Smart Greenhouse Monitoring System using Blynk IoT app

ABSTRACT

Aims: A smart greenhouse system that utilizes the Blynk IoT app is an innovative technology designed to automate greenhouse operations, thereby reducing labor and resource costs and optimizing plant growth.
Study design: In this paper we propose a real-time mobile app-based monitoring system to automate greenhouse agriculture. The system involves the usage of Blynk mobile application that allows users to monitor, control both manually and remotely as well as automation of various aspects of the greenhouse environment in real-time.
Place and Duration of Study: Department of Computer Science and Engineering, American International University-Bangladesh (AIUB), Dhaka, Bangladesh between February 2023 to April 2023.
Methodology: Multiple environmental sensors, temperature, humidity, soil moisture, light intensity, and Light Dependent Resistor (LDR) sensors continuously collect data. Farmers can remotely monitor and control the greenhouse using the Blynk IoT application. A fire sensor alarms it. Farmers can tailor alerts for environmental changes like irrigation or heating. They can manually and remotely control fans, lights, and humidifiers. If temperature, light intensity, or humidity drop below a specified threshold, the system turns on fans, lights, and humidifiers. A water pump that kicks on automatically based on soil moisture and can be regulated remotely ensures the plants get enough water.
Results: The proposed system allows for real-time updates of sensor data and enables remote control of connected devices via the mobile app from any location, with notable fast processing subject to the quality of the internet connection.
Conclusion: Upon successful implementation of this research, we anticipate the emergence of an advanced automated smart greenhouse monitoring system that will greatly benefit farmers in Bangladesh. This new method could change greenhouse and farm management, improving efficiency, cost, and crop yields.

Keywords: Smart Greenhouse System; Blynk IoT app; real-time; Environmental Sensors; Soil Moisture; Fire Sensor;

1. INTRODUCTION

The agriculture industry in Bangladesh is in a perpetual state of change, and growers are always seeking ways to increase production efficiency and yield [1-5]. One area of emphasis is greenhouse cultivation, where a controlled environment permits year-round cultivation and provides crop protection from external environmental elements. However, maintaining optimal growing conditions in a greenhouse can be difficult and requires constant monitoring of various environmental parameters. Intelligent greenhouse systems have been developed to automate this process, ensuring optimal growing conditions for crops, increasing yield, and decreasing labor and resource costs [6-12].

Monitoring and regulating greenhouse environmental parameters manually are a time-consuming and labor-intensive process. Utilizing a smart greenhouse system to automate this procedure can substantially reduce labor costs and increase crop yield. Additionally, a smart greenhouse system utilizing the Blynk IoT app provides the ability to remotely monitor and regulate the greenhouse, allowing producers to manage multiple greenhouses simultaneously [13-16]. Therefore, the purpose of this study is to investigate the potential advantages of a smart greenhouse system utilizing the Blynk IoT app and evaluate its efficacy in optimizing plant growth, reducing labor costs, and mitigating environmental hazards in greenhouse cultivation.

The goal of this study is to evaluate the potential benefits of a smart greenhouse system that integrates the Blynk IoT app in greenhouse agriculture. Specifically, this study aims to:

1. Investigate the impact of a smart greenhouse system on agricultural productivity and plant growth optimization.

2. Examine the effectiveness of a smart greenhouse system in reducing labor expenses and improving resource efficiency.

3. Evaluate the feasibility and functionality of using the Blynk IoT app to remotely monitor and regulate greenhouse environmental factors.

4. Assess the efficacy of a smart greenhouse system that utilizes the Blynk IoT app in mitigating environmental risks, such as fire threats.

5. Provide recommendations for stakeholders and producers on how to implement and operate a smart greenhouse system that integrates the Blynk IoT app in greenhouse agriculture.

The following sections are included in the paper: Section 2 is a literature review of relevant work. The proposed methodology and modeling are described in section 3. In section 4, an overview of Blynk IoT app is presented. In section 5, a comprehensive result analysis is presented, and in Section 6, we conclude the study with a conclusion.

2. LITERATURE REVIEW

Greenhouse agriculture offers a controlled environment that permits crop production with minimal interference from external factors such as climate, parasites, and diseases. Nonetheless, obtaining optimal growing conditions in a Greenhouse is a difficult task that requires constant monitoring and adjustment of environmental factors. This can be a laborious and time-consuming task, resulting in a reduction in crop quantity and quality.

To eradicate these problems, Khandelwal [17] proposed a greenhouse automation and remote monitoring system that utilized a GSM modem. For greenhouse environment data collection, the system included a variety of temperature, humidity, leaf temperature, leaf humidity, and rain sensors. Anisha *et al.* [18] presents a framework for evaluating nurseries that includes the collection of environmental data using a variety of sensors and Arduino Uno. The system enables Arduino to control the ventilation fan and modify the light source based on the changing characteristics of the sensors. Hoque *et al.* [19] propose a system for monitoring and controlling a greenhouse that collects environmental parameters such as temperature, humidity, light, and soil moisture using a variety of sensors. Arduino Uno R3 is used to process and store the acquired data, and a GSM module transmits the measured values of these parameters to the user's mobile phone via SMS. Sahu and Mazumdar [20] introduced an easy-to-install microcontroller-based circuit that can monitor and record temperature, humidity, soil moisture, and radiation levels in the surrounding environment. These values can be continuously altered and regulated to promote optimal plant growth and enhance production. The paper [21] suggests the implementation of Internet of Things (IoT) technology in greenhouse environments, utilizing the Netduino 3 microcontroller and a range of sensors to monitor moisture, temperature, sunlight, and humidity. The objective is to increase production efficiency and reduce the challenges faced by farmers, ultimately enhancing the overall productivity while ensuring optimal conditions for plant growth. This study [22] focuses on the utilization of greenhouses to cultivate plants in specific conditions, aiming to enhance yield both in terms of quantity and quality. The paper introduces an IoT-based web application designed to enable farmers to monitor their agricultural fields and assess their conditions. By leveraging open-source Arduino Uno boards and cost-effective sensors such as temperature/humidity, soil moisture, ultrasonic, PIR, pressure, and light level sensors, the system facilitates automated irrigation based on real-time sensor data, ensuring fields receive water precisely when needed.

Researchers are also developing systems with Blynk IoT app to regulate and monitor greenhouses. Aafreen *et al.* [13] present an IoT-based system designed for greenhouse telemetry and environmental control. The system is wireless and employs sensors for data collection, with the capacity to analyze and process data via the ThingSpeak cloud and GSM infrastructure. The mobile software for this system is powered by the Blynk IoT platform, which is renowned for its light weight and speedy performance. The application allows users to remotely communicate and control the greenhouse's environment, as well as receive notifications regarding any imminent irrigation needs. In their study, Khan and Karna [14] recommend employing an automated system that replaces manual control with an Arduino UNO microcontroller, environmental sensors and actuators, the ESP01 IOT module for communication, and the Blynk Application. The objective is to enhance water services to vegetation and attain optimal climatic conditions for the growth of specific plants by analyzing system-collected data with IoT. In addition, the Blynk application displays real-time system values on mobile devices for effective monitoring. This paper [23] introduces an IoT-based intelligent system that enables remote monitoring of temperature, humidity, and soil moisture levels for plant condition assessment. The system incorporates an Android application that allows users to track plant health parameters and control the timing and frequency of water sprinkling. Through sensors and the ESP8266 Wi-Fi module, data is collected and transmitted to the Blynk app. In case of critical plant conditions, users can utilize the Android application to manage a solenoid valve, ensuring the plants remain in a healthy state.

After reviewing relevant literature and conducting background research, it is apparent that implementing an automated greenhouse monitoring system can significantly improve crop productivity and quality while reducing associated costs. In this paper, we present an innovative and automated real-time monitoring and control system for greenhouses.

3. METHODOLOGY AND MODELING

3.1 Process of Work

The system is equipped with a wide variety of sensors that will assist farmers in automating a greenhouse to more effectively monitor and control conditions as required. It features sensors for both temperature and humidity so that farmers can keep track of the conditions within the greenhouse. It is equipped with a soil moisture sensor that can determine the level of moisture in the soil. A buzzer will go out if there is a fire in the greenhouse because it is equipped with a flame sensor that will alert farmers to the situation. It comes with a Light Dependent Resistor (LDR) module, which can measure the amount of light intensity in the greenhouse. All of the sensor data may be viewed on a 16x2 LD display or through the Blynk

IoT mobile app. In addition, there is a fan, a light, a humidifier, and a motor contained within the system. These components may be manually activated using a switch, or they may be activated remotely using the Blynk mobile app by selecting the Manual option. Therefore, farmers are able to easily control these devices remotely based on the current weather conditions in order to better maintain their plants. Additionally, they have the option to set the Blynk app to Auto mode. In the event that the sensor data falls below the value that has been set up, this will activate the fan, humidifier, or light automatically.

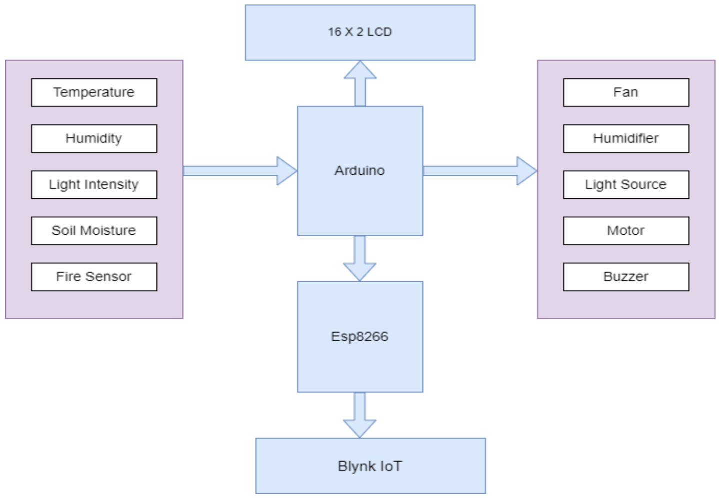

Fig.1 Block Diagram of proposed system.

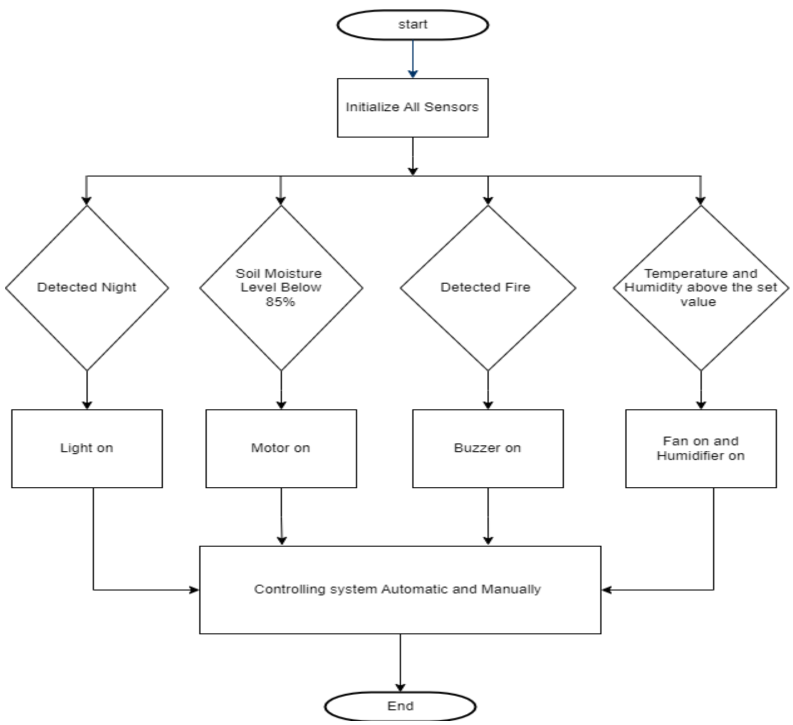

Fig.2 Flowchart of proposed system.

3.2 Used Components and Cost Analysis

Here are all the components that has been used in the system as well as the price is represented in the table.

Table 1. Component Cost Analysis

Components	**Price (BDT)**
Arduino Uno R3	950
Power Supply	350
Buck Converter (2)	70x2 = 140
Esp8266	300
4-c Relay	320
LCD 16*2 + I2C driver	350
DHT11	160
LDR Module	50
Bread Board	40
Soil Moisture	90
Flame Sensor	50
Water Pump	100
Humidifier	100
Light	100
Fan	50
Wire	250
Decoration	300
Total	**3700**

3.3 Experimental Setup

A power supply of 12 volts and 2 amps was what we utilized for the system's primary power source. This device has an input voltage of 220 volts and an output voltage of 12 volts DC. We were using a total of two buck converters. The first one reduces current from 5 amps to a maximum of 1.5 amps while the second one reduces voltage from 12 volts to 5 volts. The 5-volt supply powers both the system's primary circuit as well as the sensors. The 1.5-amp current is used by both the fan and the water motor. The screen resolution of the LCD is 16 by 2. We employed an I2C display driver in this LCD in order to cut down on the number of wires, which brought the total number of wires to a minimum of 4. The Arduino Uno R3 serves as the primary functioning circuit in this system. The Blynk IoT app receives both the sensor data and the control signals via the Esp8266 microcontroller. In order to automate the switches and make them responsive to control via the Blynk IoT app, a 4-c relay is applied.

Fig.3 Proposed experimental setup.

4. OVERVIEW OF BLYNK IOT APP

The Blynk IoT app is a robust and user-friendly mobile application that is available for free on Google Play. It is a flexible platform for developing IoT applications and connecting diverse sensors and devices for remote monitoring and control. In this study, we modified the existing templates of the Blynk IoT app to meet the needs of their smart greenhouse system. This required coding-based customizations and modifications to customize the app's functionality for greenhouse monitoring and control.

```
#define BLYNK_TEMPLATE_ID           "TMPL6TfFfjKU7"
#define BLYNK_TEMPLATE_NAME         "Green House"
#define BLYNK_AUTH_TOKEN            "ZHI_suvcagkv1YO2pv6pokXOfTGRfGT1"


#define BLYNK_PRINT Serial

#include <WiFiManager.h>
#ifdef ESP8266
#include <BlynkSimpleEsp8266.h>
#elif defined(ESP32)
#include <BlynkSimpleEsp32.h>
#else
#error "Board not found"
#endif

char* esp_ssid = "Green House";
char* esp_pass = "1234567890"; // 192.168.4.1
```

Fig.4 Initial Blynk IoT App setup code

During the initial setup procedure, users must provide their email address and password in order to access the Blynk IoT app. This ensures that only authorized users can interact with connected devices and receive real-time data, and provides secure access to the application. The setup code also allows the user to alter their email address and password if necessary, allowing for flexibility and personalization.

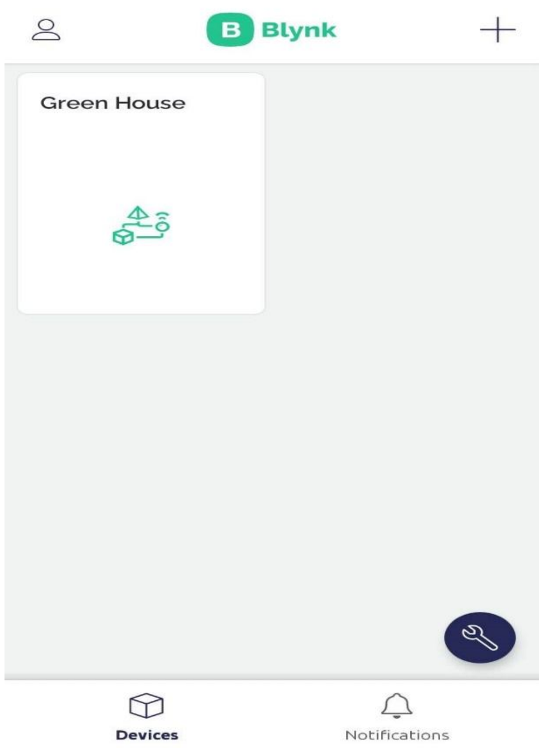

Fig.5 Modified UI(Homepage) of Blynk IoT App

The Blynk IoT app provides a user-friendly and intuitive interface for remote monitoring and control of IoT applications. Its free availability on the Google Play Store makes it accessible to a wide variety of users, including those interested in implementing smart greenhouse systems or other Internet of Thing's applications. Through customization and coding modifications we were able to adapt the Blynk IoT application to the specific needs of our study and implement the functionality of our proposed smart greenhouse system.

5. RESULTS AND DISCUSSION

5.1 Experimental Results

Sensor data can be monitored by both LCD and Blynk IoT app.

Fig.6 Monitor Sensor data via LCD

Fig.7 Monitor Sensor data via Blynk IoT app.

Soil Moisture level can be monitored by both LCD and Blynk IoT app.

Fig.8 Increasing moisture level.

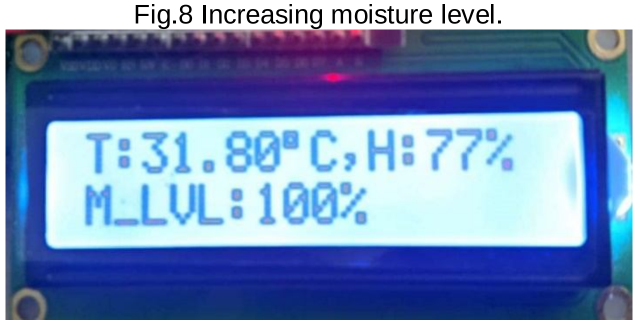

Fig.9 Monitor moisture Sensor data via LCD.

Fig.10 Monitor moisture Sensor data via Blynk IoT app.

Water pump turns on when the moisture level goes below a certain range.

Fig.11 Monitor Sensor data via LCD


Fig.12 Working of water motor.

The buzzer notifies any fire occurrence using fire sensor.

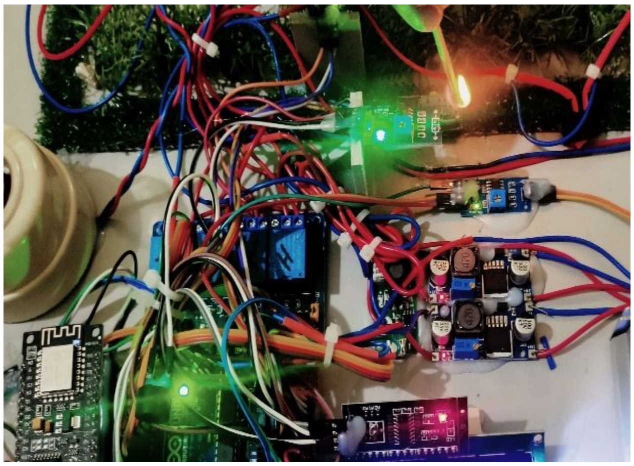
Fig.13 Working of fire sensor.

Fan, light, water motor, humidifier can be controlled via switch and remotely from anywhere through Blynk IoT app by toggling to manual mode.

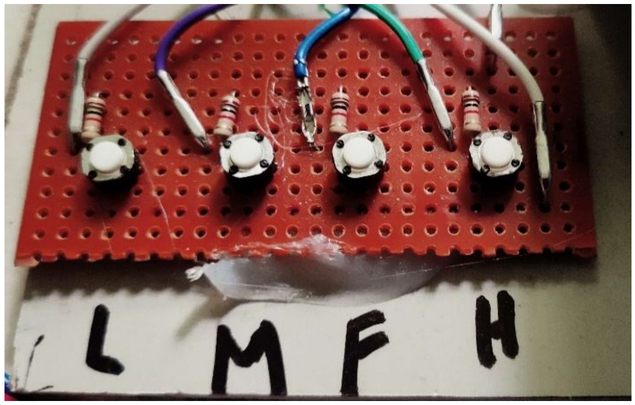

Fig.14 Manual switches.

Fig.15 Manual mode of Blynk IoT app.

Through the use of the Blynk IoT app, the system may also be switched into the Auto mode. On that scenario, the fan, the light, and the humidifier will turn on and off automatically based on the data collected by the sensors and the value that the farmers have set on the Blynk app.

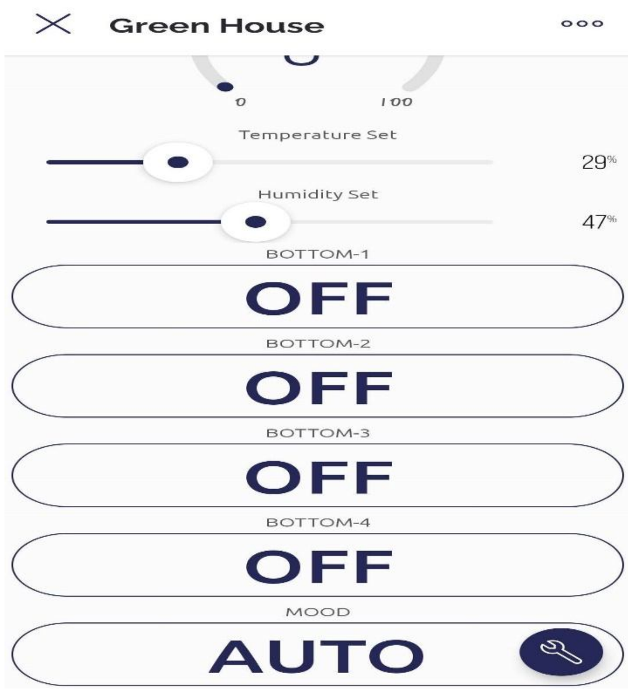

Fig.16 Auto mode of Blynk IoT app.

Light turns on when the light intensity level is below to the set value.

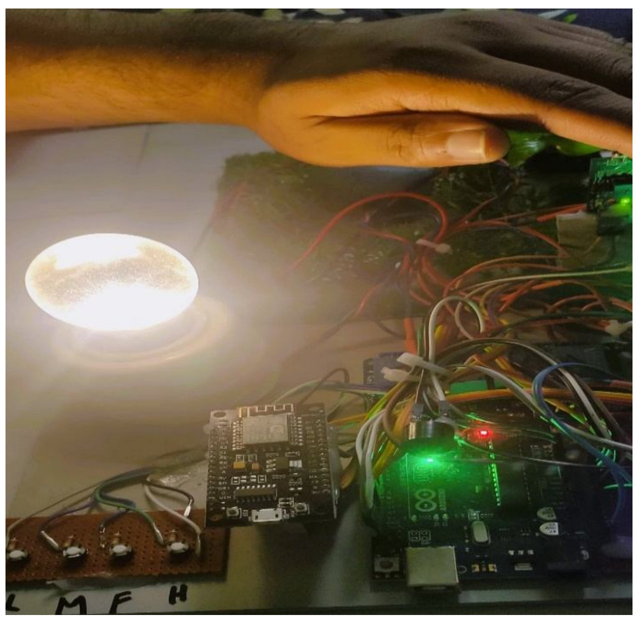

Fig.17 Automatic working of light.

Fan and humidifier turn on when the sensor data is below to the set value.


Fig.18 Automatic working of fan.

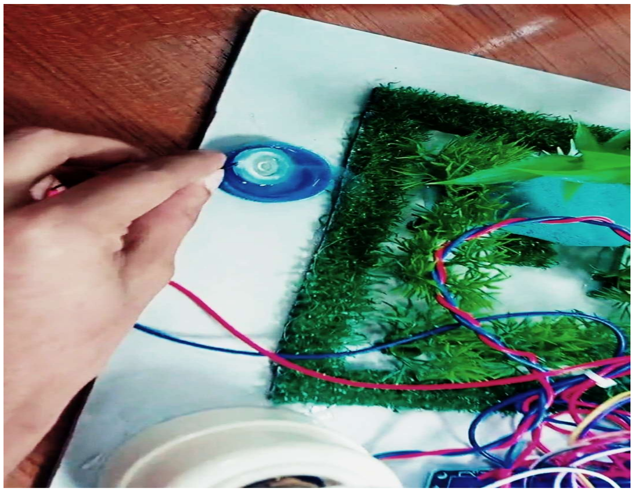
Fig.19 Automatic working of humidifier.

5.2 Comparison

In Table 2, we can examine how our approached system compares to that of others.

Table 2. Comparative Analysis

Authors	Processing Units	Manual Control	Remote Control	Auto Mode	Fire Alert
[17]	Arduino & GSM	No	Yes	No	No
[18]	Arduino & GSM	No	Yes	Yes	No
[19]	Arduino & GSM	No	Yes	Yes	No
[20]	AT89S51	Yes	Yes	No	No
[21]	Netduino 3	No	Yes	Yes	No
[22]	Arduino	No	Yes	Yes	No
[13]	Zigbee Sensors	No	Yes	Yes	No
[14]	Arduino & Blynk	No	Yes	Yes	No
[23]	Arduino & Blynk	No	Yes	No	No
Ours	**Arduino & Blynk**	**Yes**	**Yes**	**Yes**	**Yes**

In a comparison of the listed studies, our proposed system stands out in a number of ways. Firstly, we utilize Arduino and Blynk as the processing units, allowing for efficient data processing and control. Our system incorporates manual control functionality in addition to remote control and automatic mode, providing users with greater control flexibility and options.

In addition, our system includes a fire alert feature, which none of the other studies possess. This additional safety measure increases the greenhouse's overall dependability and security. Our system provides a comprehensive and advanced solution for greenhouse monitoring and control by combining these features.

5.3 Discussion

The study found that implementing a smart greenhouse system integrated with the Blynk IoT app had several positive outcomes. It significantly improved agricultural productivity and optimized plant growth by creating an ideal growing environment. The system effectively reduced labor expenses and improved resource efficiency by automating monitoring and control processes. The Blynk IoT app proved to be feasible and highly functional for remote greenhouse monitoring and regulation. The system also demonstrated efficacy in mitigating environmental risks, such as fire threats, through early detection and alert mechanisms. Recommendations include proper installation and maintenance, regular monitoring of the app, and providing training and support to users for optimal implementation and operation of the smart greenhouse system.

The code of the code of the proposed setup can be found here, https://github.com/shakib-sadat/Smart-Greenhouse-Monitoring-System-using-Blynk-app.

5.4 Limitations

While the study has shown promising results, it is important to acknowledge the limitations of the research. Firstly, the study was conducted in a specific context, which may restrict the generalizability of the findings to different greenhouse environments. Secondly, the effectiveness of the smart greenhouse system is contingent upon the quality of internet connectivity and potential technical challenges. One limitation observed during the experiment was the slower processing and updating of sensor data when the internet connection was weak. Additionally, the response time of remote-controllable devices was affected by poor internet connectivity. These limitations emphasize the need for further investigation and consideration of practical factors when implementing smart greenhouse systems.

6. CONCLUSION

In this study, we have developed a strategy for a smart and automated greenhouse system. The proposed approach can be of use to a significant number of farmers in Bangladesh. The system is cost-effective, simple to implement, and adaptable to greenhouses of varying sizes. It will also help the farmers in conveniently monitoring the greenhouse, and it will assist the plants in growing in an atmosphere that is better, healthier, and more suited according to their requirements.

In terms of future work, there are several opportunities for further exploration and enhancement of the smart greenhouse system. Firstly, integrating advanced machine learning algorithms can enable predictive analytics for optimizing plant growth conditions based on historical data and real-time sensor inputs. This would further automate and optimize the system's capabilities. Secondly, incorporating additional sensors and actuators, such as CO_2 sensors for precise control of carbon dioxide levels or automated shading systems, can enhance the overall environmental control within the greenhouse.

By focusing on these future directions, we aim to continuously advance the smart greenhouse system, ensuring its continued relevance and effectiveness in addressing the evolving needs of farmers and the agricultural industry.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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