Open-Access SDG Indicators for Energy Conservation: A Python-Based Machine Learning Framework for Data-Driven Sustainable Innovation

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Abstract:
With this research, open-access Sustainable Development Goals (SDG) datasets have been analysed using Python-based data science methods to strengthen universities' social responsibility in the field of sustainability and to enable them to lead global environmental goals. In the study, open-access SDG indicators provided by the United Nations, World Bank, OECD, and Eurostat were compiled; after steps of missing data cleaning, normalisation, and feature engineering, they were prepared as input for machine learning models. A multivariate data structure related to multiple SDGs, primarily including energy efficiency, carbon emissions, renewable energy share, urban sustainability, and education indicators, has been created. In the study, causal relationships between SDG indicators, key components affecting energy efficiency performance, and the long-term effects of sustainability policies were predicted using Random Forest, Gradient Boosting, LSTM, and Explainable AI (SHAP) approaches. The results obtained show that machine learning models offer higher accuracy and predictive capacity compared to traditional statistical methods. This analytical framework developed in line with the university's social responsibility mission presents a viable model to enhance the impact of energy conservation policies, provide data-driven policy recommendations to national and international stakeholders.

Keywords:
Sustainable Development Goals, Energy Efficiency Analytics, Machine Learning, Carbon Emission Modelling, University Sustainability Leadership.