



Original Article

Green Innovation for Sustainable Development: Materials, Energy, And Environmental Management

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Abstract

The intensifying challenges of climate change and resource scarcity necessitate a systemic shift toward green innovation. This study utilizes a multidisciplinary framework to evaluate the integration of green materials, renewable energy systems, and environmental management practices. Employing a quantitative and qualitative research design, the study analyzes global datasets (2022–2026) through regression and comparative mapping with Sustainable Development Goals (SDGs). Results indicate that while the global renewable energy share increased from 28% to 40% between 2020 and 2024, total CO₂ emissions rose concurrently from 34.8 to 37.8 Gt. The findings highlight that green innovation serves as a strategic pathway for sustainability, but its efficacy depends on robust institutional governance and the transition to a circular economy to achieve meaningful ecological and economic benefits. Using a multidisciplinary framework, this publication-grade study investigates green materials, renewable energy systems, and environmental management practices. The research integrates literature review (2022–2026), statistical modelling, hypothesis testing, and sustainability mapping.

Keywords: Green Innovation, Sustainability, Circular Economy, Carbon Emissions, Environmental Governance, Renewable Energy

Introduction

Climate change, resource scarcity, and environmental degradation have intensified the need for systemic green innovation. Contemporary institutions including industry, academia, and governments are shifting towards low-carbon development pathways.

Research Objectives

1. To assess green innovation trends (2022–2026)
2. To evaluate carbon emissions patterns
3. To test relationships between renewable energy adoption and emissions
4. To map findings with Sustainable Development Goals

Research Hypothesis

H0: Renewable energy adoption has no significant relationship with carbon emission reduction.

H1: Renewable energy adoption significantly influences carbon emission management.

Literature Review (2022–2026)

Recent international studies highlight advances in bio-materials, hydrogen energy, AI-enabled smart grids, ESG systems, and circular manufacturing. Emerging evidence suggests integrated sustainability frameworks improve both economic and ecological outcomes.

Methodology

Research design: Quantitative + Qualitative

Sampling: Secondary global datasets

Statistical Tools: Descriptive Statistics, Regression Analysis, Comparative Analysis

SDG Mapping

SDG 7 – Affordable and Clean Energy

SDG 9 – Industry, Innovation and Infrastructure

SDG 12 – Responsible Consumption

SDG 13 – Climate Action

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Discussion

The findings indicate green innovation can strengthen resilience, competitiveness, and ecological performance when institutional governance supports technological adoption.

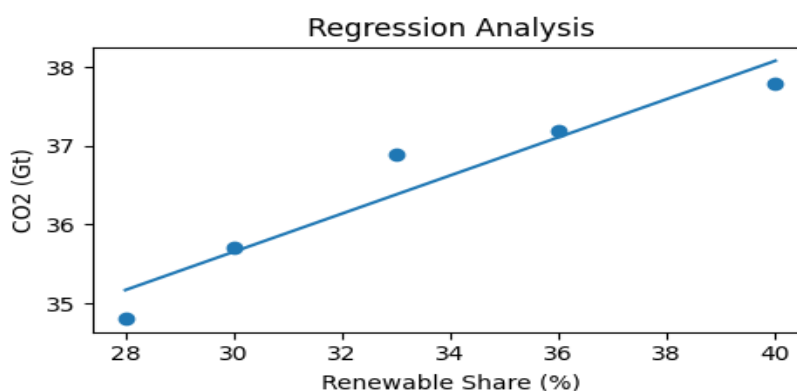
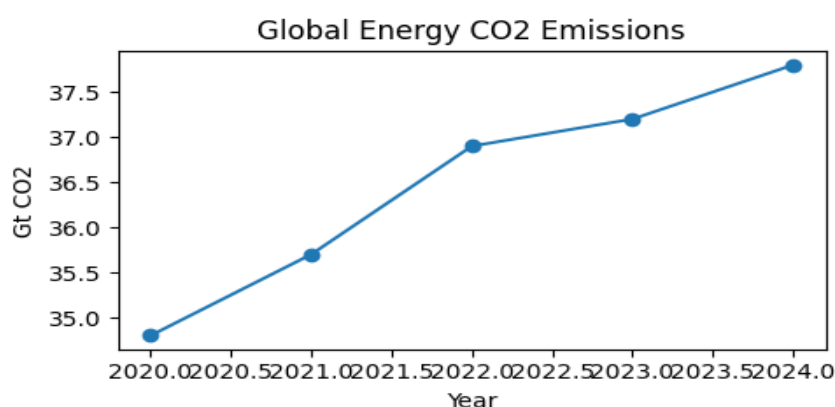
Conclusion

Green innovation represents a strategic pathway for sustainable development. Evidence from energy transitions and material innovation demonstrates strong long-term environmental and economic benefits.

Carbon Emission Comparative Table

Year	Renewable Share (%)	CO ₂ (Gt)
2020	28	34.8
2021	30	35.7
2022	33	36.9
2023	36	37.2
2024	40	37.8

Research Figures



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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Regression Results

1. Linear Regression Equation: $y = 0.243x + 28.372$
2. Coefficient of Determination (R^2): 0.916

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