ABSTRAK

Peningkatan suhu global yang berkelanjutan menjadi isu krusial yang dipengaruhi oleh emisi gas rumah kaca, termasuk dari sektor agri-pangan yang berkontribusi hingga 29,7% dari total emisi global. Penelitian ini bertujuan mengembangkan model prediksi peningkatan suhu rata-rata global berdasarkan emisi karbondioksida dari sektor agri-pangan menggunakan algoritma *Light Gradient Boosting Machine (LightGBM)* dan *Extreme Gradient Boosting (XGBoost)*. *Dataset* berasal dari *Food and Agriculture Organization (FAO) and Intergovernmental Panel on Climate Change (IPPC)* dengan 31 fitur dan 6.965 data sampel dari tahun 1990 hingga 2020. Metodologi penelitian meliputi *Explanatory Data Analysis, preprocessing* dengan imputasi *missing value* menggunakan median, *feature engineering* dasar (*temporal encoding, sinusoidal encoding, transformasi logaritmik*, dan agregasi emisi total), serta *time-aware feature engineering (lag features, rolling mean, delta, acceleration*, dan *trend positive*). Model dievaluasi menggunakan metrik R^2, RMSE, MAE, dan CV RMSE dengan pembagian data temporal 81,4% *training* dan 18,6% *testing*. Hasil penelitian menunjukkan bahwa *XGBoost* dengan konfigurasi max_depth=3, learning rate=0,05, dan n_estimator=500 memberikan performa terbaik dengan test R^2=98,58%, test RMSE= $0{,}058^0$C, dan test MAE=$0{,}036^0$C, mengungguli *LightGBM* yang memiliki test R^2=98,21%. Tingkat presisi prediksi yang tinggi ini krusial dalam konteks pemantauan target Kesepakatan Paris untuk menahan kenaikan suhu global di bawah 1.5^0C, dimana margin error yang kecil memastikan proyeksi suhu dapat diandalkan untuk evaluasi kebijakan mitigasi. *Feature engineering* berbasis *time-aware* terbukti menjadi faktor kunci keberhasilan, meningkatkan performa dari test R^2 21% menjadi 98%. Model berhasil menangkap pola temporal kompleks dan efek lag antara emisi dengan peningkatan suhu, serta mampu memprediksi peningkatan suhu tahun 2021 sebesar $1{,}439^0$C dengan tingkat akurasi tinggi.

Kata kunci: Prediksi, Suhu, Emisi, *Feature Engineering*.

ABSTRACT

The continuous increase in global temperatures has become a critical issue influenced by greenhouse gas emissions, including from the agri-food sector which contributes up to 29,7% of total global emissions. This research aims to develop a predictive model for global average temperature increase based on carbon dioxide emissions from the agri-food sector using Light Gradient Boosting Machine (*LightGBM*) and Extreme Gradient Boosting (*XGBoost*) algorithms. The dataset, sourced from the Food and Agriculture Organization (FAO) and Intergovernmental Panel on Climate Change (IPCC) with 31 features and 6.965 data samples from 1990 to 2020. The research methodology includes Expalnatory Data Analysis, data preprocessing with median imputation for missing value, basic feature engineering (temporal encoding, sinusoidal encoding, logarithmic transformation, and total emissions aggregation), and time-aware feature engineering (lag features, rolling mean, delta, acceleration, and trend positive). Models were evaluated using R^2, RMSE, MAE, and CV RMSE metrics with temporal data split of 81,4% training and 18,6% testing. Result show that XGBoost model with configuration max_depth=3, learning_rate=0,05, and n_estimator=500 provides the best performance with test R^2=98,58%, test RMSE=0,058 ^{0}C, and test MAE=0,036 ^{0}C, outperforming LigthGBM which has test R^2=98,21%. This high prediction precision is crucial for monitoring the Paris Agreement target to limit temperature rise below 1.5^{0}C, ensuring projections are reliable for evaluating mitigation policy effectiveness. Time-aware feature engineering proved key improving performance from test R^2 of 21% to 98%. The model successfully captured complex temporal patterns and lag effects between emissions and temperature increase, accurately predicting 2021's temperature increase of 1,439^{0}C.

Keywords: Prediction, Temperature, Emissions, Feature Engineering.