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Predict indoor environment of greenhouses for automatic greenhouse environmental control using machine learning techniques

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Maintaining stable crop production is the main benefit of greenhouses, which, however, would consume additional resources to control the indoor environment, as compared to open field cultivation. In consideration of Water-Food-Energy Nexus (WFE Nexus) management, it's important to build an integrated methodology to estimate and optimize the crop production and resources consumption of greenhouses. Since the crop production of greenhouses is predictable if the indoor environment is well controlled, the main thing we should consider is how to reduce the water and energy consumption as much as possible during the environmental control process for greenhouses. For this purpose, we first build a machine learning-based model to predict indoor environment, including air temperature, relative humidity (RH), and soil water content, for a greenhouse that grows crops. Then according to the suitability criteria of the crop, the predicted values are utilized for environmental control if the values violate the criteria. Under such circumstance, an estimation model is established to determine which type and level of control mechanisms upon water and energy should be activated for meeting the suitability criteria to maintain stable crop production. The study area is a cherry tomato greenhouse located at the farm in Changhua County, Taiwan, where a total of 44,310 datasets were recorded by Internet of Things (IoT) from 2018 to 2019 at a 10-minute temporal resolution. This study also evaluates the efficiency of greenhouses under different scenarios of climatic conditions. The results are expected to contribute to the automatic greenhouse environmental control for stimulating the synergies of the WEF Nexus management toward sustainable development.

Keywords: Water-Food-Energy Nexus (WFE Nexus); Greenhouse; Machine learning; Internet of Things (IoT)