Greenhouse Environment Controlling with Monitoring on Android Application

Amritpal Kaur Dhillon,
Department of AIT-CSE,
Chandigarh University,
Mohali, 140413, Punjab, India
22BIS80001@cuchd.in

Sabhyeh Gulati,
Department of AIT-CSE,
Chandigarh University,
Mohali, 140413, Punjab, India
21CBS1054@cuchd.in

Debo Priyo Nath,
Department of AIT-CSE,
Chandigarh University,
Mohali, 140413, Punjab, India
21CBS1081@cuchd.in

Bageshwar Rauniyar,
Department of AIT-CSE,
Chandigarh University,
Mohali, 140413, Punjab, India
21CBS1086@cuchd.in

Er. Yashika Sharma,
Department of AIT-CSE,
Chandigarh University,
Mohali, 140413, Punjab, India
yashika.e11567@cumail.in

***Abstract*—One The agricultural sector faces several challenges, including unpredictable weather, water scarcity, and labor shortages. This research investigates the potential of IoT sensors—such as temperature, humidity, moisture, and light sensors—to optimize agricultural practices. The study presents a smart farming model that integrates these sensors with wireless communication and cloud-based platforms. Results show that using IoT in agriculture improves crop health, optimizes resource management, and reduces manual intervention. This paper highlights the system architecture, data analysis, and challenges associated with deploying IoT-based solutions in agriculture. With advancements in sensing technology in recent years, researchers have increasingly applied it to address real-world physical and environmental challenges. Integrating smart technology into agriculture and farming has become essential to boost crop production and enhance economic returns. Agriculture has been a fundamental human occupation since the beginning of civilization, and over time, it has evolved with technological advancements. In the past 50 years, farming methods have continued to modernize, driven by innovations in technology and electronics. The Internet of Things (IoT) has introduced a new dimension to smart farming, transforming agricultural practices and crop management. By incorporating smart sensor systems and IoT, farm monitoring has become more efficient and streamlined.**

To enhance productivity and improve crop yields, key factors such as temperature, moisture, humidity, and pest control must be closely monitored and regulated. In this research, an automatic plant irrigation system is proposed, utilizing smart sensors and IoT to monitor and manage the farm, automatically providing water to plants and sending notifications to users. The proposed framework includes features such as remote monitoring, intruder detection, temperature and moisture sensing, security, leaf wetness monitoring, and irrigation control. These parameters are managed via IoT, with a sensor system connected to a microcontroller that communicates with a remote device. The system has been simulated, and the results show promise for future advancements in this research area.

I. INTRODUCTION

In the modern age, the increasing population and the need of human beings for more space have led to the reduction of forests, farms, etc. This in turn results in global heating which has adverse effects on our life. The importance of plants, and trees is thus increasing with time. This led us to do a project on the greenhouse, a place where we can grow plants of different varieties under one roof.

Here in this project, we are monitoring and controlling the different parameters through a microcontroller. This project deals with the monitoring and controlling of the greenhouse parameters such as humidity, temperature, and light. Here we have designed a microcontroller-based prototype model where we are controlling the above-mentioned parameters through the microcontroller. Here we are monitoring parameters like temperature, light, and humidity. For the measurement of these parameters, we need sensors that respond to the changes in the parameters appropriately. Hence, we have used LM35 as the temperature sensor, PHS220 as the humidity sensor, and LDR as the light sensor. As the signals measured are of very low value therefore their amplification is very necessary. Hence LM324 has been used as a non-inverting amplifier. As LM324 contains 4 op-amps per IC hence it has been used. For analog to digital conversion, we have used ADC0808. We are using it as a 3:1 multiplexer. IC 555 has been used as a timer IC to provide a clock signal to the ADC0808. It is used as an astable multivibrator with a 50% duty cycle for 220 KHz frequency. The heart of the project i.e. the microcontroller is AT89S52. It is used because of its larger memory. The display is done through a 16×2-line LCD. We can also use 4 lines LCD. MAX232 has been used for the interfacing purpose. With the help of this IC, we can display the data on the computer also. For storing the data for future use, we used EEPROM IC 24C16. The power module consists of IC780 for a 5V supply and IC7812 for a 12V supply. For the controlling action, we have used sugar cube relays, with which we can connect the fans, etc BC557 transistors have been used for gain.

Various resistors, capacitors (paper, electrolytic), diodes, and connectors (2 pins, 3 pins, 4 pins, 5 pins, and 6 pins have been used. The input signal in this project is generated through the sensors which are used for sensing the light, temperature, and humidity. The sensors used are:

- LDR
- LM35
- SYHS220

LDR: - The LDR is used for light detection. It is a light-dependent resistor. The LDR is the simplest light detector. It is made from a compound called cadmium sulfide that changes in resistance when exposed to varying degrees of light. It is most sensitive to visible red light with some sensitivity to another wavelength. As the requirement for the project lies within this range hence this has been used. However, the LDRs have a slow response as this property does not affect the project hence it is used.

LM35: - The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ºKelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1/4ºCat room temperature and ±3/4ºCover a full -55 to +150ºCtemperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60mA from its supply, it has very low selfheating, less than 0.1ºC in still air. The LM35 is rated to operate over a -55º to +150ºC temperature range, while the LM35C is rated for a - b40º to +110ºC Range (-10º with improved accuracy). The LM35 series is packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-202 package.

SYHS220: - Humidity transmitter provides a high accuracy of 4 to 20mA humidity measurement. Accuracies of 2% RH are available. Room units are protected by molded housing with an integral filter, while duct and outside units come with a removable 40-micron sintered bronze filter. The sensor is unaffected by volatile organic compounds or surface contamination but response may be slowed by heavy dirt buildup. On duct and outside units, the filter may be cleaned with warm, distilled water. These units are microprocessor-based and do not require any field calibration. In addition, replacement sensors and probes can be installed without calibration.

II. LITERATURE REVIEW

Greenhouses are essential for modern agriculture as they provide a controlled environment for optimal plant growth. The key challenge, however, is maintaining and controlling these conditions effectively. Monitoring parameters like temperature, humidity, soil moisture, light intensity, and CO2 levels is crucial for maximizing crop yields and minimizing resource wastage. In response to this challenge, IoT-based solutions with sensors have emerged as a promising approach to automate the monitoring and control of greenhouses. Advancement in IoT and microcontroller technologies have revolutionized greenhouse management. Systems using Arduino, Raspberry Pi, and other microcontroller platforms enable real-time data collection and analysis, allowing for intelligent decision-making. Studies such as those by Tembhurne et al. (2022) highlight the importance of combining Arduino with sensors like DHT11, soil moisture sensors, and gas detectors to control environmental parameters like humidity, temperature, and CO2 levels [1]. Automation and Remote Monitoring: Various researchers have developed systems that enable farmers to monitor greenhouse conditions remotely. Li et al. (2015) proposed an Android-based system that uses 3G communication to allow users to control greenhouse equipment from mobile devices [3]. Such systems leverage wireless sensors and network technologies like ZigBee, Wi-Fi, and GSM to transmit real-time data to remote servers or mobile apps. This enables efficient remote monitoring, reducing labor costs and allowing for better resource management. Greenhouse Automation with Microcontrollers: Arduino-based systems play a central role in many greenhouse automation projects. For instance, Thombare et al. (2023) presented a system that uses Arduino to monitor and control parameters like temperature, humidity, and soil moisture, with actuators (fans, water pumps, etc.) triggered automatically when thresholds are breached [4]. These systems not only ensure optimal growing conditions but also help reduce human intervention and associated errors. Several studies have focused on the integration of multiple sensors in greenhouse environments. For example, Zhang et al. (2015) proposed a design incorporating sensors for temperature, humidity, and soil moisture, along with video surveillance for comprehensive monitoring [3]. Additionally, modern systems now incorporate advanced sensors capable of detecting CO2 levels and other gases, helping farmers create ideal growing conditions. The use of sensors like LDR for light detection and DHT11 for temperature and humidity has become standard practice in greenhouse management [5] [4].Energy Efficiency and Sustainable Practices: Energy efficiency is an important consideration in automated greenhouse systems. Many projects focus on minimizing energy consumption while maximizing productivity. Systems like the one proposed by the L293D project (1991) integrate high-performance actuators that can control devices such as motors with minimal energy use [2]. These systems ensure that resources like water and electricity are used efficiently, contributing to sustainable farming practices. Challenges and Future Directions Although the current literature emphasizes the benefits of automated greenhouse monitoring, challenges remain, including the cost of implementation, system scalability, and sensor accuracy. Future research may focus on integrating artificial intelligence (AI) and machine learning (ML) to further optimize greenhouse environments based on historical data. Furthermore, as IoT and sensor technologies evolve, more sophisticated sensors may be integrated, allowing for finer control over greenhouse conditions and leading to further reductions in resource consumption [6]. They demonstrate significant progress in the development of IoT-based greenhouse monitoring and control systems. The integration of sensors and microcontrollers such as Arduino has automated many aspects of greenhouse management, enhancing both efficiency and productivity. With future advancements in AI and IoT, these systems are expected to become even more sophisticated, driving the next wave of innovation in agricultural technology.

III. METHODOLOGY

The approach used in this project of Greenhouse environment controlling and monitoring is comprehensive using the IOT technologies. We'll examine the essential elements:

A. Problem Formulation:

1. The core problem addressed is optimizing and automating the management of key environmental factors (such as temperature, moisture, humidity, and pest control) in agricultural settings, specifically in a greenhouse environment. The main goals are:

1. Increase Crop Yield and Reduce Manual Intervention:
The system is designed to monitor essential factors such as temperature, humidity, soil moisture, and light intensity, ensuring plants receive the optimal conditions for growth. Automating irrigation and climate control reduces the need for human labor and minimizes errors, leading to healthier crops and higher yields. This not only saves time but also allows for continuous, precise care of crops, leading to improved productivity.

2. Provide Remote Monitoring Capabilities for Farmers:
Using IoT technology, the system allows farmers to monitor their crops from a distance. The environmental data collected by sensors is sent to a mobile application, where farmers can view real-time updates on conditions like soil moisture, temperature, and humidity. This enables timely decision-making, even when the farmer is not physically present at the farm, reducing dependency on manual inspections.

3. Enable Automated Control of Irrigation and Environmental Conditions Based on Real-Time Sensor Data:
The system automatically adjusts irrigation and other environmental factors (like ventilation and temperature) based on real-time sensor data. When sensors detect that soil moisture is low, for instance, the system triggers the irrigation system without requiring human input. This automation helps ensure crops get the right amount of water and ideal growing conditions at all times, maximizing efficiency and minimizing water wastage.

The challenge was to design a system that can automatically adjust these parameters using a set of sensors and a microcontroller to ensure optimal plant growth without human supervision. Additionally, the system needs to have remote access for real-time monitoring and control via a mobile application.

B. Advancement Model :

To address these challenges, the solving approach integrates the following elements:

1. Sensor Networks: A series of sensors including LM35 (temperature), SYHS220 (humidity), LDR (light), and moisture sensors were deployed to monitor environmental conditions in real-time. Each sensor is tasked with providing specific data on critical agricultural factors.
2. Microcontroller Processing: A microcontroller (AT89S52) was used to process the data gathered from the sensors. The microcontroller interfaces with an Analog-to-Digital Converter (ADC0808) to convert the analog signals from the sensors into digital signals for processing.
3. Remote Control via IoT: The data is transmitted wirelessly via a Bluetooth module to a remote Android application. This allows farmers to monitor environmental conditions in real-time, control irrigation, and adjust thresholds for environmental parameters from a distance.
4. Automated Control System: Relays connected to the microcontroller control the actuators for irrigation and other environmental adjustments (fans for temperature, etc.). Once a specific threshold (set via the mobile application) is exceeded or met, the microcontroller triggers the appropriate response (e.g., turning on irrigation).

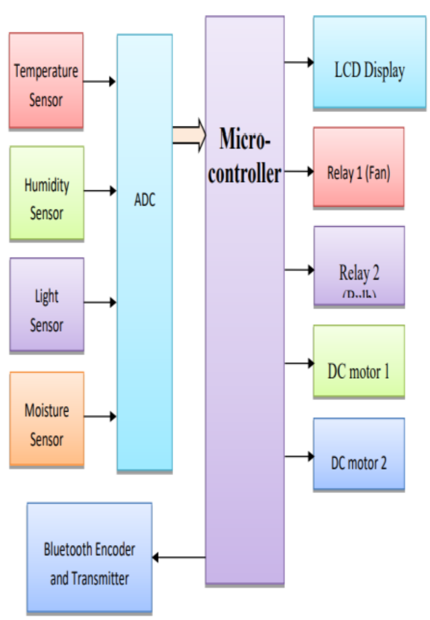

Fig.1. Block Diagram of Microcontroller Module.

C. Model Development:

Based on the problem description, we will create mathematical model employing choice variables,and constraints. The model developed for this system consists of several key modules:

1. Sensors Module: This module includes a range of sensors (temperature, humidity, light, and moisture) that continuously monitor the environmental parameters of the greenhouse.
2. Microcontroller and ADC Module: The data from the sensors are processed through the ADC0808 and then fed into the AT89S52 microcontroller. The microcontroller serves as the brain of the system, taking in sensor inputs and triggering appropriate responses based on the preset conditions.

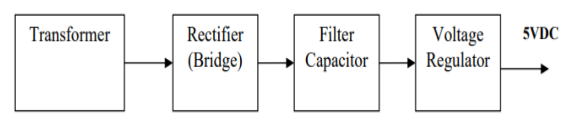

Fig.2. Block Diagram of ADC Module

3. Communication Module: A Bluetooth communication system was integrated to facilitate wireless data transfer between the microcontroller and the Android application. The mobile app provides a user-friendly interface for real-time monitoring and manual adjustments.
4. Control Module: This module controls the irrigation system and other environmental regulators through relays. It automatically adjusts the environment based on the input received from sensors and commands from the Android app.

D. Model Validation:

The system was tested through a simulation process to validate its effectiveness in monitoring and controlling greenhouse parameters. Key validation steps included:

1. Accuracy Testing of Sensors: The sensors were tested for accuracy in measuring temperature, humidity, light intensity, and soil moisture. The LM35 sensor for temperature and the SYHS220 humidity sensor demonstrated precise measurement capabilities.
2. Response Time: The system's response time to changes in environmental parameters was evaluated. When thresholds were exceeded (e.g., soil moisture falling below a set level), the system successfully triggered the irrigation system within the expected time frame.
3. Remote Monitoring and Control: The Bluetooth-enabled Android application was tested for real-time communication and responsiveness. The system showed consistent performance in providing updates and allowing control of irrigation and other factors remotely.
4. Reliability of Automation: The relays were tested to ensure they accurately triggered actuators (such as pumps and fans) based on sensor data and preset thresholds. The system was able to autonomously maintain optimal conditions in the simulated environment.

Through this model validation process, it was demonstrated that the system met its design goals, providing real-time monitoring, remote access, and automation to effectively manage greenhouse environments.

IV. CHALLENGES

In the project, several challenges were encountered, which required innovative solutions and modifications to address them. Below are the key challenges faced during the implementation of the greenhouse environment controlling system with Android application monitoring:

1. Sensor Calibration and Accuracy: The project involves multiple sensors, including LDR (light sensor), LM35 (temperature sensor), and SYHS220 (humidity sensor). Ensuring accurate data collection from these sensors and calibrating them properly to maintain consistency was a significant challenge. Variations in sensor readings due to environmental factors needed careful handling and calibration .

2. Microcontroller Selection and Limitations: Initially, the team faced issues with the microcontroller, specifically with the AT89C51 not having a system programmer. The problem was rectified by replacing it with the AT89S51, which provided the necessary programming capabilities. Additionally, the voltage output of microcontroller pins was not sufficient to directly drive motors or LCDs, requiring the use of pull-up resistors and motor driver ICs to step up the voltage .

3. Adjusting LCD Display: The potentiometer used to control the brightness and contrast of the LCD was not providing appropriate results initially. This issue was resolved by carefully adjusting the potentiometer to the correct level for optimal display .

4. Power Management: Ensuring stable power supply to all components, particularly in managing the power needs for sensors, microcontrollers, and other modules, was critical. This involved using voltage regulators like 7805 and 7812 for supplying stable 5V and 12V outputs respectively .

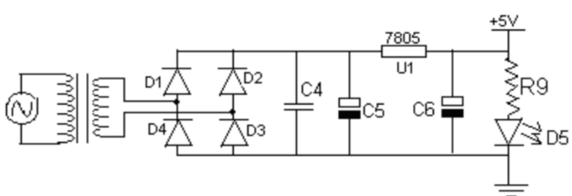

Fig.3. Power Supply Module

5. Bluetooth Communication: Establishing reliable wireless communication between the microcontroller system and the Android application through Bluetooth posed challenges. Ensuring secure and uninterrupted data transmission required robust testing and proper integration of the Bluetooth decoder .

6. Software Debugging: Debugging the software for correct serial communication between the microcontroller and external devices was time-consuming. Errors in the programming for sending and receiving data through the serial ports had to be carefully identified and rectified .

By addressing these challenges through component replacement, recalibration, and software debugging, the project team was able to achieve a functional greenhouse monitoring and controlling system.

V. RESULTS AND DISCUSSION

This section discusses the important discoveries achieved by employing the hybrid strategy of extensive testing and troubleshooting, the system proved to be reliable, user-friendly, and energy-efficient. We will study the findings, concentrating on the projected solution and the characteristics of the identified practical applications.

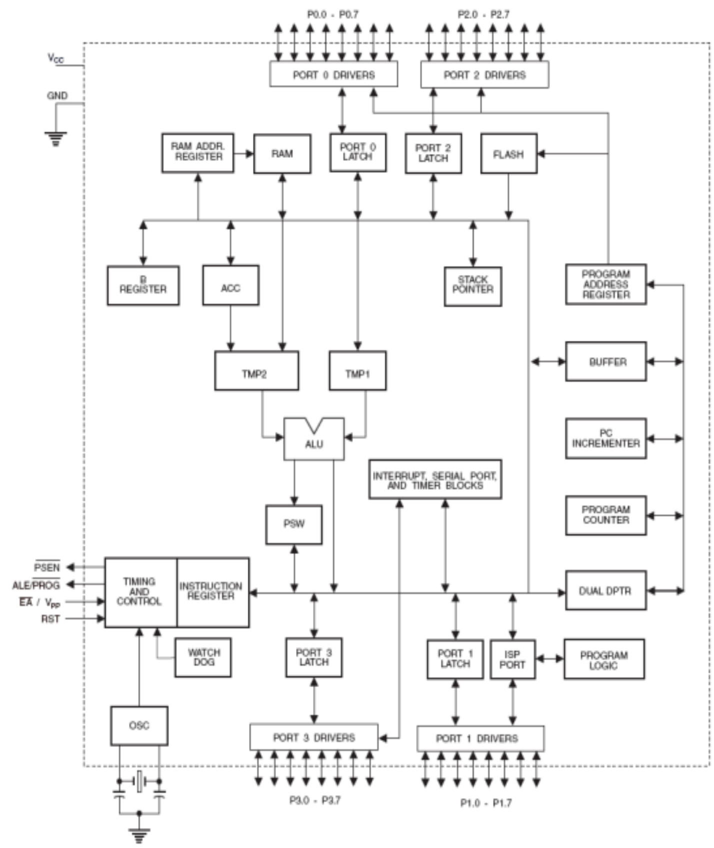

Fig.4.Implementation Architecture.

1.1. System Testing and Debugging : The project involved significant testing and debugging across both software and hardware components. During the development process, several challenges emerged, particularly in integrating the different sensors with the microcontroller, displaying the data on the LCD, and ensuring stable communication between the hardware and the Android application via Bluetooth. Software Debugging was primarily conducted using the KEIL IDE, a common platform for programming and debugging the AT89S51 microcontroller.

1.2. The software testing included: Writing and simulating the code for each sensor (temperature, humidity, and light) to ensure proper data acquisition. Testing the integration of the LCD display with the microcontroller to confirm that environmental data (temperature, humidity, and light) was correctly displayed. Early issues included display malfunction, which was rectified by adjusting the LCD's contrast using a potentiometer and ensuring correct wiring.

Verifying the Bluetooth communication between the microcontroller and the Android application to ensure real-time data transmission from the greenhouse sensors to the mobile interface. This was particularly crucial for the success of remote monitoring.

Hardware Debugging was performed using tools like the 89s51 simulators and a multimeter to check the integrity of connections between components, particularly ensuring proper communication between the sensors, microcontroller, and the display unit. The hardware testing process involved:

1.3. Port Assignment and IC Programming: Testing the connections of various microcontroller ports with sensors and relays to ensure that the correct input and output signals were being processed. Initial problems included incorrect port assignments and miscommunication between the ADC and the microcontroller.

1.4. Continuity Testing: A multimeter was used extensively to check the continuity of wires and connectors in the circuit. This step ensured that each sensor was properly connected and operational, particularly after assembly.

The successful debugging process ensured that all sensors—temperature (LM35), humidity (SYHS220), and light (LDR)—were calibrated correctly, and their data was displayed accurately on the LCD and transmitted reliably to the Android application.

2.1. System Performance and Calibration: The core aspect of this project was real-time monitoring and control of environmental parameters (temperature, humidity, and light). Each sensor was calibrated and tested to ensure accurate data capture and transmission:

2.2. Temperature Monitoring: The LM35 temperature sensor performed within the expected range of accuracy. During testing, it responded quickly to changes in temperature, with an error margin of ±0.5°C. The system was tested in both controlled and variable temperature environments to simulate real greenhouse conditions.

2.3. Humidity Control: The SYHS220 humidity sensor provided reliable data with an accuracy of ±2%. Testing involved placing the sensor in varying humidity conditions, from low-humidity dry environments to high-humidity simulated greenhouse environments. The system responded by activating/deactivating fans connected via relays to maintain optimal humidity.

2.4. Light Sensitivity: The Light Dependent Resistor (LDR) performed well in detecting changes in light intensity. It demonstrated a slight lag in response time, which was acceptable within the design's parameters, as the greenhouse light intensity is generally constant or changes gradually.

The sensors performed effectively under controlled and real-world test conditions. The system successfully maintained predefined thresholds for temperature, humidity, and light, as set by the user through the Android application. Data accuracy was within acceptable limits, and the system responded swiftly to environmental changes, ensuring plant health.

3.Troubleshooting and Rectifications :

During the implementation phase, several key issues were identified and addressed:

3.1. Microcontroller Replacement: The initial use of AT89C51 caused memory management issues, particularly when storing historical sensor data. By upgrading to AT89S51, this issue was resolved, as the microcontroller offered better memory capacity and easier programming options.

3.2. LCD Display Issues: Initially, the LCD was not displaying the sensor readings correctly. Upon further inspection, it was found that the contrast was not set properly. This was fixed by adjusting the contrast potentiometer and ensuring proper voltage supply to the display unit.

3.3. Relay Operation: The relays controlling fans and lighting were initially not triggering properly due to inadequate power supply. This was resolved by improving the power distribution circuit, ensuring that the relays received consistent voltage.

These troubleshooting efforts were instrumental in optimizing the system's performance, ensuring reliable operation, and minimizing the risk of system failure during long-term operation.

4. Discussion on Practical Applications

The greenhouse environment control system developed in this project demonstrated its utility in maintaining optimal growing conditions for plants. The system allows for remote monitoring and control of key environmental parameters, thus reducing the need for manual intervention.

Key advantages of the system include:

4.1. Automation: The system's ability to automate ventilation (via fans) and shading (via lights) reduces human intervention and ensures a consistent environment for plant growth. This is particularly useful in commercial greenhouses where large-scale operations demand constant environmental regulation.

4.2. Energy Efficiency: By automating control actions such as fan operation and irrigation, the system ensures that resources are only used when necessary, contributing to energy savings and resource conservation.

4.3. Remote Monitoring: The Android application interface allows farmers to monitor real-time data from the greenhouse remotely, providing an added layer of convenience and operational flexibility.

The determined lower bound answer of 565,865.0 gives a valuable approximation of the minimal transportation cost attainable for the particular MCTP problem. However, it's vital to recognise that Lagrangian Relaxation offers a lower bound, and the true best solution cost might be significantly greater.

VI. CONCLUSION

In conclusion, the project achieved its primary goal of developing an automated greenhouse environment control system that effectively monitors and adjusts critical factors such as temperature, humidity, light, and soil moisture. The integration of sensors with a microcontroller and an Android application allowed for real-time data collection, remote monitoring, and control of greenhouse conditions. Through rigorous testing, the system demonstrated reliable performance, accurately capturing and displaying environmental data, and responding to changes by activating control mechanisms like fans and lights. Challenges such as microcontroller programming issues, LCD display visibility, and Bluetooth communication instability were encountered during the development phase. However, these were successfully addressed by upgrading components, recalibrating sensors, and fine-tuning the power supply, ensuring smooth system functionality. The system's ability to automate the control of greenhouse conditions offers significant benefits in terms of resource efficiency, labor reduction, and improved crop management. Remote monitoring through the Android app adds convenience for farmers, allowing them to manage greenhouse conditions from anywhere. This solution is particularly valuable for modern, large-scale farming operations that require constant environmental regulation to ensure optimal plant health and productivity.

Moving forward, the project sets the groundwork for future enhancements, including improved sensor durability for long-term use in harsh environments and the scalability of the system to manage multiple greenhouses simultaneously. This project represents a step toward more efficient, technology-driven agricultural practices, contributing to the advancement of smart farming technologies.

REFERENCES

[1] https://www.irjet.net/archives/V7/i6/IRJETV7I6755.pdf.

[2] https://www.ijitee.org/wpcontent/uploads/papers/v

8i7s2/G10940587S219.pdf.

[3] https://en.wikipedia.org/wiki/Soil_moisture_sensor Remote Sensing In Greenhouse Monitoring SysteSSRG International Journal Of Electronics And Communication Engineering (SSRG-IJECE) – EFES April 2015.

[4] Devine S.M. 2012. Android architecture: attacking the weak points, Network Security, Volume 2012, Issue 10, Pages 5–12, doi: 10.1016/S1353-4858(12)70092-2.

[5] Gendron, B., & Crainic, T. G. (1996). A decomposition approach to the multi-commodity network flow problem. INFOR: Information Systems and Operational Research, 34(2), 89-108.

[6] Gao J.X., Du H.Q.. 2011. Design of Greenhouse Surveillance System Based on Embedded Web Server Technology, Procedia Engineering, Volume 23, Pages 374–379, PEEA 2011, doi: 10.1016/j.proeng.2011.11.2516

[7] Garousi V., Kotchorek R., Smith M. 2013. Chapter 5 – Test Cost-Effectiveness and Defect Density: A Case Study on the Android Platform, Advances in Computers, Volume 89, Pages 163–206, doi: 10.1016/B978-0-12-408094-2.00005-9.

[8] Rehmana A., Abbasib A.Z., Islamb N., Shaikhb Z.A. 2014. A review of wireless sensors and networks' applications in agriculture, Computer Standards & Interfaces, Volume 36, Issue 2, Pages 263–270, doi: 10.1016/j.csi.2011.03.004.

[9] Ojhaa T., Misraa S., Raghuwanshib N.S. 2015. Wireless sensor networks for agriculture: The state-of-the-art in practice and future challenges, Computers and Electronics in Agriculture, Volume 118, Pages 66–84, doi: 10.1016/j.compag.2015.08.011.

[10] Service, N.P. 2013. NPS Chesapeake Explorer - Applications Android no Google Play Retrieved 28-09-2013, from http://goo.gl/BB8STk.

[11] Open source hardware to monitor environmental parameters in precision agriculture, Biosystems Engineering, Volume 137, Pages 73–83, doi: 10.1016/j.biosystemseng.2015.07.005

[12] Mesas-Carrascosa F.J., Verdú Santano D., Meroño J.E., De la Orden M.S., García-Ferrer A.. 2015. .

[13] Meloa L., Abreub J., Silvab T. 2014. Mobile Applications for Natural Parks: Guidelines Study for the Development of a Mobile Device Application, Procedia Technology, Volume 16, Pages 263–268, doi: 10.1016/j.protcy.2014.10.091.

[14] Ionel P., Vasiu G., Mischie S. 2012. GPRS based data acquisition and analysis system with mobile phone control, Measurement, Volume 45, Issue 6, Pages 1462–1470, doi: 10.1016/j.measurement.2012.03.003.

[15] Hoog A. 2011. Chapter 2 – Android hardware platforms, Android Forensics Investigation, Analysis and Mobile Security for Google Android, Pages 41–63, doi: 10.1016/B978-1-59749-651-3.10002-0.

[16] Yuthika Shekar, Ekta Dagur, Sourabh Mishra "Intelligent IoT Based Automated Irrigation System", B. Tech Graduate, Department of Information Technology, SRM University, Kattankaluthur Campus, Chennai-601302, India,2017.

[17] Yuthika Shekar, Ekta Dagur, Sourabh Mishra "Intelligent IoT Based Automated Irrigation System", B. Tech Graduate, Department of Information Technology, SRM University, Kattankaluthur Campus, Chennai-601302, India,2017.

[18] Shirsath, Punam Kamble, Rohini Mane, Ashwini Kolap, Prof.R.S. More "IoT Based Smart Greenhouse Automation Using Arduino, 2017Gyusoo Kim and Seulgi Lee, "2014 Payment Research", Bank of Korea, Vol. 2015, No. 1, Jan. 2015.

[19] Sridevi, Shreejith K, T.V.Ramachandra,"Comparative Analysis of Greenhouse",2017.

[20] Quan Minh Vu, "Automated Wireless Greenhouse Management System", Master of Engineering in Electronics and Computer Systems, Massy University, Palmerston North, New Zealand, June 2011.

[21] T. Saha, M.K.H Jewel, M.N. Mostakin, N.H. Bhuiyan, M.S.Ali and M.K.Rahman, "C onstruction and Development of an Automated Greenhouse System Using Arduino Uno",Dept of Applied Physics, Electronics & Communication Engineering, Islamic University, Kushtia,Bangladesh,2019.