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THE ROLE OF GREEN BONDS IN FINANCING SUSTAINABLE DEVELOPMENT: A CROSS-COUNTRY ECONOMETRIC ANALYSIS

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Abstract: This study examines that I am relationship between green Bond issuance and key and environmental and macroeconomic indicators including renewable energy consumption GDP per capita and CO₂ emissions using a multi country data sets for the post 2015 period. The analysis employees a combination of descriptive statistical techniques ,Pearson correlation analysis and multiple linear regression models to access the magnitude and significance of the relationships among these variables. Empirical findings indicate that green bond issuance exhibits statistically significance positive effect on renewable energy consumption. However the impact on co₂ emission is found to be moderate suggesting the influence of additional macroeconomic and structural factors. The findings of the study highlight the growing importance of green bonds as a financial instrument for financing environmentally sustainable projects and emphasize the need for strengthening policy support to enhance their effectiveness in achieving long term environmental and economic objectives.

Index Terms - Green bonds issuance, Renewable energy, Sustainable development, Carbon emissions.

I. INTRODUCTION

In recent decades, the global economy is experiencing rapid industrialisation urbanisation and economic expansion. While these developments has significantly improved the economic growth, it also intensified challenges such as climate change, resource depletion, pollution ,deforestation and rising greenhouse gas emissions. If these issues remain unchecked, they may threaten the ability of future generations to meet their basic needs. The development strategy incorporating the needs of present generation without comprising that of future generations is Sustainable development. It aims to balance economic growth with environmental protection and social protection.

Sustainable development requires substantial financial resources to address global environmental challenges. Traditional financing mechanisms alone are insufficient to support the large scale Investments needed for Sustainable projects. In this Context, Green bonds have emerged as an important financial instrument that mobilises capital for environmentally friendly and climate related initiatives. Green bonds are financial instruments issued to raise funds for projects that generate positive environmental benefits. The capital raised through green bonds is allocated to environmentally sustainable projects , Pollution control, Climate change adaption and water management Systems. 'Climate awareness Bond' The world's first green bond is issued by European investment Bank in 2007 . Following this the world bank issued its first green bound in 2008. Green bonds are issued to finance renewable energy, energy efficiency and sustainable infrastructure projects . They not only contribute in reducing carbon emissions and promoting environmental sustainability but also support long-term economic development by encouraging investment . The role of green bonds in sustainable development can be pointed out as ,it helps to mobilise Capital for green projects , supports the achievement of sustainable development goals , reduce carbon emissions and environmental degradation, promotes any renewable energy and green technology and also improves Infrastructure financing. According to the OECD (2020) efforts to reduce carbon emissions closely linked to the issuance of green bonds, as these bonds frequently used to finance projects aimed at lowering greenhouse gas emissions (OECD, 2020)

Green bonds contributes to SDG Progress by financing projects related to Clean energy, sustainable cities and climate action which comprises the sustainable development goal number 7 , 11 and 13 respectively. According to Sarkodie and Strezov (2018) , one of the main reasons for ecological deterioration is the emission of CO₂ gases in the environment by industries. In a study conducted by international energy agency (IEA) in 2014, it estimates that approximately 55 trillion dollar is required to finance climate friendly projects by 2035.

Economies have been Increasingly adopting green bonds to finance . In Europe, countries such as Germany and France have issued Sovereign green bonds to finance renewable energy development, sustainable transport systems etc .China has emerged one of the largest green bonds Market globally and Developing economies such as India have increasingly utilised green bonds to finance green buildings, water management Systems and sustainable Urban development. Similarly Developing economies such as India has increasingly raised green bonds to finance solar power plants, wind energy

projects and other climate friendly infrastructure initiatives. According to World Bank (2014), the world leaders must promote climate friendly projects to access capital. In climate Bond initiative (2019), it witnessed an increase in issuance of green bonds worldwide and bonds with US dollar 257.7 billion issued in one year

OBJECTIVES / AIMS :

- To examine the role of green bonds in financing sustainable development across different countries.
- To evaluate the impact of green bonds on sustainable development using Cross country econometric analysis

LIMITATIONS:

- Limited availability of green bond data from some developing countries
- Differences in environmental are putting standards across countries

I. RESEARCH METHODOLOGY

The methodology section outline the plan and method that how the study is conducted. This includes Universe of the study, sample of the study, Data and Sources of Data, study's variables and analytical framework. The details are as follows;

3.1 Population and Sample

The study covers developed and developing countries such as USA, UK, Germany, India, France and China. Panel data is used for study. Data is collected over nine years from 2015 to 2024 across these countries.

3.2 Data and Sources of Data

This study relies on secondary data obtained from reputable international databases such as World Bank, International Energy Agency, IMF And climate bonds initiatives. The study includes a panel dataset of approximately 25 -30 countries that actively issue green bonds from a time period of 2015 to 2024. Study includes both developed and developing economies to ensure comprehensive analysis. Published data from sources such as World Bank indicators data on renewable energy, GDP per capita, CO2 emissions are collected. CO2 emissions data collected from World Bank for the year 2015 to 2022 and used International energy agency global energy review 2025 reports for the data from time period 2023 to 24. The green bonds issuance values are collected from climate bond initiatives - Global state of market reports.

3.3 Theoretical framework

Variables of the study contains dependent and independent variable. The study used pre-specified method for the selection of variables. The study uses Green bond Issuance as Independent variable. Carbon emissions and Renewable energy are the dependent variables and GDP Per capita is the control variable of the study.

The growing concern over environmental degradation and climate change has led to the emergence of financial mechanism that align economic development with environmental sustainability. The present study grounded in the theoretical foundations of environmental economics, sustainable finance and growth theory which collectively explain the interaction between green Bond - the financial instrument, energy transitions and environmental outcomes.

The central theoretical basis of this study is environmental Kuznets curve hypothesis, which depicts inverted U shaped relationship between economic growth and environmental degradation. The oldest stages of economic development industrial expansion increase energy consumption lead to higher carbon emission will stop however as economics mature there is a structural shift towards cleaner technologies, improved regulatory frameworks and greater environmental awareness, resulting in a decline in emissions. This study incorporates GDP per capita as or proxy for economic growth to account for this non linear relationship between it income levels and environmental quality.

The Sustainable Finance framework, which stresses the incorporation of environmental, social, and governance (ESG) factors into financial decision-making, complements this viewpoint. As a crucial tool in sustainable finance, green bonds are made especially to raise money for projects that benefit the environment, especially those involving low-carbon infrastructure, energy efficiency, and renewable energy. According to the theory, issuing more green bonds makes it easier to direct funds toward sustainable projects, hastening the shift to a low-carbon economy. The study also makes use of Green Growth Theory, which promotes the idea that technological innovation and effective resource use can lead to both economic growth and environmental sustainability at the same time. This theory states that investments in renewable energy improve energy efficiency, lessen reliance on fossil fuels, and promote long-term sustainable growth. By offering the required funding for these investments, green bonds act as a catalyst in this process. Additionally, the concepts of Endogenous Growth Theory can be used to explain how innovation and financial development support advancements in technology and the economy. According to this theory, investments in infrastructure, human capital, and innovation are crucial for long-term economic growth. In this regard, green bond financing promotes both economic growth and environmental enhancement by supporting technological developments in renewable energy. Reducing greenhouse gas emissions requires switching from fossil fuel-based energy systems to renewable energy sources, according to environmental economics.

There is a well-established theoretical relationship between the use of renewable energy and CO2 emissions, whereby a greater reliance on renewable energy results in a notable decrease in carbon emissions. Therefore, green bond financing influences environmental outcomes through the mediating variable of renewable energy. Furthermore, the importance of financial instruments in accomplishing climate goals is reinforced by the role of institutions and global policy frameworks, as highlighted by organizations like the World Bank, International Energy Agency, and Climate Bonds Initiative. These organizations emphasize that increasing green finance is crucial to fulfilling global obligations like carbon neutrality and sustainable development goals. In conclusion, the study's theoretical framework incorporates various viewpoints to explain the

dynamic relationship between the issuance of green bonds, the use of renewable energy, CO2 emissions, and economic growth. Green growth theory and sustainable finance explain how financial mechanisms facilitate environmentally sustainable investments, while the Environmental Kuznets Curve offers a macro-level explanation of the growth–environment relationship. The role of financial innovation in propelling long-term economic and technological advancement is further supported by endogenous growth theory. When combined, these theories offer a thorough framework for examining the ways in which green bond markets support both economic growth and environmental sustainability

3.4 Statistical tools and econometric models

The study uses statistical tools and econometric models. The detail of methodology is given as follows. In Statistical analysis, Descriptive analysis and Correlational analysis is used.

3.4.1 Statistical tools

3.4.1 a) Descriptive Statistics

Descriptive Statistics have been used to find the mean, median, mode, maximum, minimum, standard deviation of all the variables of the study. The descriptive statistics helps to understand the distribution and behaviour of green bond Investments and The environmental indicators used in the study. The Standard deviation, Mean and other tools used in descriptive statistics are helpful in identifying the trends and fluctuations in renewable energy adoption and carbon emissions.

3.4.1 b). Correlation analysis

The correlation analysis used in this study is pearson correlation coefficient it helps to measure the strength and direction of relationship between variables used - green bonds and CO2 emissions.

3.4.2 Econometric Models

3.4.2 a) Simple Linear Regression Model

The study uses simple linear regression model

$$Y = \beta_0 + \beta_1 X + \epsilon$$

Y – Dependent variable

β_0 – Intercept

β_1 – slope Intercept

X - Independent variable

ϵ - error term

3.4.2 b) Multiple Linear Regression Model

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \epsilon$$

- Y - Renewable Energy (%) → Dependent variable
- β_0 – Intercept
- β_1 – slope Intercept
- X_1 - Independent variable - Green Bond Issuance (USD)
- X_2 - GDP per Capita (Current US\$)
- X_3 - CO₂ Emissions (kt)
- ϵ - error term .

Model valuation & Diagnostic tools

a) Goodness of Fit

Goodness of Fit measure were used to assess how well the econometric model explains the relationship between independent and dependent variables of the study.

• R (Correlation Coefficient)

Correlation coefficient it indicates the strength and direction of linear relationship between the independent variable in the study that is green bond issues and each of the dependent variable such as renewable energy, carbon emissions and GDP per capita.

• R² - Coefficient of Determination-

it chooses the proportion of variation in the dependent variable, e.g.: CO2 emissions explained by green bond issuance- the independent variable. If our R² is equal to 0.67 it means 67% of radiation in CO2 emission is explain by green bond issues.

- Adjusted R²

Adjusted R² refines by the number of independent variables included in the model. It helps to evaluate the combined effect of green Bond issuance, renewable energy and GDP per capita without over estimating the model accuracy.

b) Hypothesis Testing

- t-test (for individual coefficients)
- p-values

T – test and p values are used in the study to check statistical significance of variables.

c) Standard Error

- Standard error is employed to measure accuracy of regression estimates

Equations

This study uses both statistical and econometric equations for data analysis. Few of the important equations used in the study is explained here :

$$\text{Mean of the variable} = \bar{x} = \frac{\sum x}{n} \quad \dots\dots\dots \text{eq.1}$$

X = Individual observations

N = Number of observations

Mean value is used in this study to find out the average value of each variable over the study period.

$$\text{coefficient correlation (karl pearson's)} = r = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}} \quad \dots\dots\dots \text{eq.2}$$

Correlation of coefficient formula used in this study is Karl Pearson 's correlation coefficient and it is used to measure the strength and direction of relationship between green bond issue and the selected variables.

X = Green Bond Issuance

Y = CO₂ emissions / Renewable energy / GDP

$$\text{Variance} = \sigma^2 = \frac{\sum(x-\bar{x})^2}{n} \quad \dots\dots\dots \text{eq.3}$$

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \epsilon \quad \dots\dots\dots \text{eq.4}$$

- Y - Renewable Energy (%) → Dependent variable
- β₀ – Intercept
- β₁ – slope Intercept
- X₁ - Independent variable - Green Bond Issuance (USD)
- X₂ - GDP per Capita (Current US\$)
- X₃ - CO₂ Emissions (kt)
- ε - error term .

The multiple linear regression model used in this study evaluates how greenbond issuance along with renewable energy consumption, economic growth jointly effects environmental outcomes. It provides a more comprehensive understanding of the determinants of Co2 emissions.

$$t = \frac{\beta_i}{SE(\beta_i)} \quad \dots\dots\dots \text{eq.5}$$

β_i = Estimated coefficient

$SE(\beta_i)$ = Standard error of the coefficient

The t test equation is used to get test whether individual variables such as green bond issuance ,GDP per capita have statistically significant effect on the dependent variable - renewable energy

II. RESULTS AND DISCUSSION

The table below depicts the Green bond issuance across the six countries under study over a period of nine years from 2015-2024.

Table 4.1: Green bond Issuance: country wise distribution

Year	India	China	UK	USA	Germany	France
2015	1.1	16.9	0.9	7.6	1.6	3.2
2016	1.6	22.4	2.0	15.9	4.4	5.0
2017	3.3	23.0	4.6	14.0	8.1	15.0
2018	7.1	31.3	5.1	34.0	6.5	14.2
2019	10.3	31.0	9.2	51.3	12.6	29.5
2020	6.5	44.8	14.2	51.1	40.2	32.1
2021	7.4	68.2	25.5	90.2	59.0	45.0
2022	10.7	90.2	20.6	61.1	62.5	35.4
2023	7.2	83.5	32.7	59.9	67.5	30.0
2024	5.7	68.9	33.0	84.7	73.3	31.5

Source: Climates bond initiatives – Global state of the market Reports

Table no.1 shows the country wise distribution of green bond issuance in nine years. In 2015, China counts the largest share of green bond issuance among the selected countries under study, Whereas India issues the lowest share of green bonds in the year. In 2024, according to Global state of market reports, USA issues more green bonds and India counts the least.

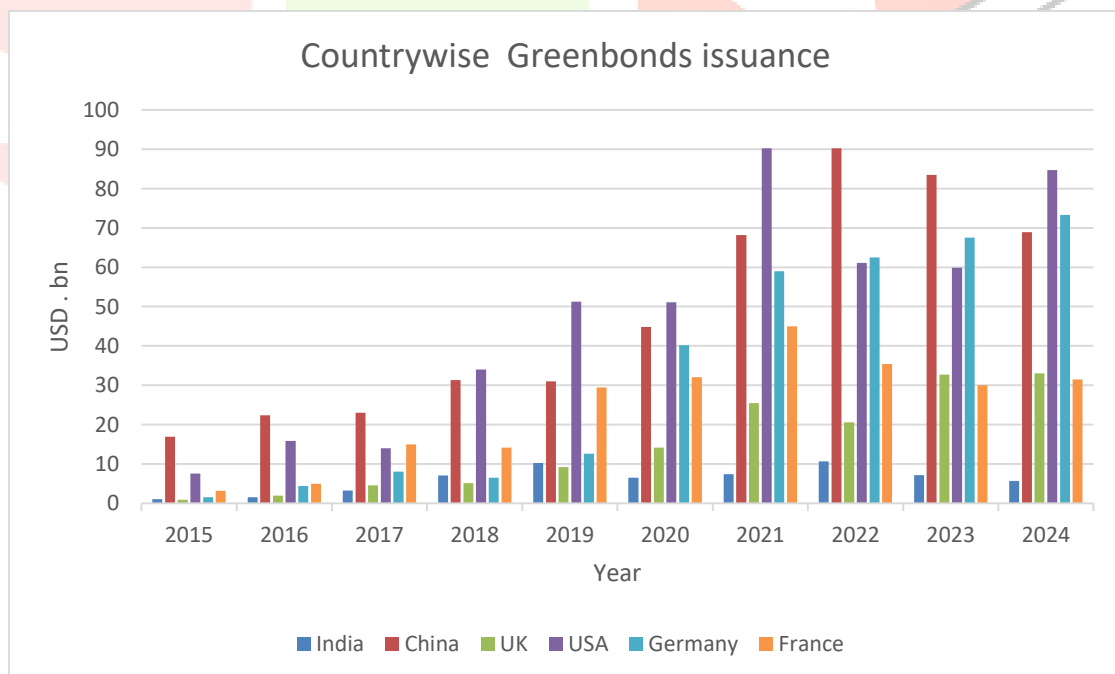


Fig no.1 country wise distribution of Green bond issuance

Figure no.1 illustrate the country wise distribution of green bond issuance for past nine years. China counts the largest share of green bond issue and from 2015 onwards to 2017. Since 2018 USA counts for the largest share of green bond issuance among these selected countries. In 2024, USA counts the largest share followed by Germany, China and UK.

4.2 Results of Descriptive Statics of Study Variables

Table 4.1: Descriptive Statistics

	Green Bond Issuance (USD bn)	Renewable Energy (%)	GDP per Capita (US\$)	CO ₂ Emissions (kt)
Mean	28.46	17.545	37308.5	3416055
Median	22.7	14.8	42455	1630760
Mode	14	14.2	46216	305000
Standard Deviation	24.09	9.33	24229.46	4004723
Minimum	0.9	6.6	1598	271000
Maximum	84.7	39.5	85810	12150000

Table no.4.1 presents that descriptive statistics of the variables under study. The main value of green bond issuance is 28.46 USD billion indicating the average level of green finance activity among the selected countries where as renewable energy consumption averages 17.54% and the average GDP per capita is 37308.5 USD. The median values for green Bond issue and is 22.7 and that of renewable energy is 14.8 and GDP per capita is 42455. The relatively high standard deviation values for most variable suggest disparities among the countries which is further reflected in the wide range between the minimum maximum values.

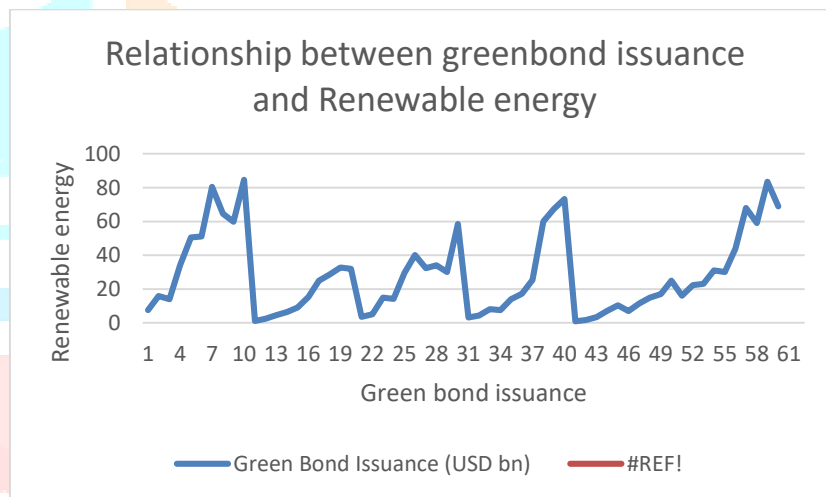


Fig no. 2: Relationship between green bond issuance and Renewable energy

The above figure illustrates the relationship between green bond issuance and renewable energy. The horizontal Axis measures green Bond issuance and vertical axis measures the level of renewable energy. The graph indicates a generally positive and fluctuating trends among the relationship between two variables. At lower levels of green bond issuance, renewable energy values remain relatively modest with volatility. As Green bond issuance increases, there is noticeable upward trend in Renewable energy levels suggesting higher investment through green bonds is associated with greater adoption of renewable energy.

Table 3. correlation matrix

	Green Bond Issuance (USD bn)	Renewable Energy (%)	GDP per Capita (Current US\$)	CO ₂ Emissions (kt)
Green Bond Issuance (USD bn)	1	0.203	0.348	-0.386
Renewable Energy (%)	0.20312	1	-0.643	-0.092
GDP per Capita (Current US\$)	0.348962	-0.64312	1	-0.415
CO ₂ Emissions (kt)	-0.386083	-0.09246	-0.41522	1

Table no.3 presents the correlation matrix showing the relationships between green Bond issue, renewable energy consumption, GDP per capita and CO₂ emissions. The result show that green bond issuance shows a positive correlation with a renewable energy consumption (0.203) suggesting that higher levels of green bond issuance financing are associated with slow increase in renewable energy adoption. Similarly, green Bond issues exhibits or moderate positive relationship with GDP per capita (0.348) indicating that financial market of these countries issue greater volumes of green bonds.

In contrast green Bond issuance show a negative correlation with CO₂ emissions minus (0.386) the study suggested that increase issuance of green bonds is associated with reduction carbon emissions.

Table no.4: Regression analysis

	<i>Coefficients</i>	<i>t Statistics</i>	<i>P-value</i>
Intercept	34.22235	19.66603147	8.15E-27
Green Bond Issuance (USD bn)	0.181656	4.603216131	2.43E-05
GDP per Capita (Current US\$)	0.00043	-10.76907148	2.91E-15
CO ₂ Emissions (kt)	-1.7E-06	-7.008232935	3.35E-09

Table no.4 presents the result of a regression analysis examining the relationship between the dependent variable Renewable energy and independent variables green bond issuance, Carbon emissions and GDP per capita under study. The regression results indicate that green bond issuance has a positive and statistically significant impact on Renewable energy consumption. The coefficient of green bonds is 0.1816 and the associated p-value is 2.91E-15 which indicates that Green Bond issuance contributes positively to expansion of Renewable energy and the relationship is statistically significant too. The coefficient for GDP per capita is 0.0043 which indicates positive relationship between economic development and renewable energy consumption. This suggests that countries with higher income levels tend to invest sustainable energy sources. The coefficient for CO₂ emissions is -1.7×10^{-6} indicating higher levels of carbon emissions are associated with lower shares of renewable energy.

SIMPLE REGRESSION MODEL

$$RE_{it} = \beta_0 + \beta_1 GB_{it} + \beta_2 GDP_{it} + \beta_3 CO_{2it} + \epsilon_{it} \quad \dots \text{eq.(1)}$$

- RE = Renewable Energy (%) → Dependent variable
- GB = Green Bond Issuance (USD bn)
- GDP = GDP per Capita (Current US\$)
- CO₂ = CO₂ Emissions (kt)

Green bonds are debt instruments designed to finance environmentally sustainable projects particularly to mitigate climate issues and generate renewable energy infrastructure. Increased green Bond issuance is expected to facilitate investment in sustainable energy projects. Green bonds may contribute to higher renewable energy and reduction in carbon emissions.

H1: Green bond issuance positively influences renewable energy consumption.

H2: Green bond issuance contributes to the reduction of CO₂ emissions.

H0: Green bond issuance has no significant relationship with renewable energy consumption or CO₂ emissions.

Null Hypothesis (H₀):
Green bond issuance has no significant effect on renewable energy consumption.

$$H_0: \beta_1 = 0$$

Alternative Hypothesis (H₁):
Green bond issuance significantly affects renewable energy consumption.

$$H_1: \beta_1 \neq 0$$

$$RE = 34.22 + 0.18(GB) + 0.00043(GDPPC) - 1.7 \times 10^{-6}(CO_2)$$

- RE – Renewable energy
- GB- Green bonds
- GDP PC- GDP Per capita
- CO₂- Carbon emissions

From table no.4 the hypothesis testing results can be interpreted as follows:

The intercept value represents the value of the dependent variable when all explanatory variables are zero, here the value for the intercept is 34.22. The p value is extremely small, less than 0.05 which means the intercept is statistically significant. The coefficient of green Bond issue is 0.18 indicates that an increase in green bond issuance leads to positive change in the dependent variable that is renewable energy. Green Bond issuance has no significant effect since p is less than 0.05 therefore the study reject the null hypothesis.

The coefficient of GDP per capita is 0.00043 which suggests that changes in GDP per capita influence the dependent variable- renewable energy. The very high absolute t-value indicates strong statistical significance and since the p value is less than 0.05 GDP per capita significantly effects the model. Similarly, the negative coefficient of CO₂ emission inch gates or negative or involve strip between CO₂ emissions and renewable energy.

In short,

- Green Bond issuance has a statistically significant positive effect.
- GDP per capita is also statistically significant.
- CO₂ emission show us significant negative relationship.

Table no. 5: Regression Statistics

Regression Statistics	
Multiple R	0.829383
R Square	0.687877
Adjusted R Square	0.671156
Standard Error	5.355759
Observations	60

The R² value indicates that approximately 68.79% of the variation in renewable energy consumption is explained by the explanatory variables in the model. The adjusted R² value accounts for the number of explanatory variables included in the model. it indicates that after adjusting for the number of predictors, about 67.12% of the variation in renewable energy consumption is explained by the model. The multiple R² value represents the correlation between the observed and predicted values of the dependent variable. Here the multiple R value is 0.829 which is close to 1 indicating a strong relationship between the variables in the model. The standard error of the regression model is 5.35 which measures the average deviation of the Observed values from the predictive values of the renewable energy consumption. A lower value indicates the regression model fits the data reasonably well.

CONCLUSION

The study on the topic 'Role of green Bond in financing sustainable development: Cross country econometric analysis' examines the relationship between green bond issuance and renewable energy consumption ,economic growth and carbon emission across selected countries over the study period. The findings of the study reveal that green bonds play a significant role in promoting environmentally sustainable investment particularly by facilitating the expansion of renewable energy infrastructure. According to the study, there arises positive relationship between the green Bond issuance and renewable energy consumption indicating that green financing mechanisms are effective in channeling toward cleaner energy sources

The study suggests that as GDP per capita continuous to rise it is often associated with increase carbon emissions high lighting that persistent trade of between economic development and environmental sustainability. In short, the study emphasis the importance of strengthening green financial instruments and policy frameworks to achieve sustainable economic growth..

III. ACKNOWLEDGMENT

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REFERENCES

Journal Papers:

1. Umair Saeed Bhutta, Adeel Tariq, Muhammad Farrukh, Ali Raza, Muhammad Khalid Iqbal, Green bonds for sustainable development: Review of literature on development and impact of green bonds, Technological Forecasting and Social Change, Volume 175, 2022, 121378,
2. Climate Bonds Initiative (2024). *Sustainable Debt Global State of the Market Report*
3. [https://www.oecd.org/content/dam/oecd/en/publications/reports/2017/10/co2-emissions-from-fuel-combustion-2017_g1g7ca18/co2_fuel-2017-en.pdf?utm](https://www.oecd.org/content/dam/oecd/en/publications/reports/2017/10/co2-emissions-from-fuel-combustion-2017_g1g7ca18/co2_fuel-2017-en.pdf?utm_source=direct&utm_medium=direct)
4. <https://www.climatebonds.net>
5. <https://www.iea.org>
6. <https://data.worldbank.org>
7. International Energy Agency (IEA). (2025). *Global Energy Review 2025: CO₂ Emissions*. Paris: IEA. Retrieved from <https://www.iea.org/reports/global-energy-review-2025>
8. World Bank. (2025). *Renewable energy consumption (% of total final energy consumption)* [World Development Indicators Data]. Retrieved from <https://data.worldbank.org/indicator/EG.FEC.RNEW.ZS>
9. Climate Bonds Initiative. (2025). *Global State of the Market 2024*. London: CBI. Retrieved from <https://www.climatebonds.net/data-insights/publications/global-state-market-2024>