Harnessing Renewable Energy for Carbon Emission Reduction: A Case Study of Sri Lanka's Path to Environmental Sustainability

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Introduction

🌍🔥 Climate change and environmental degradation have made **CO_2 emissions** a key global issue.

⚠️🍾 CO_2 is a major **greenhouse gas**, driving **global warming** and requiring urgent reduction.

♻️⚡ **Renewable energy** is a sustainable alternative that can **reduce CO_2 emissions** and promote environmental sustainability.

🌎🔋 Many countries are transitioning to **clean energy** to reduce fossil fuel dependence and meet climate goals.

🇱🇰🌞 The country relies heavily on **non-renewable energy** and must balance **growing energy demands** with environmental responsibilities.

📊🔍 This research examines the **role of renewable energy in reducing CO_2 emissions** in Sri Lanka, providing insights into sustainable energy policies.

Objectives

📊 Analyze the relationship between **renewable energy adoption** and **CO_2 emissions** in Sri Lanka.

🔋 Assess the effectiveness of different **renewable energy sources** in reducing emissions.

💡 **Evaluate current policies**, their alignment with sustainability goals, and propose strategic policy recommendations.

Methodology

✅ **Data Preparation**: cleaned by removing rows with excessive missing values (>75%) and imputing with column-wise means.

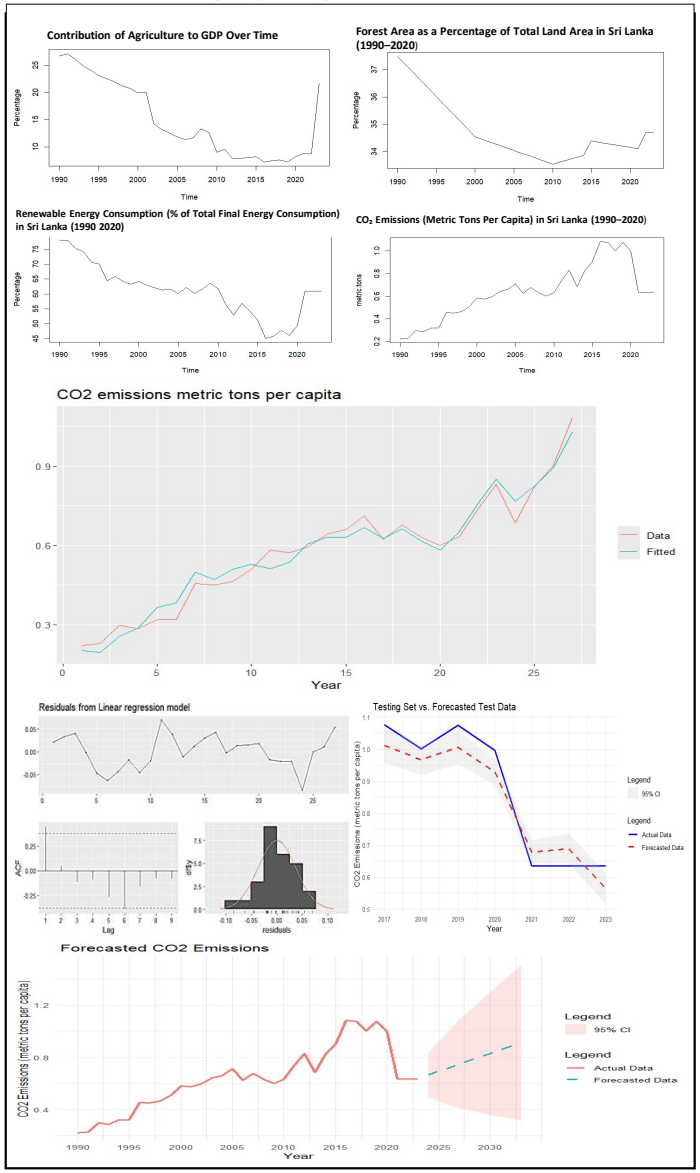
🔋 **Variable Selection**: key environmental metrics like renewable energy consumption and CO_2 emissions.

⚡ **Data Transformation**: Key variables were consolidated into a structured dataset with standardized data types.

📊 **Stationarity Testing**: Time-series data was examined for trends and seasonality, with transformations applied to non-stationary variables.

📜 **Lag Analysis**: Cross-correlation analysis was used to identify delayed impacts of renewable energy on CO_2 emissions.

Results



Discussion

📊 **Historical Trends (1990–2023)** ⏳

- **CO_2 emissions** increased **until 2015**, followed by a **sharp decline** .
- Possible reasons: **industrialization, energy shifts, and sustainability policies**.

📈 **Model Evaluation & Performance** 🔍

- The **regression model** performed well (**Adjusted R^2 = 0.9655**), explaining most variations
- **RMSE (36.84), MAE (28.09), and MAPE (74.66%)** show **moderate errors** .
- **Residual analysis confirms** key **regression assumptions** are satisfied.
- **Minimal autocorrelation** detected, but refinements can improve accuracy.

🔮 **Predictive Insights (2024–2033)** 🔍

- **Forecasts indicate** a **gradual rise in CO_2 emissions** .
- **Wider confidence intervals** in later years suggest **uncertainty** in long-term predictions.
- These insights help **policymakers** plan proactive **climate strategies**.

🌎 **Key Findings from Predictor Analysis**

- **CO_2 emissions strongly correlate** with:
- 🌾 **Agricultural GDP contribution**, 🌲 **Forest area**, ⚡ **Renewable energy usage**
- Predictors effectively **explain emissions trends with minimal bias** .

Model Refinement

- Address **residual autocorrelation** using **lagged predictors and models (ARIMA, SARIMA)**.
- Incorporate **more relevant variables** for improved predictions.

Policy Actions

- Strengthen **renewable energy adoption** & **forest conservation**.
- Maintain the **post-2015 emission decline** while tackling **future risks.**

Conclusion

✅ **Renewable energy adoption** plays a crucial role in **reducing CO_2 emissions** and promoting **environmental sustainability** in Sri Lanka.

✅ The effectiveness of **solar** ☀️**, wind** 🌬️**, and hydro** 💧 **energy** varies, highlighting the need for a **diverse energy mix**.

✅ While current **policies** support renewable energy, **stronger implementation, incentives** 💰**, and infrastructure development** 🏗️ are essential for long-term impact.

✅ Sri Lanka must continue investing in **clean energy** and adopting **strategic policies** to achieve a **sustainable and low-carbon future**.

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