# Enhancing Crop Prediction and Resource Management: A KNN-Based Approach Coupled with IoT-Driven Smart Irrigation for Rice, Wheat, and Corn Cultivation

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***Abstract--* In places where water shortages are a big problem, using too many fossil fuels for water-table pumping makes extraction ratios worse, which makes climate change and global warming worse. Sustainable farming needs good groundwater management because population growth raises food needs. This study shows how Internet of Things (IoT) devices can be used with a K-Nearest Neighbours (KNN) algorithm to automatically guess what kind of crop it is (corn, wheat, or rice) and the best way to water it. Using sensors to measure soil wetness, temperature, humidity, and total dissolved solids (TDS), our system figures out on its own how much water each crop needs each day based on how it grows. Arduino UNO microcontrollers and the Adafruit bridge handle real-time sensor data, which lets precise irrigation scheduling happen without any help from a person. The Internet of Things Smart Irrigation System is introduced in this paper. It is a big step forward for modern farming. By giving farmers automated, data-driven insights, the system encourages farming methods that are good for the environment and last, while also making farming as efficient as possible. This new technology could help farmers grow more crops and protect important water sources in the long run. As the Internet of Things keeps getting better, this abstract shows a complete answer that could change agriculture by getting rid of the need for manual labour.**

## I. INTRODUCTION

By 2050, population growth to 9.7 billion will demand 70% more food production. India relies on agriculture for GDP growth [16]. Agriculture drives national prosperity. The major freshwater consumption is agriculture 69% [8]. India uses its vast natural resources poorly. Water sufficed. We must save water and increase food production to keep up with global expansion[6]. Reduced agricultural water depletion by irrigation. Agriculture using irrigation needs tons of water. Water utilization on this arduous process must be reduced with an efficient irrigation system[2]. Water scarcity has been eased by drip irrigation, sprinkler systems, automated irrigation, and network-based irrigation automation [12]. Farmers water crops traditionally. When numerous fields are dispersed across regions, these approaches are inefficient and time-consuming [8]. Automation has made irrigation more efficient and easier for farmers [12]. IoT technologies are being developed to monitor and maintain crops without human intervention. Smart farming solutions monitor crops and automate irrigation with IoT sensor[1]. Automated irrigation systems save water, increase plant quality, and optimize irrigation. Modern technologies like IoT, Cloud Computing, Machine Learning, Renewable Energy, Sensors, WSNs, and embedded computing improve irrigation systems. Cloud computing provides dynamically scalable and frequently virtualized resources over the Internet [11]. Technology allows vast volumes of data to be collected and analyzed to better planning and decision-making [8]. An integrated irrigation control system using IoT sensors, cloud storage, and a user-friendly mobile app is provided in this study. Arduino UNO captures real-time soil moisture, weather, and crop needs data with soil moisture and DTH-II sensors. Adafruit bridges relay data to central processors. This study predicts daily irrigation water needs using regression. It uses sensor data and K-Nearest Neighbours algorithms to predict. No studies have used this strategy. Our research combines technology for precision. Farmers contribute significantly to India's GDP, hence a robust IoT framework in agriculture is needed. This framework should include all applicable technologies to boost yield and quality. This should save electricity and water and help cultivate profitable, cost-effective crops [1]. The aforementioned technique will manage water and produce responsibly in India, where irrigation is needed. These challenges prompted this endeavor to address Indian agriculture's water and productivity issues. Next portions of the essay follow this order. Section III Methodology follows the Literature Survey. Section IV addresses Methodology. Section V evaluates results. Part VI closes and outlines future efforts.

## II. LITERATURE SURVEY

These articles describe the research, investigations, and advances that lead to IoT-based smart irrigation systems with cloud storage and mobile apps. These systems' technology advances, environmental benefits, and economic implications show their current and future promise. IoT technologies for smart agriculture address resource depletion, water waste, labor, cost-effectiveness, and productivity. Aims affect solution complexity, technology (Cloud-computing, Big Data Analytics, Machine Learning), Raspberry Pi, Arduino, and sensors. The literature review includes recent publications and studies of our suggested system. R. Nageswara Rao et al. [11] used Raspberry Pi and two sensors (temperature and soil moisture) to monitor field activities, irrigation concerns, and production in Precision Agriculture. Cloud computing and data-based technologies simplified his hardware. Thaher and colleagues [8] created a cloud-based IoT smart irrigation system. Arduino Uno sent YL-69, soil moisture, humidity, and XBee ZigBee modules to Raspberry Pi for processing and uploading to ThingSpeak IoT cloud. M Monica et al.'s smart irrigation system [12] uses Arduino Uno and a GSM module to track soil, light, and temperature data. Comparing data to last year's in Spark fun cloud determined the threshold. Threshold settings determine Bluetooth or app motor control. 2017 conserved more water than 15-16. To reduce water use, administration, and expense, Sanket Salvi et al. [13] presented an IoT-based multi-level irrigation system with Cloud-based data analysis. A soil moisture sensor (YL-69), DHT11 sensors, and a light intensity sensor on Arduino Uno were transferred to ThingSpeak Cloud via Bluetooth (HC-05) for storage and analysis in MATLAB. UV LEDs and motor pump turned on/off automatically. In Cloud & IoT-based Smart Agriculture, El-Taibi Bouali et al. [3] reduced water consumption by 71.8% with a solar panel-powered smart irrigation system. Node-Red uses WSN data for drip irrigation and lights. Through Arduino Nano, Raspberry Pi gatewayed solar-powered DHT11, PIR, fire, HC-SR04, AC, and ZigBee sensors. Fuzzy logic makes decisions. Researchers in [4] used solar photovoltaic pump modules and a North-west China battery to power the system. Integrate SCM, LoRaWan, and mobile apps. High initial investment paid off over time. This work has helped us understand the challenges of designing a comprehensive automated smart irrigation system using multiple sensors, the Thingspeak Cloud, Machine Learning algorithms, Renewable Energy integration, LoRaWan, Arduino Uno, and Raspberry Pi, and the modifications needed for our approach. To reduce expense and workload, the scientists used a regression technique from Machine Learning to determine daily irrigation water needs from Raspberry Pi sensors, which regulate an electromagnetic valve to turn off/on the motor [15]. Wirelessly send and access cloud data with a Java program. EC-1258, DHT11, Thermistor, and Arduino-connected sensors' twice-daily data was analyzed using ground statistics, SVM, extrapolation, and cluster groups. SVM is accurate and successful with ML classification algorithms (Reconstruction Forest, AC (Cluster analysis), Binary incremental division (RT), SVM). A frequency module, LoRaWan, sent sensor signals from a microcontroller (PIC) to a gateway for concentration and internet transmission [7]. Apps send ThingSpeak MQTT data. The crop monitor processes images. The system was powered by solar photovoltaic pump modules and stored in a North-west China battery. Integrate SCM, LoRaWan, and mobile apps. High initial investment paid off over time. We now understand the challenges of designing a comprehensive automated smart irrigation system using multiple sensors, the Thingspeak Cloud, Machine Learning algorithms, Renewable Energy integration, the LoRaWan protocol, Arduino Uno, and Raspberry Pi, and the modifications needed to suit our approach.

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III. METHODOLOGY

### *A. Block Diagram*

Arduino Uno sensors read temperature, humidity, soil moisture, and total dissolved solids (Fig. 1). This information controls the water pump to keep the soil moist for plant growth. Raspberry Pi connects Arduino Uno to the cloud. Sensor data is cleaned before storage and processing in the cloud. Machine learning algorithms on the Raspberry Pi 4 can assess historical data, anticipate the future, and calculate the best watering periods to maximise resource use and crop development.

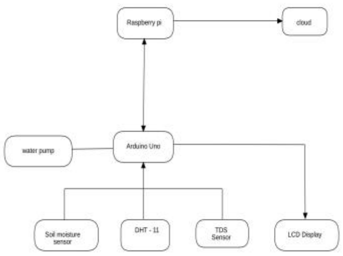


Fig. 1 Block Diagram

The Arduino and Raspberry Pi-based irrigation control system schematic diagram in Fig. 2 shows component integration. The diagram shows an Arduino Uno connected to a TDS sensor, soil moisture sensor, DHT11 sensor, and two-channel relay module-controlled 5V submersible water pump. An LCD provides real-time data visualization. Serial connectivity connects the Arduino Uno to a Raspberry Pi 4, which processes sensor data using a KNN algorithm. A complete IoT system for water management automates irrigation control depending on environmental parameters.

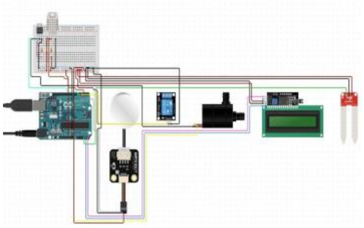

Fig. 2 Schematic Diagram

Figure 3 demonstrates how the Arduino-based system receives sensor data, controls irrigation, and presents it on an LCD screen. Turn on the Arduino Uno and configure the devices. Arduino collects sensor data like soil wetness. To assess irrigation demands, the Arduino compares soil moisture to a threshold after gathering data. If soil moisture decreases below the cut-off, Arduino switches on the water pump via the relay module. Pumps are off when soil moisture exceeds the threshold. Arduino shows sensor and irrigation system data on an LCD monitor. This simplifies system display and interaction. This flowchart shows how the Arduino-based system's sensor data collection, irrigation control, and data presentation functions ease irrigation management and real-time weather monitoring.

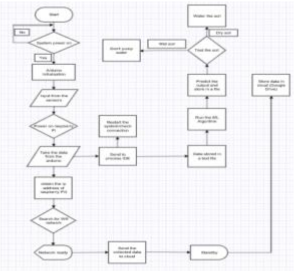

Fig. 3 Flowchart of the sequence occurs in Arduino and Raspberry Pi

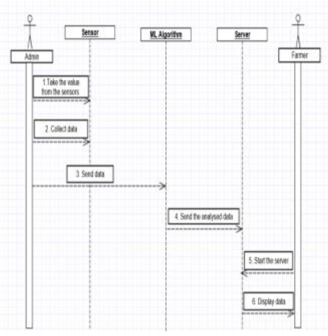


Fig. 4 Sequence Diagram

## IV. RESULTS

Intelligent IoT-based Automated Irrigation System incorporates Arduino and Raspberry Pi 4. Soil temperature, moisture, and TDS are monitored by strategically positioned sensors. These sensors give data to the Arduino microcontroller for processing. Automatic watering is done with the Arduino and a water pump actuator. Serial data goes to the Raspberry Pi 4 controller. This study predicts rice, wheat, and maize soil conditions using KNN machine learning. This forecast uses TDS sensor data. Raspberry Pi 4's machine learning algorithm trains datasets on dry, very dry, wet, and slightly damp soil. The software can forecast accurately. Raspberry Pi 4 predicts crop demands and sends Arduino control signals to start the water pump and field irrigation. Farmers can control irrigated fields using a cloud-based website. Fig. 6 shows the full prototype. Fig. 7 shows the Raspberry Pi 4 as an intelligent analysis edge processor. This study predicts soil conditions utilizing soil moisture, temperature, TDS, and trained datasets for distinct soil types using KNN machine learning.

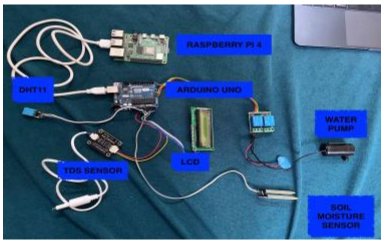


Fig. 6 Complete Setup

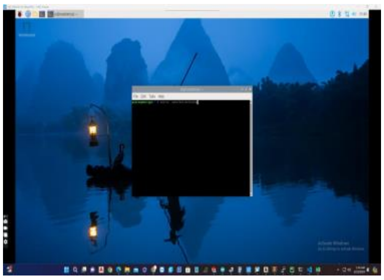

Fig. 7 Raspberry Pi OS and Terminal

Fig. 8 shows rice as the forecast crop based on hypothetical values of rice-specific parameters including temperature, humidity, and TDS (Total Dissolved Solids) from Adafruit IO. The technique uses machine learning algorithms to correlate climate with crop development factors to provide the forecast. In Fig. 9, the Raspberry Pi terminal interface executes the K-Nearest Neighbours (KNN) algorithm with a score of 65%. The procedure is running on dataset4.csv, a pre-processed dataset uploaded to the system. The dataset should include historical or experimental data on environmental conditions and crop types. This data will train and evaluate a machine-learning model that predicts crop types based on environmental circumstances.

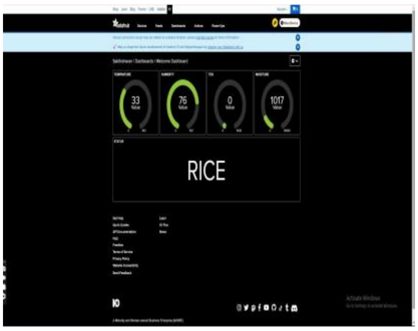


Fig. 8 Adafruit output visualisation

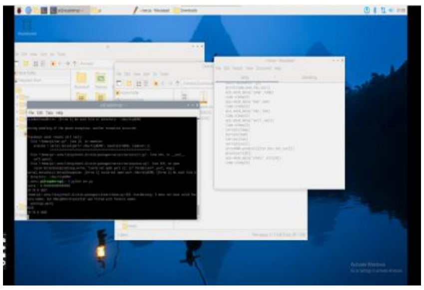

Fig. 9 KNN predicting the crop in Raspberry Pi and Score of the Model

Fig. 10 shows how the soil moisture sensor affects water pump operation. The Arduino microcontroller activates the water pumps by lighting the pump indicators or moving the pumps. Arduino logic activates irrigation to solve dry soil conditions. Additionally, the LCD’s current temperature, humidity, and Total Dissolved Solids (TDS) data. This data is presented to help users understand the monitored region's environmental conditions. This data helps monitor and control environmental variables, enabling educated irrigation and crop management decisions.

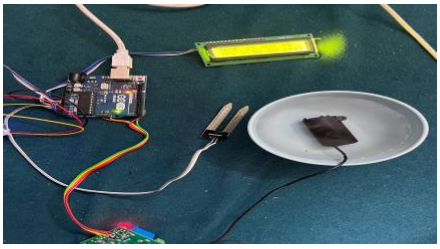

Fig. 10 Water Pumping

## V. CONCLUSION AND FUTURE WORK

Arduino and Raspberry Pi 4 microcontrollers built and integrated an IoT-based Automation Irrigation System. KNN machine learning identifies the best crop variety. Soil moisture, temperature, humidity, and TDS are evaluated. Real-time water monitoring and control boost crop productivity and resource use. Multiple research and development paths can improve system performance. Future environmental monitoring research may focus on enhanced sensors and technology. Aerial pictures track crop health and soil pH. Continuous machine-learning algorithm improvement is needed for prediction. Data analysis may benefit from deep learning. Remote monitoring and control, water-saving methods, and convergence with other intelligent agricultural technology improve system efficiency and sustainability. Further research in these areas will make the Intelligent Internet of Things (IoT)-based Automated Irrigation System more advanced and resilient to meet modern agriculture's needs.

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