IOT-ENABLED DRIP IRRIGATION FOR REAL-TIME WATER MONITORING OF STRAWBERRY FARM

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ABSTRACT

This study, "IoT-Enabled Drip Irrigation for Real-Time Water Monitoring of Strawberry Farm," investigated the feasibility and benefits of implementing an IoT-enabled drip irrigation system at Humming Strawberry Farm in Amaballo North, Bagabag, Nueva Vizcaya. Addressing challenges in traditional irrigation, such as water shortages and uneven distribution, the research aimed to optimize water use, enhance crop yields, and enable remote monitoring. The system utilized soil moisture and temperature/humidity sensors to gather real-time environmental data. An Arduino Mega microcontroller processed data to automate drip irrigation, ensuring precise water delivery. Remote control was facilitated through a Wi-Fi module and the Blynk IoT platform, allowing farmers to monitor and manage the system remotely. A prototype was developed and tested at the farm from April 11 to May 11, 2025. Results showed a significant 32% reduction in water usage (190 liters vs. 280 liters for traditional irrigation). Strawberry yield increased by 31% in weight (4.6 kg vs. 3.5 kg) and 36% in quantity (95 vs. 70 strawberries). Furthermore, labor requirements for irrigation were substantially reduced from 1.5 hours to 15 minutes daily. These statistically significant findings ($p < 0.05$) validate the system's effectiveness in water conservation and agricultural productivity, demonstrating a promising solution for sustainable farming.

Keywords: IoT (Internet of Things), drip irrigation, real-time monitoring, water monitoring, strawberry farm, agriculture

INTRODUCTION

Agriculture in the Philippines has seen major improvements through technology, especially in irrigation. For water-sensitive crops like strawberries, traditional methods often lead to water waste, uneven distribution, and poor timing. IoT-enabled drip irrigation offers a smart solution that uses sensors and automated systems to deliver precise quantities of water and nutrients directly to plant roots. This method improves water efficiency, reduces nutrient loss, and supports better crop growth. This study explored the use of an IoT-based drip irrigation system at Humming Strawberry Farm in Amballo North, Bagabag, Nueva Vizcaya. It focused on real-time monitoring, efficient water delivery, and data-driven decisions to enhance strawberry farming and promote sustainable agriculture.

METHODOLOGY

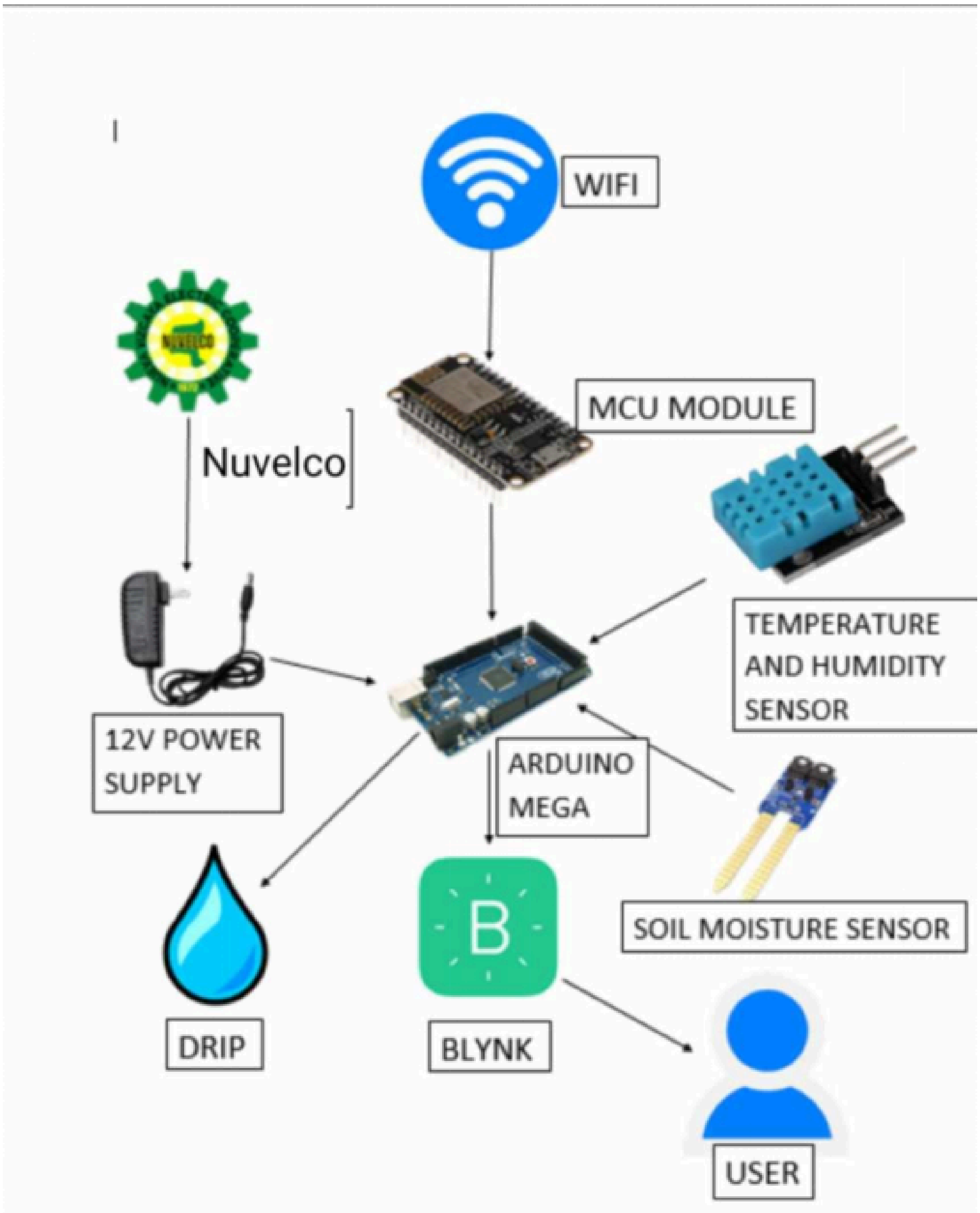
This study employed a quasi-experimental design with a pre-test and post-test control group. In the pre-test phase, baseline data on strawberry yield, water usage, and farm management practices were collected using traditional irrigation methods at a designated control area within Humming Strawberry Farm. This baseline data served as a benchmark for comparison with the post-test results.

In the post-test phase, the IoT-enabled drip irrigation prototype was designed, installed, and implemented at a separate experimental area within the farm. Data on strawberry yield, water usage, farm management practices, and system performance were collected from both the control area (traditional irrigation) and the experimental area (IoT prototype) during this phase. The data collected in the post-test phase were compared with the baseline data from the control area to assess the impact of the IoT prototype on strawberry production, water efficiency, and farm management.

Figure 1
Amballo North, Bagabag, Nueva Vizcaya

Source: FB page: *Humming Strawberry Farm*

Figure 2
Diagram of the Parts

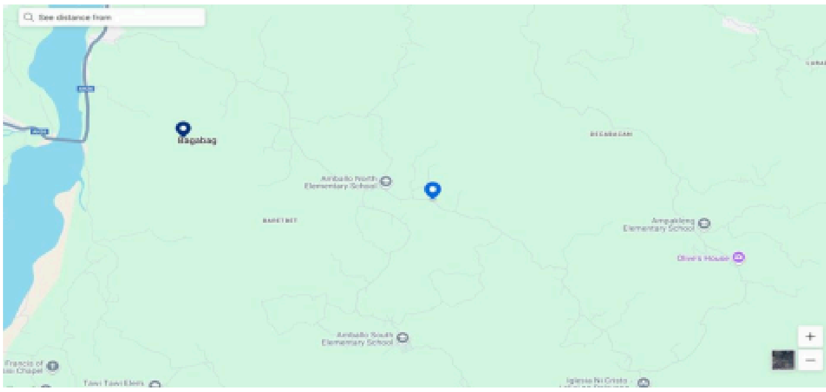


Research Locale

The research was conducted at Humming Strawberry Farm located in Amaballo North, Bagabag, Nueva Vizcaya, Philippines. This strawberry farm was chosen due to its suitable climate for strawberry cultivation and the willingness of the farm owner to participate in the study.

Figure 4

Map Location of Humming Strawberry Farm



Source: *Google Maps location of Humming Strawberry Farm, Amaballo North, Bagabag, Nueva Vizcaya, Philippines*

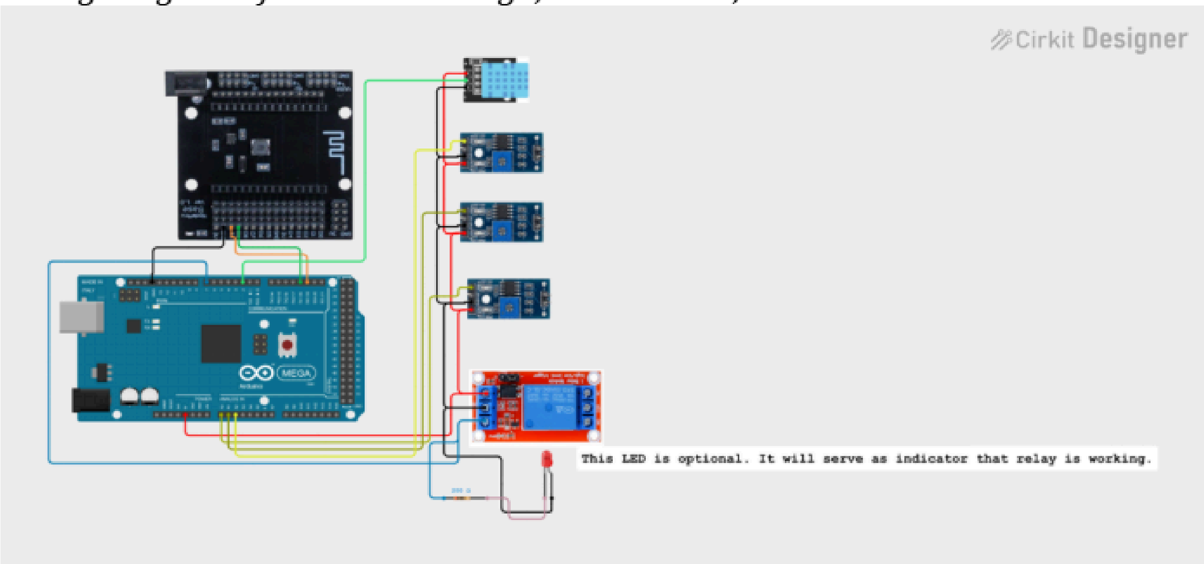
Research Instruments

Data collection for this study involved several key components. Sensors played a crucial role, with soil moisture sensors installed for real-time monitoring of soil moisture levels and temperature, and humidity sensors tracking environmental conditions around the strawberry plants. Additional sensors were incorporated based on the final system design. A data logger was also used to collect and store sensor data at regular intervals.

Yield monitoring involved recording the weight and quantity of strawberries harvested during each study phase to assess productivity. A water meter was installed to precisely measure the volume of water used by both the traditional irrigation system and the new IoT system. Furthermore, farm management records, including data on fertilizer application and pest control, were gathered through interviews with the farm owner/manager and reviews of existing farm records. Finally, surveys were conducted with farm workers to gauge their perceptions of the new irrigation system and its impact on their daily tasks.

Figure 5

Wiring Diagram of the Arduino Mega, MCU Module, and the sensors



Prototyping

The initial stage of the project involved assembling a functional prototype of the IoT irrigation system using the identified hardware. This prototype enabled validation of component compatibility, functionality testing, and identification of system limitations prior to full-scale deployment.

Challenges and solutions during prototyping:

Sensor Calibration: Soil moisture sensors must be calibrated to reflect the specific soil conditions in Amballo North. This was resolved by iterative testing and software-based adjustments in the microcontroller code. Maintaining a stable Wi-Fi connection proved challenging. A Wi-Fi extender was installed, and the optimal position of the NodeMCU was determined to ensure reliable operation.

Figure 6
Prototyping of the Iot Irrigation System

RESULTS AND DISCUSSION

Coding

The operational logic of the IoT irrigation system was implemented in the Arduino IDE and deployed to an ESP8266 NodeMCU. The software read soil moisture values from the sensors. It activated the irrigation mechanism when values fell below a predefined threshold (49% in this case).

Core functionalities of the code included:

Reading and interpreting analog signals from the soil moisture sensor.

Comparing sensor readings against the threshold.

Triggering the relay module to open the solenoid valve when irrigation is needed.

Allowing manual override or scheduling via the Blynk mobile app.

Figure 7
Node MCU Code

```
#define BLYNK_TEMPLATE_ID "TMPL6fgOLGCjt"
#define BLYNK_TEMPLATE_NAME "Drip Irrigation IoT"
#define BLYNK_AUTH_TOKEN "qdw8RFc2dKisdoZJMsamMl1BxaJkItAy"

#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

char auth[] = "qdw8RFc2dKisdoZJMsamMl1BxaJkItAy";
char ssid[] = "Secret"; // WiFi Name
char pass[] = "Secret12345";  // Password

void setup() {
  Serial.begin(9600);
  WiFi.begin(ssid, pass);

  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.println("Connecting to WiFi...");
  }
  Serial.println("Connected to WiFi");

  Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
}

void loop() {
  Blynk.run();

  if (Serial.available()) {
    String data = Serial.readStringUntil('\n');
    data.trim();
    Serial.println("Received: " + data);

    if (data.startsWith("Pump")) {
      if (data == "Pump On") {
        Blynk.virtualWrite(V1, 1);
      } else if (data == "Pump Off") {
```

```
      } else if (data == "Pump Off") {
        Blynk.virtualWrite(V1, 0);
      }
    } else {
      double temp = data.substring(0, data.indexOf(',')).toDouble();
      data = data.substring(data.indexOf(',') + 1);

      double hum = data.substring(0, data.indexOf(',')).toDouble();
      data = data.substring(data.indexOf(',') + 1);

      int soil1 = data.substring(0, data.indexOf(',')).toInt();
      data = data.substring(data.indexOf(',') + 1);

      int soil2 = data.substring(0, data.indexOf(',')).toInt();
      int soil3 = data.substring(data.indexOf(',') + 1).toInt();

      // Send data to Blynk
      Blynk.virtualWrite(V2, temp);
      Blynk.virtualWrite(V3, hum);
      Blynk.virtualWrite(V4, soil1);
      Blynk.virtualWrite(V5, soil2);
      Blynk.virtualWrite(V6, soil3);
    }
  }
}

BLYNK_WRITE(V1) {
  int value = param.asInt();
  if (value == 1) {
    Serial.println("Pump On");
  } else {
    Serial.println("Pump Off");
  }
}
```

Figure 8

Arduino Mega Code

```
#include "DHT.h"

#define DHTPIN 2
#define DHTTYPE DHT11
#define RELAY_PIN 7

#define SOIL_1_PIN A0
#define SOIL_2_PIN A1
#define SOIL_3_PIN A2

DHT dht(DHTPIN, DHTTYPE);

const int MOISTURE_THRESHOLD = 40;
unsigned long lastSensorRead = 0;
const unsigned long sensorInterval = 50

bool relayState = false;

int soil1 = 0;
int soil2 = 0;
int soil3 = 0;

void setup() {
  Serial.begin(9600);
  Serial1.begin(9600);

  dht.begin();

  pinMode(SOIL_1_PIN, INPUT);
  pinMode(SOIL_2_PIN, INPUT);
  pinMode(SOIL_3_PIN, INPUT);
  pinMode(RELAY_PIN, OUTPUT);
}

void loop() {
  if (millis() - lastSensorRead >= sensorInterval) {
    lastSensorRead = millis();

    double temp = dht.readTemperature();
    double hum = dht.readHumidity();

    soil1 = map(analogRead(SOIL_1_PIN), 1000, 450, 0, 100);
    soil2 = map(analogRead(SOIL_2_PIN), 1000, 450, 0, 100);
    soil3 = map(analogRead(SOIL_3_PIN), 1000, 450, 0, 100);

    soil1 = constrain(soil1, 0, 100);
    soil2 = constrain(soil2, 0, 100);
    soil3 = constrain(soil3, 0, 100);

    Serial1.print(temp);
    Serial1.print(",");
    Serial1.print(hum);
    Serial1.print(",");
    Serial1.print(soil1);
    Serial1.print(",");
    Serial1.print(soil2);
    Serial1.print(",");
    Serial1.println(soil3);

    delay(10);

    Serial.print("Temp: ");
    Serial.print(temp);
    Serial.print("C, Hum: ");
```

```
Serial.p
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// Auto
bool sh                    ISTURE_THRESHOLD);

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    Ser
  }
}

}

if (Seria
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  command

  if (com
    digi
    rela
  } else
    digi
    rela
  }
}
}
```

User Interface (UI)

The user interface enabled farmers to monitor and control the IoT-enabled drip irrigation system.

1. UI Platform/Technology

Blynk App: A mobile or web-based application using the Blynk platform was used.

2. UI Features and Functionality

Real-time Data Display:

Display of soil moisture, temperature, and humidity levels.

Remote Access and Management:

Farmers can use the application to remotely monitor sensor data, receive alerts, and control the irrigation system.

Manual Control Options:

Users could override the automated irrigation schedule manually.

Customizable thresholds:

Users can set specific thresholds for soil moisture, temperature, and humidity levels.

3. UI Design and Layout

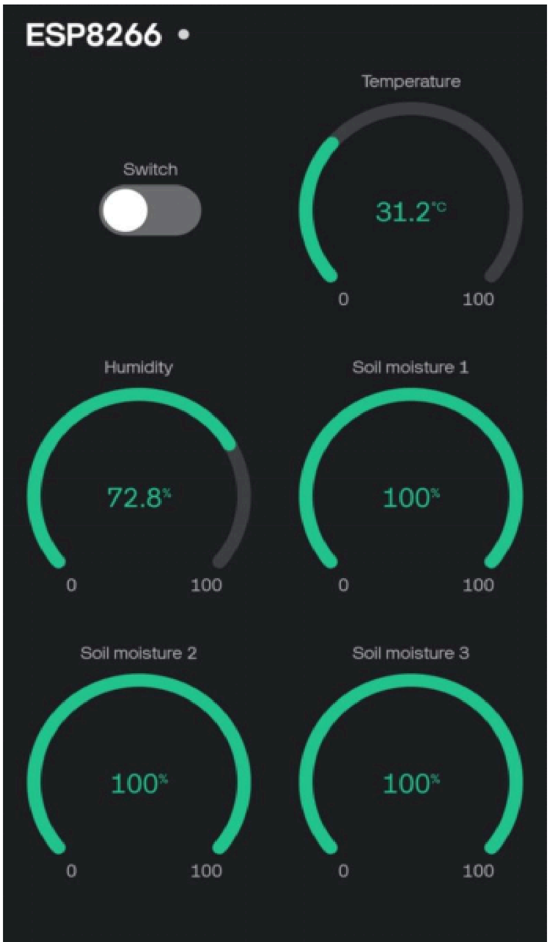
The UI was designed to be user-friendly and intuitive for farmers.

4. User Experience (UX) Considerations

The system provided a simple and efficient way for farmers to manage their irrigation systems.

5. Screenshots and mockups of the Blynk application were included to demonstrate the UI.

Figure 9
Blynk User Interface(UI)



CONCLUSION

The "IoT-Enabled Drip Irrigation for Real-time Water Monitoring of Strawberry Farm" study successfully presented the design, development, and implementation of a miniature prototype tailored for Humming Strawberry Farm in Amaballo North, Bagabag, Nueva Vizcaya. This innovative system directly fulfilled the general objective of revolutionizing water management in strawberry cultivation.

Through the strategic design and development of this IoT-based solution, environmental sensors for precise soil moisture, temperature, and humidity monitoring were integrated alongside an automated drip irrigation system controlled by an Arduino Mega. This directly addressed the aim of optimizing water use by delivering precise quantities to the plants' root zones, significantly minimizing waste and maximizing efficiency.

Moreover, implementing a user-friendly interface through the Blynk platform empowered farm managers with critical remote monitoring and control capabilities. This data-driven approach not only facilitated informed irrigation scheduling but also significantly enhanced crop yield and quality by maintaining optimal growing conditions.

Ultimately, this research provided a practical and innovative solution that champions sustainable agricultural practices. The successful deployment and evaluation of this IoT-enabled drip irrigation prototype at Humming Strawberry Farm is a compelling testament to the power of technology to foster efficiency, sustainability, and increased productivity in high-value crop cultivation, such as strawberries, for Filipino farmers. It lays the groundwork for future advancements in smart farming, paving the way for more resilient, resource-efficient agricultural landscapes.

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