An Efficient NDVI-Based NARX Machine Learning Model for Predicting Soil Moisture in Leafy Vegetable (Basella alba) for Precision Irrigation

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Leafy vegetables like Malabar spinach require optimal soil moisture (SM) to ensure steady physiological activity, improved nutrient uptake, and higher leaf yield. Excessive water application, based on current ET based irrigation methods may affect plant growth, vigor, and vegetable quality. Excessive watering is not only a waste but also can drain nutrients out from the root zone. Since the health of leafy vegetables like Malabar spinach are strongly associated with canopy greenness, Normalized Difference Vegetation Index (NDVI) - which quantifies vegetation greenness - can serve as a reliable indicator of this crop's health. NDVI variations reflect change in SM and can provide an opportunity to develop machine learning (ML) models for efficient irrigation. The nonlinear autoregressive exogenous (NARX) algorithm, which can use external variables and past system responses to predict future system responses is used in this research. With a goal to predict required SM to produce healthier Malabar spinach, the NARX ML methodology consists of: (1) data collection, (2) data processing for NDVI calculations and ML model, (3) NARX development, (4) model parameter selection, and (5) analysis of model outputs; in order to capture SM dynamics based off of past NDVI and SM levels. Results show that the NARX model can successfully capture SM dynamics to predict fluctuations in daily SM levels efficiently with a high accuracy. For example, the R value for model prediction is as high as 0.91. An analysis shows that application of this model can save significant revenue and water savings if the model is installed in a pump controller.

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