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Research article

Greenhouse gas emission, GDP, tertiary education, and rule of law: A comparative study between high-income and lower-middle income countries

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ABSTRACT

Global climate change is a pressing concern, particularly in underdeveloped countries. Because greenhouse gases are a key cause of climate change and economic growth is tied to emissions. The study aimed to determine how the Gross Domestic Product (GDP), Tertiary Education, and Rule of Law could be utilized more effectively to reduce greenhouse gas emissions.

The study used data from 30 Lower-Middle Income Countries (LMICs) and 10 High-Income Countries (HICs), as grouped by the World Bank, for the period between 2000 and 2014. In this study, sum of greenhouse gas emission is the response variable and GDP value, Gross enrollment in tertiary education, Rule of law index are the key explanatory variables. Independent sample *t*-test and multiple linear regression models were applied to analyze the data.

The study found a significant impact of GDP on greenhouse gas emissions [0.722, (0.653, 0.790), $p < 0.01$] for LMICs and [-0.605, (−0.728, −0.482), $p < 0.01$] for HICs. For Tertiary Education, the regression model coefficient is [-0.187, (−0.274, −0.100), $p < 0.01$], and [0.480, (0.356, 0.603), $p < 0.01$], respectively for the LMICs and HICs. And the Rule of Law index [-0.046, (−0.112, 0.020), $p = 0.170$], and [0.099, (−0.028, −0.227), $p = 0.125$] for LMICs and HICs respectively came out as statistically not significant although from the mean test, the difference between the mean of the variable Rule of Law of LMCs and HICs is statistically significant [$p < 0.01$] thus, it has some impact on the efficient use of economic growth.

This study concludes that in the LMICs, greenhouse gas emissions are highly positively associated with GDP and the negative coefficient for tertiary education indicates it holds down the emissions. For the HICs, it is evident that GDP is not a major driver and positive significance for tertiary education indicates that the greenhouse gas emissions may result from extravagant operations that might be linked with higher tertiary education, which requires further analysis.

1. Introduction

Greenhouse gas emissions are one of the alarming issues for the world. As a result of high greenhouse emissions, the temperature of the world is gradually increasing year after year [1–3]. Since 1880, the Earth's average temperature has risen by 0.14 °F (0.08 °C) per decade; however, since 1981, the rate of warming has increased by more than twice that, to 0.32 °F (0.18 °C) per decade [4]. This rise

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in global temperature has a significant relation with global energy consumption, as noble researches have depicted that, the greenhouse gas emissions from energy use are a major contributor to global warming [5,6], studies show a strong positive effect of energy consumption on greenhouse gas emission [7,8]. And as global energy consumption is closely related to the size of the economy [5], this study considered the GDP of a country to be a key variable to explain the variations in greenhouse gas emissions. As a result, global policymakers are aware that the temperature is rising quickly and have made an effort to identify the key causes of greenhouse gas emissions.

1.1. Literature review

In recent years, several researchers have discovered a link between GDP and greenhouse gas emissions [9–11]. According to a study conducted in Ukraine, there is a long-term relationship between GDP and greenhouse gas emissions, and a rise in GDP per capita can contribute to the adoption of clean energy [12]. Greenhouse gas emissions and their relationship to economic growth has recently been investigated regionally or nationally, and it is found that economic growth has a positive impact on global energy consumption and it is statistically significant [13]. A study attempted to determine the long-run impact of carbon emissions and energy consumption on economic growth in Turkey from 1960 to 2010 [9]. And they have found that in Turkey, energy use has a positive impact on economic growth while carbon emissions have a negative effect. In another study, the authors tried to show the relationship between energy consumption, CO_2 emissions, and economic growth in Turkey and they have found positive long-run elasticity estimates of emissions concerning energy consumption. They also found that when GDP per capita increases, carbon emissions per capita increase as well [14]. In the case of Canada, unidirectional causality runs from energy consumption and economic growth to greenhouse gas emissions, which means there is a relation between economic growth and greenhouse gas emission [15]. A work which was done in Bangladesh and showed the relationship between economic growth and CO_2 emissions. The author has established that CO2 emissions increase as the GDP contribution of industry and services expansively rises [16]. Research of 16 Asian countries found that in the long run, bidirectional Granger causation exists between energy consumption, GDP, and greenhouse gas emissions, as well as between GDP, greenhouse gas emissions, and energy consumption [17]. A study on carbon capture storage (CCS) showed that CCS can reduce CO2 emission by 54% in EU and 33% globally in the year 2025 [18] but such reduction is not sufficient to stabilize climate, therefor increasing energy efficiency is needed. This study aims to model econometric and greenhouse gas emission data supplemented by awareness, rule of law, population, and trade-openness data to figure out efficient use of economic growth to reduce greenhouse gas emission.

1.2. Aims and scope

The study on economic growth and greenhouse gas emissions has gotten researchers' attention for the last few years, but there is no research study that considers the efficiency of using economic growth to reduce emissions. While researchers have found a cointegrated relationship between CO2 emissions, economic growth, energy consumption, trade and urbanization [19]. The relationship between energy consumption, environment, and growth has been the subject of numerous studies that have concentrated on various nations, time periods, proxy variables, and econometric approaches. This study has applied econometric steps particularly at a macro level, for the time period of 15 years, with the goal of studying if economic growth can be used efficiently with respect to Tertiary education as proxy indicator of people's awareness and the Rule of law index, Population growth, and Industry share percentage of GDP as proxy indicator of trade openness of a country to reduce greenhouse gas emissions and comparing the efficiency to help take urgent actions to address the Sustainable Development Goal 13. For this reason, it is crucial to think about how to make the most of economic expansion in order to find a solution to the crisis that has spread over the world. The goal of this study is to show how economically strong countries have managed to cut their greenhouse gas emissions while economically poor economies lag behind, which can be confirmed from the study of inequality of carbon emission between rich countries and poor countries [20], the authors have found inequality by employing decomposition of Gini index. It will assist to meet the mission statement Sustainable Development Goals 13 [21] goal of "Take immediate action to combat climate change and its implications" in terms of reducing greenhouse gas emissions and addressing rising global temperatures.

The novelty of this research is that it studied the impact of Tertiary education and Rule of law index on greenhouse gas emission related to economic growth and compared it on a broader scale of 30 and 10 countries of LMIC and HIC groups classified by The World Bank.

2. Highlights

- Drivers of greenhouse gas emission examined on a macro level of 40 countries, further divided into 2 categories of LMIC and HIC as classified by the World Bank and derived insights about efficient use of economic growth to reduce greenhouse gas emission.
- Economic growth positively impacts greenhouse gas emissions in LMICs [0.722, (0.653, 0.790), $p < 0.001$] while in HICs [-0.605, (-0.728, -0.482), $p < 0.001$], the impact is negative.
- Gross enrollment in tertiary education (people's awareness) is a significant driver of greenhouse gasses.
- Improving the Rule of Law index helps to address more variation in greenhouse gas emission.

3. Nomenclature

LMICs=Lower Middle-Income Countries. HICs=High Income Countries. CCS=Carbon capture storage. SumGWG=Total sum of the emission of CO_2, N_2O, and CH_4 gasses in kilotons for a particular country. GDPValue=Current Gross Domestic Product for a particular country in USD$. TertiaryEd=Gross enrollment in tertiary education for both sexes of a particular country. RuleofLaw=An index of the particular country's law enforcement, ranging from negative 2.5 to positive 2.5 where closer to negative 2.5 indicates weak rule of law, and closer to positive 2.5 indicates strong rule of law. IndShare=Industry and construction as a percent of GDP for a particular country. PopGrowth=Population growth percentage of a particular country. MLR=Multiple linear regression. VIF=Value inflation factor

4. Methods

4.1. Study setting

In the High-Income group, 10 of the 32 High-Income OECD (The Organization for Economic Cooperation and Development) countries were chosen, and they were randomly selected countries from North America, Europe, Australia, and Asia to remove continental variation. In the Lower Middle-Income group, 30 of the 51 countries were chosen to avoid the countries with a lack of data. In order to deal with the about 3% of the data that was missing, linear interpolation was used [22,23], as it was discovered to be the best method for all complexity levels [24]. Flow-chart of this study can be found in Fig. 1.

4.2. Data collection (methods and procedure)

Data was collected from (i)The World Bank, (ii) The Food and Agriculture Organization Corporate Statistical Database (FAOSTAT), and (iii) Our World in Data and were merged, then analyzed and processed using Python data manipulation libraries Pandas and NumPy. Data from 2000 to 2014 were collected to avoid approximately 30% of missing data if the data had been collected up to 2021. The following variables were used:

(1) SumGWG[1]: sum of CO_2, N_2O, and CH_4 emissions in kilotons (kt, or 106 kg) from FAOSTAT [25];
2) GDPValue[2]: GDP (current US$) from The World Bank: Data [26];
(3) TertiaryEd[3]: gross enrolment in tertiary education for both sexes from Our World in Data [27];
(4) RuleofLaw[4]: an index of the country's law enforcement from The World Bank: Data [28];
(5) IndShare[5]: industry and construction as a percent of GDP from The World Bank: Data [29];
(6) PopGrowth[6]: population growth from The World Bank: Data [30].

All the variables were standardized to be fitted on a regression model and to be on the same scale of measurement. The supplementary predictor variable of IndShare is the industry and construction share as a percentage of GDP, which represents a country's trading level. Because of its close relationship to GDP, the component often establishes a strong relationship with greenhouse gas emissions. As a result, any rise in trade may simply result in increased CO2 emissions, as observed in the cases of China, India, Turkey, and Malaysia [31–33]. And the variable PopGrowth is the annual percentage of population growth, which has a positive link with CO2 emissions in both industrialized and developing civilizations [34–36].

4.3. Data analysis

From the extensive review of literatures, it is discovered that Panel Unit Roots [37–39], Panel Cointegration Approach [37,40], Environmental Kuznets Curves (EKC) models [41,42], Single or Multi-Country Granger Causality Analysis [43,44], and various Regression techniques [45,46] have been employed to discover the relation between economic growth and greenhouse gas emission. In this study, Multiple Linear Regression (MLR) model is used considering number of advantages compared to other models, namely:

(i) It is a relatively simple and easy to understand model.
(ii) Allows for hypothesis testing to determine if an estimate is statistically significant.
(iii) Provides goodness of fit score such as adjusted R-squared values to determine how good the model is.
(iv) Allows for estimation of the magnitude and direction of the relationship between dependent and c variables.

Also, evidence of practicality of using MLR model is present as, if the number of predictors is not large, and no multicollinearity

[1] Sum of CO2, N2O, and CH4 emissions in kilotons (SumGWG).
[2] GDP (current US$) (GDPValue).
[3] Gross enrolment in tertiary education for both sexes (TertiaryEd).
[4] An index of the country's law enforcement (RuleofLaw).
[5] Industry and construction as a percent of GDP (IndShare).
[6] Population growth (PopGrowth).

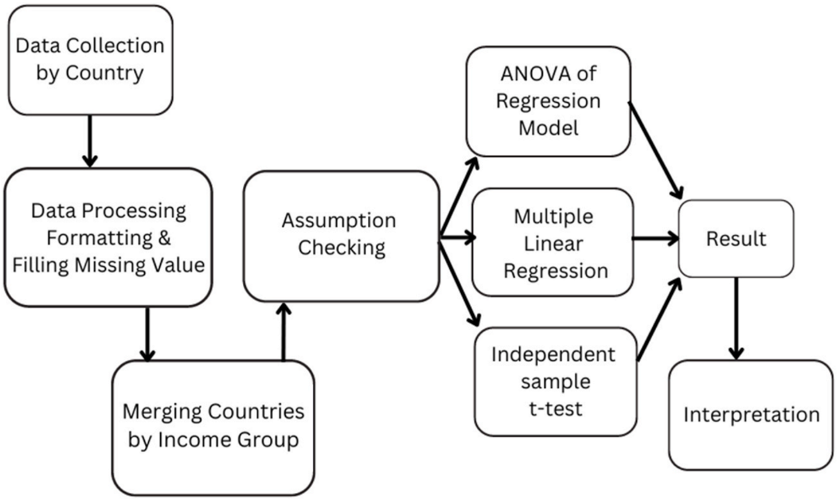

Fig. 1. Research flow chart.

exists, the MLR model with traditional Ordinary Least Square (OLS) technique is a feasible option [47].

There are some drawbacks of the MLR model compared to other mentioned models, namely:

(i) Non-Linear relationship between greenhouse gas emission and other explanatory variables may lead to inaccurate and biased estimates.
(ii) Presence of multicollinearity in the variables can also be misleading.
(iii) Endogeneity of the explanatory variables.
(iv) The inaccuracy and missing data can reduce the validity of the estimates.

Appropriate measures were taken to increase the strength of the analysis and to omit the drawbacks as much as possible.

The data was analyzed using a variety of descriptive and inferential statistical tools. Frequency tables and graphical representation were employed for descriptive studies, while the linear regression model was used for inferential analysis. For the multiple linear regression model, the standardized scores of the data were employed, as all the variables were not in the same measuring scale.

First, an independent sample *t*-test [48] was conducted to know if there is a statistically significant difference between HICs and LMICs in terms of all the explanatory variables; second, a Multiple Linear Regression (MLR) at a 95% confidence interval as novel works have been done to decompose the composition of greenhouse gas emissions using the MLR model [49–51].

As for modeling the data, the technique of MLR was adopted as a function of various indicators. The MLR model is a type of regression model when there is more than one predictor for a response variable. A multiple regression model in its most general form is

$$y_i = \beta_0 + \beta_1 x_{i1} + \ldots + \beta_n x_{in} + \varepsilon_i \tag{1}$$

Where β denotes the coefficients of the variables and ε denotes the error term. In this study, SumGWG is the response variable, and GDPValue, TertiaryEd, RuleofLaw, IndShare, PopGrowth, and Code are the explanatory variables. Thus, equation (1) becomes:

$$y_{SumGWG} = \beta_0 + \beta_1 x_{GDPValue} + \beta_2 x_{TertiaryEd} + \beta_3 x_{RuleofLaw} + \beta_4 x_{IndShare} + \beta_5 x_{PopGrowth} + \beta_6 x_{Code} + \varepsilon_i$$

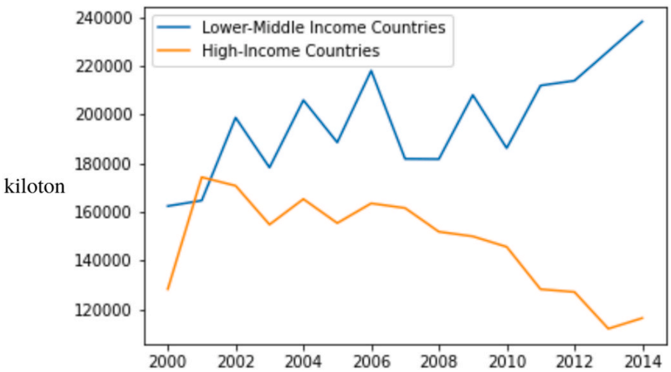

Fig. 2. Mean of greenhouse gas emission over year.

In this case, SPSS v23 is used to generate the model. Simple correlation and VIF (variance inflation factor) were looked at in order to determine whether the MLR assumptions were being violated. To check for the absence of autocorrelation, heteroscedasticity, and residual normality, the post-estimation model diagnosis was carried out [52]. To run the MLR model, the standardized values for all the variables were obtained.

5. Results

For the LMICs the blue line, from [Fig. 2], it is evident that an upwards graph of mean greenhouse gas emission over the year starting around 1,60,000 kiloton per year in 2000 to 2,40,000 kiloton per year in 2014, but in case of HICs we see a downward graph of greenhouse gas emission per year in [Fig. 2] the yellow line, starting from 1,30,000 kiloton per year in 2000 to a sharp increase in 2001 to 1,70,000 kiloton and then gradually decreasing to 1,10,000 kilotons in the year 2014. Descriptive statistics for both participant groups can be seen in [Table 1].

5.1. Adjusted R-squared

For the case of LMICs [Table 2], the adjusted R-squared is 0.545. That means our predictor variables are able to explain 54.50% of the variation in the response variable, which is considered a moderate effect size of the model [53,54].

In the case of the HICs [Table 2], the adjusted R-squared value is 0.695, which means employed predictor variables can explain the variation of the response variable by 69.50%, and it can be termed a strong effect size. In the study of the decomposition of greenhouse gas emission, the value of adjusted R-squared above 80% might indicate overfitting of the model and become irrelevant as this is a vast field of study and many unconventional drivers of gas emission cannot even be taken into account.

5.2. Coefficients

Turning to the section on the coefficients of the model, one can get a clear picture of the regression model. From the values of the coefficients, in the case of LMICs [Table 3], the coefficient for GDPValue is [0.722, (0.653, 0.790), $p < 0.001$] with a p-value less than 0.001, which means this variable is highly significant. Compared to the other variables, GDPValue gives a major positive shock in the emissions of greenhouse gasses. Also, it can be said that, in LMICs, economic growth is a major driver of gas emissions. The coefficient for TertiaryEd is [−0.187, (−0.274, −0.100), $p < 0.001$]. That means the emission of greenhouse gas reduces by 0.187 units for a 1 unit increase in gross enrollment in tertiary education, with a p-value less than 0.001, this variable is statistically significant. For the variable RuleofLaw, the model gives a coefficient of [−0.046, (−0.112, 0.020), $p = 0.170$], which means if the RuleofLaw index increases the emission will decrease by a small number. However, this variable is statistically insignificant, indicated by the p-value of 0.170. Now the variable IndShare is associated with a coefficient of the value of [0.149, (0.081,0.217), $p < 0.001$] which that means in LMICs, Industry Share (% of GDP), increases the emission of greenhouse gas, and with a p-value less than 0.001, this variable is statistically significant. And the coefficient for PopGrowth is [−0.172, (−0.261, −0.082), $p < 0.001$] and its p-value is also less than 0.001. Collinearity analysis also checked VIF, as there were no variables with a VIF of more than 3, it was assured that no multi-collinearity was evident.

In the case of HICs [Table 3], economic growth affects greenhouse gas emissions in a totally opposite direction compared to the LMICs. The coefficient for GDPValue is [−0.605, (−0.728, −0.482), $p < 0.001$] which means gas emission decreases with the increase of economic growth and the variable is statistically significant with a p-value less than 0.001. TertiaryEd has a coefficient value of [0.480, (0.356,0.603), $p < 0.001$] indicating the increase of greenhouse gas emissions with the increase in TertiaryEd and is significant with a p-value less than 0.001. For the variable RuleofLaw, the coefficient is [0.099, (−0.028, 0.227), $p = 0.125$]. This variable positively impacts gas emissions but, in this case also, like the case of HICs, this variable is statistically insignificant for the LMICs because of the p-value of 0.125. IndShare has a higher impact in this case with a coefficient of [0.427, (0.306, 0.547), $p < 0.001$] increase in IndShare increases the gas emission by a significant number and also has a p-value less than 0.001 which makes it statistically significant. PopGrowth also has a positive impact reasoning for the coefficient value of [0.239, (0.134,0.345), $p < 0.001$]. In

Table 1

Descriptive Statistics of the selected variable for both groups.

	HIC				LMIC				P value[a]
	Minimum	Maximum	Mean	Std. Deviation	Minimum	Maximum	Mean	Std. Deviation	
SumGWG	−101935.2	774689.2	147086.2	215768.7	−30576.0	30607114	197645.5	442373.4	0.064
GDPValue	21,230.18	17,600,000	3,211,581	3,873,375	860.52	2,040,000	106,157	252,885	<0.001
TertiaryEd	9.81	96.32	60.19	18.82	1.88	84.19	20.28	15.88	<0.001
RuleofLaw	0.39	1.92	1.48	0.38	−1.74	0.35	−0.71	0.46	<0.001
IndShare	10.42	32.51	22.94	4.81	10.00	72.15	28.15	9.48	<0.001
PopGrowth	−1.85	2.40	0.76	0.64	−4.53	4.20	1.55	1.18	<0.001

This p-value is obtained from the independent sample *t*-test between two group of countries.

HIC: High-Income Countries; LMIC: Lower-Middle Income Countries.

[a] GDPValue is given in million USD in this table.

Table 2
Model Summary of regression model groups.

Group	R square	Adjusted R square	Std. Error of the Estimate	F Change	Sig. F Change
HIC	0.708	0.695	0.552	57.662	<0.001
LMIC	0.551	0.545	0.674	90.516	<0.001

HIC: High-Income Countries; LMIC: Lower-Middle Income Countries.

Table 3
Coefficients of regression models for both groups.

	HIC			LMIC		
	Coefficient	*P*-value	VIF	Coefficient	*P*-value	VIF
Constant	−3.151E-016	1.000		6.3E-017	1.000	
GDPValue (GDP value)	−0.605	<0.001	1.908	0.722	<0.001	1.199
TertiaryEd (Tertiary education)	0.480	<0.000	1.903	−0.187	<0.001	1.922
RuleofLaw (Rule of law index)	0.099	0.125	2.034	−0.046	0.170	1.117
IndShar e (Industry share)	0.427	<0.001	1.818	0.149	<0.001	1.178
PopGrowth (Population growth)	0.239	<0.001	1.393	−0.172	<0.001	2.044
Code	−0.619	<0.001	2.527	0.043	0.224	1.224

HIC: High-Income Countries; LMIC: Lower-Middle Income Countries.
VIF: Value Inflation Factor.

this case, also, no variable was recorded to have a VIF of more than 3. Hence, there was no multicollinearity evident.

Now to know the significance of the MLR model for both groups the authors have conducted ANOVA test. For conducting the ANOVA test it is needed to set null hypothesis as,

H_0: There is no relationship between the response and predictor variables, or the model is not statistically significant. In the LMICs, there are 6 predictor variables, and 450 entries for 30 countries, so the degrees of freedom will be 6 for regression and 443 for residuals. From [Table 4], the calculated F = 90.516, which is greater than the tabulated F = 1.774 for degrees of freedom 6 and greater than 120. As the calculated F is greater than the tabulated F, the null hypothesis of there is no relationship between the response and predictor variables, or the model is not statistically significant is rejected. From [Table 4], For HICs, the calculated F = 57.662 which is also greater than the tabulated F = 1.774 for degrees of freedom 6 and greater than 120. Hence, in this case also, the null hypothesis can be rejected and say that the regression model for both LMICs and HICs are statistically significant.

Finally, the data was checked if it violates any of the classical assumptions of the Regression model. To check for the normality of the residuals if the standardized scores of the response variable (SumGWG) against the regression standardized residuals for both the cases is plotted, it can be seen [Figs. 3 and 4] approximately a normal distribution. However, the residuals of the LMICs show a slightly leptokurtic curve. This might be due to the outliers in the dependent variables, which we had to take into account because of the country-wise variation in the data. The data approximately holds the classical assumptions of the MLR model.

6. Discussion

The study explored the data to understand the environmental and economy related characteristics of the two-participant group of countries. In particular, the World Bank's classification of countries by virtue of their income were adopted as, (i) High-Income Countries and (ii) Lower-Middle Income Countries. It has been found that in each group, Georgia in LMICs and Japan in HICs, the greenhouse gas emissions are negative. However, they are not carbon-negative countries, as in this case, s um of greenhouse gas emission represents the emissions total of 8 indicators collected from FAOSTAT. The study also found a clear picture of the performance regarding efficient use of economic growth to reduce greenhouse gas emission of two participant group of countries as LMICs have a significant upwards trend while the graph of the HICs is going down. For the LMICs, the mean of gross enrollment in tertiary education for both sexes per year ranges approximately from 16% to 24% in an upwards linear trend, the rule of law index ranges approximately from −0.6 to −0.7 and Industry s hare hovers around 28%. In the case of HICs, the mean of Gross enrollment in tertiary

Table 4
ANOVA of regression models.

		Sum of Squares	df	Mean Square	F-value	p-value
HIC	Regression	105.43	6	17.57	57.66	<0.001
	Residual	43.58	143	0.31		
	Total	149.00	149			
LMIC	Regression	247.29	6	41.22	90.52	<0.001
	Residual	201.71	443	0.46		
	Total	449.00	449			

HIC: High-Income Countries; LMIC: Lower-Middle Income Country.

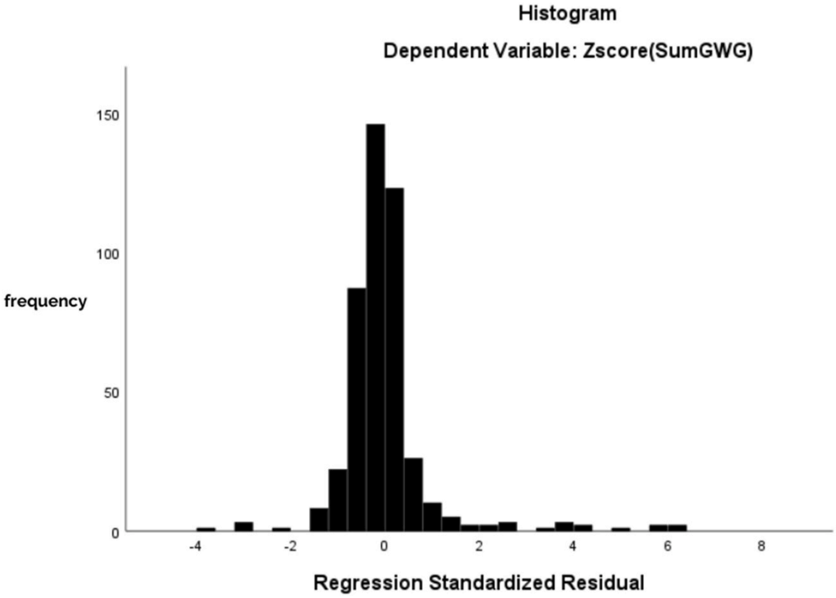

Fig. 3. Regression residual histogram for LMICs.

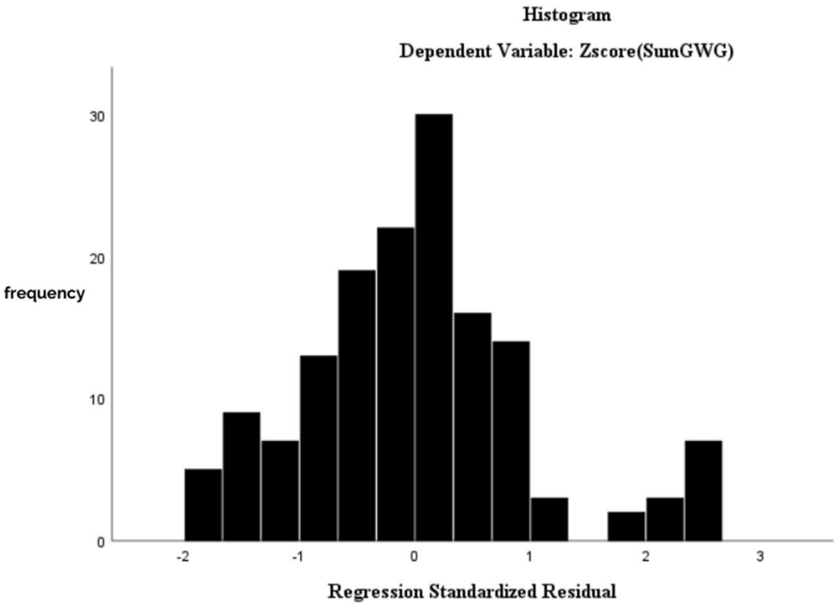

Fig. 4. Regression residual histogram for HICs.

education for both sexes per year is a linear upward trend approximately from 52% to 61%, the rule of law index hovers around +1.5 and Industry s hare is a downward linear trend from 24% to 21%. In the case of the Rule of law index, the mean of two groups was significantly different. Hence, effects of predictor variables in both cases are different, and they should have an effect on the emissions of greenhouse gases. These findings support the author's initial view that efficient use of economic growth can reduce greenhouse gas emissions by using tertiary education as a proxy indicator of awareness or efficiency, and the rule of law index to assess the transparency and compliance of the industry and manufacturing sector regarding environmental stability. The authors have observed that greenhouse gas is hugely driven by economic growth in LMICs where the GDP is relatively smaller, but in HICs, where the GDP is relatively higher, there is an inverse relationship between economic growth and greenhouse gas emission. Greenhouse gas emissions in HICs are generally lower than in LMICs for several reasons. A study revealed that there is an inequality in CO_2 emissions between poor and rich countries [55]. This claim is further strengthened by the finding from Ref. [56] that rich countries are outsourcing their requirements of pollution-intensive products to poor countries, thereby displacing their emission. One reason is that high-income countries tend to have more advanced and efficient technology as the tertiary education is higher in these countries, which allows them to produce goods and services with less energy and fewer emissions. Additionally, HICs tend to have more robust regulations and policies in place to limit emissions and promote clean energy. Furthermore, HICs also tend to have more diversified economies, with a greater emphasis on service sectors, which typically have lower emissions than heavy industry and manufacturing.

For LMICs, the impact of gross enrollment in tertiary education for both sexes on greenhouse gas emission was negative. This could indicate that people are becoming more aware and efficient in their energy use, and that advanced measures are being implemented in small-scale businesses, but only 79.6% [57] of the people have electricity access, and not having a high-flying economy reduces the operation engagement of the people. Thus, an increasing rate of people with tertiary education might reduce the emission of greenhouse gases. Nevertheless, in HICs, the impact of gross enrollment in tertiary education for both sexes on greenhouse gas emission was positive. This might indicate that, in a highly developed environment, where 100% of the people [57] have electricity access, high-end technologies and power generation is going on and a higher number of people with tertiary education engages a lot more operations than the lower percentage of people with tertiary education in the developing countries.

Although the rule of law index had no statistically significant impact on explaining variations in greenhouse gas emissions for any participant country group, the data suggests that a higher rule of law index may be related with lower levels of emissions. The results revealed that in HICs with a mean rule of law score of around +1.5, the six predictor factors employed in the study explained around 69.5% of the variation in emissions. The same predictor variables only explained roughly 54.5% of the variation in LMICs, where the mean rule of law score is around −0.6. This suggests that a higher rule of law index may play a role in lowering emissions.

To the best of the authors' knowledge, no other study in the existing literature has used the classification of countries as HICs and LMICs as a factor, nor has it investigated the relationship between people's awareness, the rule of law index, and greenhouse gas emissions in order to compare the observed results. Adjusted R-squared values for MLR models have been reported as high as 0.994 [51], 0.896 for CH_4 emissions alone, 0.403 for N_2O alone [45], and 0.99 [49]. The authors of this study, on the other hand, discovered lower adjusted R-squared values, with a value of 0.545 for the LMICs model and 0.695 for the HICs model. These values, however, can still be deemed to have a modest impact size [53,54].

7. Strength and limitation

The strength of this study considered the fact that, it examined the variation in greenhouse gas emission with respect to difference in economic condition of participant group of countries, and figured out the impact of unconventional drivers of greenhouse gas emission which are usually overlooked in other studies in the same domain.

Limitations of this study are acknowledged as,

(i) This study could not take into account the income groups of Low-Income Countries (LICs), Upper-Middle Income Countries (UMICs).
(ii) All the countries in LMICs and HICs could not be included into the sample due to incomplete data.
(iii) This study only considered data from the year 2000 to 2014 to eliminate missing data.

8. Conclusion

It is observed that, there is significant difference in the predictor variables GDP value, Tertiary education, Industry share, and Population growth for both groups, and thus a different impact on the response variable is recorded. In LMICs, there was a strong positive association between emissions and GDP, but a negative association with tertiary education. This suggests that higher levels of education in lower-middle income countries may lead to more environmentally conscious behavior, resulting in lower emissions. However, in HICs, the study found that GDP was not a major driver of emissions, and that there was a positive association between emissions and tertiary education. This suggests that higher levels of education may be associated with extravagant operations that lead to higher emissions. Furthermore, these findings question the efficacy of government policies toward the rule of law index.

This study unveils further scopes of research on the optimal state of tertiary education and the rule of law index for any country to reduce greenhouse gas emissions, the regional decomposition of the major drivers of global warming, and the impact of the contrast of socioeconomic conditions on the environment.

Author contribution statement

Hamed Bin Furkan: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Kazi Md. Rakibul Hasan: Analyzed and interpreted the data; Wrote the paper.

Md Jamal Uddin: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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