with a margin for safety); and establishing microinsurance systems for farmers.

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