Design and Development of Web-Based Mushroom Monitoring System with Smart Sprinkler

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Abstract:- The design and development of a Web-Based Mushroom Monitoring System with Smart Sprinkler (MMS) for Mushroom House is presented in this study. The system utilizes Internet of Things (IoT) technology and sensor devices to enable real-time monitoring and control of environmental conditions within mushroom houses. The MMS incorporates features such as temperature, humidity, CO2 level monitoring, and smart sprinklers for precise irrigation management. By collecting and analyzing data on environmental conditions and crop performance, farmers can make informed decisions to improve productivity. The study follows the Agile methodology for software development and employs purposive sampling to gather data from IT experts, fungiculture experts, and system end-users. The results show that the MMS offers a reliable and efficient solution for mushroom cultivation, enhancing productivity and resource utilization.

***Keywords**:- Agriculture Technology, Internet of Things (IoT), Monitoring System, Mushroom Cultivation, Smart Sprinkler, Web-Based System.*

I. INTRODUCTION

In recent years, the agricultural sector has witnessed significant advancements in technology, leading to the development of innovative solutions to enhance farming practices and increase productivity (Cortez, 2020). One area that has gained considerable attention is mushroom cultivation, which holds tremendous potential in terms of nutritional value and economic profitability. With the growing demand for mushrooms in both domestic and international markets, there is a need to optimize the farming process to ensure efficient production and high-quality yields.

In the Philippines, the market potential for mushrooms has been steadily growing. According to a study by Dela Cruz and Barroga (2018), the increasing demand for mushrooms in both domestic and international markets present a promising opportunity for mushroom farmers. The rising awareness of the nutritional benefits and culinary versatility of mushrooms has contributed to their popularity among consumers.The favorable climate and suitable conditions in the Philippines make it an ideal location for mushroom cultivation. The Food and Agriculture Organization (FAO) conducted a study in 2018, showing significant growth in the country's mushroom industry. This growth is driven by the rising demand for mushrooms in the local market as well as for export purposes. These findings indicate a promising market potential for mushroom farmers in the Philippines.

It is well known that the Philippines has a wide variety of edible mushroom species. Pleurotus ostreatus (oyster mushroom), Lentinula edodes (shiitake mushroom), and Ganoderma lucidum (reishi mushroom) are a few of the species that are frequently grown in the nation (Ong et al., 2019). The country's abundant biodiversity contributes to the presence of various edible mushroom species. Alongside oyster mushrooms (Pleurotus spp.), shiitake mushrooms (Lentinula edodes), and straw mushrooms (Volvariella volvacea) are also frequently grown in the Philippines (Villanueva & de Guzman, 2018). These mushrooms have gained popularity due to their nutritional content, distinct flavors, and potential health benefits.

Several studies have examined the key factors involved in successful mushroom cultivation. Environmental conditions, such as temperature, humidity, light, and ventilation, play a critical role in the growth and development of mushrooms (Royse, 2014). It is important to maintain these conditions within the mushroom house to ensure optimal growth and prevent the proliferation of contaminants.

Proper substrate preparation is another crucial aspect of mushroom cultivation. The choice and preparation of the substrate significantly impact the growth and yield of mushrooms. Various substrates, including agricultural by-products such as straw, sawdust, and corn cobs, have been used successfully in mushroom cultivation (Chang & Miles, 2004). The substrate must undergo appropriate treatment, such as pasteurization or sterilization, to eliminate competing organisms and provide a favorable environment for mushroom mycelium colonization.

The selection of suitable spawn, which refers to the inoculated substrate used to propagate mushrooms, is also vital for successful cultivation. High-quality spawn with vigorous mycelial growth is essential to ensure efficient colonization of the substrate and subsequent fruiting body formation (Royse, 2014). Spawn can be obtained from reputable suppliers or produced in-house using reliable and tested techniques. Also, by considering these key factors—optimal environmental conditions, proper substrate preparation, and appropriate spawn selection—mushroom cultivators can increase the chances of achieving high-quality yields and minimizing the risk of contamination. It is crucial to stay updated on the latest research and best practices in mushroom cultivation to improve productivity and maximize success.

➢ *System Purpose and Description*

Traditional mushroom farming methods often rely on manual labor and regular monitoring of environmental conditions such as temperature, humidity, light, and ventilation. These factors play a crucial role in the growth and development of mushrooms. However, manual monitoring can be time-consuming and labor-intensive for farmers, leading to challenges in maintaining consistent and optimal conditions within the mushroom houses.

To address these challenges, the development of automated systems using web-based technologies has emerged as a promising solution. This research project focuses on the design and implementation of a Web-Based Mushroom Monitoring System with Smart Sprinkler (MMS) for Mushroom House. The MMS leverages the power of Internet of Things (IoT) and sensor devices to enable real-time monitoring and control of the mushroom house environment.

The Web-Based Mushroom Monitoring System utilizes a micro-controller, such as the Arduino Uno, to gather data from various sensors attached within the mushroom house. These sensors provide critical information about temperature, humidity, CO2 levels, and other environmental parameters necessary for optimal mushroom growth. The collected data is then transmitted to a web-based interface accessible to the users, allowing them to remotely monitor and regulate the mushroom house conditions.

Additionally, the integration of smart sprinkler systems within the monitoring system can address the challenge of irrigation management. These systems can be programmed to deliver precise amounts of water at specific times based on the requirements of the mushroom cultivation process (Yusoff et al., 2020). This automation reduces the need for manual irrigation, optimizes water usage, and ensures consistent moisture levels, leading to improved crop yield and quality.

Implementing web-based mushroom monitoring systems with smart sprinklers can also provide farmers with data analytics and insights. By collecting and analyzing data on environmental conditions and crop performance, farmers can make informed decisions and adjustments to their cultivation practices, leading to increased efficiency and productivity (Yusoff et al., 2020).

➢ *Scope and Limitations*

The study “Web-Based Mushroom Monitoring System with Smart Sprinkler “aimed to address the specific needs of farmers by conducting a comprehensive analysis of existing studies, technologies, devices, and software related to the development of the system. The study focused on creating a real-time monitoring system and a smart sprinkler for mushroom houses, utilizing the ARDUINO UNO Microcontroller and various sensors to monitor environmental conditions.

The developed smart farming system (IoT) presented in the study aimed to optimize farmers' time and resource management. It provided features such as temperature monitoring, CO2 level detection, light level measurement, humidity monitoring, and smart sprinklers. The system allowed for remote monitoring of the mushroom progress in real-time. However, it should be noted that the system was not designed to address insect-related issues in the agriculture facility.

Overall, the study contributed to the advancement of agricultural technology by designing and developing a reliable web-based system that enables efficient monitoring and control of mushroom cultivation, helping farmers improve their productivity and resource utilization.

II. METHODOLOGY

➢ *Research Design*

This research project was developedby employment of Software Development Life Cycle (SDLC) methodology using Agile. It is an iterative and incremental approach to software development that emphasizes collaboration, flexibility, and continuous delivery. Agile methodologies, such as Scrum or Kanban, break down the development process into smaller iterations called sprints, where cross-functional teams work collaboratively to deliver working software in short cycles (Agile Alliance, n.d.).

Fig 1 Project Design and Development

This methodology focusses on customer satisfaction through continuous involvement and feedback. Requirements and solutions evolve through the collaborative effort of self-organizing teams. The methodology emphasizes adaptability to changing requirements and encourages close communication between developers, stakeholders, and end-users throughout the development process.

It also follows several key practices to enhance the development process. These practices include expressing requirements as user stories, dividing work into sprints, utilizing frameworks like Scrum or Kanban, conducting daily stand-up meetings, implementing continuous integration and testing, and enabling continuous delivery. By adopting Agile methodologies, organizations can experience

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advantages such as improved customer satisfaction, faster time-to-market, increased adaptability to changing requirements, and enhanced collaboration among team members.

➢ *Sampling Procedure*

In this study, the researchers employed a purposive sampling technique to select participants. Purposive sampling, also known as judgmental or selective sampling, is a non-probability sampling method where researchers use their judgment to choose individuals who fit specific criteria or profiles (Alchemer, 2021). This sampling approach allows researchers to intentionally select participants who possess relevant knowledge or experiences related to the study's objectives.

To gather data for evaluating the developed system, the researchers utilized printed questionnaires as a research instrument. Questionnaires are commonly used in research to collect information from respondents in a structured manner. They can be conducted face-to-face, via telephone, or through computer-based surveys (Saul, 2018). Questionnaires offer a cost-effective and efficient means of gathering a large volume of information from a diverse sample of individuals.

The utilization of purposive sampling in this study ensured that participants with specific expertise or characteristics relevant to the research objectives were included. By employing printed questionnaires, the researchers were able to systematically gather data from respondents in a standardized and organized manner. This approach allowed for the collection of a substantial amount of information from a wide range of individuals efficiently and at a lower cost.

➢ *Respondents*

In this study, the researchers identified three distinct groups of respondents: the IT experts, the Fungiculture experts, and the System End-users. Each group played a crucial role in evaluating the developed system and providing valuable insights from their respective expertise.

The IT experts group consisted of a diverse range of individuals with expertise in web programming and information technology. This group included three (3) web programmers, who possessed technical skills and knowledge in developing web-based systems. Additionally, three (3) IT professors contributed their academic expertise in the field of information technology. Two (2) IT consultants, with their professional experience and consulting background, provided valuable insights on system development and implementation strategies. The involvement of IT experts in the study ensured a comprehensive evaluation of the technical aspects of the developed system and adherence to industry best practices.

The Fungiculture expert group consisted of individuals with specialized knowledge and experience in mushroom cultivation. These experts were considered authorities in the field of Fungiculture and were selected based on their expertise in cultivating mushrooms. The study involved a total of two (2) Fungiculture expert respondents who provided valuable insights on the specific requirements and challenges related to mushroom cultivation. Their input was crucial in ensuring that the developed system aligned with the needs and practices of the Fungiculture industry.

Lastly, the System End-users group was divided into two sets: ten (10)mushroom house Owners and the fourteen (14) staff or employees. The Owners represented individuals who owned or managed the mushroom cultivation facilities, while the staff or employees were the individuals directly involved in the day-to-day operations of the facilities. The study included a total of 24 System End-user respondents, emphasizing the importance of their feedback in evaluating the practicality and usability of the developed system. The perspectives of the System End-users were instrumental in assessing how well the system supported their workflow and addressed their specific needs.

Table 1 Distribution of Respondents

Classification	Population	Percentage
IT Experts	8	23.53%
FungicultureExpert	2	5.88%
End Users (SWRD personnel)	24	70.59%
Total	**34**	**100%**

By including these three groups of respondents - the IT experts, the Fungiculture experts, and the System End-users - the study encompassed a comprehensive evaluation of the developed system from different angles. The IT experts provided technical expertise, the Fungiculture experts ensured alignment with industry requirements, and the System End-users represented the end-users' perspective. This multi-dimensional approach helped ensure the reliability, functionality, and practicality of the system in real-world Fungiculture settings.

- *Research Locale*

The study was conducted at Bote Mushroom Farm, which is situated in Purok 4 Barangay Rio Chico, in the Municipality of General Tinio, Nueva Ecija province, Philippines. Bote Mushroom Farm aims to enhance mushroom production rates in the municipality, recognizing that farming serves as the primary livelihood for a majority of the local residents.

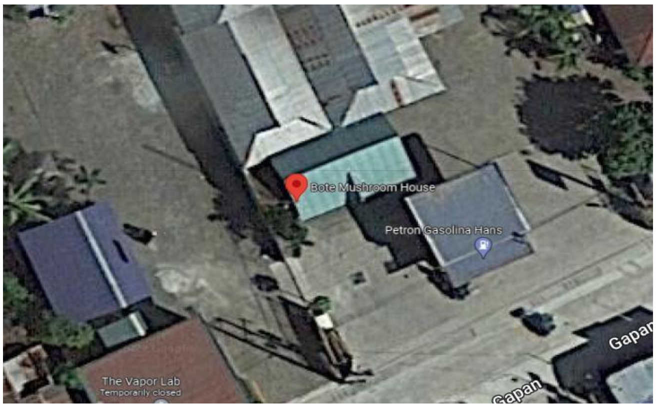

Fig 2 Google Earth View of the Research Locale

Despite its location at the base of the Sierra Madre Mountain Ridges, the topography of the area is generally flat, making it well-suited for agricultural activities, including the cultivation of rice, vegetables, and fungi. The developed system, designed to improve mushroom production, will soon be implemented at Bote Mushroom Farm. The mushroom house at Bote Mushroom Farm is a single room measuring fifteen meters in width and height, with operations commencing in the year 2012.

Fig 3 The Facility of Research Locale

III. RESULTS AND DISCUSSION

➢ *Project Initialization and Requirement Analysis Stage*

The development of MMS: A Mushroom Monitoring System with Smart Sprinkler was initiated to address the need for precise monitoring of mushroom growth and the identification of factors that affect its development. The aim was to create a real-time monitoring system that would enhance production and reduce manual monitoring efforts for farmers.

During this stage, the researchers conducted extensive research and interviews to determine the necessary features for the Mushroom Monitoring System. Additionally, the researchers explored various platforms and devices that could be utilized. The preference was given to developing the system from scratch to ensure its extensibility and the ease of implementing future expansions. Extensibility refers to the system's ability to accommodate the addition of new capabilities or functionality. This was a crucial aspect of the project since it involved not only a Real-Time Monitoring System but also the integration of devices such as Arduino to facilitate a climate control system.

Fig 4 Interview with the Owner of Bote's Mushroom House

By emphasizing extensibility and considering the integration of additional devices, the researchers aimed to develop a Mushroom Monitoring System that would not only provide real-time monitoring but also offer enhanced functionality and control over the mushroom growth environment.

➢ *Designing Stage*

After analyzing the data, the researchers proceeded to develop and prepare system designs that encompassed the work packages and functionalities of the MMS (Mushroom Monitoring System). The system designs included the Use Case Diagram, Context Diagram, and Data Flow Diagram. These designs were crucial in guiding the development team and serving as references for the work breakdown structure.

The first design created was the Use Case Diagram, which depicted the interactions between system users or roles. Figure 5illustrates two actors: the Administrator and the Employees. The Administrator role had the authority to manage system settings and configurations, define and manage sensor configurations, and generate monitoring reports about the system.

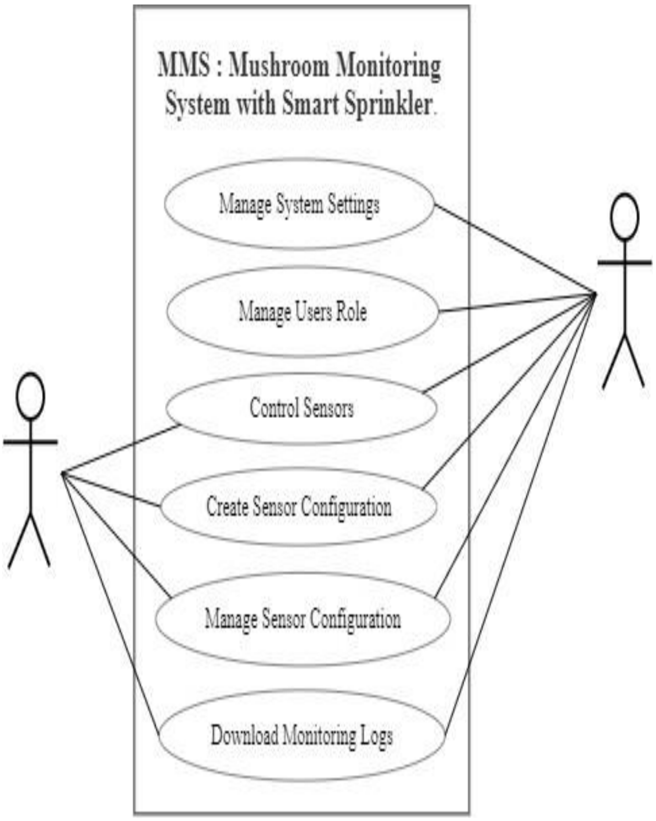

Fig 5 Use Case Diagram

For easy visualization of data processes, external entities, and the overall system, a Context Diagram or DFD Level 0 was constructed. This diagram provided a high-level view of the system's functions and processes. Figure 6 displays the Context Diagram, where four main functions were identified: system settings and user management, real-time monitoring logs, sensor configurations, and report generation.

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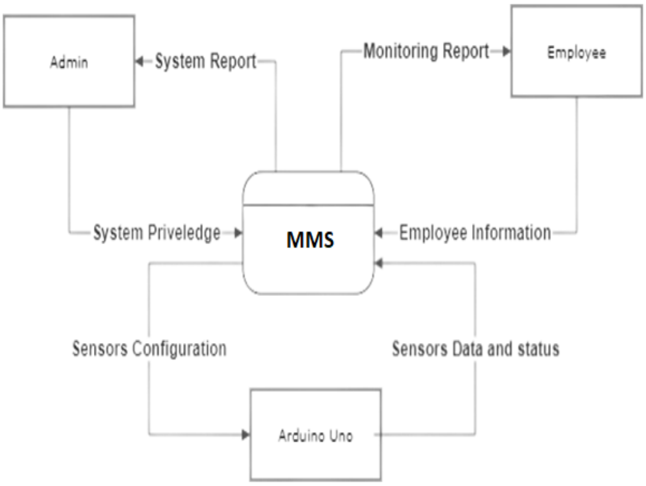

Fig 6 Context Diagram

To further elaborate on the subroutines or processes within each identified functionality, a Data Flow Diagram Level 1 was generated. These diagrams provided more detailed insights into the system's operations and data flow.

In order for the MMS to function properly, a database consisting of 10 tables, collectively referred to as the MMS Database, was utilized. These tables stored and managed the necessary data for the system to operate effectively.

Through the development of these system designs and the establishment of a comprehensive database structure, the researchers laid the foundation for the subsequent stages of the MMS development process. These designs and database tables served as the basis for implementing the system's functionalities and ensuring efficient data management.

- *Development and Testing*

During this stage, the researchers employed a Scrumban board to monitor the progress and track specific tasks known as "Sprint Backlogs." The Scrumban board was a customized Excel application consisting of six columns: "Sprint Backlogs," "In Progress," "Peer Review," "In Test," "For Revision," and "Deploy in the Hosting." Each column represented the status of the corresponding backlog, with "Sprint Backlogs" indicating planned but unfinished tasks .

For the development and modification phases, the researchers utilized Visual Studio and Arduino IDE as text editors to enhance the readability of the programming syntax. These environments provided a conducive workspace for coding and making necessary modifications.

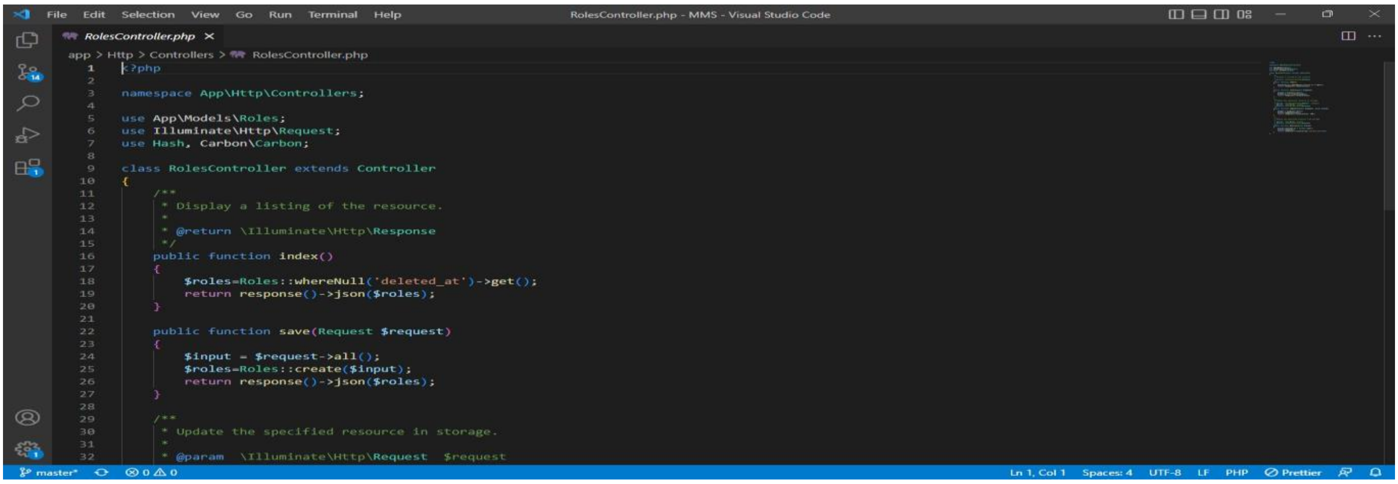

Fig 7 Visual Studio Code Text Editor Environment

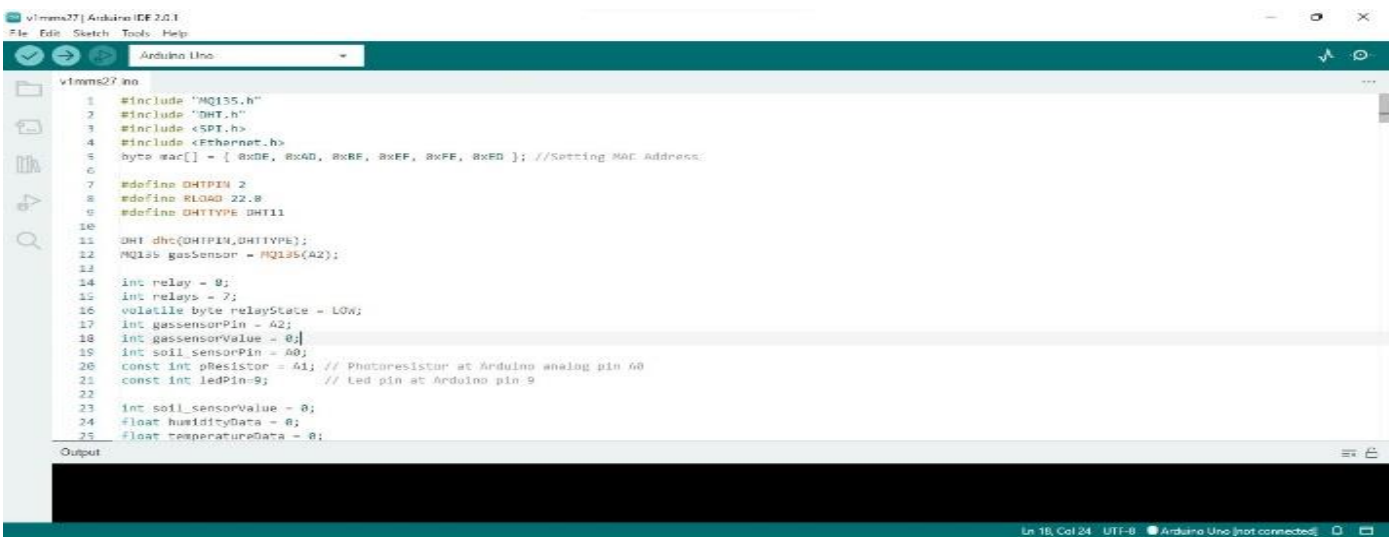

Fig 8 Arduino Integrated Development Environment

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Additionally, as the Project Monitoring System with Smart Sprinkler incorporates hardware components, it requires the assembly of the Arduino board and sensors. The smart sprinkler should activate based on the data readings from the sensors, and the software needs to analyze the data to trigger the components accordingly. This involved manually manufacturing the smart sprinkler by combining the necessary hardware parts.

Fig 9 Smart Sprinkler Prototyping

To test the developed prototype, the researchers employed the XAMPP open-source package. XAMPP is a widely popular PHP development environment known for its ease of installation and comprehensive components such as Apache distribution, MariaDB, PHP, and Perl. These components are essential for web developers, and XAMPP simplifies the testing process.

➢ *Deploymentand Evaluation Stage*

To facilitate the deployment and evaluation process, the MMS was installed on a hosting site called Railway Made. Railway Made is a cloud platform that simplifies the shipping of software projects, accommodating projects of any programming language and size. The researchers opted for Railway Made due to its compatibility with the Laravel framework, which was used to develop the MMS. This choice made the deployment process easier, as Railway Made includes features such as database configuration and environment variables, reducing the configuration time required for Laravel projects. Moreover, Railway Made supports automatic deployment of Laravel projects, further streamlining the deployment process. When all were setup, the researchers demonstrate how the system works to all the evaluators.

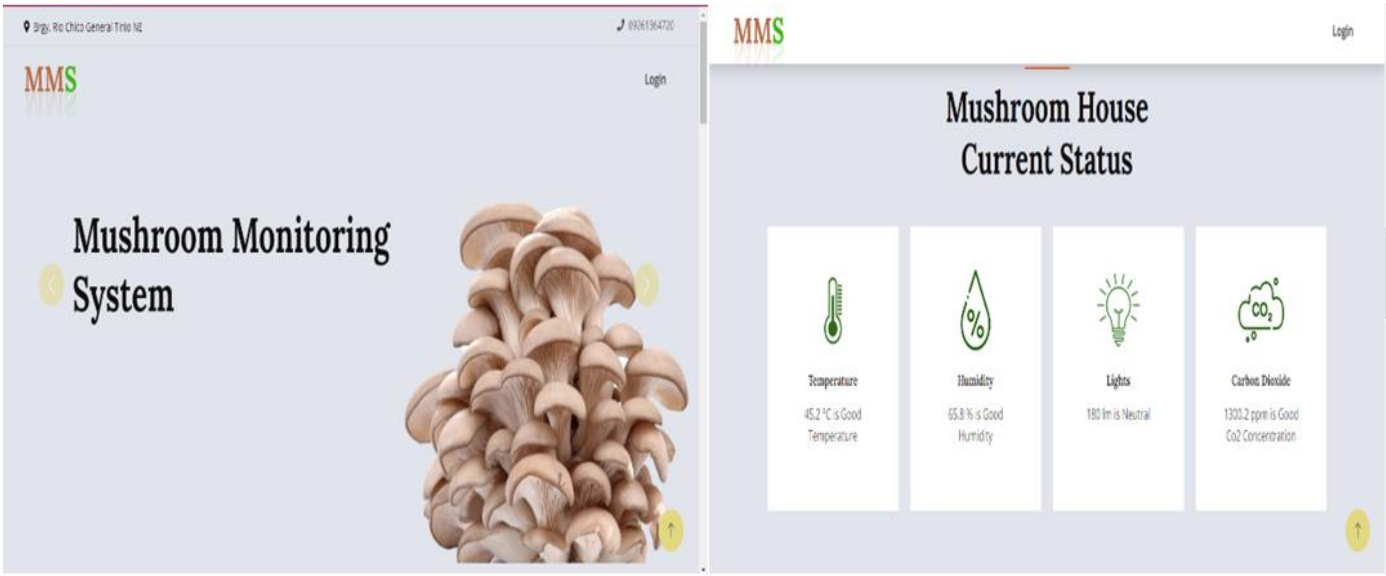

Fig 10 The Software Output

In addition to the demonstration, the researchers also created two user manuals to provide comprehensive guidance to end-users. These manuals serve as valuable resources, offering clear instructions and explanations on how to effectively utilize the system. By providing detailed documentation, the researchers aimed to ensure that users have a smooth and seamless experience with the MMS.

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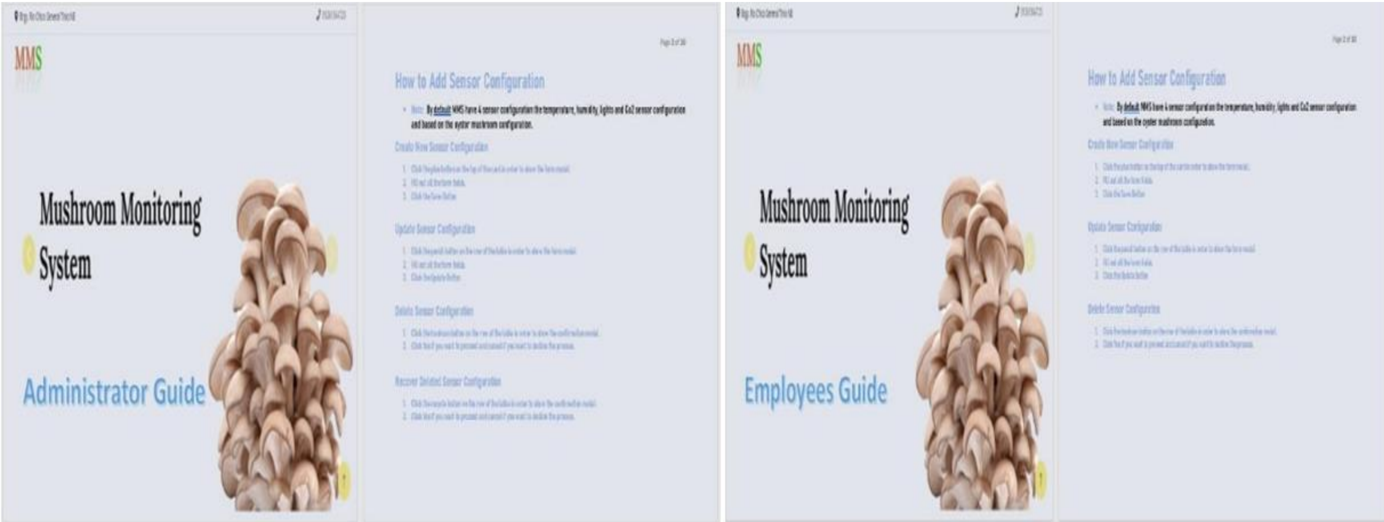

Fig 11 Users' Guide

The successful deployment marks an important milestone for the Project Monitoring System with Smart Sprinkler. With its installation on Railway Made and the availability of user manuals, the system is now ready for use by the intended users. The combination of seamless deployment, comprehensive documentation, and endorsement from experts and end-users sets the stage for efficient monitoring of mushroom growth, improved production, and streamlined farming processes in the research locale's mushroom house.

The Project Monitoring System with Smart Sprinkler received approval from both experts and end-users, confirming that it successfully achieved its goals and objectives and was deemed suitable for use in the research locale's mushroom house.

However, the experts also emphasized that prototyping of the hardware components is not enough.In order to make the Project Monitoring System with Smart Sprinkler marketable, it is essential to consider more than just its functionality and validation. Packaging and presentation are key factors that contribute to its appeal to the target audience. This involves investing in professional design services to create an attractive product, focusing on an intuitive user interface and experience, using sustainable packaging materials, establishing a strong brand identity, implementing effective marketing strategies, providing comprehensive documentation and support, and offering flexible pricing and packaging options. By addressing these considerations, the capstone project can be transformed into a market-ready product that successfully appeals to the target audience. It highlights the significance of prioritizing the overall user experience, branding, packaging, and support to enhance marketability.

IV. CONCLUSION

The development of the Web-Based Mushroom Monitoring System with Smart Sprinkler (MMS) for Mushroom House has shown great potential in improving mushroom cultivation practices. By leveraging IoT technologies and sensor devices, the MMS allows for real-time monitoring and control of environmental conditions within the mushroom house, leading to enhanced productivity and resource utilization.

The integration of smart sprinkler systems within the MMS addresses the challenge of irrigation management by automating the irrigation process based on the specific requirements of mushroom cultivation. This automation optimizes water usage, ensures consistent moisture levels, and ultimately improves crop yield and quality.

Furthermore, the MMS provides data analytics and insights through the collection and analysis of environmental conditions and crop performance data. This valuable information allows farmers to make informed decisions and adjustments to their cultivation practices, leading to increased efficiency and productivity.

Overall, the Web-Based Mushroom Monitoring System with Smart Sprinkler (MMS) offers a promising solution to optimize mushroom cultivation practices. By adopting this technology and staying informed about advancements in the field, mushroom farmers can enhance their productivity, improve crop quality, and contribute to the sustainable growth of the mushroom industry.

RECOMMENDATION

Based on the findings and the successful implementation of the MMS, it is recommended that mushroom farmers adopt web-based monitoring systems with smart sprinklers to optimize their cultivation practices. By implementing such systems, farmers can benefit from real-time monitoring, automated irrigation management, and data analytics capabilities. These advancements can significantly improve productivity, reduce manual labor, and minimize the risk of contamination.

Additionally, it is essential for farmers to stay updated on the latest research and best practices in mushroom cultivation. Continuous learning and knowledge-sharing among farmers, researchers, and experts can contribute to the ongoing development and refinement of mushroom cultivation techniques.

Moreover, further research and development efforts should focus on expanding the capabilities of the MMS. This may include integrating additional sensors to monitor other vital parameters, such as air quality and carbon dioxide levels, as well as exploring advanced data analytics techniques to provide more in-depth insights and predictive models for crop management.

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