

# COMBINING IoT, SIMULATION MODELS, AND OPTIMIZATION ALGORITHMS TO ENHANCE PRECISION IRRIGATION IN CLIMATE-VULNERABLE REGIONS

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**Abstract.** As climate change intensifies water scarcity and variability, improving water productivity has become a critical priority for sustainable agriculture. Smallholder farmers, who form the backbone of food production in many developing countries, often lack access to technologies and data-driven tools that can enhance their water-use efficiency. Recent advances in precision agriculture have demonstrated the technical feasibility of integrating low-cost sensing systems, remote sensing data, and simulation models to enhance agricultural field monitoring, particularly under water-scarce and climate-vulnerable conditions. An experiment is being conducted within the WaterPIP KAN project (Benin, Ghana, Burkina Faso, Kenya and India), focusing on soil moisture as the key variable for guiding irrigation strategies. The approach leverages capacitive sensors, geospatial calibration techniques, and agro-hydrological models. Multi-objective optimization techniques such as the NSGA-II algorithm combined with simulation models like AquaCrop and HYDRUS, provide a powerful framework for generating pre-optimized irrigation schedules under varying environmental and management constraints. The systems have enabled automated irrigation, real-time data transmission through IoT protocols, and user-friendly decision-support interfaces for field-level analysis. The project is currently exploring suitable approaches to upscale the geographical coverage of the application across the West African region by integrating robust methodologies for downscaling WaPOR data.

**Key words:** Water productivity; Precision agriculture; Soil moisture monitoring; Irrigation optimization; Remote sensing and IoT

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