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Use of Artificial Neural Networks to Estimate Evapotranspiration for Efficient Irrigation Management

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Abstract : This study deals with the estimation of reference evapotranspiration (ET_0) in an agricultural context, focusing on efficient irrigation management to meet the growing interest in the sustainable management of water resources. Given the importance of water in agriculture and its scarcity in many regions, efficient use of this resource is essential to ensure food security and environmental sustainability. The methodology used involved the application of artificial intelligence techniques, specifically Multilayer Perceptron (MLP) Artificial Neural Networks (ANNs), to predict ET_0 in the state of Paraná, Brazil. The models were trained and validated with meteorological data from the Brazilian National Institute of Meteorology (INMET), together with data obtained from a producer's weather station in the western region of Paraná. Two optimizers (SGD and Adam) and different meteorological variables, such as temperature, humidity, solar radiation, and wind speed, were explored as inputs to the models. Nineteen configurations with different input variables were tested; amidst them, configuration 9, with 8 input variables, was identified as the most efficient of all. Configuration 10, with 4 input variables, was considered the most effective, considering the smallest number of variables. The main conclusions of this study show that MLP ANNs are capable of accurately estimating ET_0, providing a valuable tool for irrigation management in agriculture. Both configurations (9 and 10) showed promising performance in predicting ET_0. The validation of the models with cultivator data underlined the practical relevance of these tools and confirmed their generalization ability for different field conditions. The results of the statistical metrics, including Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and Coefficient of Determination (R2), showed excellent agreement between the model predictions and the observed data, with MAE as low as 0.01 mm/day and 0.03 mm/day, respectively. In addition, the models achieved an R2 between 0.99 and 1, indicating a satisfactory fit to the real data. This agreement was also confirmed by the Kolmogorov-Smirnov test, which evaluates the agreement of the predictions with the statistical behavior of the real data and yields values between 0.02 and 0.04 for the producer data. In addition, the results of this study suggest that the developed technique can be applied to other locations by using specific data from these sites to further improve ET_0 predictions and thus contribute to sustainable irrigation management in different agricultural regions. To summarize, this study has helped to advance research in the field of irrigation management in agriculture. It provides an accessible and effective approach to ET_0 estimation that has the potential to significantly improve water use efficiency and promote agricultural sustainability in different contexts.

Keywords : agricultural technology, neural networks in agriculture, water efficiency, water use optimization
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