APPLIED INFORMATION TECHNOLOGY AND COMPUTER SCIENCE
e-ISSN: 2773-5141

AITCS

Vol. 6 No. 2 (2025) 1609-1623
https://publisher.uthm.edu.my/periodicals/index.php/aitcs

IoT-Based Plant Growth Monitoring System

Saymaharan Mohan[1], Nureize Arbaiy[1]*

[1] *Fakulti Sains Komputer dan Teknologi Maklumat,*
Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, 86400, MALAYSIA

*Corresponding Author: nureize@uthm.edu.my
DOI: https://doi.org/10.30880/aitcs.2025.06.02.086

Article Info

Received: 19 July 2025
Accepted: 3 November 2025
Available online: 30 November 2025

Keywords

IoT, Growth Monitoring System, Disease Detection, Web-Based System, Agriculture, Plants

Abstract

Impatiens flowers require frequent maintenance due to their preference for shady weather. An Internet of Things (IoT)-Based Plant Growth Monitoring System can maximize productivity, minimize human labor, and provide real-time data to improve plant growth. Due to their meticulous temperature, humidity, light, and water requirements, Impatiens flowers have been used as a case study to develop an automated growth monitoring system. Currently, visual inspection methods are used to monitor plant development. However, this method has limited the capacity for decision-making, especially during unexpected weather fluctuations. Furthermore, operational efficiency can be compromised by the absence of a computerized record-keeping system. An Internet of Things (IoT)-Based Plant Growth Monitoring System is proposed to overcome these difficulties, which can monitor environmental variables using sensors. DHT11 sensors for temperature and humidity monitoring, soil moisture sensors for controlling watering requirements, light sensors for optimal light exposure, and raindrop sensors for rainfall monitoring from the system. Real-time data collection will increase production, save water consumption, and improve plant care. PHP programming and Agile approach are used in the system development for this project. By using this technology, data-driven decision-making will become easier, plant health will be improved, and high-quality services will be provided while encouraging sustainable behavior and reducing environmental impact.

1. Introduction

A systematic approach to collecting, preserving, and assessing data related to plant growth is essential for efficient nursery management in agriculture [1]. Plant nurseries are critical providers of various plants, including flowers, fruit, and landscape trees [2]. Efficient management of these diverse plants requires continuous monitoring [3][4] of environmental factors such as temperature, humidity, soil moisture, and light conditions to optimise plant health and sustainability. Traditionally, nursery management relied on manual methods such as logbooks or paper records to monitor and document vital information. These methods are time-consuming and susceptible to human error, making it difficult to track trends or respond promptly to changing conditions. In today's data-driven world, an IoT-Based Plant Growth Monitoring System significantly improves nursery operations, enabling accurate and real-time plant health monitoring.

In this project, a study has been conducted at Anna Nursery in Kampung Parit Kadir, Senggarang, Batu Pahat, Malaysia. The nursery offers various plants and gardening products, serving professional and amateur landscapers. In addition to selling plants, the nursery provides landscaping services that include plant selection, soil preparation, and garden design. Impatiens plants have been selected as the focal species for this Internet of

Things (IoT) project. Impatiens are popular flowering plants known for their ability to thrive in shaded areas, requiring consistent watering, temperature, humidity, and light care. These characteristics make them ideal candidates for highlighting the benefits of an automated plant growth monitoring system. By providing precise, real-time data, the IoT-Based Plant Growth Monitoring System can enhance the care and production of Impatiens plants while reducing manual labor.

At Anna Nursery, daily operations are managed by a dedicated team of laborers responsible for plant cultivation, upkeep, and customer service. The nursery is owned and operated by Ms. Ruby, who oversees every aspect of the business, from financial management to client interactions. Under her leadership, Anna Nursery has earned a reputation for excellent service and high-quality plants. However, the reliance on visual inspection alone limits the nursery's ability to make data-driven decisions and optimize plant care.

In recent years, advancements in IoT technology have allowed for the seamless integration of digital systems within agricultural settings [5]. These technologies address common issues like inconsistent data collection and enable farmers and nursery owners to achieve greater precision in environmental monitoring and decision-making [6]. By implementing IoT solutions, nurseries can gain actionable insights, optimize resource usage, and enhance plant health and productivity [7].

The existing manual management approach presents several challenges. Tracking historical trends or making informed decisions based on past performance becomes difficult without recorded data. If the nursery lacks a central database for analyzing past sales, weather conditions, or plant growth rates, it could struggle to recall the precise temperature ranges needed for the growth of certain flower species. Suppose unexpected weather changes occur, like an early frost or a sudden heatwave. In that case, employees might not react fast enough to safeguard fragile plants, leading to significant decreases in quality and earnings. Ultimately, the nursery's lack of digital record-keeping limits its capacity to analyze trends, adjust to environmental shifts, and improve plant health and productivity. A digital system could help them make informed decisions, safeguarding its inventory and reputation.

To address these challenges, an IoT-Based Plant Growth Monitoring System is proposed. This system integrates multiple sensors to monitor and optimize plant conditions continuously. The DHT11 sensor tracks temperature and humidity, ensuring the growing environment remains within optimal parameters. The soil moisture sensor provides real-time data on soil hydration, allowing nursery staff to manage watering needs effectively. A light sensor (LDR) monitors light exposure, which is crucial for plants like impatiens that thrive in shaded areas. A raindrop sensor measures precipitation levels to help nursery staff stay informed about natural watering conditions.

Anna Nursery, which serves a diverse clientele and a variety of plant species, is an ideal candidate for an IoT-based solution due to its size and the demands of managing both plant sales and landscaping services. The ability to gather, store, and analyze environmental data in real-time will help Anna Nursery reduce water usage, optimize plant care, and enhance customer satisfaction by ensuring high-quality plants.

By using this comprehensive IoT-Based Plant Growth Monitoring System, Anna Nursery can enhance its operations, optimize plant growth, and improve decision-making processes. This technological shift will reduce the dependency on manual labor and increase the overall efficiency and productivity of the nursery, ensuring that every plant receives the care it needs to thrive. The IoT-Based Plant Growth Monitoring System will not only support the monitoring of environmental parameters but will also be instrumental in forecasting potential issues and generating alerts for nursery staff, enabling proactive care and mitigating risks. This digital approach aligns with the growing need for sustainable practices, ensuring that Anna Nursery can continue providing high-quality services while minimizing environmental impact.

This paper is organized into five sections. Section 1 introduces the project background. It is followed by Section 2 related work. Project methodology is explained in Section 3. Section 4 demonstrates the results and discussion. Section 5 gives the conclusion.

2. Related Work

The progress of Internet of Things (IoT) technologies has led to notable enhancements in diverse sectors such as agriculture and horticulture. Effective control of environmental factors is essential in plant nurseries to promote ideal plant development and preserve resources. The IoT-Based Plant Growth Monitoring System's project utilizes IoT sensors like DHT11 temperature and humidity sensors, soil moisture sensors, LDR light sensors, and raindrop sensors to monitor crucial environmental factors that impact plant growth. By combining these sensors with the ESP8266 microcontroller and cloud-based platforms such as ThingSpeak, the system offers live updates on the health of plants and surrounding environmental factors. Nursery managers can use a web-based interface to view this data, enabling them to make informed decisions on irrigation, lighting, and other crucial aspects.

Anna Nursery, located in Batu Pahat, Johor, Malaysia, is a wholesale plant nursery that focuses on a range of plants, such as flowering plants, fruit trees, and landscape trees. The main plant being studied for the project is Impatiens. This colourful and well-liked ornamental flower requires particular environmental conditions. Impatiens balsamina is a plant that blooms annually during the rainy season. Reaching heights of 20 to 75 cm, it

Applied Information Technology and Computer Science Vol. 6 No. 2 (2025) p. 1609-1623

features a sturdy yet gentle stem known as balsam, garden balsam, and rose balsam. Commonly referred to as Touch-me-not, also known as spotted snapweed, it is indigenous to India and Burma. It thrives in partial shade and belongs to the Balsaminaceae family. It includes a broad range of shapes, types, and pitches. Balsam takes around 60 to 70 days to grow from planting. To produce flowers, beginning early is crucial [8].

The nursery employees track essential environmental elements like temperature, humidity, soil moisture, and light conditions by hand to ensure the best growth. This includes routine visual examinations and manual documentation on paper or spreadsheets. This manual approach allows nursery management to modify watering schedules, handle lighting, and regulate the temperature in growing areas. Although this method is feasible, it frequently lacks accuracy and prompt responses, especially when environmental circumstances quickly shift or during non-peak times.

The proposed IoT-Based Plant Growth Monitoring System aims to overcome these challenges by offering real-time monitoring and automated alerts, ensuring optimal conditions for plant growth and reducing resource wastage. By implementing this system, Anna Nursery can enhance efficiency, minimise human error, and improve plant care for better yield and quality.

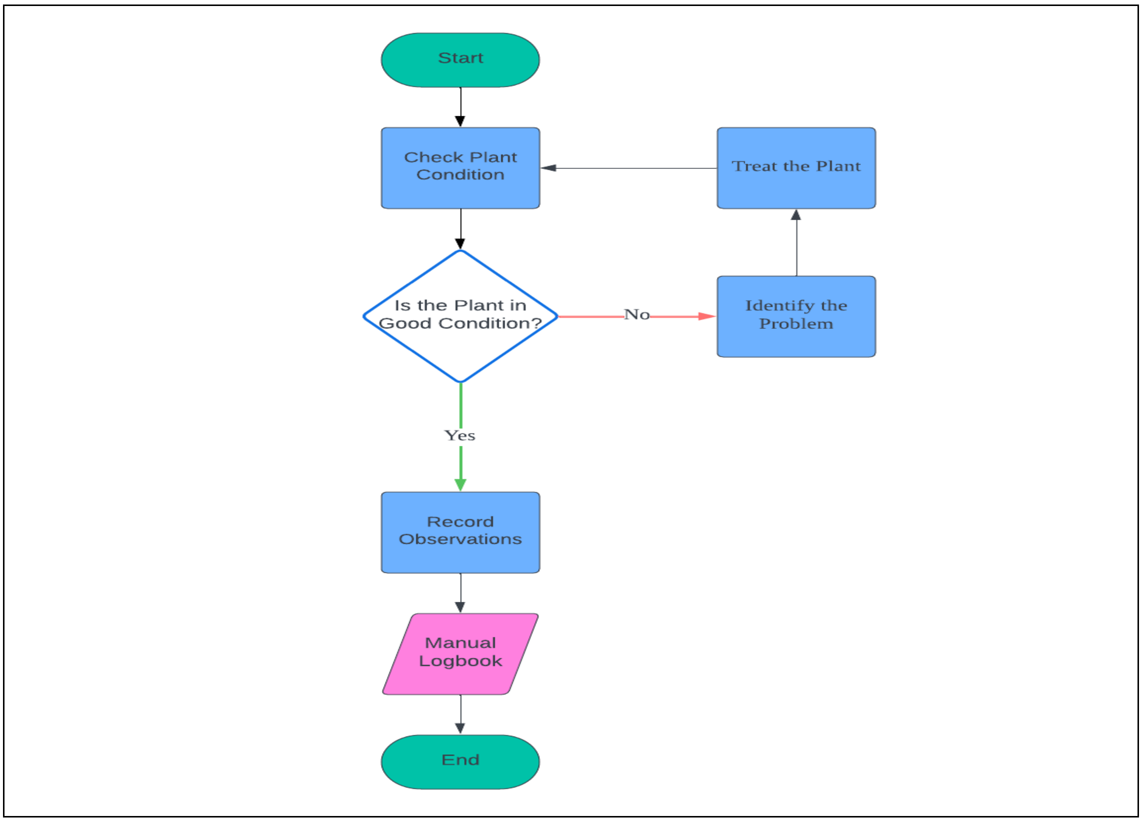

Fig. 1 *Current Way of Anna Nursery's Flowchart*

Using IoT technology, the IoT-Based Plant Growth Monitoring System for Anna Nursery improves plant care specifically for Impatiens. The hub that enables the connection of environmental sensors to gather and send real-time data is the ESP8266 microcontroller with Wi-Fi capability at its foundation. This arrangement keeps track of important factors for plant growth, like temperature, humidity, soil moisture, light intensity, and rainfall. The DHT11 sensor monitors temperature and humidity levels, and the Soil Moisture Sensor monitors the moisture content of the soil. The Light Sensor (LDR) monitors light levels for best plant growth, while the Raindrop Sensor identifies rain to avoid excessive watering.

Information gathered by the sensors is constantly collected and transmitted to the cloud using HTTP or MQTT protocols, enabling nursery workers to get immediate updates on environmental conditions. The IoT system automates data gathering, minimising the requirement for manual supervision and guaranteeing that the Impatiens plants are properly cared for according to the conditions. This automated process reduces human error, enhances operational efficiency, and ensures that the plants receive the necessary environmental conditions for optimal growth at all times, whether the nursery is actively monitored or not. Furthermore, the data collected can be used for historical analysis, enabling continuous improvements in plant care practices at Anna Nursery.

Table 1 *Application of IoT in Corp Monitoring*

No	Year	Application	Findings (Sensor used and Result)
1	Sambath, M et al., 2019 [9]	IoT-Based Garden Monitoring System	Sensors used: Moisture sensor and Temperature sensor Results: The system will function by utilizing sensor data to predict the plant's optimal growth.
2	Emamian, M et al., 2022 [10]	Cloud Computing and IoT-Based Intelligent Monitoring System for Photovoltaic Plants Using Machine Learning Techniques	Sensors used: Humidity sensor, Temperature sensor and Irradiance sensor Results: This research aims to create a cost-effective and accurate monitoring system to enable precise monitoring of PV plants.
3	Chamara, N et al., 2022 [11]	Ag-IoT for crop and environment monitoring: Past, present, and future	Sensors used: Temperature sensor, Light intensity sensor, Accelerometers and Soil moisture sensor Results: Ag-IoT systems allow for a data flow in contemporary farming which comprises gathering, sending, storing, displaying, assessing, and making choices.
4	Drakshayani, S et al., 2022 [12]	Smart Plant Monitoring System using NodeMCU	Sensors used: Humidity, LDR and Soil moisture Results: This will help the farmer comprehend the connection between plant parameters and plant growth.
5	Guerrero-Ulloa, G et al., 2023 [13]	Internet of Things (IoT)-based indoor plant care system	Sensors used: Temperature and humidity, Soil moisture sensor Results: Aim to automatically care for potted plants to enhance air quality and create healthier indoor environments within a building.

The web-based platform enhances the IoT system by providing a user-friendly interface for nursery staff to access and manage data and receive real-time alerts. This integration enables staff to quickly address any changes impacting plant health and offers past data for analysis. Implementing this approach will enhance productivity and decision-making, resulting in healthier plants and improved resource management at Anna Nursery. The convenience of a centralized online platform helps streamline daily operations and optimizes the overall efficiency of plant care management.

Table 2 *Web-Based System in Production Nursery Management*

Author,Year	Application	Findings
Lea-Cox et al [14]	A Nursery and Greenhouse Online Knowledge Center: Learning Opportunities for Sustainable Practice	An online knowledge hub is the most efficient way to deliver information, given the diverse and widespread audience we are targeting. This research demonstrated that the
Kaptein et al [15]	An irrigation control system with a web-based interface for the management of Eucalyptus planting stock in a nursery	An automated irrigation system, which utilises media water content measurements, can effectively schedule irrigation for Eucalyptus seedlings, resulting in possible water conservation.
Ruett et al., [16]	Model-based evaluation of management options in ornamental plant nurseries	Decision Analysis methods can guide decisions on strategies for managing diseases in ornamental plant production.
Ampatzidis,et al., .[17]	Cloud-based harvest management information system for hand-harvested specialty crops	Gathering relevant data promptly is the initial key to improving harvest-related decision-making on the farm. Not many methods and strategies have been created and implemented to monitor labour data for speciality crops
Tan et al., [18]	Cloud-Based Harvest Management System for Specialty Crops	A harvest management system has been developed by integrating a cloud-based web application with specially designed labour monitoring devices (LMDs) to monitor and track harvest labor.

The comparison reveals that while Arable, Plantix, and CropX provide valuable environmental monitoring features, none fully meet the unique needs of Anna Nursery, which specializes in Impatiens plants. The suggested IoT-based system distinguishes itself by combining live monitoring of temperature, humidity, soil moisture, light intensity, and rainfall detection with personalized notifications and reports. It offers a solution tailored to Impatiens growth, optimized for nursery settings, ensuring better control and data-driven plant care. Additionally, the rain detection feature helps prevent overwatering, and the seamless data transmission via ThingSpeak enhances its functionality, making it ideal for the nursery's operations. Furthermore, the user-friendly interface and lack of predictive complexity make it especially suitable for nursery staff with varying levels of technical expertise.

Table 3 *System's Comparison*

System/ Features	Arable	Plantix	Crop X	New System
Login	√	X	√	√
Real-Time Monitoring	√	X	√	√
Environmental Data Tracking	√	X	√	√
Alert/Notification System	√	X	X	√
Data Storage and Analysis	√	X	√	√
User Dashboard	√	X	√	√
Reporting	√	X	√	√
Pest and Disease Detection	X	√	X	√
Focus on Specific Plant (Impatiens)	X	X	X	√
Rain Detection for Overwatering Prevention	X	X	X	√

*New system: IoT-Based Plant Growth Monitoring System

3. Methodology

This project utilizes Agile methodology because of its flexible, adaptable, and iterative development approach. Agile enables constant adaptations in a plant nursery due to changing factors like plant growth stages and user requirements. The repetitive process of Agile allows for quick prototyping and testing, minimizing risks and ensuring the final product meets the nursery's operational objectives and needs. Figure 2 illustrates the Agile.

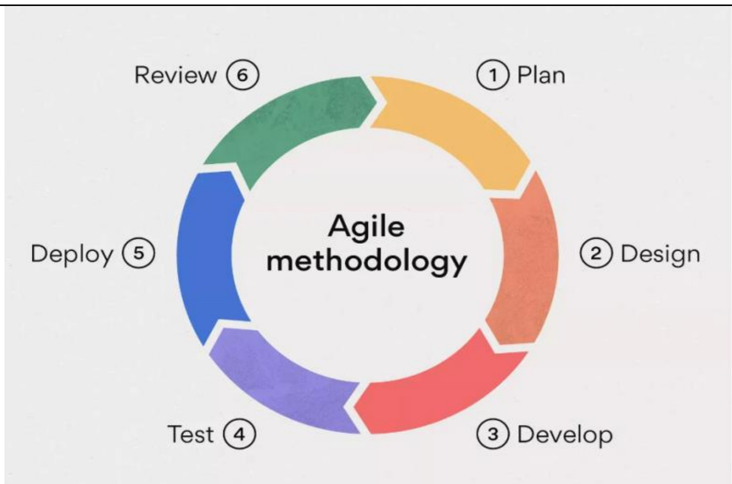

Fig.2 *Agile Method*

3.1 Plan

In the planning phase, the project's objectives and requirements were defined in collaboration with key stakeholders, including Anna Nursery personnel and the nursery manager. The primary goal is to develop an IoT-Based Plant Growth Monitoring System capable of efficiently monitoring multiple environmental variables such as temperature, humidity, soil moisture, light intensity, and rainfall. This phase involved identifying specific requirements, including selecting sensors like the ESP8266 microcontroller, DHT11 for temperature and humidity, capacitive soil moisture sensor, light sensor (LDR), and raindrop sensor.

It also included specifying data parameters to monitor and desired system features such as analytical tools, data storage capabilities, and real-time notification. The project was divided into smaller, manageable tasks or user stories, and a roadmap was created to outline critical milestones and deliverables. Tasks were prioritized based on their significance and feasibility to ensure maximum value with each iteration.

The planning phase also encompassed resource allocation, defining roles and responsibilities, and setting deadlines for each sprint or iteration, ensuring a structured and timely project progression.

3.2 Design

The system includes six main modules to facilitate efficient plant growth monitoring and management.

Table 4 *Functional Requirement*

Module	Description
Login and Registration Module	Allow new users to register accounts before logging in.
	Validate credentials to redirect users to the dashboard.
	Provide role-based access control for Administrators and Staff. -
Plant Management Module	Enables live tracking of soil moisture, temperature, and humidity.
	Enable adding, editing, and deleting plant details.
	View plant details.
Sensor Management Module	Add, edit, delete and view IoT sensor details.
	View sensor value.
Notification Module	Generate notification when conditions exceed predefined thresholds (Example: Low Soil Moisture). Enables Administrator to add, edit, delete and view notifications to provide notifications in the form of reminders or tasks to the Nursery Staff.
Reporting Module	Generate on-demand and periodic reports with visualizations (Example: Graph).
	Enable report downloads in formats such as CSV or PDF.
Plant Disease Detection Module	Allow users to upload plant images for analysis.
	Use machine learning to detect potential plant diseases.
	Provide treatment recommendations.

Table 5 *Non-Functional Requirement*

Requirement	Description
Performance	The system must have high availability, with minimal downtime, ensuring consistent usability.
Operational	The system should load within 1 minute to deliver responsive user experience.
Security	Ensure role-based access control and robust authentication for data security.
Cultural and political	Ensure compatibility with major web browsers to enhance accessibility for diverse user groups.

The Use Case Diagram represents the IoT-Based Plant Growth Monitoring System's overall functionality and how different actors (users) interact with the system. In this case, the primary actors are the Administrator and Nursery Staff. Each actor has different roles and access to various features of the system.

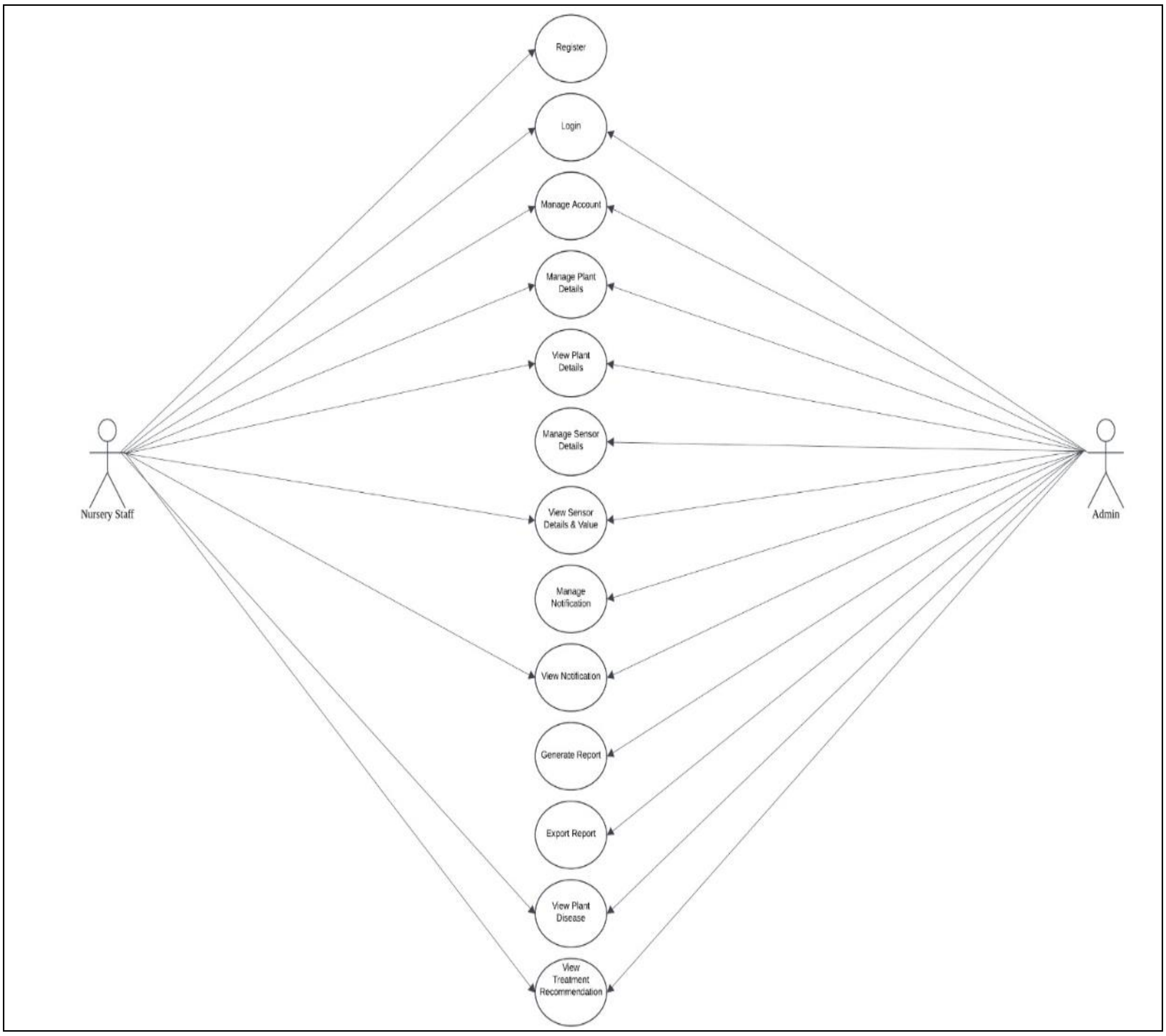

Fig.3 *Use Case Diagram of IoT-Based Plant Growth Monitoring System*

A class diagram is a type of UML diagram that visually represents the structure of a system by showing its classes, their attributes, methods, and relationships. It's used in object-oriented software design to model the static structure of a system.

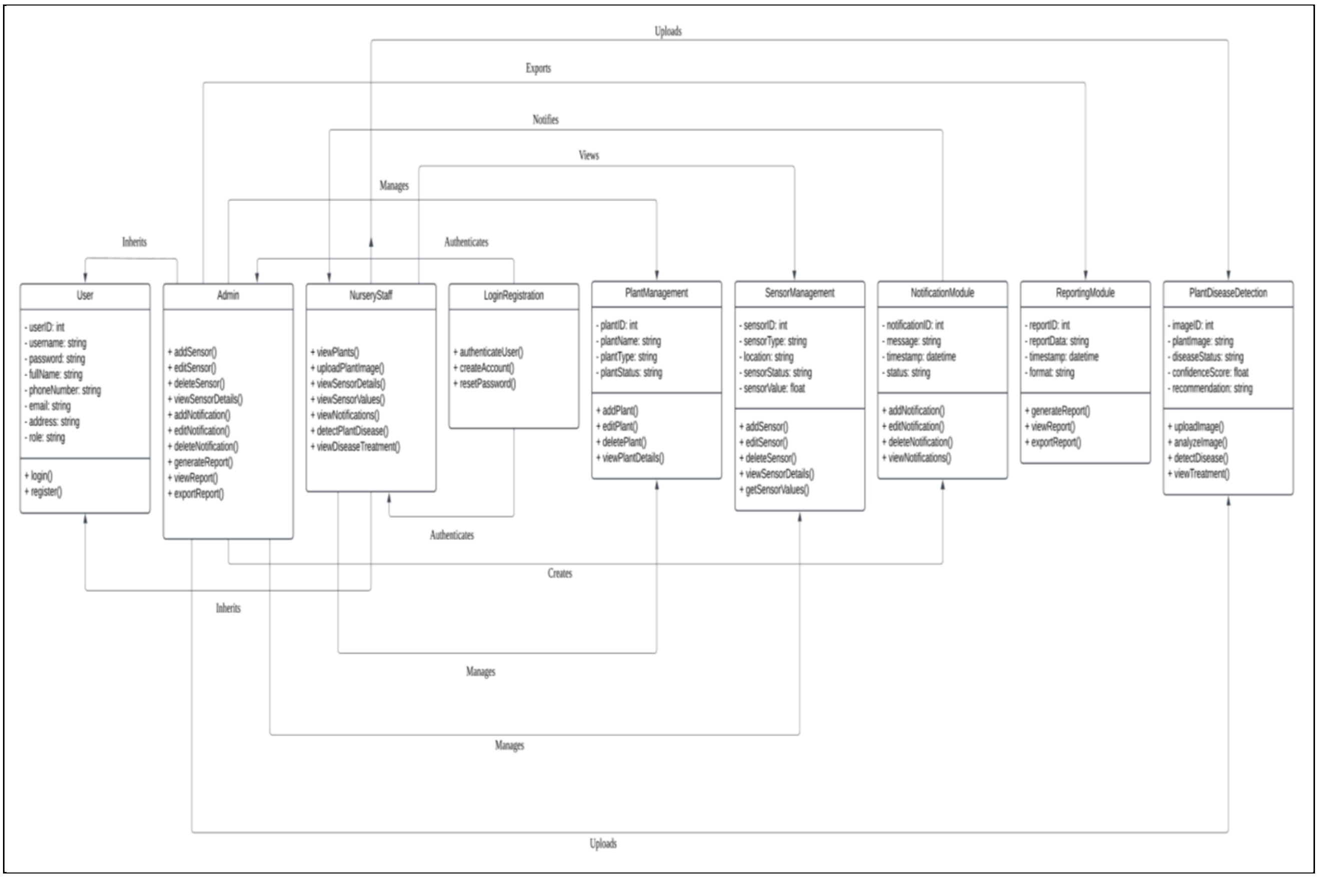

Fig. 4 *Class Diagram*

An Entity Relationship Diagram (ERD) is a visual representation of how different entities (objects or concepts) relate to each other in a system. ERDs are commonly used in database design to model the structure of a database and ensure data integrity.

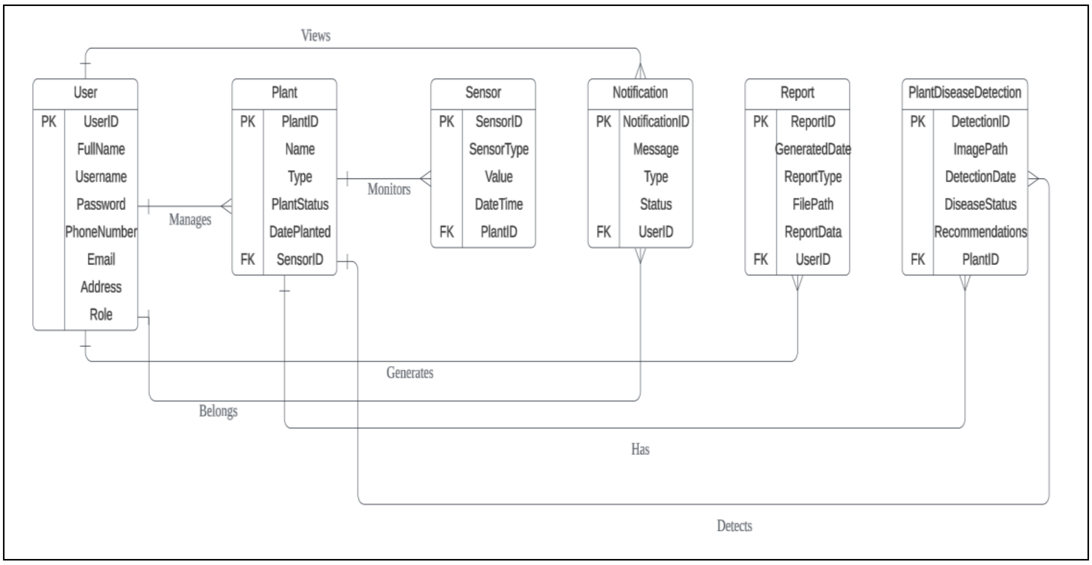

Fig. 5 *Entity Relationship Diagram*

The following tables have been carefully extracted and refined for a robust database schema:

i. Tbl_user (userID, username, password, fullName, phoneNumber, email, address, role)
ii. Tbl_admin (adminID, userID)
iii. Tbl_staff (staffID, userID)
iv. Tbl_login (loginID, userID, loginTimestamp)

v. Tbl_plant (plantID, plantName, plantType, plantStatus)
vi. Tbl_sensor (sensorID, sensorType, location, sensorStatus, sensorValue)
vii. Tbl_notification (notificationID, message, timestamp, status)
viii. Tbl_reporting (reportID, reportData, timestamp, format)
ix. Tbl_disease (imageID, plantImage, diseaseStatus, confidenceScore, recommendation)

The following are the interfaces that have been designed based on each process. They are created by using Canva.

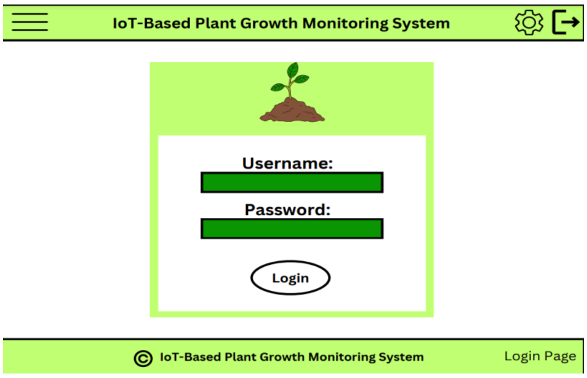

Fig. 6 *Login Interface*

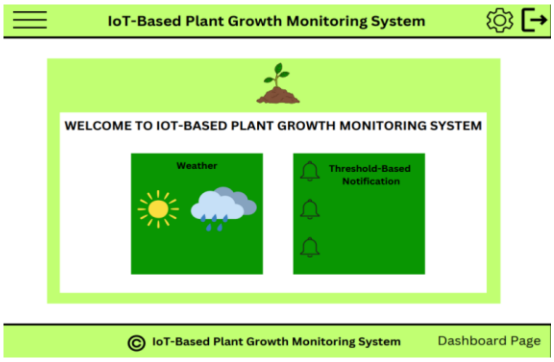

Fig. 7 *Dashboard Page*

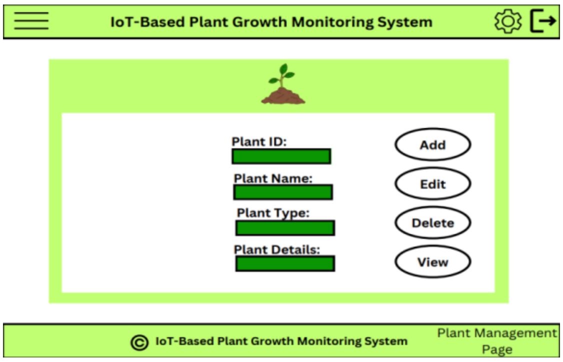

Fig. 8 *Plant Management Page*

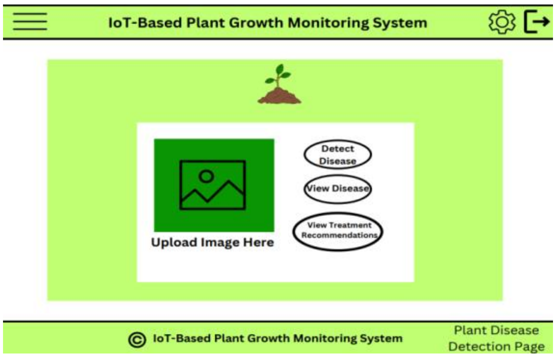

Fig .9 *Plant Disease Detection Interface*

4. Result and Discussion

This chapter explains the Implementation and Testing Phases of the IoT-Based Plant Growth Monitoring System. The implementation involved creating web interfaces for both admin and nursery staff users, integrating IoT sensors to collect real-time environmental data such as temperature, humidity, soil moisture, and light intensity, and enabling AI-based plant disease detection through image uploads. The system was built using PHP, HTML, CSS, JavaScript, and MySQL for the web platform, with ESP8266 microcontrollers handling data transmission to the server. Additionally, the plant disease detection module was implemented using a Teachable Machine model integrated with TensorFlow to analyze leaf images and provide health diagnostics. Testing was conducted to ensure that all functional modules worked as intended and provided accurate, timely information for plant monitoring and decision-making.

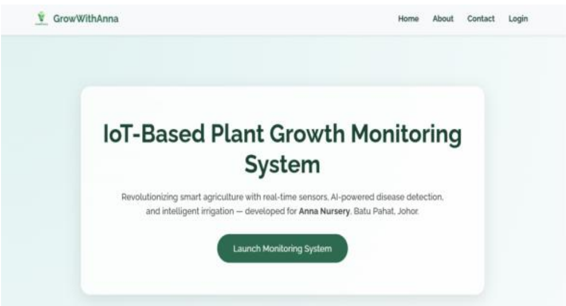

Fig. 10 *Homepage*

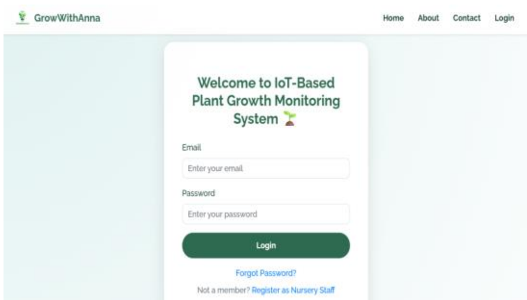

Fig. 11 *Account Login User Interface*

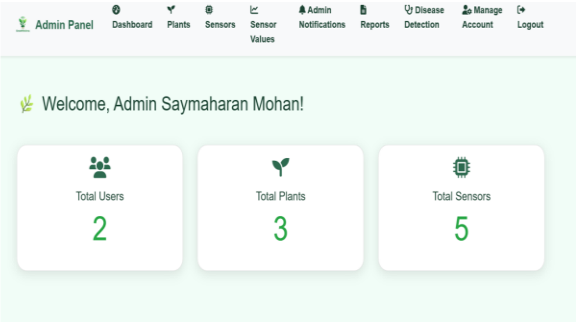

Fig. 12 *System Dashboard User Interface*

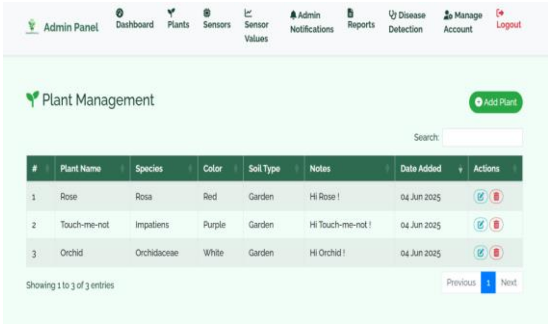

Fig. 13 *Plant Management Interface*

The Account Login Interface and System Dashboard provide secure access and centralized control for the IoT-Based Plant Growth Monitoring System. The homepage introduces the system, while the login page allows registered users to access it. After logging in, admins are taken to a dashboard showing key statistics and links to manage plants, sensors, notifications, and reports. The Plant Management Interface lets admins add, edit, delete, and search plant records, helping maintain accurate and organized data.

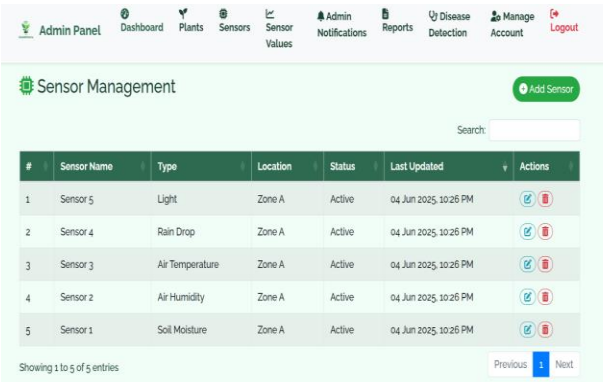

Fig. 14 *Sensor Management Interface*

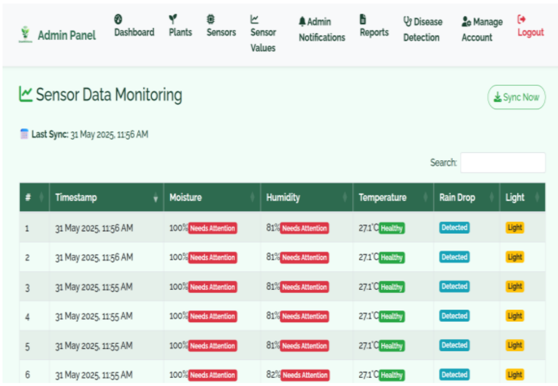

Fig. 15 *Sensor Readings Interface*

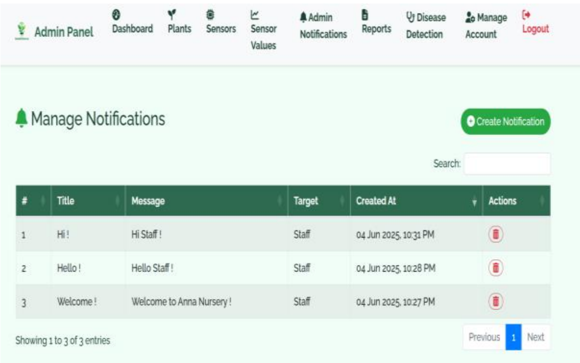

Fig. 16 *Admin Notification Interface*

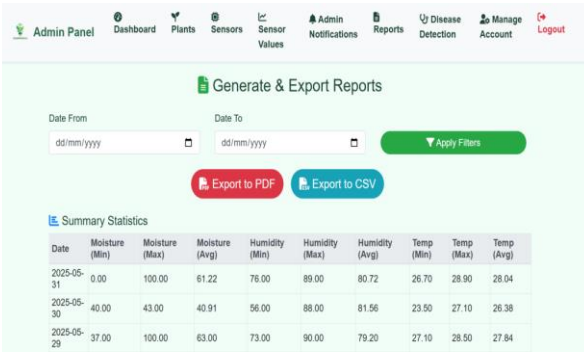

Fig. 17 *Generate Sensor Report Interface*

The Sensor Management Interface lets the admin view, add, edit, and delete sensor records, showing details like type, location, and status. The Sensor Readings Interface displays real-time data such as temperature, humidity, and moisture, with alerts like “Healthy” or “Needs Attention.” The Admin Notification Interface allows the admin to create and manage messages for staff, while the Generate Sensor Report Interface helps filter sensor data by date and export summaries as PDF or CSV. These interfaces support efficient sensor control, data monitoring, communication, and reporting.

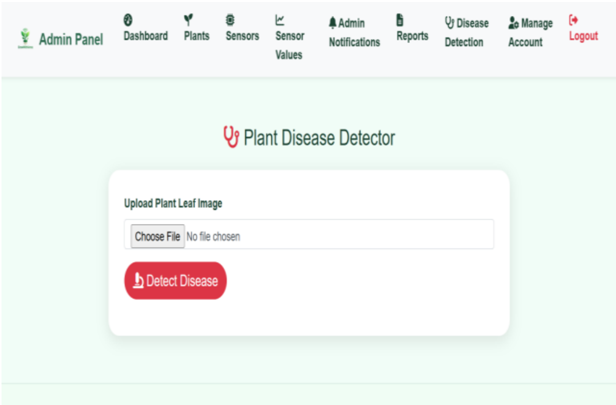

Fig. 18 *Plant Disease Detection Interface*

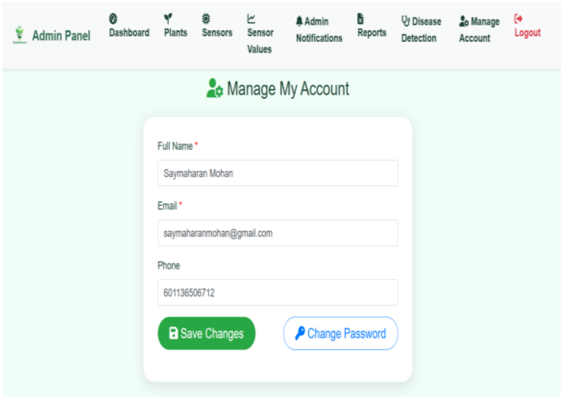

Fig. 19 *My account Interface*

The Plant Disease Detection Interface allows the admin or nursery staff to upload a plant leaf image and use an AI model to detect diseases, helping identify issues early for better plant health. The My Account Interface enables the admin to update their personal details and change their password, ensuring account information stays secure and up to date.

5. Conclusion

By utilizing cutting-edge IoT technology and machine learning, the IoT-Based Plant Growth Monitoring System is a complete solution created to improve plant care and management, especially for Impatiens plants. Important environmental parameters like temperature, humidity, soil moisture, light intensity, and the presence of rain can all be monitored in real time thanks to the system. The system helps Anna Nursery maintain ideal growing conditions for plants by offering automated notifications and actionable insights.Administrators and nursery employees can carry out their duties more effectively thanks to essential features like role-based access, sensor management, plant disease detection, and report generation. The ESP8266 microcontroller and software tools like TensorFlow and ThingSpeak are integrated to guarantee the system's scalability, dependability, and user-friendliness.In addition to enhancing plant productivity and health, this project aims to minimize possible plant losses, optimize resource use, and cut down on labor-intensive tasks. In the end, the system sets a standard for horticultural innovation by assisting in the development of more intelligent and sustainable nursery management techniques.

Acknowledgement

The authors would like to thank the Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia for its support.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

This journal requires that all authors take public responsibility for the content of the work submitted for review. The contributions of all authors must be described in the following manner:

The author confirms sole responsibility for the following: **study conception and design**: Saymaharan, Nureize; **data collection**: Saymaharan, Nureize; **analysis and interpretation of results**: Saymaharan, Nureize; and **draft manuscript preparation**:Nureize. All authors reviewed the results and approved the final version of the manuscript.

References

[1] P. R. Krishnan, R. K. Kalia, J. C. Tewari, and M. M. Roy, *Plant Nursery Management: Principles and Practices*. Central Arid Zone Research Institute, Jodhpur, 2014, p. 40.
[2] M. Anu, "Farmers' knowledge and practice regarding plant nursery management," Ph.D. dissertation, Dept. of Agricultural Extension & Information System, 2016.
[3] S. M. C. Porto, C. Arcidiacono, and G. Cascone, "Developing integrated computer-based information systems for certified plant traceability: Case study of Italian citrus-plant nursery chain," *Biosystems Engineering*, vol. 109, no. 2, pp. 120–129, 2011.

[4] S. Z. Teoh and N. B. Arbaiy, “Succulent plant management information system for nursery gardening store,” *Applied Information Technology and Computer Science*, vol. 4, no. 1, pp. 1342–1359, 2023.
[5] N. Mumtaz, T. Izhar, G. Pandey, and P. K. Labhasetwar, “Utilizing artificial intelligence for environmental sustainability,” in *Artificial Intelligence for Renewable Energy Systems*, Woodhead Publishing, 2022, pp. 259–279.
[6] S. G. Rodrigues, M. M. Silva, and M. H. Alencar, “A proposal for an approach to mapping susceptibility to landslides using natural language processing and machine learning,” *Landslides*, vol. 18, pp. 2515–2529, 2021.
[7] S. Abbas *et al.*, “Modeling, simulation and optimization of power plant energy sustainability for IoT enabled smart cities empowered with deep extreme learning machine,” *IEEE Access*, vol. 8, pp. 39982–39997, 2020.
[8] S. Kumar, S. Hariprabha, S. Kamalakannan, R. Sudhagar, and K. Sanjeevkumar, “Effect of panchagavya on germination and seedling growth of balsam (Impatiens balsamina),” *Plant Archives*, vol. 20, no. 1, pp. 3735–3737, 2020.
[9] M. Sambath, M. Prasant, N. B. Raghava, and S. Jagadeesh, “IoT based garden monitoring system,” in *Journal of Physics: Conference Series*, vol. 1362, no. 1, p. 012069, IOP Publishing, Nov. 2019.
[10] M. Emamian *et al.*, “Cloud computing and IoT based intelligent monitoring system for photovoltaic plants using machine learning techniques,” *Energies*, vol. 15, no. 9, p. 3014, 2022.
[11] N. Chamara, M. D. Islam, G. F. Bai, Y. Shi, and Y. Ge, “Ag-IoT for crop and environment monitoring: Past, present, and future,” *Agricultural Systems*, vol. 203, p. 103497, 2022.
[12] S. Drakshayani, Y. LaksmiManjusha, P. Ramadevi, V. Madhuravani, and K. R. Suguna, “Smart plant monitoring system using NodeMCU,” in *Proc. 2022 Int. Conf. Electronics and Renewable Systems (ICEARS)*, Mar. 2022, pp. 525–530.
[13] G. Guerrero-Ulloa *et al.*, “Internet of Things (IoT)-based indoor plant care system,” *Journal of Ambient Intelligence and Smart Environments*, vol. 15, no. 1, pp. 47–62, 2023.
[14] J. D. Lea-Cox *et al.*, “A nursery and greenhouse online knowledge center: Learning opportunities for sustainable practice,” *HortTechnology*, vol. 20, no. 3, pp. 509–517, 2010.
[15] N. D. Kaptein, M. J. Savage, and M. E. Light, “An irrigation control system with a web-based interface for the management of Eucalyptus planting stock in a nursery,” *Southern Forests: A Journal of Forest Science*, vol. 81, no. 1, pp. 31–37, 2019.
[16] M. Ruett, C. Whitney, and E. Luedeling, “Model-based evaluation of management options in ornamental plant nurseries,” *Journal of Cleaner Production*, vol. 271, p. 122653, 2020.
[17] Y. Ampatzidis, L. Tan, R. Haley, and M. D. Whiting, “Cloud-based harvest management information system for hand-harvested specialty crops,” *Computers and Electronics in Agriculture*, vol. 122, pp. 161–167, 2016.
[18] L. Tan, R. Haley, and R. Wortman, “Cloud-based harvest management system for specialty crops,” in *Proc. 2015 IEEE Fourth Symp. Network Cloud Computing and Applications (NCCA)*, Jun. 2015, pp. 91–98.

Appendix A : System Testing Form (Stakeholder)

UTHM
Universiti Tun Hussein Onn Malaysia

Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor

System Testing Form

Student's Name : Saymaharan A/L Mohan

Matric No : CI220124

Project Title : IoT-Based Plant Growth Monitoring System

**Note: This System Testing Form is provided to obtain feedback from system users to find out the extent of the capabilities of the developed system. This form has 2 parts, namely Part A and Part B. Please answer all questions.

Please tick (/) the appropriate evaluation box.

Part A

1	Not Satisfactory
2	Satisfying
3	Moderately Good
4	Good
5	Very Good

Num.	Questions	1	2	3	4	5
1.	User-friendly system					/
2.	System uses appropriate colors					/
3.	System uses attractive displays					/
4.	Text displays make it easy for users to read and understand to use the system					/
5.	Position the login display in the appropriate place					/

Part B

Please tick (/) the answer Yes or No.

Num.	Questions	Answer	
		Yes	No
System's Content			
1.	The content presentation is informative and relevant to plant growth monitoring	/	
2.	All buttons, links, and detection features work as intended	/	
3.	The system provides sufficient information on environmental data (e.g., temperature, humidity, soil)	/	
4.	The system helps administrators and nursery staff access plant details and condition data effectively	/	
User Friendly			
1.	The system is easy to use for plant monitoring and disease detection tasks	/	
2.	Users can easily navigate between features like sensor readings, charts, and disease detection	/	
3.	The system supports users in making informed decisions about plant health management	/	
Text			
1.	The text used is clear and easy to read	/	
2.	Terminology used (e.g., growth, disease detection) is appropriate and domain-relevant	/	
3.	Instructions (e.g., for uploading leaf images) are easy to follow	/	
4.	The font size is suitable for comfortable reading	/	
Graphics			
1.	The background and visual layout are appropriate for presentation	/	
2.	Colors used help distinguish environmental conditions or alert levels	/	
3.	The interface design, including charts and disease detection panels, is attractive and user-friendly	/	
Overall System Assessment			
1.	The system is an effective digital tool for real-time plant growth monitoring	/	
2.	The system is user-friendly and functions reliably	/	
3.	The disease detection and sensor values are displayed accurately	/	
4.	The sensor data and database values are displayed accurately in the interface	/	

Comments / Suggestions :

Signature and Stamp (if any) :

Date : 9.6.2025

Appendix B : System User Manual

❖ **Introduction**

This user manual guides users of the IoT-Based Plant Growth Monitoring System, detailing its use in standard steps. It is divided into two main parts: server setup and environment, and system operation guide.

❖ **Server and Environment Setup**

This section outlines the guidelines for setting up the system's environment, including minimum hardware and software requirements and database setup.

❖ **Minimum Hardware and Software Requirements**

The minimum specifications include:

- Operating System: Windows 10 or newer (64-bit recommended)
- CPU: 2.0 GHz dual-core processor or better (Intel Core i3 equivalent or higher recommended)
- Memory: 8 GB of RAM (16 GB or more recommended)
- Storage: 128 GB SSD or more (256 GB or 512 GB SSD recommended)
- Internet Connection: 25 Mbps download / 3 Mbps upload or higher recommended
- Browser: Latest stable version of a modern web browser (Google Chrome, Mozilla Firefox, Microsoft Edge, Safari)
- Display: 1280 x 720 resolution or higher (1920 x 1080 Full HD recommended)
- Graphics: Integrated graphics (Dedicated GPU recommended for intensive applications)
- Peripherals: Keyboard and Mouse/Trackpad

❖ **Database Setup**

To activate the server, users must install XAMPP (https://www.apachefriends.org), extract the system file to C:\xampp\htdocs, open XAMPP, and start "Apache" and "MySQL" modules. Then, select "Admin" from Apache to access the Localhost Dashboard, navigate to "phpMyAdmin," select "Import," click "Choose File," and select the provided database file (u381499631_iot_growth.sql).

❖ **System Operation Guides**

This section provides comprehensive guidance on utilizing the web-based features of the IoT-Based Plant Growth Monitoring System.

A. Landing Page

The initial entry point for both Admin and Nursery Staff. It features navigation links: "Launch Monitoring System Button" to Login , "About Nav-Link" to the About page , "Contact Nav-Link" to the Contact page , "Login Nav-Link" to the Login page , and "Home Nav-Link" returns to growwithanna.site.

B. Register Page

Allows new Nursery Staff to create an account by entering full name, email, phone, password, and confirming password, then clicking "Register". Admin do not use this page. Existing users can click "Login here" to go to the Login page.

C. Login Page

Accessible to both Admin and Nursery Staff. Users enter email and password, then click "Login". Options include "Forgot Password?" to go to the Forgot Password page and "Register as Nursery Staff" to go to the Register page.

D. Forgot Password Page

Accessible to both Admin and Nursery Staff. Users enter their email address and click "Send Reset Link" to receive reset instructions. Users can also click "Back to Login" to return to the Login page.

E. Dashboard Page (Admin & Nursery Staff)

Upon login, users are directed to their respective dashboards, serving as a central hub for monitoring.

i. Admin Dashboard

Provides a comprehensive overview with "Total Users" , "Total Plants" , "Total Sensors" , "Live Data Monitoring" (Temperature, Humidity, Soil Moisture) , and "Plant Status Overview". Navigation includes User Management, Plant Management, Sensor Management, Live Data, Reports, and Profile settings. This dashboard is exclusive to Admin.

ii. Nursery Staff Dashboard
Designed for daily operational tasks, focusing on "Total Plants" and "Live Data Monitoring" (Temperature, Humidity, Soil Moisture) , and "Plant Status Overview". Navigation includes Plant Management, Live Data, Reports, and Profile settings. This dashboard is exclusive to Nursery Staff.

F. Plant Management Page
Both Admin and Nursery Staff have full access to view, add, edit, and delete plant records. The page displays plant name, species, location, health status, notes, and date added. Actions include "Add Plant" , "Edit" , and "Delete" (with confirmation).

G. Sensor Management Page
Admin have full access to view, add, edit, and delete sensor records. Nursery Staff can only view sensor details. The page displays sensor name, type, location, status, and last updated. Admin actions include "Add Sensor" , "Edit" , and "Delete".

H. Sensor Data Monitoring Page
Accessible to both Admin and Nursery Staff for viewing real-time sensor data (Timestamp, Moisture, Humidity, Temperature, Rain Drop, Light). Only Admin can click "Sync Now" to manually refresh data.

I. Manage My Account Page
Both Admin and Nursery Staff can access their own profile to update full name, email, and phone , then click "Save Changes". Users can also click "Change Password" to update their password.

J. Plant Disease Detector Page
Accessible to both Admin and Nursery Staff. Users can click "Choose File" to upload a plant leaf image , then click "Detect Disease" to initiate the detection process. Results (presence and type of disease) are displayed upon successful detection.

K. Generate & Export Reports Page
Exclusive feature for Admin. Admins can select a date range, click "Apply Filters" , and the system displays a report with data like Date, Time, Plant Name, Sensor Type, and Sensor Reading. Reports can be exported as "PDF" or "CSV".

L. Manage Notifications Page
Notifications are managed and viewed differently by user roles.

i. Admin: Manage Notifications Page
Admin only can create and manage system-wide notifications. They can click "Create Notifications" to compose new messages and "Delete" existing ones.

ii. Nursery Staff: My Notifications Page
Nursery Staff only can view notifications created by Admin. They can click "Mark Read" to acknowledge notifications and track their status.