Evaluation of the Self-Organizing Map and the Adaptive Neuro-Fuzzy Inference System Machine Learning Techniques for the Estimation of Crop Water Stress Index of Wheat under Varying Application of Irrigation Water Levels for Efficient Irrigation Scheduling

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Abstract : The crop water stress index (CWSI) is a cost-effective, non-destructive, and simple technique for tracking the start of crop water stress. This study investigated the feasibility of CWSI derived from canopy temperature to detect the water status of wheat crops. Artificial intelligence (AI) techniques have become increasingly popular in recent years for determining CWSI. In this study, the performance of two AI techniques, adaptive neuro-fuzzy inference system (ANFIS) and self-organizing maps (SOM), are compared while determining the CWSI of paddy crops. Field experiments were conducted for varying irrigation water applications during two seasons in 2022 and 2023 at the irrigation field laboratory at the Civil Engineering Department, Indian Institute of Technology Roorkee, India. The ANFIS and SOM-simulated CWSI values were compared with the experimentally calculated CWSI (EP-CWSI). Multiple regression analysis was used to determine the upper and lower CWSI baselines. The upper CWSI baseline was found to be a function of crop height and wind speed, while the lower CWSI baseline was a function of crop height, air vapor pressure deficit, and wind speed. The performance of ANFIS and SOM were compared based on mean absolute error (MAE), mean bias error (MBE), root mean squared error (RMSE), index of agreement (d), Nash-Sutcliffe efficiency (NSE), and coefficient of correlation (R^2). Both models successfully estimated the CWSI of the paddy crop with higher correlation coefficients and lower statistical errors. However, the ANFIS (R^2=0.81, NSE=0.73, d=0.94, RMSE=0.04, MAE= 0.00-1.76 and MBE=-2.13-1.32) outperformed the SOM model (R^2=0.77, NSE=0.68, d=0.90, RMSE=0.05, MAE= 0.00-2.13 and MBE=-2.29-1.45). Overall, the results suggest that ANFIS is a reliable tool for accurately determining CWSI in wheat crops compared to SOM.

Keywords : adaptive neuro-fuzzy inference system, canopy temperature, crop water stress index, self-organizing map, wheat
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