

## Optimizing Water Usage in Sugarcane Farming Through IoT Technologies

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**Abstract** Automation in agriculture can transform the traditional and fixed method of farming into a smart and dynamic, resulting in increased yield with lesser human supervision. This transformation is possible through the use of cutting-edge innovations such as artificial intelligence, robotics, and sensors. These technologies facilitate tasks like cultivating, harvesting, and monitoring agricultural products to be done more efficiently and accurately, resulting in increased productivity and lower labor costs.

The proposal presents an IOT-based automatic drip system that keeps tabs on the desired soil level of moisture in a sugar cane farm by means of automatic watering, thus optimizing the water usage. The system uses microcontroller in conjunction with the Blynk application platform to implement the control unit. A combination of moisture level sensor, temperature and humidity sensor and rain sensor is used to maintain the desired moisture level. The system uses these values, which are directly displayed on a farmer's mobile device, to use the appropriate quantity of fertilizer and water, thus preventing over- or under-fertilization. IOT allows farmers to stay informed about the status of their pumps, valves, rain, humidity, temperature, and soil moisture content.

**Keywords:** Irrigation, water management, IoT, Drip System, Blynk App.

### 1. Introduction

Sugarcane farming is a cornerstone of the global agricultural industry, providing raw material for sugar production, ethanol, and other byproducts. However, it is also one of the most water-intensive crops, requiring vast amounts of irrigation throughout its lifecycle. In an era where water scarcity is a growing concern, optimizing water usage in sugarcane farming is essential for sustainable agriculture. The integration of Internet of Things (IoT) technologies offers a promising solution to this challenge, enabling precise monitoring and efficient use of water resources [1][2].

#### The Challenge of Water Use in Sugarcane Farming

Sugarcane cultivation demands significant water inputs due to its long growth cycle and high transpiration rates. Traditional irrigation methods, such as flood irrigation, often result in water wastage due to evaporation, runoff, and inefficient distribution. Over-irrigation not only depletes valuable water resources but can also lead to soil

degradation, nutrient leaching, and reduced crop yields [3]. Agricultural practices, irrigation effectiveness, and the length of crop growth, affect the total water demand.

The development of a crop can be broken down into four distinct stages.

**Germination** (0–45 days): 300mm

**Tillering phase** (45–120 days): 550mm

**Grand growth phase** (120–270 days): 1000mm

**Ripening phase** (270–360 days): 650 mm Germination

#### **Germination:**

During the germination phase, the crop requires approximately 300mm of water. This stage typically lasts for 0–45 days and is crucial for the initial growth of the plant. The availability of water during this period is vital to ensuring successful seed germination and establishment. The fundamental principle of irrigation is to provide small amounts of water at regular intervals, in order to maintain a slightly damp but not overly soft soil. Underwatering causes the soil to become dry, which causes the buds to dry out and causes a lower and delayed germination rate. An increased volume of water application is associated with the occurrence of bud rot, which can be attributed to fungal infestation, inadequate aeration, and excessive soil moisture.

#### **Tillering:**

The tillering phase is an important stage in the growth of plants. During this phase, the plant produces additional shoots called tillers, which contribute to increased yield. Proper irrigation during tillering is crucial as it ensures optimal moisture levels for root development and nutrient uptake. However, overwatering during this stage can lead to waterlogging and hinder root growth, ultimately affecting the overall health and productivity of the plant. Therefore, maintaining a balance between adequate irrigation and avoiding excessive water application. A scarcity of water would lead to a decrease in tillering, an increase in tiller mortality, and consequently a decline in the overall stalk population. A scarcity would diminish the process of tillering, amplify tiller mortality, and consequently result in a decrease in the stalk population.

#### **Grand Growth**

Insufficient water during the rapid growth stage results in the reduction of internode length, which in turn leads to shorter cane length and decreased cane weight. This can lead to decreased sugar production and a general decline in crop productivity. There is a higher demand for water in the atmosphere during the tillering and grand growth phases, which typically occur during hot weather. This can result in lower sugar yields and overall reduced productivity of the crop.

The tillering and grand growth phases predominantly align with the period of hot weather, during which there is a higher atmospheric requirement for water.

#### **Ripening phase**

The process of ripening necessitates a moderate level of moisture stress in order to facilitate the accumulation of sugars. An abundant availability of water results in sustained vegetative growth, thereby impeding the accumulation of sugar.

It is imperative to prevent soil cracking, as even the smallest fissures could harm the root structure. There may be significant cane weight loss, cane breakage, pith formation, an increase in the percentage of fiber, and a decline in juice quality if the old crop is stressed and does not receive the necessary amount of water. The tillering phase is of utmost importance and thus necessitates an optimal provision of water. The occurrence of a shortage would result in a decrease in tillering, an increase in tiller mortality, and consequently, a decline in the overall stalk population.

## How IoT Can Transform Water Management

IoT technologies provide farmers with real-time data and actionable insights to optimize water usage [4] [5]. Here are some of the ways IoT can revolutionize water management in sugarcane farming:

**Soil Moisture Sensors:** IoT-enabled soil moisture sensors measure the water content in the soil at various depths. These sensors help farmers determine the optimal timing and amount of irrigation, ensuring that water is only applied when and where it is needed.

**Weather Monitoring Systems:** IoT devices can track local weather conditions, such as temperature, humidity, rainfall, and wind speed. By analyzing this data, farmers can adjust irrigation schedules to align with weather patterns, reducing unnecessary water usage.

**Smart Irrigation Systems:** Automated irrigation systems, powered by IoT, use data from soil moisture sensors and weather forecasts to deliver precise amounts of water directly to the root zone. Techniques like drip irrigation, combined with IoT controls, can significantly reduce water wastage [6].

**Remote Monitoring and Control:** IoT platforms enable farmers to monitor and control irrigation systems remotely via smartphones or computers. This reduces labor requirements and ensures timely interventions to address water-related issues.

**Predictive Analytics:** Advanced IoT systems integrate machine learning algorithms to predict future water needs based on historical data and crop growth stages. This proactive approach minimizes water usage while maximizing crop productivity.

## Benefits of IoT-Driven Water Management

**Water Conservation:** By applying water only when necessary, IoT systems can reduce water consumption by up to 50% compared to traditional methods.

**Improved Crop Yields:** Precise water management ensures that crops receive adequate hydration, leading to healthier plants and higher yields.

**Cost Savings:** Reduced water usage and lower labor requirements translate into significant cost savings for farmers.

**Environmental Sustainability:** Minimizing water wastage helps preserve local water resources and prevents soil and water pollution caused by runoff.

**Real-Time Decision-Making:** IoT systems provide immediate feedback, allowing farmers to make informed decisions quickly [7].

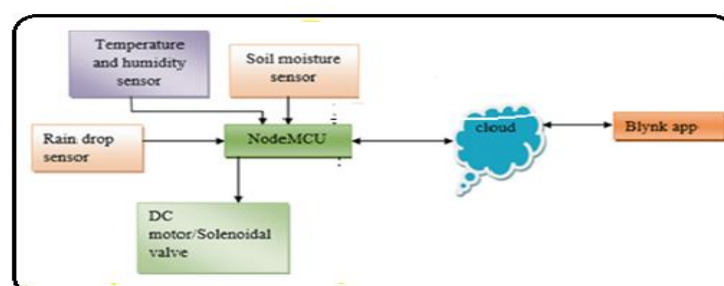


Figure 1: Block diagram representation of the system

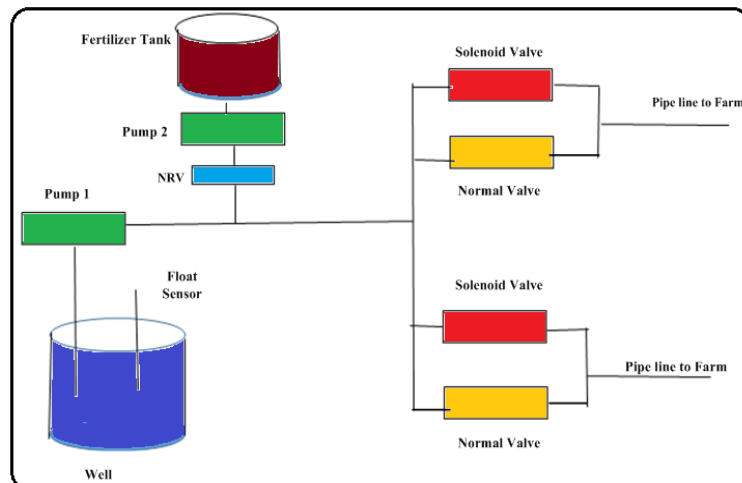
## Methodology

The entire process is being automated through the use of drip or sprinkle irrigation techniques. In this work we are considering a land area of approximately 2 acres, which we intend to divide into two separate plots. This division is motivated by the advantages it offers in terms of efficient irrigation and fertilization, a practice

commonly adopted by many farmers. Subsequently, the two acres will be interconnected through the utilization of sensors.

These sensors will monitor soil moisture levels and nutrient content in real-time, allowing for precise irrigation and fertilization adjustments. This interconnected system will ensure that both plots receive the optimal amount of water and nutrients, maximizing crop yield and minimizing resource waste.

In this analysis, we will consider the case of a well as a water resource commonly utilized by farmers for the purpose of irrigation. Additionally, we take into account the use of reservoir tanks for the storage and distribution of fertilizers.



**Figure. 2: Block diagram of irrigation system**

Figure 2 explains that the pump 1 serves as the primary pump for supplying water to the farm from the well, utilizing the main water pipeline. Pump 2 refers to the second pump in our system, which is specifically linked to the fertilizer tank. Its purpose is to facilitate the transportation of fertilizer through a dedicated pipeline, which in turn is connected to the primary water pipeline. A non-return valve is employed at the junction where the fertilizer pipeline connects to the main pipeline. This valve serves the purpose of preventing the occurrence of reverse pressure in the fertilizer tank, which may arise due to excessive water pressure in the pipeline. Which will result in a disruption to the fertilization process.

The primary pipeline is subsequently subdivided into sub-lines for the purpose of conducting plot-based activities carried out by farmers in agricultural settings. Farmer can control the sub-lines via their mobile phones by connecting the solenoid valves to them. Additionally, we employ conventional ball valves on the same line as a backup measure in the event of solenoid valve failure due to network loss or any form of electrical disruption. The proposed system entails an automated fertilizer tank that enables farmers to remotely fertilize their farms using a mobile application, thereby providing them with the flexibility to do so from any location and at any time.

### Working of irrigation system

The Node MCU ESP32 Wi-Fi module has been used as the controller in our study. This facilitates the farmers to have the ability to remotely initiate or terminate the operation of pumps and valves at their convenience, regardless of their location or the time of day [8]. The study employs a soil moisture sensor to detect and measure the moisture content in the soil. Additionally, a rain sensor is used to detect the presence of rainfall [9]. Furthermore, a DHT sensor is employed to measure the temperature and humidity levels of the surrounding environment. All of these sensors are interconnected with the ESP32 module, enabling the transmission of sensor readings directly to the Blynk App on the farmer's mobile device, providing access to the data from any location [10]. The process flow is speculated as with the help of figure.3.

The system allows the farmer to monitor the soil moisture, rainfall, temperature, and humidity levels remotely, making informed decisions about irrigation and crop management [11]. Moreover, the real-time data can be used to set up automated alerts and notifications, ensuring timely actions to be taken based on changing environmental conditions.

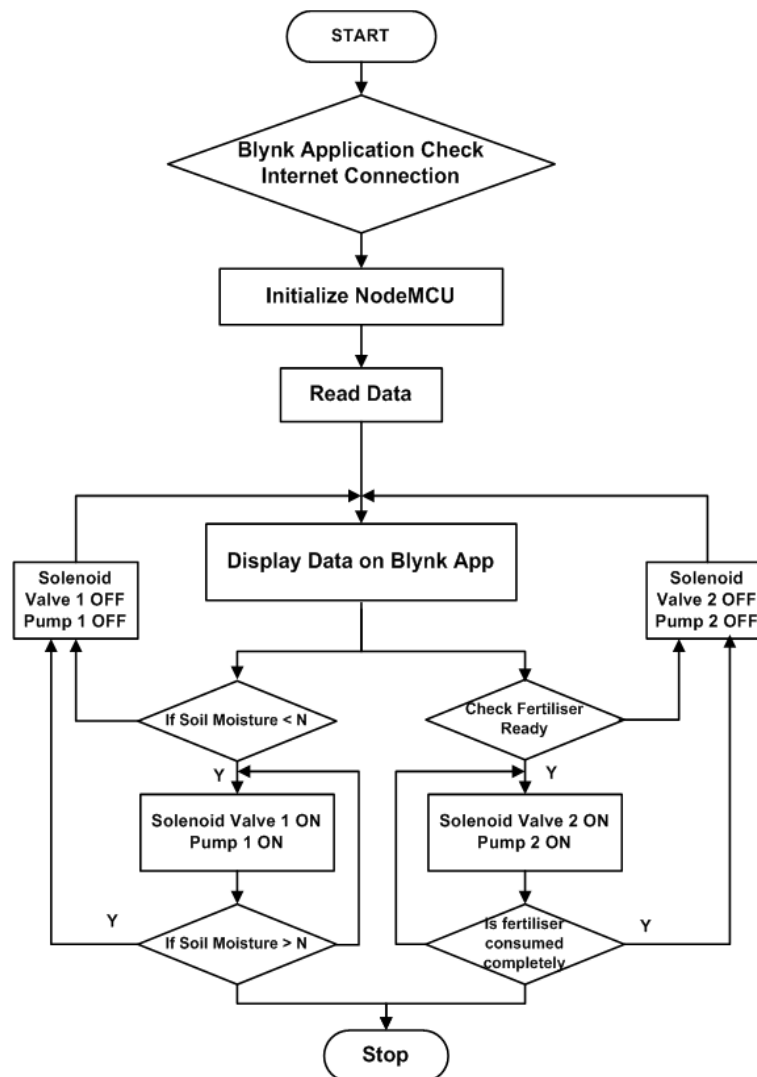
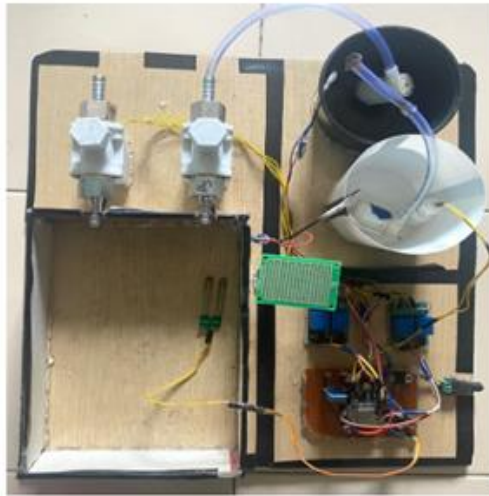


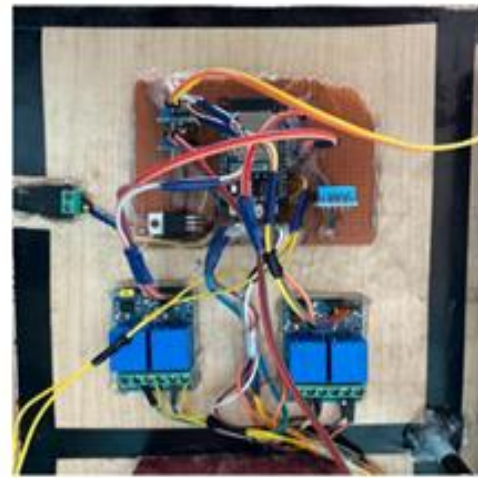
Figure. 3: Flow chart of the system

A water level sensor, specifically a float sensor, has been employed to detect low water levels in well. In the event of a low water level, the motor will be automatically deactivated as it is unable to effectively remove undesirable substances such as mud from the well. The entire assembly and EPS32 connections can be seen in figure 4 (A) and (B) respectively.

Additionally, it will provide notifications in the mobile application. The solenoid valve as shown in figure 4 (A) is connected to the water supply line and can be controlled remotely through the mobile application. This allows users to conveniently turn the water supply on or off as needed, ensuring efficient usage and conservation of water resources.



(A)



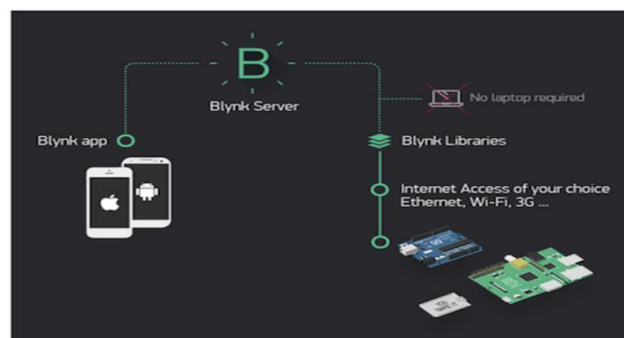
ESP32 Connections

(B)

**Figure 4: Project Model (A) and Sensor Connections (B) of Irrigation System**

Blynk is an Internet of Things (IoT) platform designed for iOS and Android smartphones, enabling users to remotely control Arduino, Raspberry Pi, and Node MCU devices. This software application is utilized for the purpose of constructing a visual interface or human-machine interface (HMI) through the compilation and provision of the suitable address on widgets that are accessible.

The Blynk platform consists of three fundamental elements: The Application, the Server, and the Libraries. An application has the ability to create the user interface. The server is responsible for managing all communication between the application and the designs. Libraries facilitate communication between equipment and the server by utilizing instructions. NodeMCU is the main components in the above design. It is connected to an external power source through a link. The next crucial component is the Relay. Relay is connected to NodeMCU and used in conjunction with a water siphon. By employing the Blynk application, we can operate all devices through the Blynk server. Schematic of this working is shown in figure 5.



**Figure 5: Blynk App Working diagram**

## Result and Discussion

The implementation of this project, which incorporates the Internet of Things (IoT) concept, has been verified to function effectively. It involves connecting various soil parameters to a NodeMCU device and successfully controlling it remotely using a BLYNK application. As the crop considered is sugarcane, water requirement for this crop is very huge. It is found that this system provides substantial water conservation of 40-50%, enabling efficient irrigation. This technology will revolutionize the agricultural industry by maximizing irrigation coverage while minimizing water and time requirements. Farmers can now efficiently irrigate larger areas, resulting in increased crop yields and overall productivity. Additionally, this system helps conserve water resources and reduce the environmental impact of irrigation practices.

## Challenges and Considerations

While IoT offers substantial benefits, its adoption in sugarcane farming is not without challenges. High initial costs, lack of technical expertise, and limited internet connectivity in rural areas can hinder implementation [12]. Governments, agricultural organizations, and technology providers must collaborate to address these barriers by offering subsidies, training programs, and affordable IoT solutions [13].

The integration of IoT technologies in sugarcane farming represents a paradigm shift in water management practices. By leveraging real-time data and advanced analytics, farmers can optimize irrigation, conserve water, and enhance crop productivity. As water scarcity becomes an increasingly pressing issue, adopting IoT-driven solutions is not just a choice but a necessity for the future of sustainable agriculture.

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