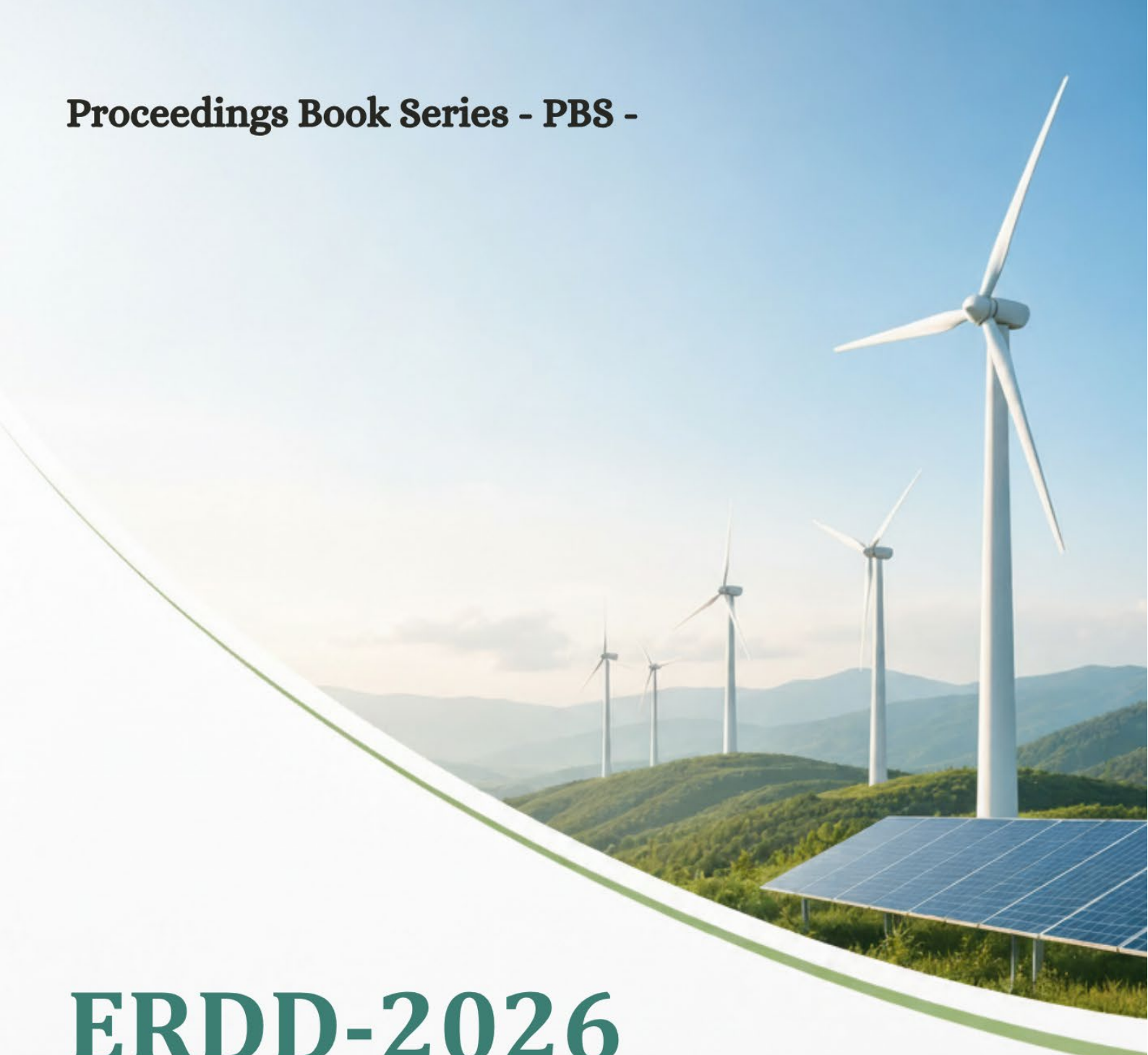


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Smart Energy Monitor: A Java-Based Application with Artificial Intelligence for Household Electricity Consumption Prediction

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ABSTRACT

Global electricity consumption has increased considerably in recent years, particularly in residential buildings. According to the International Energy Agency (IEA), global electricity demand increased by 4.3% in 2024, highlighting the need for intelligent solutions that improve energy efficiency. This project investigates how an Artificial Intelligence-enhanced software application can help users monitor, predict, and reduce household electricity consumption.

The proposed solution, **Smart Energy Monitor**, is a Java-based desktop application integrated with a Machine Learning module developed in Python. The application allows users to enter information about household electrical appliances, including their power rating and daily operating hours. It calculates current electricity consumption and predicts future energy usage using a model trained on real household electricity consumption datasets.

The proposed methodology includes data collection and preprocessing, training and evaluating the prediction model, and integrating the Artificial Intelligence module with the Java application. The system also detects abnormal consumption patterns, generates warning messages, and provides personalized recommendations to reduce electricity consumption and improve energy efficiency.

The expected results indicate that the proposed system can accurately estimate and forecast household electricity consumption while increasing users' awareness of their energy usage. The integration of Artificial Intelligence with software engineering demonstrates the potential of intelligent decision-support systems for residential energy management and future smart home applications.

In conclusion, this project presents a practical approach for combining Java applications with Artificial Intelligence to support sustainable energy management. The proposed system contributes to reducing electricity waste, encouraging energy-efficient behavior, and promoting environmental sustainability.

Keywords— Artificial Intelligence, Machine Learning, Household Electricity Consumption, Smart Home, Java Application, Energy Efficiency.

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Eco-Friendly Innovation and Sustainability in Food Sauce Formulation: A Review on Challenges, Emerging Trends, and Market Drivers

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ABSTRACT

Food sauces constitute a diverse category of processed food products that significantly contribute to the sensory and nutritional qualities of meals. However, consumers are increasingly concerned not only with nutritional and sensory aspects but also with sustainability considerations. In this context, eco-friendly innovation plays a key role in meeting consumer expectations while contributing to circular economy. This study aims to explore the sauce innovation sector by focusing on formulation strategies, ingredient selection, functional and nutritional improvements, associated challenges, and emerging market trends. A scoping review methodology was employed to map and synthesize the existing literature on recent advances in clean-label formulations and sustainable practices. Findings highlight several challenges within the food sauce sector, including the need to improve product stability and shelf-life while reducing reliance on artificial food additives and ensuring consistent sensory quality when replacing conventional ingredients. In addition, current market trends indicate a growing demand for sustainable food products, thereby driving innovation in sauce formulation and processing. However, consumer awareness of the potential value of agro-industrial by-products remains limited, leading to their marginalization despite their promising role in improving nutritional value and sustainability in sauce eco-conception. These results underscore the necessity of improving consumer awareness regarding the benefits of by-product valorization to support market acceptance and encourage more sustainable consumption patterns. By aligning sauce innovation with sustainability goals, upcycling stands as an inclusive and eco-innovative pathway to redefine local and by-products as a key resource in sauce production. Furthermore, multidisciplinary alliances, stakeholder participation, and policy coherence are essential for promoting equitable and significant change across the entire sauce value chain.

Keywords— Food sauce, agro-waste, clean-label formulation, eco-friendly innovation, sensory and nutritional quality, consumer expectation, market trend, sustainability.

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Planning and Optimizing the Water-Energy-Food Nexus in the Sahel: MAED-MESSAGE Diagnostic of Niger's Energy Mix, 2021–2050

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ABSTRACT

Introduction: Sahelian countries share a structural triple vulnerability: energy poverty, water stress, and dependence on traditional biomass, three dimensions embedded in the Water-Energy-Food (WEF) nexus [1]. Niger illustrates these challenges acutely, with only 22.5% electricity access [2] and 73% of primary energy from traditional biomass, driving watershed degradation along the Niger River. **Research Question:** Can an integrated MAED-MESSAGE diagnostic protocol quantify the WEF nexus trajectory of Niger's power sector over the full 2021–2050 horizon, and what investment is required to sustain nexus co-benefits beyond 2035? **Methodology:** The IAEA's MAED model [3], calibrated on 2021 data (−4.8% deviation, within the IAEA ±20% threshold), quantifies final energy demand under three contrasted scenarios (S1-BAU, S2-SNAE+, S3-NDC+), while MESSAGE [4] optimizes least-cost electricity supply under each scenario's constraints (10% discount rate). A composite nexus score was built on four equally-weighted pillars (low-carbon share, electrical sovereignty, preserved forest area, rural electrification rate), scored on explicit quantitative thresholds at two horizons (2035 and 2050). **Results:** The diagnostic reveals a non-monotonic electricity mix trajectory: a nexus performance peak in 2035 (100% sovereignty, low-carbon share of renewables plus nuclear up to 91.5%, versus 29.02% for renewables alone as reported in [5]) followed by a mechanical decline through 2050 (23.5–31.7%), for lack of a second planning wave beyond 2035; power-sector CO₂ emissions rebound from 0.122 Mt in 2035 (S1-BAU) to 5.3–9.9 Mt in 2050. Water-food co-benefits from biomass-to-electricity substitution remain stable throughout, preserving up to ~27,000 ha/year of watershed forest. The composite nexus score confirms this asymmetry, declining from 3.0–4.8/5 in 2035 to 2.3–4.3/5 in 2050. Closing the post-2035 gap requires USD 13.3 to 21.7 billion depending on scenario; the most ambitious scenario (NDC+) also shows the best capital intensity (545 k\$/GWh versus 639 for BAU). **Discussion:** This mismatch between national planning horizons (2035) and climate horizons (2050) is likely shared by other Sahelian countries. The Kandadji dam (130 MW, 1.596 billion m³ reservoir, 45,000 ha of irrigation), advancing SDGs 2, 6, 7 and 15, is the most stable nexus asset. A MESSAGE [4] shadow-price analysis confirms this: Kandadji's capacity constraint carries an identical marginal value across scenarios (US\$2,800/kW in 2030, plateauing at US\$1,247/kW from 2045, in 2000 US\$), an exogenous technical ceiling rather than a model cost trade-off, and a lower bound, as its non-electric benefits are not monetized. The 1,000 MW nuclear fleet underpinning the 2035 low-carbon base remains a planning assumption whose feasibility is not assessed here. **Conclusion:** This reproducible, data-calibrated protocol provides decision-makers with a dated, quantified roadmap: planning for the 2036–2050 investment wave must begin now, given the 8–10 year maturation of large projects; the protocol is transposable to other Sahelian countries.

Keywords— water-energy-food nexus; MAED-MESSAGE; Sahel; Niger; Kandadji; energy roadmap; NDC; reproducible planning

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Perovskite Solar Cells for Extreme Environments: Effects of Thermal Cycling and Electron Irradiation

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ABSTRACT

Perovskite solar cells (PSCs) combine high power conversion efficiency with low mass and simple fabrication, making them attractive for photovoltaic applications in demanding environments, including space. However, their operational reliability under environmental stress remains a challenge. Previous studies have shown that temperature variations and particle irradiation can modify PSC performance through changes in the perovskite layer, interfaces, and charge transport properties [1–4]. Partial recovery of the photovoltaic response after irradiation has also been reported for some device architectures [1,5]. However, comparative studies of thermal cycling and electron irradiation using the same photovoltaic parameters remain limited.

This work examines the effects of repeated thermal cycling and 1 MeV electron irradiation on PSC photovoltaic performance, with particular attention to the sensitivity of the main photovoltaic parameters to each stress. Two experimental protocols were performed. Devices were first subjected to repeated temperature variations between controlled limits, while their response was monitored using current density–voltage (J–V) measurements. In a second experiment, devices were exposed to 1 MeV electron irradiation at different accumulated fluences, and J–V characteristics were recorded after each irradiation step. The open-circuit voltage (Voc), short-circuit current density (Jsc), fill factor (FF), and maximum power density (Pmax) were extracted in both experiments. Thermal cycling produced measurable changes in the photovoltaic response, with variations in Voc, Jsc, FF, and Pmax during the experiment. Under 1 MeV electron irradiation, a fluence-dependent degradation was observed in all four photovoltaic parameters, with differences in their evolution as the electron fluence increased. Partial recovery of the photovoltaic response was also observed after irradiation.

The observed effects are consistent with different degradation processes. Thermal cycling can affect the multilayer structure through repeated thermal expansion and contraction and associated interfacial stresses, whereas electron irradiation can introduce radiation-induced defects affecting charge transport and recombination. The partial recovery suggests that part of the radiation response may be reversible, although further time-dependent measurements are needed to determine its origin.

The results show distinct photovoltaic responses to thermal and radiation stresses and support the assessment of PSC reliability under extreme environmental conditions, particularly for space photovoltaic applications.

Keywords— Perovskite solar cells, thermal cycling, 1 MeV electron irradiation, radiation tolerance, space photovoltaics.

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Machine Learning-Based Prediction of Transport-Related CO₂ Emissions Across Heterogeneous National Contexts

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ABSTRACT

In this paper, we investigate transport-related CO₂ emissions (TCO₂) across 31 countries using a set of socioeconomic, energy, sectoral, and meteorological factors as well as temporal indicators. Correlation analysis reveals a large variability between the studied countries, with socioeconomic indicators and sectors showing consistently positive and negative relationships with TCO₂ emissions. In contrast, renewable energy consumption generally exhibits negative correlations. To estimate TCO₂, we used three machine-learning models, such as Support Vector Regression (SVR), Ridge Regression (RR), and Random Forest (RF). The best model was RF ($R^2 = 0.87$, MAPE = 3.08%), followed by SVR with moderate accuracy, while the performance of RR was inadequate to predict the TCO₂. In terms of national-level predictions, the RF method has good generalization ability, with very high accuracies (<10% rRMSE) obtained in several developed nations (i.e., Germany, Denmark, the United States, France, and Portugal) along with reasonable performance in developing countries (i.e., China, India, and Tunisia, etc.). However, the regression plot shows a strong agreement between observed and estimated values, with only minor deviations, particularly at milder and higher emission levels. These results confirm that the RF approach can be applicable in heterogeneous contexts.

Keywords— Transport-related CO₂ emissions; Machine learning; Random Forest; Renewable energy; Cross-country analysis; Emission prediction; Sustainable transport.

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Machine Learning Approaches for Predicting Transport-Related CO₂ Emissions in North Africa

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ABSTRACT

In this study, we address the gap in TCO₂ emissions prediction in the North African region by developing a machine learning framework for Algeria, Morocco, and Tunisia. The correlation analysis revealed that population and urbanization rate are the main positive drivers of transport-related CO₂ emissions, whereas renewable energy contributes to emission reduction. Four machine learning algorithms (RF, SVR, XGBoost, and MLP) were developed and evaluated for TCO₂ prediction. The developed models achieved strong predictive performance during training, with R² values exceeding 0.994 and very low prediction errors. On test dataset, SVR provided the best performance for Algeria (R² = 0.98), RF showed the highest accuracy for Morocco (R² = 0.96), and MLP outperformed the other models for Tunisia (R² = 0.99). These results demonstrate the capability of ML learning techniques to predict TCO₂ emissions and emphasize the need for selecting the most appropriate model to each country.

Keywords—Transport-related CO₂ emissions; Machine learning; Carbon emission prediction; North Africa; Sustainable transportation

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