DEVELOPMENT OF IoT-BASED AND CONTROLLED ENVIRONMENT NURSERY FOR IMPROVED GERMINATION AND GROWTH OF GARLIC

ANDRA CAMILLE B. CAGAT
REGINA JANE A. GARNACE
MARIA RUEDEN MANGAOIL
DEXTER JOHN P. PERDIDO
AEAN GABRIELLE D. TAYAWA
JANDEL JADE T. TEJADA

THESIS

Department of Computer Engineering
College of Engineering
MARIANO MARCOS STATE UNIVERSITY
City of Batac 2906 Ilocos Norte

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APPROVAL SHEET

This thesis manuscript entitled, **DEVELOPMENT OF IoT-BASED AND CONTROLLED ENVIRONMENT NURSERY FOR IMPROVED GERMINATION AND GROWTH OF GARLIC** prepared and submitted by ANDRA CAMILLE B. CAGAT, REGINA JANE A. GARNACE, MARIA RUEDEN C. MANGAOIL, DEXTER JOHN P. PERDIDO, AEAN GABRIELLE D. TAYAWA, and JANDEL JADE T. TEJADA for the degree of Bachelor of Science in Computer Engineering, is hereby endorsed.

DIONISIO S. BUCAO
Member, Advisory Committee

ARTBELLSON B. MAMURI
Member, Advisory Committee

DIANA ROSE A. TAMBOGON
Member, Advisory Committee

ALJAY B. SANTOS
Chair, Advisory Committee

_____
Date Signed

Accepted in partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Engineering.

VLADIMIR P. IBAÑEZ
Department Chair

_____
Date Signed

SHARONA Q. BARROGA
Dean

_____
Date Signed

RECORDED BY:

ANESSA M. DELA CRUZ
Research Coordinator

BIOGRAPHICAL SKETCH

Andra Camille B. Cagat was born on the 17th day of May in the year 2002. She was the youngest child of Mr. Edwin A. Cagat, a fish vendor, and Mrs. Normalyn B. Cagat, a daycare worker. She is currently residing in Purok Salucag, Dacal, Sanchez Mira, and Cagayan. Her older sister is Hannah Kaye B. Cagat, who graduated from Cagayan State University (CSU) with a degree in Hotel Restaurant Management and is currently working at the Engineering Department of our municipality.

In the year 2014, she graduated from Dacal-Pukel Elementary School with distinction. After which, she finished both her junior and senior high school at the Sanchez Mira School of Arts and Trades (SMSAT), where she excelled academically and in sparts, especially basketball, and graduated with honors.

During her junior high school years, she chose technical drafting as her main course, and she passed the National Certification II for Technical Drafting way back in 2019. Then, she graduated from Science, Technology, Engineering, and Mathematics during her senior years.

She desires to become an architect someday, but due to some circumstances, she pursued becoming an engineer at Mariano Marcos State University (MMSU), mesmerized by new technologies and robots, which led her to computer engineering. She learned different programming skills, software, and hardware and met different friends (pets aw-aw) who helped her through college years. Her family and loved ones

are her ultimate source of energy, and she is constantly reminded that her family never gets tired of giving her the best education that she could have, so there is no way to give up. All she knows is that she shouldn't give up because her family is rooting for her to become the first engineer in the family.

She is guided by the principle, *"You are here for a reason; know that things take time, and it will be okay. Trust your guts."*

ANDRA CAMILLE B. CAGAT

"Success is not final; failure is not fatal; it is the courage to continue that counts." – **Winston Churchill**

Laoag City, the capital of Ilocos Norte, stands as a vibrant and historically rich city in the northwestern Philippines. In its midst, Regina Jane A. Garnace entered the world on March 24, 2002, at Mariano Marcos Memorial Hospital & Medical Center in Batac City. She is the daughter of Jefte J. Garnace and Gina A. Garnace. She was the sole sibling born in Batac, while all her other siblings were born in Laoag City. Despite facing criticism and discrimination as she grew up due to her differing physical appearance from her siblings, these challenges only served to strengthen her resilience.

Completed her primary education at Tangid Elementary School in 2014. Her conscientiousness toward her grades deepened throughout her secondary education. In junior high school, she pursued the Basic Education Curriculum strand, a completer as an academic achiever, and in senior high school, she specialized in Accountancy, Business, and Management, ultimately graduated as an academic achiever at Ilocos Norte National High School. Her first dream is to become a teacher but in her tertiary education, her path took a new direction when she enrolled at Mariano Marcos State University, College of Engineering, to pursue a Bachelor of Science in Computer Engineering. This shift marked the beginning of an exciting journey toward fulfilling her dreams and making a lasting impact in the world of technology. During her college years, her academic excellence was recognized as an academic achiever thrice- during her 1st year, 1st and 2nd semester and 4th year, 1st semester.

The path she took was far from easy; it was paved with tears, relentless hard work, unwavering dedication, and steadfast commitment. She was clueless about what this course entailed; she wasn't even remotely familiar with anything related to it. But despite the uncertainty and the steep learning curve, she pressed on. She refused to let her lack of familiarity deter her from pursuing her dreams. With each hurdle she faced, she grew stronger and more determined. She embraced the challenges as opportunities to learn and grow, knowing that every setback was just a steppingstone on the path to success. Though the journey ahead may be daunting, she is fueled by the fire within her-the burning desire to carve out her place in this world. With perseverance as her guiding light and courage as her compass, she marches onward, ready to conquer whatever lies ahead.

REGINA JANE A. GARNACE

Tempted and challenged by mathematics, Maria Rueden C. Mangaoil enrolled in Bachelor of Science in Computer Engineering at Mariano Marcos State University in 2020. She is the daughter of Ruben M. Mangaoil and Wilhelmina C. Mangaoil, with three siblings. Born on March 18, 2002, and raised in Solsona, Ilocos Norte, also known as "Zona Del Sol". She is known for being a happy-go-lucky student. Maria Rueden not only has an interest in solving problems but also shows a strong interest in hardware, academic papers, ball games, and various musical instruments.

Maria Rueden completed her primary education at Barcelona-Aguitap Elementary School (BAES) in Solsona, Ilocos Norte. She studied at Talugtog Solsona National High School (TSNHS) in her secondary education. Talugtog Solsona National High School (TSNHS) has profoundly influenced Maria Rueden's life, shaping her into the individual she is today. It was during this period that she began to dream and challenge her academic capabilities. Together with her best friend, she aspired to achieve distinction before transitioning to college, culminating in their high school graduation with honors. In college, she was recognized as an academic achiever twice. And later in the month of May 2024, she passed her Professional Civil Service Examination. It was only recently that Maria Rueden developed her fascination with designing web applications.

Motivated by her personal awareness of the issues that farmers encountered in crop production, Maria Rueden made a significant contribution as a researcher in the study "Development of an IoT-based and Controlled Environment Nursery for

Improved Germination and Growth of Garlic." Her involvement in this endeavor aims to improve agricultural technologies while providing help to farmers.

Fueled by an intense drive to succeed, Maria Rueden aspires to a rewarding, secure work path that is marked by accomplishment and contentment.

MARIA RUEDEN C. MANGAOIL

Dexter John Pascua Perdido was born on August 6, 2002, in Antipolo City, Rizal, and currently resides in Brgy. Tabucbuc, Marcos, and Ilocos Norte. He is the son of Gloria Pascua Perdido and Carlos Jacinto Perdido. He has five siblings: Mark Louie, Louie Dexter, Maricar, Mitzi, and Minette. From a young age, he showed a keen interest in computers, which sparked his ambition to become a computer engineer.

He began his education journey at the age of five, enrolling in Tabucbuc Elementary School, where he completed his primary education in 2014. He then pursued his junior high school education at Marcos National high School (Santiago Campus) from 2014 to 2018. For his senior high school education, he attended Marcos National High School (Main Campus), where he chose the Humanities and Social Sciences academic strand, completing his studies in 2020.

In 2020, he embarked on a new chapter in his academic career by enrolling at Mariano Marcos State University to pursue a Bachelor of Science in Computer Engineering. This decision was driven by his long-standing passion for computers and his desire to delve deeper into the field of computer engineering.

Throughout his academic journey, he has demonstrated a commitment to his studies and a deep passion for technology. His experiences and education have equipped him with the knowledge and skills necessary to excel in the field of computer engineering. He believes that technology has the power to transform lives and create a better future, and he is dedicated to contributing to this transformation through his work and expertise. Consistently seeking opportunities to expand his understanding of

emerging technologies, he stays abreast of the latest developments and trends. His collaborative projects have honed his technical skills and fostered a strong sense of teamwork and innovation. Excited to leverage his expertise, he aims to tackle complex challenges and drive technological advancements that benefit society.

DEXTER JOHN P. PERDIDO

Aean Gabrielle D. Tayawa, born on May 19, 2002, in Makati, is a driven individual with a passion for technology and innovation. As the eldest son of Arleen Josie D. Tayawa and Ronald Albino B. Tayawa, Aean has been nurtured in an environment that values hard work, perseverance, and continuous learning.

Aean's educational journey has been marked by excellence and dedication. Starting from his favorite years at Bakersfield Learning Center for both kindergarten and elementary education, he demonstrated a keen interest in academics and extracurricular activities. His pursuit of knowledge continued through Josiah Christian Values High School for Junior High, where his passion for computer engineering began and flourish. Graduating with high honors from Divine Word High School, Sanchez Mira, for senior high school, Aean solidified his academic foundation. His commitment to academic excellence carried over to his college years at Mariano Marcos state University, where he pursued a Bachelor of Science in Computer Engineering. Aean's diligence and hard work were evident as he earned the distinction of being a four-time college scholar, maintaining a remarkable academic records with grades consistently below 1.75.

Aean's professional journey has been enriched by hands-on experience and the practical application of his academic knowledge. During his OJT training at Tayawa Tolentino CPAs and Company, he was tasked with creating a complex file management system for the company's portal. This experience not only honed his technical skills

but also provided valuable insights into real-world applications of computer engineering principles.

Looking ahead, Aean is determined to continue his pursuit of academic and professional growth. His future plans include pursuing a master's degree, where he aims to delve deeper into his field of study and contribute to cutting-edge research and innovation. Aean sees his undergraduate thesis as a steppingstone towards achieving his long-term aspirations, as it not only showcases his academic prowess but also demonstrates his readiness to tackle complex challenges in the field of computer engineering.

AEAN GABRIELLE D. TAYAWA

"Success is not the key to happiness. Happiness is the key to success. If you love what you are doing, you will be successful."-**Albert Schweitzer**

Jandel Jade T. Tejada was born on June 5, 2002, in Quinarayan, Narvacan, Ilocos Sur. He has always embraced the philosophy that passion for one's work leads to success. He has two siblings: Doreene Grace T. Tejada, a licensed Chemical Engineer, and Joris Dwen T. Tejada, a high school student.

His education started at Quinarayan Elementary School, where his interest in technology began. He continued at Narvacan National Central High School, in both junior and senior high. During his senior years, he focused on Science, Technology, Engineering, and Mathematics (STEM), and graduated as an academic achiever, which reinforced his enthusiasm for the field.

Recognizing his talents, he pursued a degree in computer engineering at Mariano Marcos State University. There, he engaged in a comprehensive curriculum that equipped him with various skills and knowledge. He learned programming languages such as Java, Python, Assembly, C/C++, and PHP. Additionally, he gained knowledge in database management with MySQL and MongoDB, and delved into microcontrollers and microprocessors.

During his college years, his academic excellence was recognized through academic scholarships. He was a college scholar during his 2nd year 2nd semester and 4th year 1st semester, which highlights his consistent dedication and exceptional performance.

His academic accomplishments showcase his dedication and passion for learning. His journey is marked by a relentless pursuit of excellence, driven by his love for technology and innovation. As he continues to expand his horizons, he remains committed to making significant contributions to the field of computer engineering, inspired by the belief that loving your work is the true path to success.

JANDEL JADE T. TEJADA

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Prior to completing this journey successfully, the researchers encountered a number of challenges and rewards. The researchers would want to express gratitude to:

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Engr. Diana Rose Tambogon, for also proving the researcher's guidance they needed and for sharing her knowledge about the study.

Their families, friend, and loved ones, who showed undying support financially, spiritually, and morally.

The thesis leader would also like to take a moment to express his deepest gratitude to his girlfriend, **Kimberly Mae B. Reodique,** for her endless support, patience, and love. Her belief in him and her constant encouragement have been a source of strength and motivation. Thank you, Kimberly, for always being there for him.

The researchers are truly grateful to all those mentioned; they have been the motivation for the researchers to complete the thesis.

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j.j.t.

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Definition of Terms

To facilitate the understanding of this study, different terms are defined herein:

MQTT	MQTT (Message Queuing Telemetry Transport) A lightweight messaging protocol designed for efficient communication between devices, commonly used in IoT applications to facilitate data exchange.
ESP32	A low-cost, low-power system-on-chip (SoC) microcontroller developed by Espressif Systems, widely used in IoT projects due to its versatility and integrated Wi-Fi and Bluetooth connectivity.
MongoDB	An open-source NoSQL database system designed for scalability and flexibility. It stores data in a JSON-like format, allowing for dynamic schemas and easy scalability.
Graphical User Interface (GUIs)	A Graphical User Interface (GUI) is a visual interface that lets users interact with devices or software through icons and visual elements, replacing text-based commands with intuitive graphical controls.

IoT (Internet of Things)	The Internet of Things (IoT) is a network of interconnected devices that communicate over the internet, enabling data exchange and automation across various domains.
Raspberry Pi 4	A compact, affordable single-board computer with a quad-core ARM Cortex-A72 CPU, 2GB to 8GB RAM, dual-band Wi-Fi, Bluetooth 5.0, Gigabit Ethernet, USB 3.0, and dual micro-HDMI ports supporting 4K displays. It's used for education, hobby projects, and professional applications.
Adafruit BME280	The Adafruit BME280 is a compact sensor that measures temperature, humidity, and barometric pressure. It offers high accuracy and supports I2C and SPI interfaces, making it ideal for environmental monitoring and IoT projects.
TSL 2561	The TSL2561 is a digital light sensor that measures ambient light from 0.1 to 40,000+ lux. It uses I2C, operates at 2.7V to 3.6V, and features dual photodiodes for accurate readings in various lighting conditions. It's ideal for applications like automatic brightness adjustment.
Tape Measurement	A tape measure is a flexible ruler used to measure length or distance, marked inches or centimeters.

Leaf Color Chart

A leaf color chart is a tool for assessing plant nutrient status by comparing leaf color to a standardized scale. It's used in agriculture and horticulture for optimal plant health.

ABSTRACT

CAGAT, ANDRA CAMILLE B., GARNACE, REGINA JANE A., MANGAOIL, MARIA RUEDEN C., PERDIDO, DEXTER JOHN P., TAYAWA AEAN GABRIELLE D., and **TEJADA, JANDEL JADE T.** 2024. **Development of IoT-Based and Controlled Environment Nursery for Improved Germination and Growth of Garlic**. Undergraduate Thesis. College of Engineering, Mariano Marcos State University. City of Batac 2906 Ilocos Norte. 99pp.

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Garlic cultivation faces challenges worldwide, including in the Philippines. Researchers developed an IoT-based system to optimize garlic germination by monitoring and controlling environmental factors using Raspberry Pi 4 and Esp32, along with temperature, humidity, and luminosity sensors. Data is communicated via MQTT to Ngrok for GUI-based control.

The system was tested against traditional methods using three light intensity levels: high (6.4 to 7k lumens), medium (5.4k to 5.8k lumens), and low (5k to 5.2k lumens), simulating natural sunlight with a photoperiod of 10 hours. The study found no significant differences in plant height, color of leaves, or number of leaves across these light levels. Different light intensities affect garlic germination, with low intensity yielding the most germinated garlic (73.34%), followed by medium (71.67%), and high (70.00%), compared to the less effective traditional lighting, which had 35.83% germinated garlic. This suggests the 5k to 5.2k lumens range is optimal for garlic

germination. Additionally, the IoT-based system showed significantly lower mortality rates: 26.66% at low intensity, 28.33% at medium, and 30.00% at high, compared to 64.17% with traditional methods. These statistically significant differences at the 5% level indicate consistently lower mortality rates with the IoT system across all light intensities, demonstrating its superiority in garlic germination. Optimal light intensity for germination was identified at 5k lumens.

Keywords: Optimum Lumens, Germination and Growth of Garlic, Mortality Rate, Garlic Production, IoT-based vs Traditional.

DEVELOPMENT OF IoT-BASED AND CONTROLLED ENVIRONMENT NURSERY FOR IMPROVED GERMINATION AND GROWTH OF GARLIC

Undergraduate thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Engineering from the Mariano Marcos State University, City of Batac, Ilocos Norte. Prepared under the guidance of Engr. Aljay B. Santos.

ANDRA CAMILLE B. CAGAT
REGINA JANE A. GARNACE
MARIA RUEDEN C. MANGAOIL
DEXTER JOHN P. PERDIDO
AEAN GABRIELLE D. TAYAWA
JANDEL JADE T. TEJADA

INTRODUCTION

Background of the Study

Garlic (*Allium sativum*), a member of the Liliaceae family, holds a distinguished status worldwide for its dual significance in both medicine and gastronomy.

Globally, garlic is cultivated primarily as an annual crop. Today, across diverse cultures, garlic is commonly employed as a seasoning or spice and ranks as the second most commonly used dietary supplement. Rich in sulfur compounds, essential trace minerals, and enzymes, garlic exhibits notable antiviral, antibacterial, antifungal, and antioxidant properties. While garlic can be consumed raw, it is more commonly utilized after being chopped, minced, sliced, or juiced. Furthermore, cooking garlic not only enhances its flavor but also augments its nutritional benefits (Bongiorno et al., 2008).

Despite its significance, garlic production is insufficient in many regions of the world due to genetic and environmental variables affecting yield and yield-related attributes. Garlic's development is mostly influenced by the time of planting since a short photoperiod and low temperature foster vegetative growth while a long photoperiod and high temperature promote bulb formation. The numerous growth and development features of the garlic bulb are strongly influence by the date of sowing and plant age. In most places, when winters are moderate and there is some rainfall, followed by dry summers, garlic is grown (Tomer , et al., 2018).

The agricultural industry plays a pivotal role in upholding the world's economic stability. Numerous policies have been implemented to bolster this strategic position, encompassing initiatives to attain food self-sufficiency, diminish imports, and promote exports. Among the significant agricultural commodities, garlic holds a prominent place, with every country prioritizing its cultivation and aiming to achieve self-sufficiency in garlic production by the year 2021 (Waryanto et al., 2019).

The Philippines is no exception to the challenges faced by garlic farmers worldwide. Garlic is a staple in Filipino cooking, appearing in dishes such as adobo and sinigang. Garlic also has cultural and therapeutic relevance, making it household essential in many Filipino homes. The Philippines is still far from achieving self-sufficiency in garlic production. Traditional garlic growing procedures in the Philippines mostly entail planting cloves during the wet season. However, because garlic is sensitive to environment factors, this method typically results in irregular yields (Mamaril, 2016).

As of 2018, the country's self-sufficiency rate stood at a mere 9.02% (SEARCA, 2020). Primary garlic suppliers to the Philippines include China, India, and Hong Kong. According to SEARCA (2020), local garlic varieties, although smaller in size compared to the imported counterparts flooding the market, offer superior taste and aroma.

In the Philippines, it is planted once a year on well-drained or sandy loam soil in particular locations with distinct wet and dry seasons. For the best bulb development in its early growing stage, the crop needs a cold climate (November to February), and short days are advantageous. Bulbs require a relatively dry soil, a dry atmosphere, and a reasonably high temperature throughout the maturation stage, which is primarily from March to April. Garlic is mostly produced in the Ilocos Region, with Ilocos Norte and Ilocos Sur being the two most productive provinces (Adorada et al., 2023). The country's largest producer of garlic is the Ilocos Region, which produces between 60% and 65.8% of the nation's total yield (5,10,000 metric tons) (Billedo & Paller, 2020).

Ilocos Norte has devoted 1,880 hectares, 130 hectares in Ilocos Sur and four hectares in Pangasinan while La Union has no land set aside for commercial garlic cultivation (Micua, 2017). But the amount of garlic produced and the area harvested is declining. (Lubang, 2018). It possesses a distinct comparative advantage due to its favorable agro-climatic conditions. Nevertheless, this region has witnessed a decline not only in production volume but also in cultivated and harvested areas in recent years, largely due to competitive factors (Simeon, 2020).

A native garlic cultivar found in Ilocos Norte, Philippines, is called Ilocos Pink Garlic (IPG). Though it has recently gained recognition for having modest in vivo beta-adrenergic receptor inhibitory effect, not many research have described its genetic and metabolic profile to set it apart from other types of garlic (Relacion et al., 2023). In Ilocos Norte, Ilocos Pink (IPG), also referred to as "*gameng*," is distinguished by its pink cloves and white skin with brown striations on the outside. It is one of the garlic varieties from the Philippines with a distinct maturity period and skin tone (BPI-NSIC, 2021). Ilocos Pink can significantly produce higher survival rates (%) and bulb yield per hectare (kg) and these varieties are recommended for bulb production (Elias & Camalig Jr., 2023).

The rising global population has intensified the difficulties in food production and prompted agricultural systems to adopt the Internet of Things (IoT) in lieu of traditional methods (Afzali et al., 2021). The advent of wireless communications, coupled with the rise of cloud computing, widespread sensing, and the utilization of

big data, has brought about transformative effects on every facet of our daily existence (AlKameli & ElMedany, 2021).

The Internet of Things (IoT) has emerged as a revolutionary force in agriculture, enabling the real-time monitoring and control of environmental variables. By integrating IoT sensors, data analytics, and automation systems, it becomes possible to create a controlled environment nursery designed for the production of garlic. This system offers precise management of crucial factors such as temperature, humidity, and light, ensuring the ideal conditions for the healthy development of garlic germination.

This research project has the goal of exploring and developing an IoT-driven controlled environment nursery tailored specifically for garlic cultivation. The system will employ IoT sensors to continually observe and gather data on the environmental conditions within the nursery. Furthermore, the project will investigate the potential benefits of this technology-driven approach, including enhanced resource efficiency and increased yield.

This study has the potential to revolutionize agriculture by providing the opportunity for exact monitoring and control of critical growing conditions.

Objectives of the Study

In response to the challenges faced in garlic cultivation, this study aimed to develop an IoT-based and controlled environment nursery tailored for the germination and growth of garlic.

The objectives of this research include:

1. To develop an IoT-based controlled environment nursery for germination and growth of garlic.
2. To develop a web application and mobile application for the IoT-based System.
3. To determine the optimum lumen (light intensity) for the germination and growth of garlic.
4. To evaluate the mortality rate of the IoT-based system with traditional garlic cultivation method.

Significance of the Study

The result of this study aimed to benefit the following:

Farmers. IoT-based and controlled environment nurseries can help farmers grow more garlic, of higher quality, and with less environmental impact.

Consumers. Consumers benefit from a more reliable supply of high-quality garlic, leading to improved culinary experiences. The consistent availability of fresh garlic enhances the overall quality of food products.

Advancement in Agricultural Technology. This research contributes to the ongoing advancement of agricultural technology by incorporating IoT (Internet of Things) technology into the cultivation of garlic. It showcases the potential for technology-driven solutions to improve crop production.

Educational Value. The study can serve as a valuable educational resource for agricultural students, researchers, and practitioners. It can inspire further research and innovation in the field of IoT-based agriculture.

Scope and Delimitations of the Study

The study was conducted at the Garlic Research Center and Food Laboratory of Mariano Marcos State University, City of Batac, Ilocos Norte, Philippines. The researchers designed and developed an IoT-based system to monitor and control the environmental conditions essential for the germination and growth of garlic, such as temperature, humidity, and light. The developed nursery was equipped with sensors that were developed to create a control algorithm to maintain the desired environmental conditions in the nursery. A user interface was also developed to monitor and control the system.

The study excluded the phases beyond germination. For a duration of one month, data collection was focused on the germination and growth of garlic until the regular garlic plants reached a growth stage considered appropriate for the study's purpose.

REVIEW OF LITERATURE

This chapter includes three sub-headings: the literature and studies and conceptual framework.

Literature and Studies

According to a study Khokhar (2023), garlic bulb development is influenced by a variety of factors, including cold conditioning, temperature, photoperiod, plant population, clove weight, soil nutrients, irrigation, plant growth regulators, and genetic responses. Garlic growers perceive their livelihoods to be vulnerable to climate variability. They employ a variety of coping strategies, but the most common is irrigating the land more during dry season using water pumps. Age and farming experience have a significant relationship with the coping mechanisms employed (Declaro-Ruedas, 2020).

A study also shows that storage temperature affects the quality of garlic, including biochemical quality, such as alliinase activity. Volatile Organic Compound (VOC's) can be used as molecular markers to assess garlic quality, with four Volatile Organic Compound VOC's) (azulene, octanal, o-Xylene and 4-methylhexadecane) being significantly associated with alliinase activity (Ludlow et al., 2021).

According to the study by Atif et al. (2019), photoperiod and temperature combinations significantly affect garlic growth and bulb quality. Longer photoperiods

(14 or 16 hours) and higher temperatures (25 or 30 degrees Celsius) resulted in the largest bulbs with the shortest growth period. However, the highest bulb weight was obtained with a 12-hour photoperiod.

Pre-planting low temperature storage and period length of seed cloves can significantly affect the bulbing process of garlic genotypes. The best treatment for increasing internal sprout length and internal sprout growth rate was 10°C for 30 days. In the field, garlic "clone17" at 15˚C for 30 days gave the best results for increasing the germination. The highest increase in yield was obtained with garlic, cv. "Egaseed1" at 15˚C for 15 days and at 10˚C for 21 days of garlic "Clone17". The heaviest clove weight was obtained when garlic bulbs of the two tested genotypes were stored at 10˚C for 30 days before planting (Youssef, 2013).

In terms of nutritive quality, the study found that the highest levels of total soluble solids (TSS), soluble protein, soluble sugar, total sugar, glucose, sucrose, fructose, starch, total phenols, and total flavonoids were obtained with a 14-hour photoperiod and 30 degrees Celsius temperature. These increases were correlated with bulb characteristics and bulbing index.

Overall, the study found that the best combination of photoperiod and temperature for garlic growth and bulbing is 14 hours and 30 degrees Celsius, respectively. However, the optimal combination may vary depending on the cultivar.

The findings of this study have important implications for garlic growers. By understanding the effects of photoperiod and temperature on garlic growth and

development, growers can adjust their management practices to produce high-quality garlic bulbs.

IoT-Based Nursery Management System

Naik et al.,(2021) discusses an IoT-based nursery management system designed to maintain optimal weather conditions for plant growth. The system automates the control of temperature and humidity, reducing human intervention and improving plant health. The tiny plants are grown in the nursery, and hence, the health of the plant plays an important role. The nursery, tissue culture areas are providing farmers good yielding plants. A user-friendly interface for IoT applications in agriculture. The study emphasizes the development of web and mobile applications that allow farmers to remotely monitor and manage nursery conditions.

Impact of Environmental Conditions and Cultivation Methods

A study by Kaur et al,.(2023) provides a comparative analysis of an IoT-enabled smart vertical farming system using hydroponics with traditional cultivation methods. The study concludes that the IoT-based system demonstrates better plant production, suggesting a lower mortality rate compared to traditional methods.

Figure 1. Germinated Garlic Cloves at 7 to 14 Days

Garlic is grown from cloves and requires short and cool days at the start of growth and long and warm days nearer harvest. Garlic cloves will germinate in 7 to 14 days at a temperature of 55°F. The optimum soil temperature for growing garlic is between 45°F and 85°F (7-29°C). Full sun exposure is recommended for the best bulb development as shown in Figure 1 (Albert, 2024).

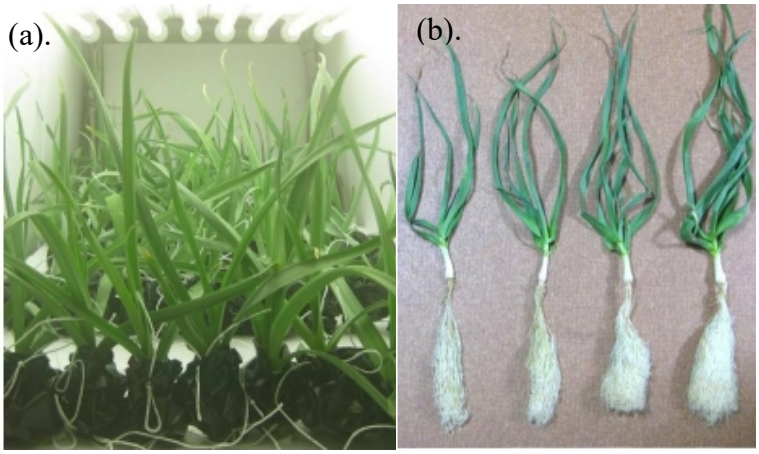

Figure 2. Garlic Plants taken (a). 40 days after plantation at 460 µmol m^{-2} s^{-1}, and (b). 2 months at different light intensity levels

Light is an important factor in limiting plant growth as shown in Figure 2. Plants require light for photosynthesis and to control many hormonal and morphological changes in the plant. The fresh and dry mass accumulation of garlic plant increased significantly with an increase in light intensity levels from 75 to 460 µmol m^{-2} s^{-1}(Naznin et al., 2015).

Figure 3. Characteristics of Garlic Leaves

The number of leaves on a garlic plant can vary depending on the variety and growing conditions. Typically, a mature garlic plant has several leaves, usually ranging from 5 to 7 as shown in Figure 3. These leaves emerge from the base of the plant and contribute to its overall growth and health. Garlic leaves exhibit distinct color changes during different growth stages. Early growth stages: The leaves are green as the plant focuses on vegetative growth. Later stages: As the garlic plant matures, the leaf color may transition from pale green to a deeper dark green. Yellow and brown hues may also appear, especially as the plant prepares for bulb formation (Franklin, 2023).

The length of garlic leaves varies based on the variety and environmental factors. On average, garlic leaves can be anywhere from 30 to 60 centimeters (12 to 24

inches) long. The width of the leaves typically ranges from 5 to 7 centimeters (2 to 3 inches). Longer leaves contribute to better photosynthesis and overall plant vigor (Wikifarmer, 2024).

IoT-based Automated Greenhouse with Monitoring and Control using MQTT Protocol

According to Baccay et al. (2021), an efficient and controlled environment for plant growth is created by combining traditional agriculture with new technologies in an IoT-based automated greenhouse. It combines sensors (such light, humidity, temperature, and CO2 sensors), actuators (like watering systems, fans for forced air circulation, and shade screens), and controllers (microcontrollers like Arduino or Raspberry Pi). Together, these elements maximize crop growth, minimize resource usage, and provide remote monitoring and control. Efficient communication between devices is made possible via the MQTT protocol, which guarantees real-time modifications based on sensor data. Precision farming, data-driven decision-making, and sustainable practices are some of the advantages of IoT-based greenhouses, despite several drawbacks (reliability, security, and expense). As you learn more about this subject, take into account real-world applications and case studies.

Conceptual Framework

Figure 4 depicts the study's conceptual framework, which has the Input, Process, and Output. Input discusses about the challenges and gaps of the study. In Process, Phase I demonstrates thorough planning and design. Phase II depicts the system development, wherein researchers developed and integrated the software and hardware of the system and configured the Cloud MQTT. In Phase III, the researchers prepared and planted the garlic cloves and test the system first. Phase IV then proceed to implementation of the developed system and evaluation. Lastly, the output or result of the system will address the problem.

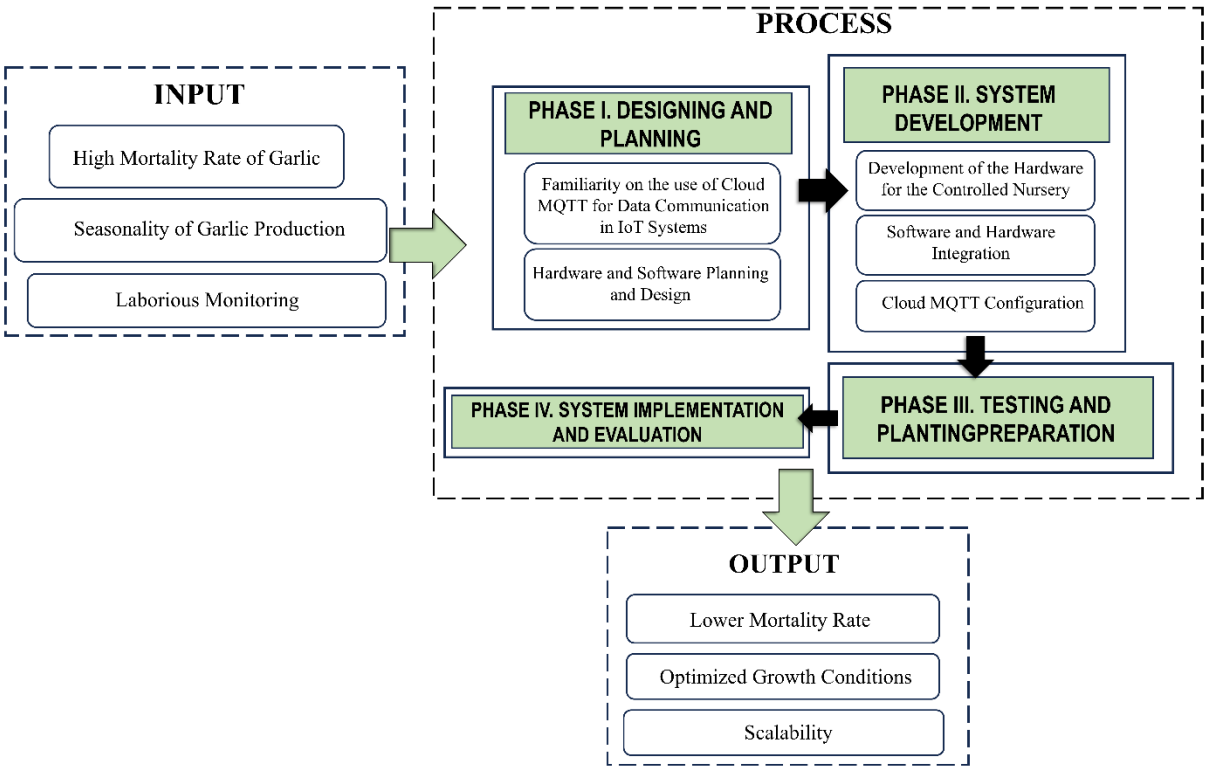

Figure 4. Conceptual Framework

METHODOLOGY

This chapter explains in detail the procedures in conducting the research. It includes detailed discussions of the research design, explanation of variables, description of experimental materials, sampling procedures, description of research instrument used, steps in collecting data and the methods of analyzing the data (Agustin, *et al.,* 2001). This section includes the locale of the study, the research design, the variables of the study, a broad outline of the experimental procedure, data gathering procedures, and how the data were analyzed (Agustin and Ocampo, 2002).

Locale of the Study

The researchers conducted mock testing at the Crops Research and Laboratory - Food Laboratory of Mariano Marcos State University, City of Batac, Ilocos Norte, Philippines, as shown in Figure 5. This shows the map of the Garlic Research Center-Food Laboratory where the study was developed, conducted and evaluated.

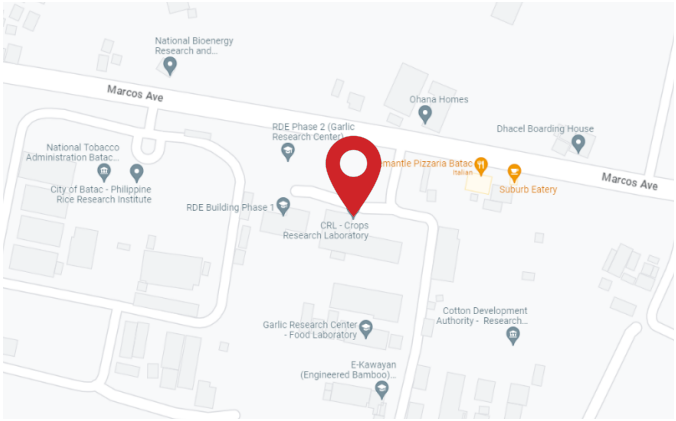

Figure 5. Google Map of the Garlic Research Center

Design Procedure

The design procedure of the study involves several phases that include system design, system block diagram and materials selection. The purpose of the design procedure is to create a system that is capable of automating and controlling the environment nursery for the germination and growth of regular garlic. To achieve this, the conceptual framework was developed, which outlines the different phases of the system's design.

This section of the paper discussed how each system's phases relate to different requirements and materials.

Design and Planning

The designing and planning stages are the first steps in the development process of the study. The researchers began by determining and defining the problem, solutions, outputs, and the capabilities of the system. Second, the researchers looked at existing recent studies and methodologies that helped develop the system. The researchers also familiarize the Cloud MQTT for data communication in IoT systems.

Below is the detailed plan for development of hardware and software, including specifications and design considerations.

Hardware

Figure 6 shows the final design and planning of the rack. Each of the four layers of the rack utilizes a grow light and a varying height for the study treatment. Additionally, microcontrollers and a relay are installed on top of the rack. A light sensor has been attached to the first layer of the racks.

Figure 6. Design and Planning for Rack

Moreover, Figure 7 shows the design and planning for the temperature. The researchers also mounted a shelf for the humidity and temperature sensor.

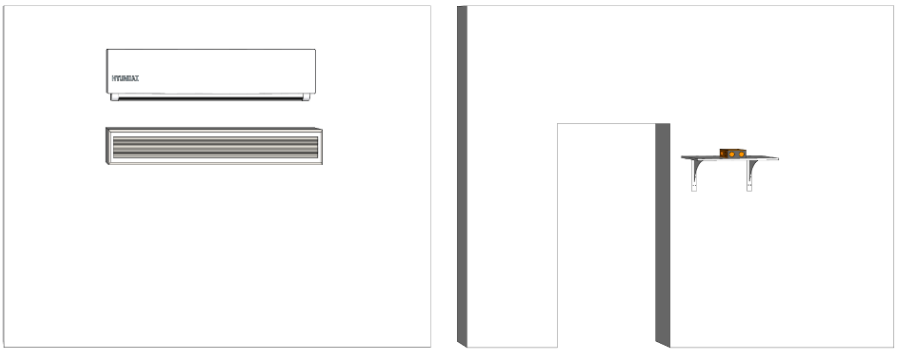

Figure 7. Design and Planning for the Temperature of the Nursery

Actuators like air conditioning and grow lights are also included in the system to regulate the lumen, photoperiod and temperature of the nursery. The researchers also

installed LCD monitoring and control outside of the nursery as an additional option for the users. The researchers created a user-friendly application that allows users to monitor and control the nursery's environment.

Software

Figure 8 illustrates the storyboard of the web and mobile applications. The application requires users to log in and register before proceeding to the homepage.

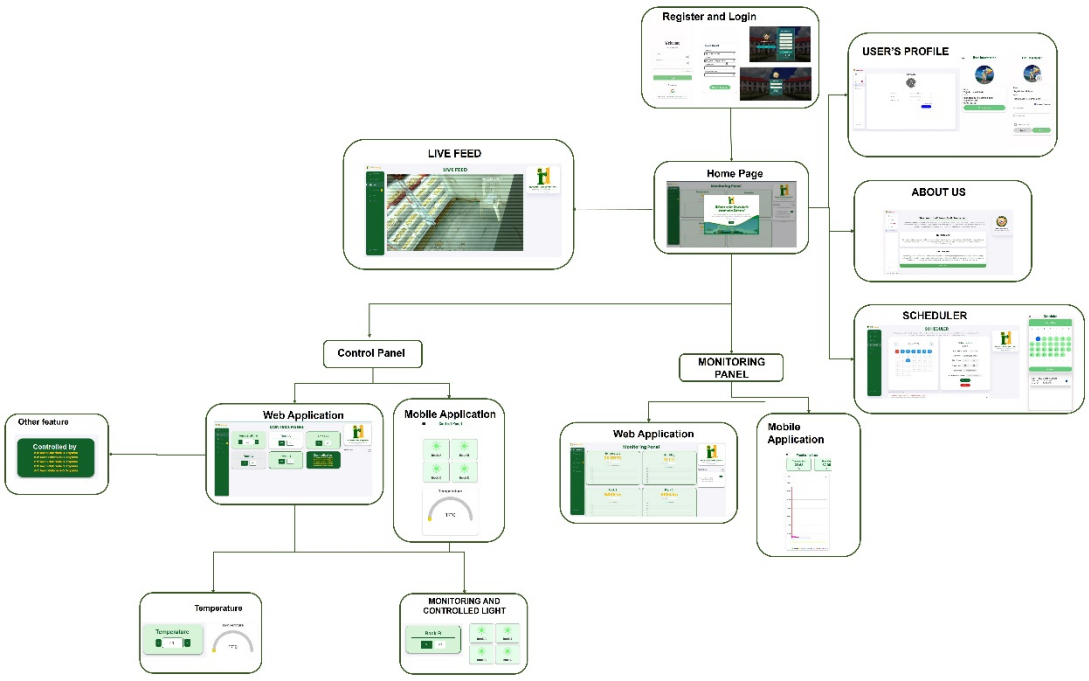

Figure 8. Applications' Story Board

Finally, the homepage includes the monitoring panel, control panel, live feed, user's profile, about us, and scheduler. The story board assisted the researchers in developing the application's functionality and design.

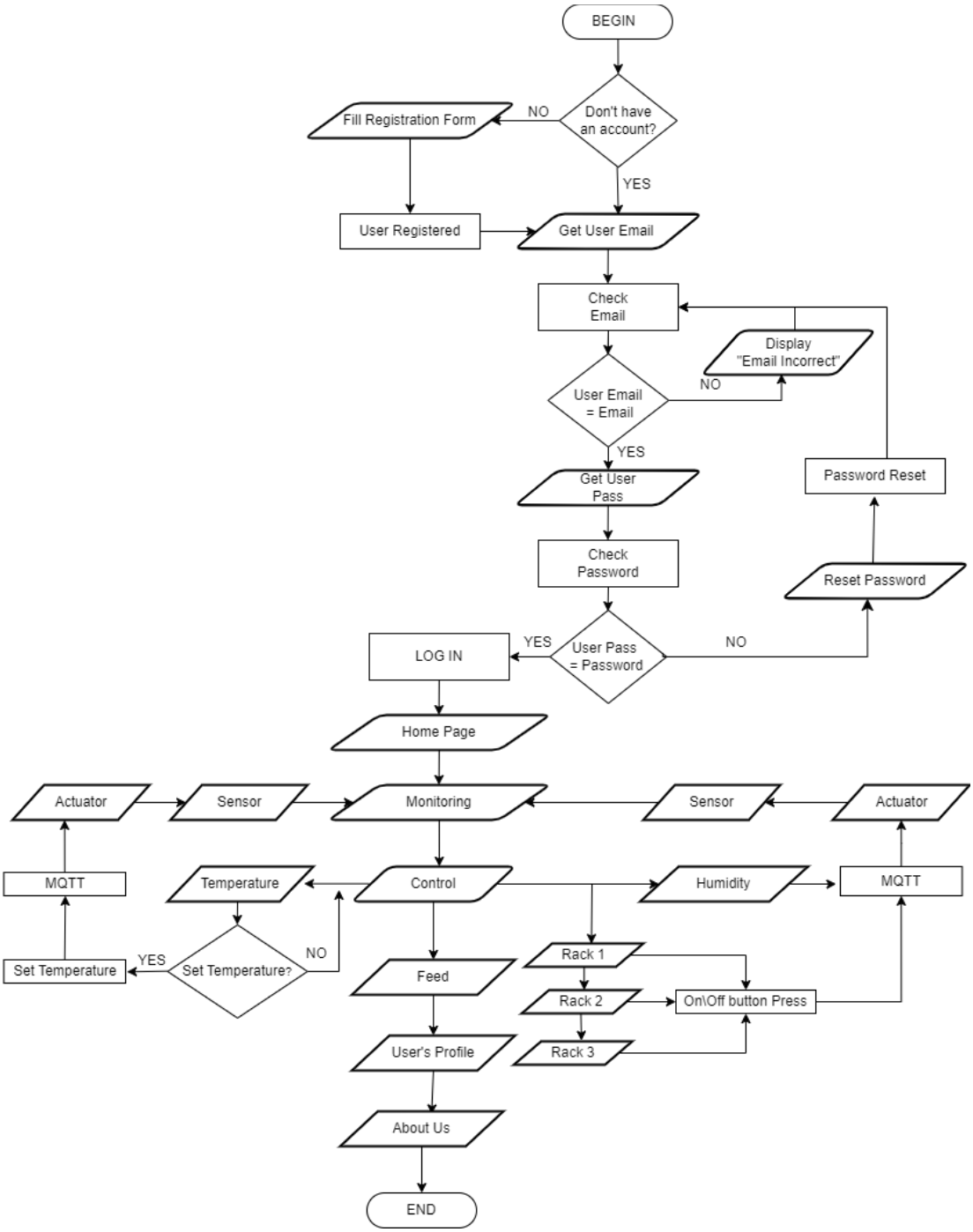

Figure 9. Front-End General Flow Chart

Figure 9 displays the front-end general flowchart for both the web and mobile applications. The flowchart below was designed by the researchers to help the users

comprehend the functionality of the system. This served as a manual outline of how the system functions.

Back End Component Software

The researchers offered a concise and illustrative explanation of the structure and relationships between data in the database with the help of the database design schema flowchart, as shown in Figure 10. The flowchart has tables where the data is stored.

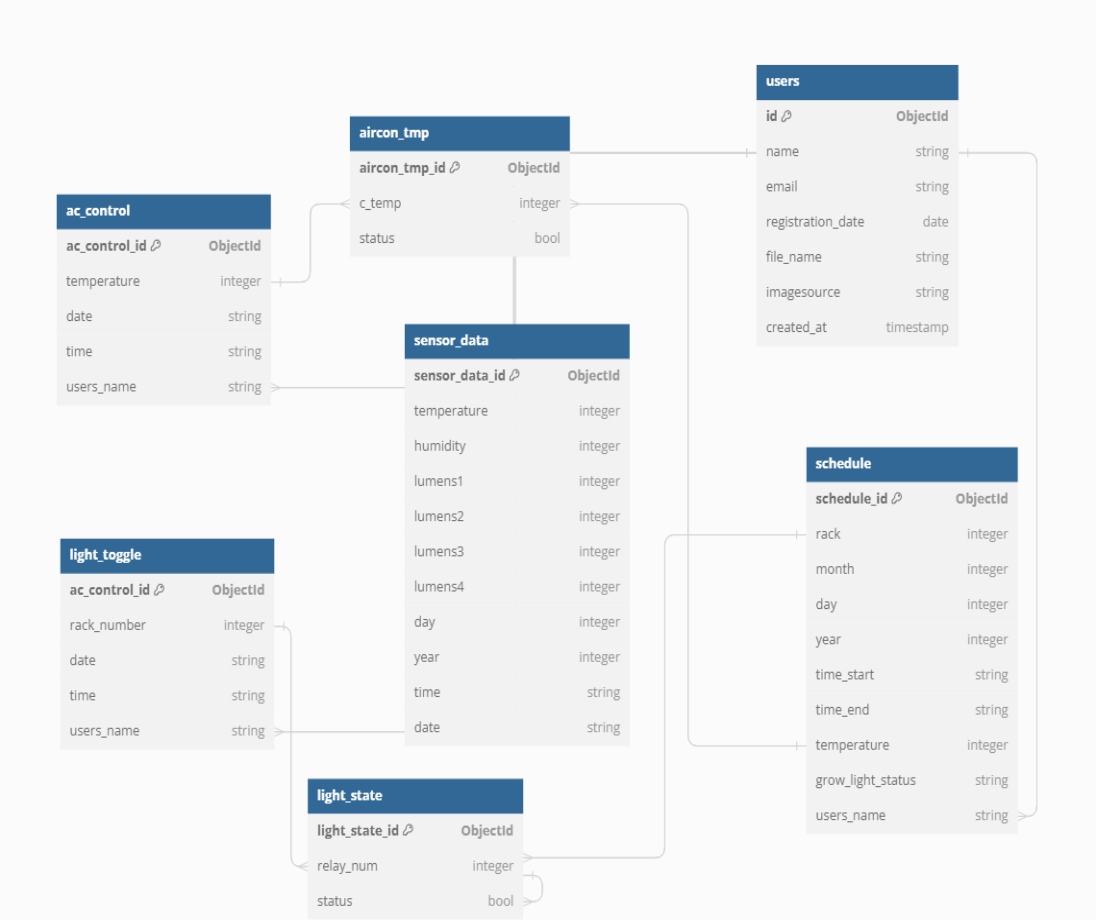

Figure 10. Database Design Schema Flowchart

Mobile Application Software

Figure 11 displays the case diagram of the mobile application. This study's case diagram is designed to illustrates the interactions between users and the system. Also, it demonstrates the high-level functions and scope of the system.

Figure 11. Case Diagram of Mobile Application

As presented above, it shows the actors and the events that were involved within the system. Users were asked to register and log in on the website to access the homepage. Also, the user had access to the entire system's control panel and can track all gathered data by viewing the monitoring panel.

System Development

The next phase is the system development**.** This phase describes how the hardware and software components were built. It also deals with how the researchers fabricated the system, which consists of temperature and humidity sensors, and light sensors. To further understand this phase, the researchers explained below how the system was developed.

Development of the Hardware

The circuit diagram of hardware shows in Figure 12.

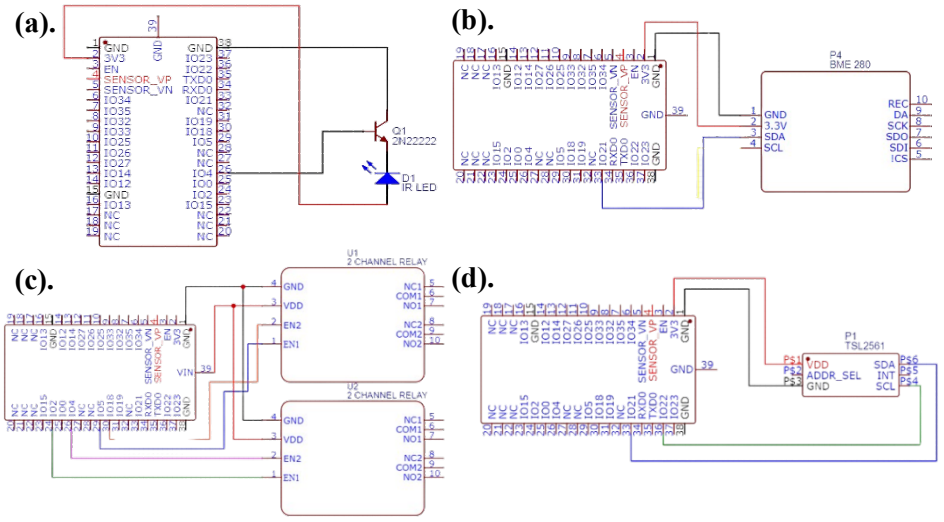

Figure 12. Actual Circuit Diagram of Hardware (a). the remote control of the air conditioner, (b). the sensor for the temperature and humidity,(c).controlled grow lights, and (d). the sensor for the lumen of the controlled nursery

Four ESP32s and a Raspberry Pi 4 were used as the primary units for the system that the researchers developed. The researchers also employed an Adafruit BME280 temperature and humidity sensor for assessing the nursery's temperature. Finally, the researchers equipped a TSL 2561 sensor to identify garlic's lumens.

Software and Hardware Integration

The system block diagram for the ESP32, Raspberry Pi 4, and its peripherals is shown in Figure 13. The user interface is designed, and then it interacts with the user interfaces of the web and Android applications to allow users to access the internet via those applications. The applications communicate with the MQTT Server to be able to transmit commands and acquire data. The MQTT Server managed the Raspberry Pi and cloud hosting.

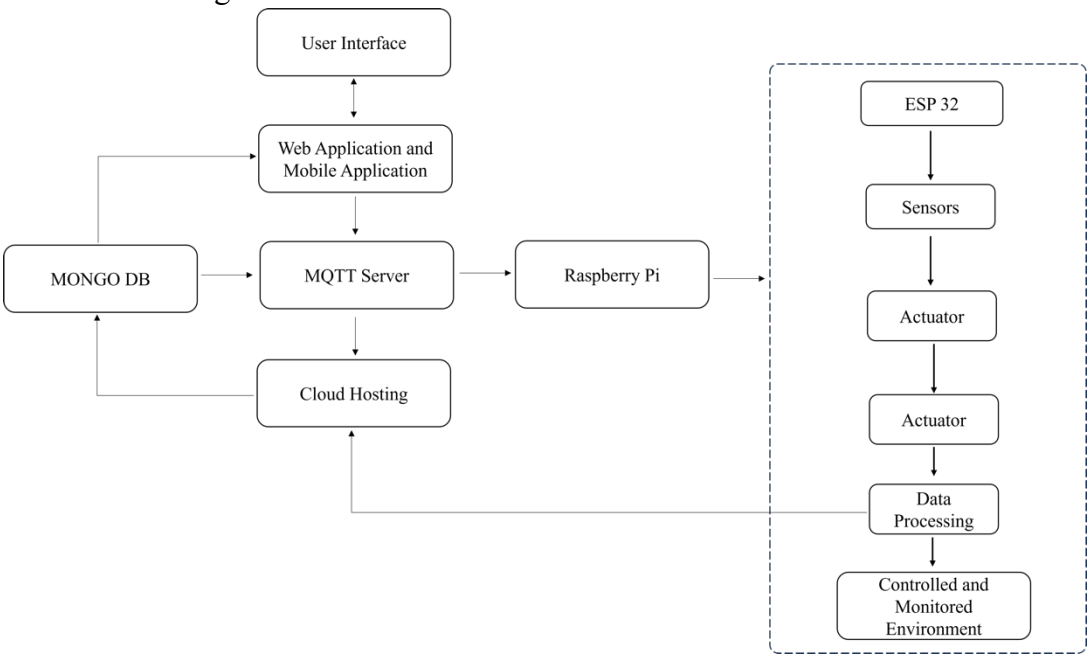

Figure 13. System's Block Diagram

Thus, to be able to collect the data, monitor and control the environment of the nursery, the microcontroller (ESP32) and its peripherals such as relay, IR transmitter, light sensors, and temperature and humidity sensor are connected to the Raspberry Pi. The researchers installed sensors on the racks to gather the data. When the data is processed, it is sent back to the cloud and stored on MongoDB. The stored data in MongoDB can then be viewed by the users through the web application and mobile application.

Testing and Preparation

The third phase is for the preparation and testing of the system. The researchers test the system first to ensure its functionality. After testing, the researchers prepared the needed resources for planting the garlic seeds. Below is a detailed explanation of the researchers testing and preparation.

System Testing

The researchers firstly test the system in order to ensure that the system operates properly, the researchers conducted observation and functionality testing.

The researchers examined the sensors and microcontrollers for 24 hours to inspect their functionality. Also, they observed for 24 hours the ranges of the lumen for each variety of rack and the traditional. Functionality testing aims to evaluate the

sensors capacity to precisely measure parameters of the environment, such as temperature, humidity, and lumens. Furthermore, the observation testing is intended to assess the system ability to function for a long period of time. The researchers ensured that the system hardware and software were effective and dependable for the user. Following system testing, the integrated hardware and software are deployed in the nursery.

The researchers monitored and maintained the conditions in the nursery once a day and made adjustments as needed to ensure that the garlic were getting the temperature, lumens, and humidity they needed. The nursery is deployed with a web camera and sensors to monitor the temperature, lumens, and humidity, respectively.

Preparation and Planting Garlic Seeds

In preparation for the planting, the researchers first asked farmers and researchers at CRL about the traditional way of planting the garlic. Firstly, the researchers prepared a ratio of 2:1:1 needed soil for planting: two (2) parts ordinary garden soil (topsoil), one (1) part carbonized rice hull, and one (1) part organic fertilizer with a nitrogen (N) range of 200-250 mg/kg, a phosphorous (P) range of 50-70 mg/kg, and a potassium (K) range of 86-132 mg/kg and put it on a container. After preparing the soil, the researchers soaked the garlic clove overnight. Finally, after soaking the cloves, the researchers now plant the cloves in a container with a length of 41 cm, a width of 25 cm, and 15 cm of a base with a soil depth of 9.5 cm, and put all the

containers in the nursery. Also, the nutrients in the soil for both the controlled nursery and the traditional are the same for the precise evaluation of the effectiveness of the system.

System Implementation and Evaluation

The last phase is for the implementation and evaluation of the system. After the testing and preparation phase, the researchers implemented and evaluated the system. Below is a detailed explanation of the researchers testing and preparation.

Implementation of the System

The researchers made a partnership and implemented the study in the Crop Research Laboratory (CRL) at Mariano Marcos State University, as depicted in Figure 14.

Figure 14. MMSU R&D CRL

The collaboration with CRL provided the researchers with garlic seedlings, a location, and resources necessary to develop the system.

System Evaluation

The system evaluation pertains to the data gathered within the controlled nursery environment.

The researchers implemented three treatments in the controlled nursery with 30 samples per rack to determine the optimum lumen required for germinating garlic and planted 30 samples of garlic cloves outside. The treatments are differentiated as low with an intensity range from 5k to 5.2k lumens, medium with a range from 5.4k to 5.8k lumens, and high with a lumen range of 6.4k to 7k lumens. The differentiated light intensity level is based on the measured lumen in the greenhouse outside for the traditional garlic cultivation method. The height, color, and number of leaves per rack and the number of germinated garlic are the parameters for calculating the light intensity level needed for garlic growth. To evaluate the mortality rate, the researchers compared the controlled nursery mortality rate to the traditional garlic cultivation method in the greenhouse available at Crop Research Laboratory.

Figure 15. Tape Measurement

To determine the height of the garlic leaves, the researchers collected precise measurements using the tape measure depicted in Figure 15. To guarantee that the garlic varied in height and numbers of the garlic germinated, the researchers collected data once a week.

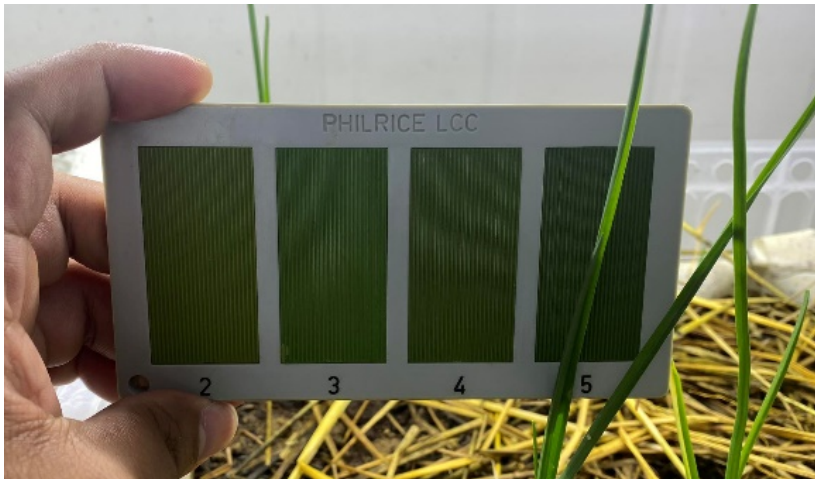

Figure 16. Leaf Color Chart

In order to determine the precise color of the garlic leaves, the researchers also employed the leaf color chart, which is depicted in Figure 16. On a scale of 1 to 5, the garlic is shown as unhealthy in points 1 and 2, as healthy in points 3 and 4, and as healthiest in point 5.

Fabrication

This section contains the design specifications and 3D model, cost-estimates and the Gantt Chart for the development of the system.

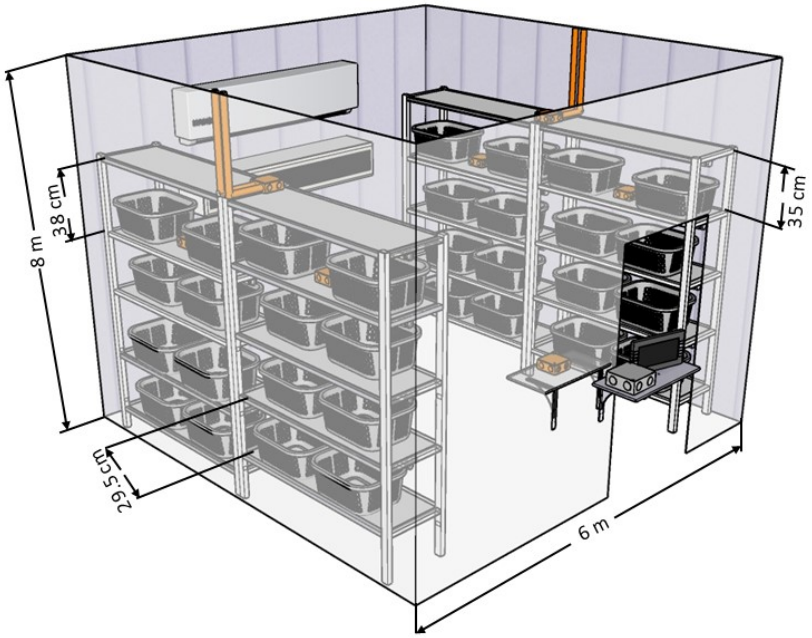

Figure 17. System's Specification and Design

The system's specifications and design are presented in Figure 17. To implement the study, the researchers developed the system in the nursery. The nursery has an 8-meter height and 6-meter width. The nursery is equipped with sensors, actuators, racks, an LCD display, and containers.

To evaluate the optimum lumen, the researchers decided to use racks to further utilize the space of the seed bank in the CRL. The rack has been classified as low with a height of 38 cm, medium with 35 cm, and high with 29.5 cm. The height of the rack is based on the measured lumen in the greenhouse outside for traditional cultivation method. To equip the necessary parts for the development, the storage shelf is

constructed of metal. The sensor is placed below the grow light, and the humidity and temperature sensors are mounted in front of the air conditioner.

Each rack can accommodate 8 containers and can be planted with 15 samples per container. The rack has 120 cloves of garlic planted. Also, the LCD display is mounted outside of the nursery for additional monitoring and control by the users.

The aim of the designed nursery is to develop a system for the germination and growth of garlic.

COST OF MATERIALS USED FOR THE THESIS STUDY

Table 1 presents the prices for the acquired materials and software used necessary for Developing the IoT-based and Controlled Environment Nursery for Germination and Growth of Garlic. The materials listed below were for the development of the study.

Table 1. Cost of materials used for the thesis study

MATERIALS	QUANTITY	UNIT COST	TOTAL COST
ESP32	4	₱ 205.00	₱ 820.00
Raspberry Pi 4	1	₱3,799.00	₱3,799.00
Adafruit BME280	1	₱ 1,300.00	₱ 1,300.00
TSL2561	4	₱ 465.00	₱ 1,860.00
IR Transmitter	1	₱ 14.00	₱ 14.00
2N2222 Transistor	1	₱ 20.00	₱ 20.00
Electrical Wires	10 m	₱ 250.00	₱ 250.00
Grow Light	16	₱750.00	₱ 12,000.00
Air conditioner	1	₱22,999.00	₱22,999.00
Relay	4	₱145.00	₱580.00
Junction Box	1	₱185.00	₱185.00
PVC Pipes	13	₱35.00	₱455.00

PVC Hose	10 m	₱15.36	₱153.60
Pipe Adaptors	14	₱35.00	₱490.00
Rack	4	₱1,450.00	₱5,800.00
Ngrok Hosting	1	₱5,600.00	₱5,600.00
LCD	1	₱1,965.00	₱1,965.00
Web Camera	1	₱1,000.00	₱1,000.00
Sprayer	2	₱145.00	₱290.00
Internet Modem/Router	1	₱209.00	₱209.00
Electric Bill	Monthly	₱2,840.40	₱2,840.40
Maintenance Fee		₱11,520.00	₱11,520.00
TOTAL:			**₱74,150.00**

Gantt Chart

Figure 18 shows the Gannt chart of the development of the system. It shows the timetable in developing the system including researching and finding hardware that will be used.

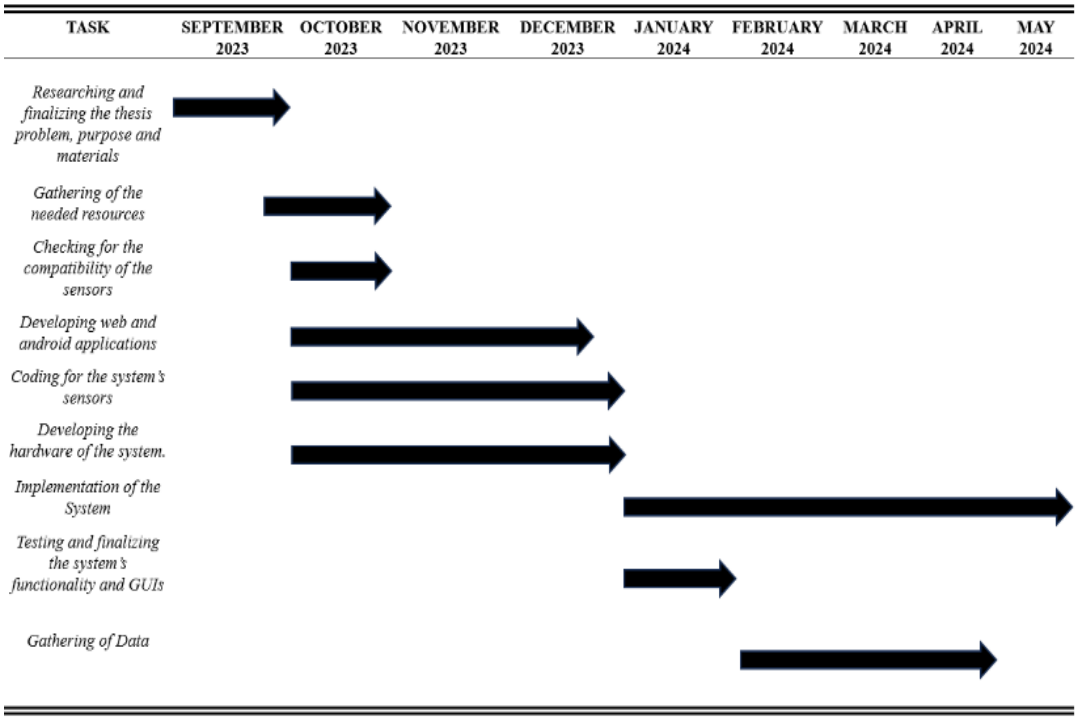

Figure 18. Gantt Chart

The Gantt Chart for the development of the system from temperature, humidity and lumen training through testing and data gathering is shown in Figure 18. The system's development began in early September 2023. This involved developing the systems hardware and software until May 2024.

The development of the system's hardware was conducted at the Crops Research Laboratory - Food Laboratory of Mariano Marcos State University in October 2023 until the end of December. Testing and finalizing the system's functionality and GUIs were done from January 2024 to February 2024. Lastly, the data gathering began in February 2024 until April 2024.

Testing Procedure

This section contains all of the methods utilized to acquire the study's data, as well as all of the conventional testing techniques, tools, and equipment's.

Data Gathering Procedures

All the data required for the system was gathered using a variety of procedures. These are the methods, such as:

Observation. The researchers recorded the data on environmental conditions, crop growth, and any issues or challenges faced.

Statistical Analysis. The researchers conducted statistical analysis at various phases of the data collection process to extract valuable insights, make data-driven decisions, and contribute to the overall objectives of the research.

Functionality Testing. To ensure that the software and hardware are functioned together effectively, the researchers managed the growing environment for a full day. In addition, the researchers continuously recorded temperature, humidity, and light levels in the growing environment.

Data Analysis

This part discusses the statistical measures, tests, and other analysis that were used in the study. Moreover, this section presents the formulae of statistical tools, legend of symbols in the formulae, and the manner of how data were presented and interpreted.

Statistical Tool

In evaluating the effectiveness between the IoT-based and controlled nursery in the germination and growth of garlic and the traditional method, the researchers first determined the required intensity for germination using ANOVA F-STATIC.

$$F = \frac{MSB}{MSW} \tag{1}$$

Where:

MSB = variability between traditional method and controlled nursery means

MSW= the variability within each nursery.

If the result of the ANOVA F-Static Test is significant at the 5% level, then the Least Significant Difference (LSD) Test is used. Least Significant Difference (LSD) Test performs pairwise comparisons to assess if there are significant differences between the groups.

To assess the influence of an IoT-based controlled environment nursery on garlic growth compared to the traditional method the statistician used the ANOVA F-STATIC and mortality rate. In the study of KARABULUT & GÖKÇE (2022), they use the same formula to determine the resistance level of some onion cultivars or inbreed lines.

$$MR_j = \frac{DS_i}{IP} \times 100\% \quad (2)$$

Where:

DSi = number of dead seedlings

IP = initial population

This statistical approach helped the researchers identify which of the controlled nursery and traditional methods that were tested were critical for optimizing garlic growth.

RESULTS AND DISCUSSION

This chapter discusses the processes that led to the realization of the objectives of the study. A thorough discussion of the developed system and its features and the results and interpretation of the data gathered is also included.

Developed IoT based and Controlled Environment Nursery for Germination and Growth of Garlic

Garlic is an annual crop grown throughout the world. Since it is grown on an annual basis, farmers and consumers face a number of challenges, including rising local garlic costs, limited production, and adverse weather conditions (Adorada, et al., 2023). Thus, the researchers have developed an IoT based and controlled environment nursery featuring multiple essential elements illustrated in Figure 19. To begin with, the Raspberry Pi 4 and Esp32 are utilized as the nursery's main processing units. Furthermore, the Adafruit BME280 temperature and humidity sensors, as well as the TSL2561 Digital Sensor Breakout (luminosity sensor) with relay, are connected to the Esp32 to obtain accurate temperature, humidity and lumen measurements.

Also, Raspberry Pi is a hardware platform that can run software applications; it will serve as an edge device, collecting data from sensors, processing it, and communicating with the rest of the system via Message Queuing Telemetry Transport

(MQTT), a lightweight messaging protocol designed specifically from the Raspberry Pi to Ngrok, which can execute commands via the Graphical User Interface (GUIs).no

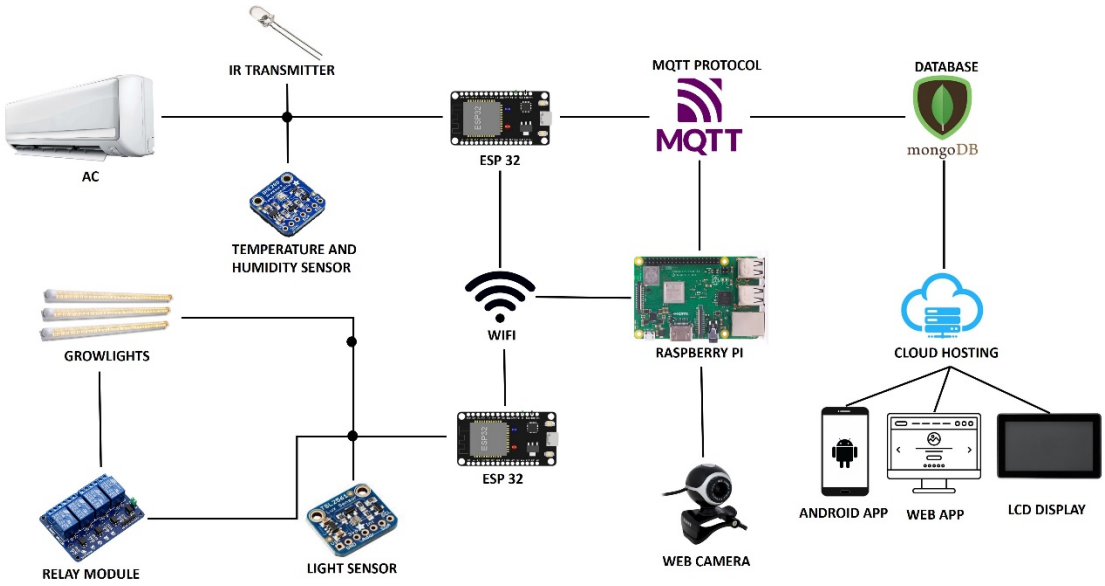

Figure 19. System Architecture

The researchers ensure that, by incorporating the system, the gathered data is transmitted precisely to MongoDB. The outside of the nursery includes a mounted 106.3 mm x 7.23 mm x 68 mm LCD touchscreen that enables users or visitors to interact with the controlled nursery immediately without running mobile or online applications. Also, a web camera is deployed inside of the controlled nursery and integrated with the applications to monitor inside of the controlled nursery.

Other than that, the researchers developed a Graphical User Interface (GUIs) – a web and mobile application – for the developed IoT based and controlled environment nursery, which was employed to display a real-time sensor data, control actuator (such as relays for controlling environmental conditions), and view past information stored in MongoDB. The Graphical User Interface (GUIs) gave users an interface that allowed

them to interact with the controlled nursery. The mobile application used Android Studio throughout the development of the Graphical User Interface (GUI) layout and design, while the web application utilized the Python library together with Python Flask. The researchers guarantee the software programs are utilized with functions that help users in accessing data or information through graphs, and that the Graphical User Interface (GUIs) are easy to navigate. To be able to allow users to create a schedule to control the light, the researchers also included a scheduler. Additionally, the researchers make sure that users can access the software programs from anywhere at any time.

In summary, the researchers developed a controlled nursery that can automate and control the environment and also collect data in real-time. As a result, the system is an essential tool for researchers and farmers.

Figure 20. Developed Controlled Nursery

Figure 20 shows above the picture of the actual controlled system. This shows the picture of the developed IoT based and controlled environment nursery for

germination and growth of garlic. The researcher assembled the racks and installed the grow lights. Additionally, the researchers also ensure that the circuit of the developed nursery is safe for the users.

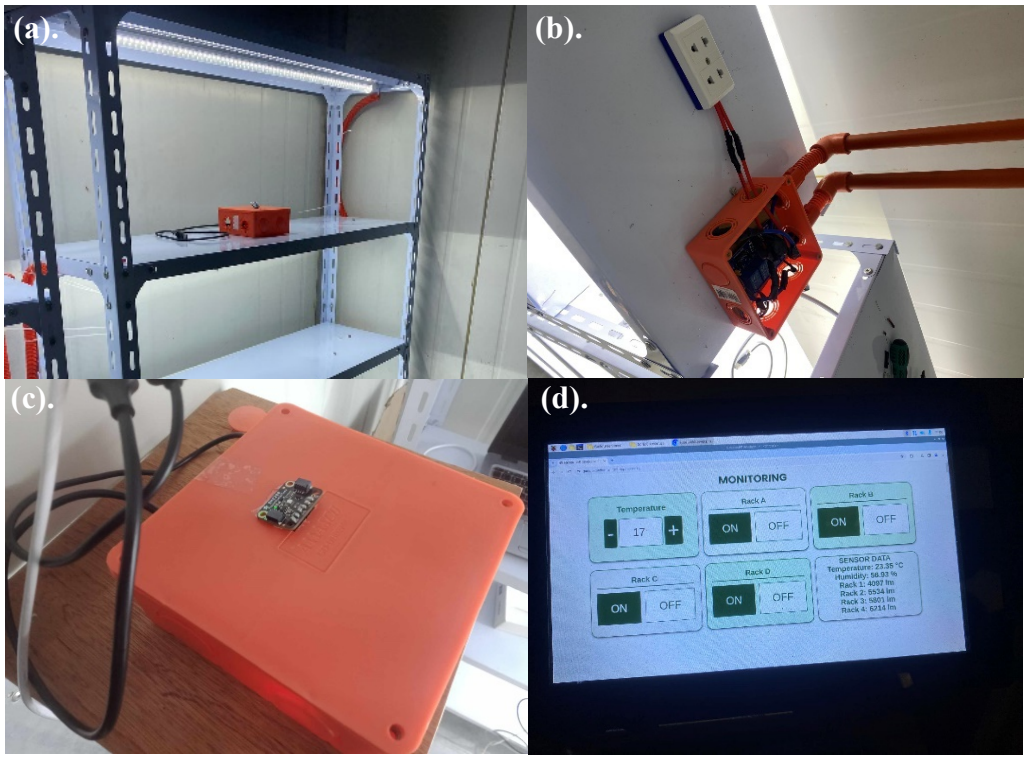

Figure 21. Developed Hardware in Controlled Nursery (a). installed light sensor (b).the installed relay for controlling the grow light (c). the installed temperature and humidity sensor; and (d). the integrated LCD touchscreen.

Developed Web-Based Application for Users

The researchers developed an Online Website Registration/Log in Form which consists registration and log in function which are presented respectively.

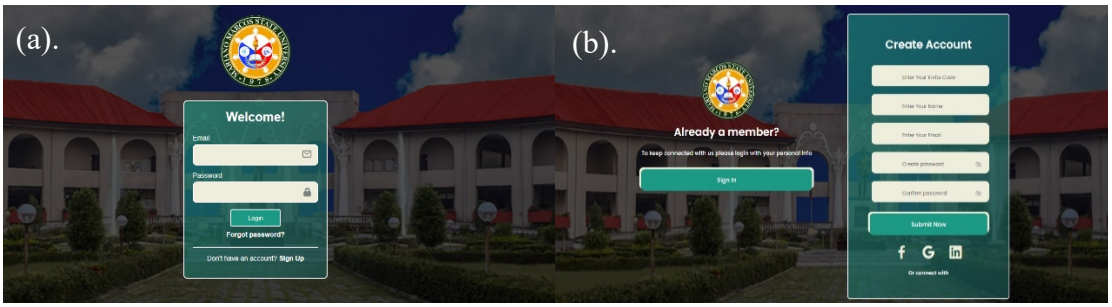

Figure 22. Web Application User's (a). log in and (b). register

Figure 22 shows the homepage of the web application, where users can register or log in. The user will register and log in over the internet, which can be done on a phone or a computer. The collected personal data will be saved in the database.

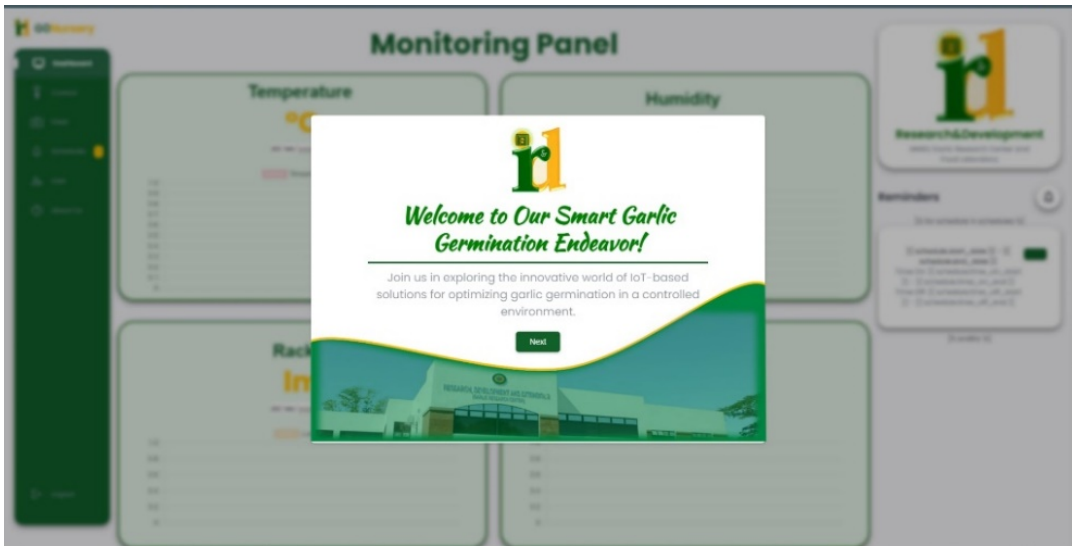

Figure 23. Web Application User's Home Page

After logging in, the user will proceed to Figure 23, which shows the home page of the web application. Here, the users should be able to gain a bit of information about the system.

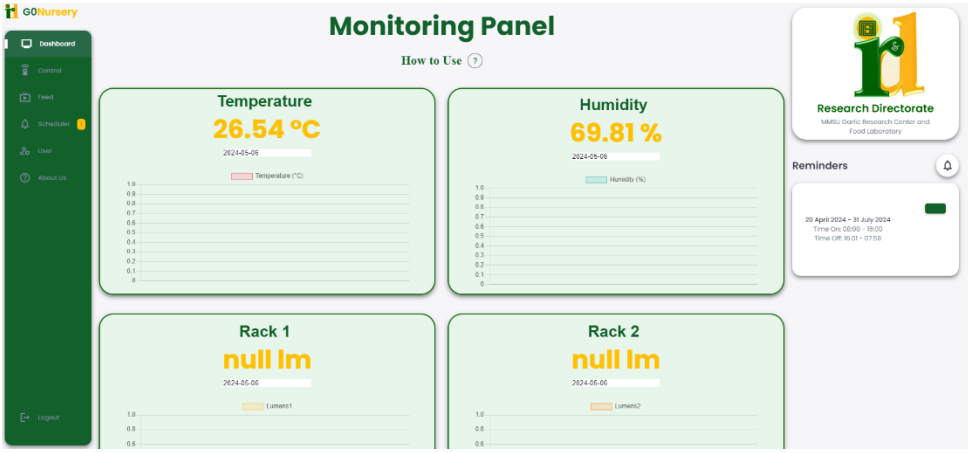

Figure 24. Web Application User's Monitoring Panel

Figure 24 shows the monitoring panel of the system's web application, which allows users to see the real-time temperature, humidity and lumens, as well as the data charts of the data gathered through sensors. The monitoring panel also had a how-to-use feature for the first-time users.

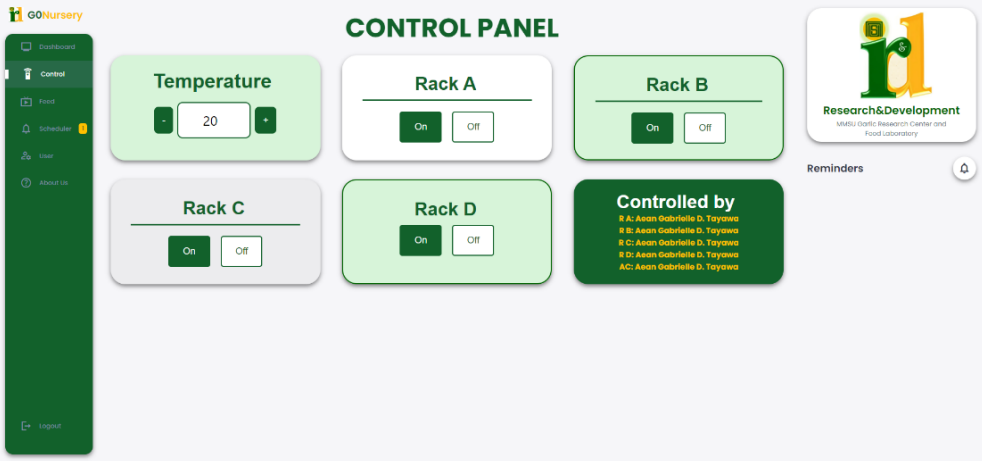

Figure 25. Web Application User's Control Panel

Figure 25 shows the control panel of the system's web application, which allows users to turn on and off the lights as well as set the nursery temperature. Furthermore, researchers added a panel that allows other users to see who is in control of the system.

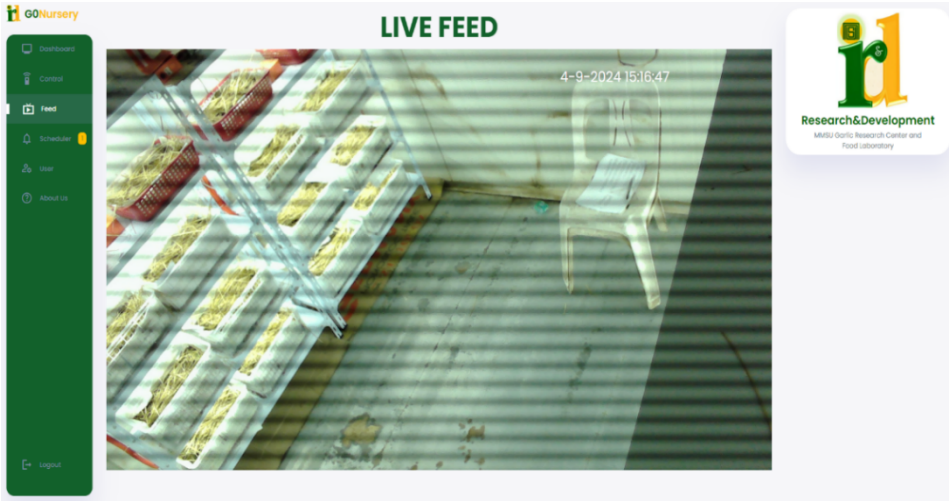

Figure 26. Web Application User's Live Feed

The live feed that shows in Figure 26 enables the users to view inside of the nursery anytime and anywhere.

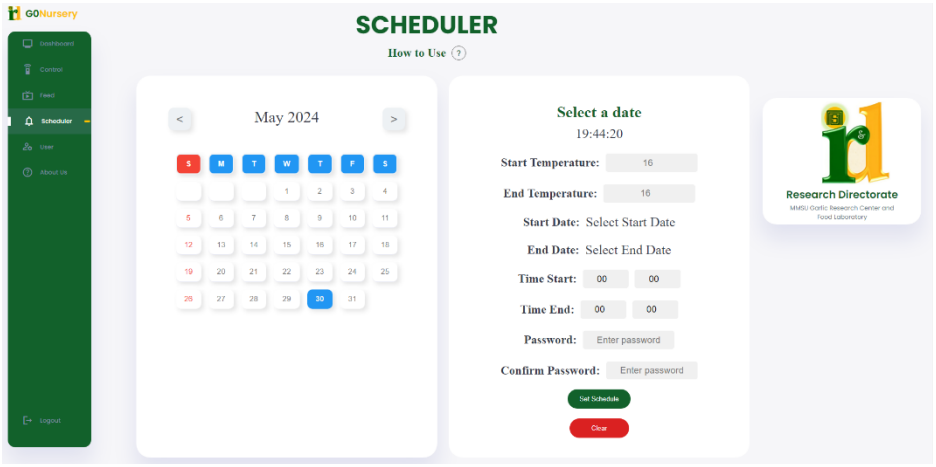

Figure 27. Web Application User's Scheduler

The scheduler feature of the web application has the how to use button which allows first time users to know how to use the page. Furthermore, the scheduler allows users to control the date and time of turning on or off the lights and also setting the temperature of the nursery, as shown in Figure 27 above.

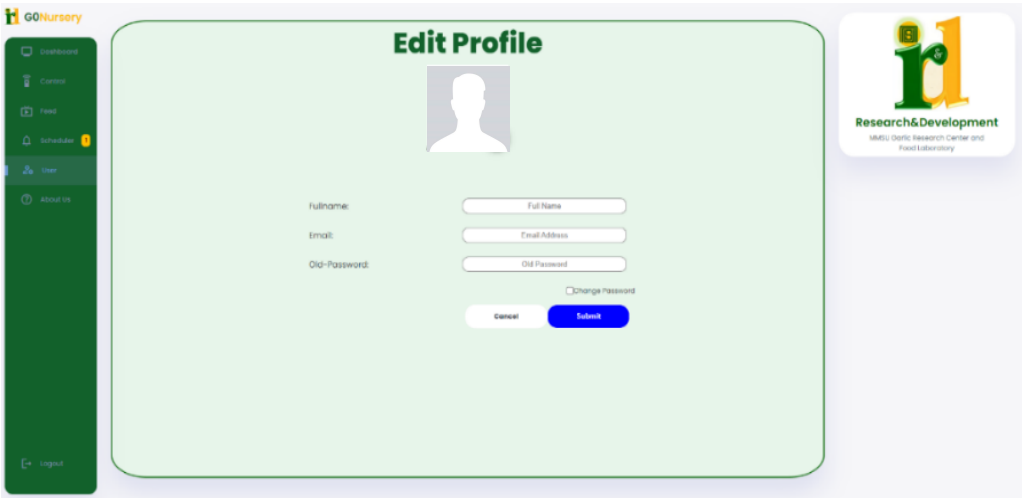

Figure 28. Web Application Users Profile

Figure 28 depicts the user profile in the system web application; users have the ability to modify their information using this system feature.

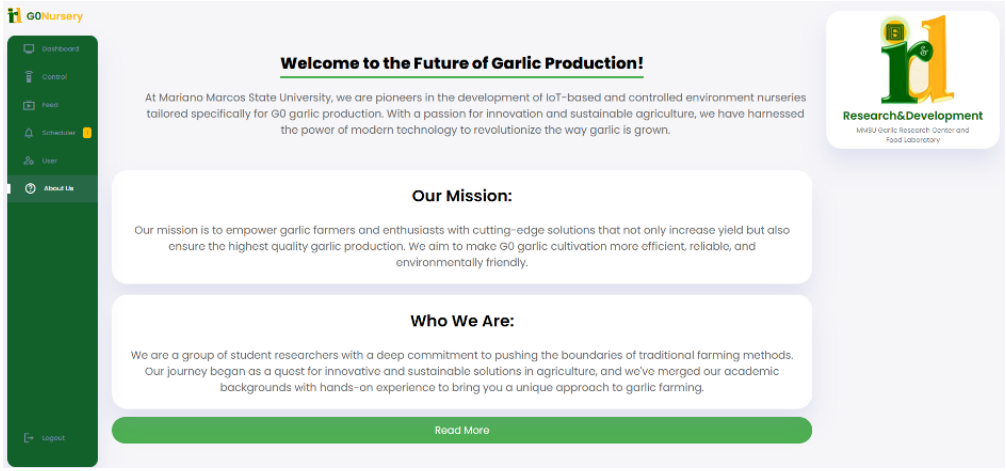

Figure 29. Web Application User's About Us

Figure 29 displays information about the web application. This feature allows users to gain insight into the researcher's mission and vision. Also on this page, users would be able to view the developers of the system.

Developed Web-Based Application for Administrator

The following is a web application developed by the researchers for administrator:

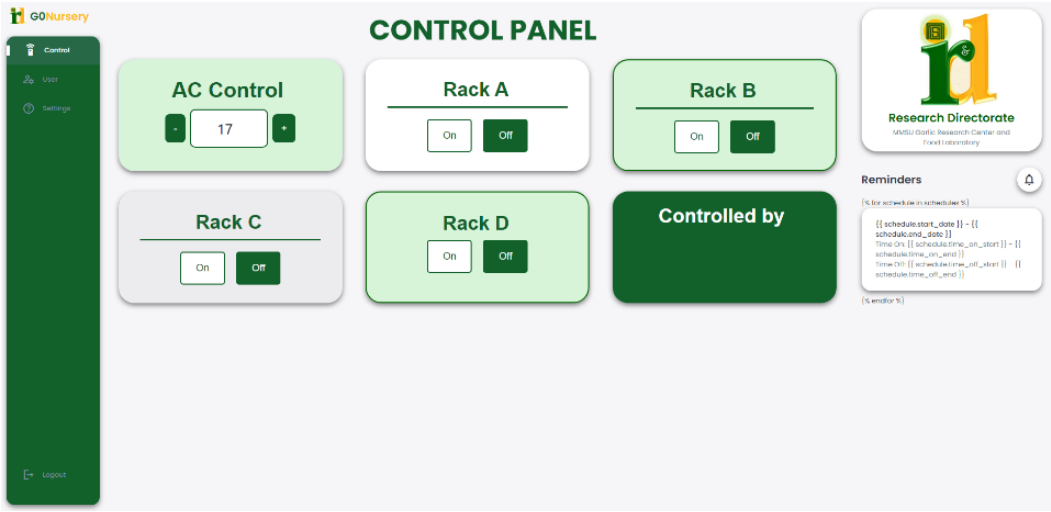

Figure 30. Web Application Admin's Control Panel

Figure 30 shows the control panel for admin. The admin can control the light, and temperature of the nursery. Additionally, admin can view the details to whom is in control of the system.

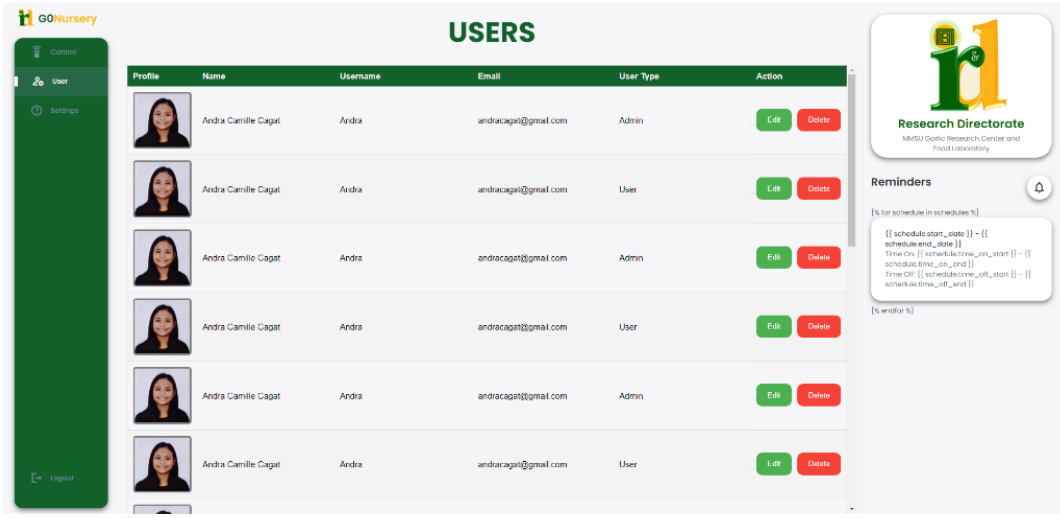

Figure 31. Web Application Admin's Users Panel

Admins can view the list of the registered users through the Users Panel, as shown in Figure 31. Furthermore, administrators have the authority to edit and delete the information of users.

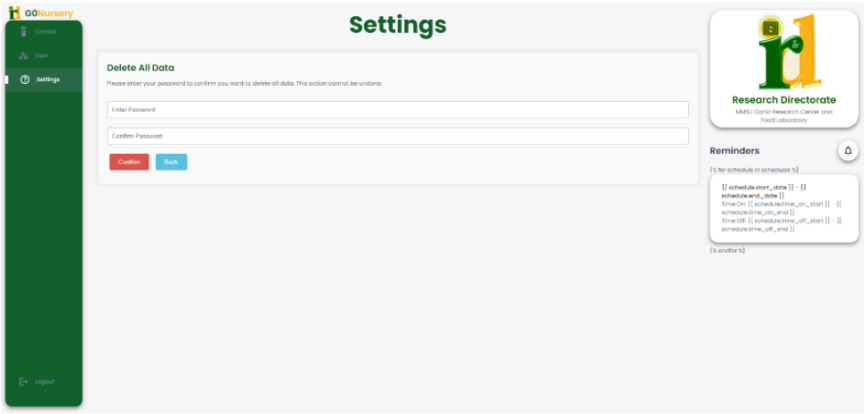

Figure 32. Web Application Admin's Settings

The admins web application also has settings, as shown in Figure 32. This is to allow the administrator to permanently delete the data in the charts.

Developed Mobile Application for Controlled Nursery

The researchers also developed an Mobile Registration/Log in Form which consists registration and log in function which are presented respectively.

(a). (b).

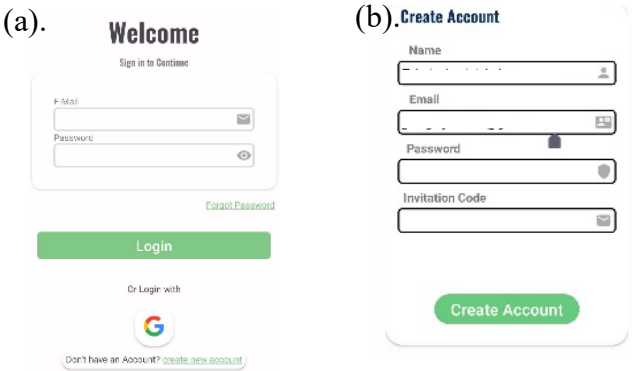

Figure 33. Mobile Application (a). Log-In Form and (b). Resgistration

Figure 33 shows the homepage of the system's android application through mobile phone, where the users can log in or register.

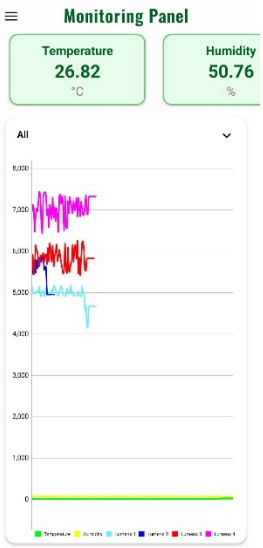

Figure 34. Mobile Application Monitoring Panel

Figure 34 depicts the monitoring panel of the Android application, which displays real-time values of temperature, humidity, and lumen intensity. The data can be displayed with graphs, allowing the user to easily track the details.

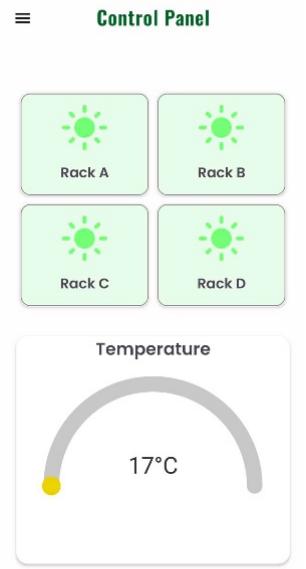

Figure 35. Android Application Control Panel

Figure 35 illustrates the control panel of the Android application, where users are able to control the light by switching on and off and the temperature of the system by sliding the button. Additionally, the control panel has a feature called cool down, where users can't control the light for 6 seconds. This feature will help the grow light and the application prevents multiple toggles, avoid electrical surges, and software stability.

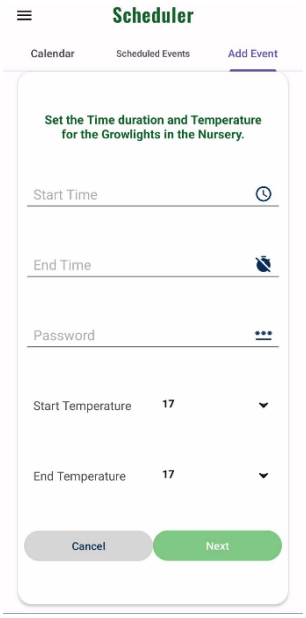

Figure 36. Android Application Scheduler

Figure 36 shows the scheduler of the Android application, allowing users to set up a schedule controlling the lights to turn on and off. This scheduler aims to be convenient for users.

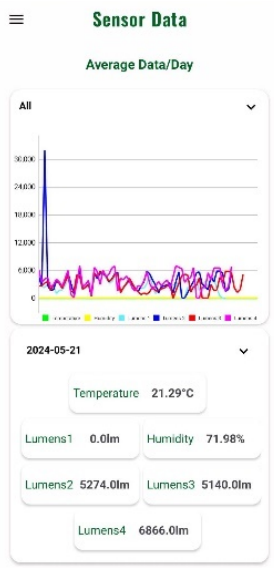

Figure 37. Android Application Sensor Data

Figure 37 shows the sensor data of the scheduler, enable user to easily track the details of the sensors.

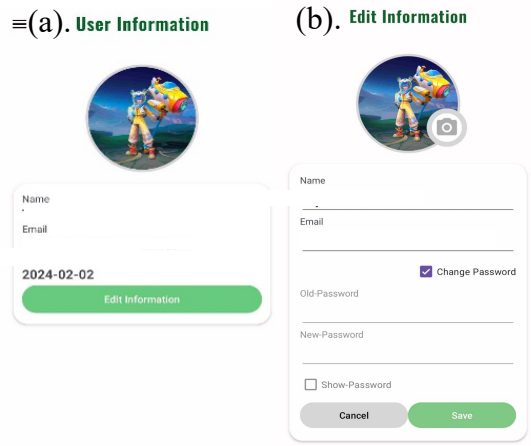

Figure 38. Android Application User information (a). view and (b). modify or edit their information.

Figure 38 shows the other feature of the android application where in users can view and modify or edit their information.

Evaluation of the Collected Data

The collected data was subjected to mortality rate and analysis of variance (ANOVA) using the Statistical Tool for Agricultural Research (STAR). All significant pairs of treatment means were compared using the Least Significant Difference (LSD) test at 5% level of probability.

Optimum Lumen Needed for Germinating Garlic

Growing garlic is crucial since there are several factors affecting the growth of garlic: temperature, humidity, nutrients, and lumen (Smart Gardener, 2023). When it comes to the nutrients in the soil needed to germinate garlic the researchers prepare a nitrogen (N) range of 200-250 mg/kg, a phosphorus (P) range of 50-70 mg/kg, and a potassium (K) range of 86-132 mg/kg for both the controlled nursery and the traditional way of planting. The soil has a pH level of 5.8-6.0, according to Smart Gardener (2023), the soil preference of the garlic should have at least a pH level of 5.5 to 7.0. Notably, Rankel (2024) discusses in their study that the garlic needed a 50-75% humidity ideal for the garlic's health and bulb growth; thus, the system's humidity ranges from 50-60%. The temperature is also a factor in the growth and health of the garlic, so the researchers set the temperature during the day at 20ºC to 25ºC and 17ºC to 20ºC at night. In a study it was revealed that the garlic needed a lower temperature (20ºC to 25ºC) during the day and a higher temperature (17ºC to 20ºC) at night with a longer

photoperiod to break the dormancy of the garlic (Kamenetsky-Goldstein, Rabinowitch, & Zemach, 2014).

Table 2. difference in optimum lumen (light intensity) for the germination of garlic

Light Intensity	Number of Germinated Garlic
Low (5k-5.2k lumen)	73.34a
Medium (5.4k to 5.8k lumens)	71.67a
High (6.4 to 7k lumens)	70.00a
Control (Traditional)	35.83b
Significance	*

Note:
a - IoT-based
b - traditional
** - significant at 5% level of significance*

Table 2 compares the impact of different light intensities on the germination of garlic, categorizing the lumens into low, medium, and high levels, with a traditional lighting method as a control. The results indicate that the low light intensity yields the highest number of germinated garlic, with a rate of 73.34%, suggesting that this light level is highly effective for germination. The medium intensity follows closely with a rate of 71.67% germinated garlic, and the high light intensity results in 70.00% germinated garlic. Although the high intensity is slightly less effective than the lower intensities, it still promotes substantial germination. In comparison, the traditional lighting methods yield significantly fewer germinated garlic, a rate of 35.83%, indicating they are much less effective than the controlled light conditions.

The findings suggest that low light intensity is the most effective. However, the medium and high light intensities also show strong germination rates, indicating that garlic can be effectively germinated within a range of 5k to 7k lumens.

Table 3. effects of optimum lumen (light intensity) levels in garlic leaves

Light Intensity Levels	Plant Height	Color of Leaves	Number of Leaves
Low (5k to 5.2k)	5.21	3.7	2.9
Medium (5.4k to 5.8k)	5.21	3.58	3.4
High (6.4 to 7.0k)	5.10	3.78	3.4
Significance	ns	ns	ns

Note:
ns – not significant

Table 3 shows the effect of different light intensity level to the garlic leaves. The findings shows that there is no significant effect of light intensity level in terms of plant height, color of leaves, and number of leaves.

Though each rack has the same values when it comes to nutrients in the soil, temperature, and humidity. According to the measured lumen in traditional method of planting, the light intensity of the sun has 5k to 7k lumens, thus the researchers classified the lumen of the nursery into high (6.4 to 7k lumens), medium (5.4k to 5.8k lumens) and low (5k to 5.2k) with a 10-hour photoperiod. In a study it was revealed that cool weather is needed by the crop during its early stage of growth (Garlic Production Guide, 2020) with 10 hours of light and 14 hours of darkness (Timepieces in Our Plants, 2023).

Mortality Rate between IoT-based System and Traditional Methods

Table 4 indicates the tabulation of the mortality results under the different levels of light intensity in the study.

Table 4. Difference of mortality rate of the IoT-based system with traditional garlic cultivation method significant at 5% level of significance

Light Intensity	Mortality Rate
Low (5k-5.2k lumen)	26.66a
Medium (5.4k to 5.8k lumens)	28.33a
High (6.4 to 7k lumens)	30.00a
Control (Traditional)	64.17b
Significance	*

Note:
a - IoT-based
b – Control (traditional)
** - significant at 5% level of significance*

The mortality rates of garlic under different light intensities compared to traditional garlic cultivation methods is shows in Table 4. The results demonstrate significantly lower mortality rates in the IoT-based system. At low intensity, the mortality rate is 26.66%, at medium intensity it's 28.33%, and at high intensity, it's 30.00%. In stark contrast, the traditional method exhibits a much higher mortality rate of 64.17%. The differences are statistically significant at the 5% level. These disparities persist across all light intensities, indicating a consistent pattern of lower mortality rate

in the IoT-based system. Even at the highest light intensity tested, the mortality rate remains notably low in the IoT-based system compared to the traditional method.

The findings suggest that the IoT-based system can produce more germinated garlic than the traditional cultivation method. The significant difference in garlic mortality rates between the IoT-based system and traditional cultivation methods underscores the importance of careful cultivation practices in ensuring plant health and survival. Further research and optimization of cultivation practices in the IoT-based system are warranted to address the observed disparities and improve garlic production outcomes.

SUMMARY, CONCLUSIONS AND RECOMMENDATION

This chapter of the manuscript is divided into three parts, namely: 1) Summary of Findings, 2) Conclusions, and 3) Recommendations.

Summary

The IoT-based and controlled-environment nursery for growing garlic was developed by the researchers to determine the optimum lumen and mortality rate of the system and the traditional cultivation method. The researchers classified three treatments using traditional cultivation methods to identify the optimum lumen required for garlic germination. The treatments were categorized into three categories: low (5k to 5.2k lumen), medium (5.4k to 5.8k lumen), and high (6.4k to 5.8k lumen). In the germination of garlic, the low light intensity level is the most effective, with an average of 73.34% germinated garlic. Furthermore, the mortality rate between the IoT-based and controlled environment nursery and traditional cultivation methods is used to determine the effectiveness of the system. The IoT-based and controlled environment nursery has a mortality rate of 26.66%, indicating that the system significantly had lower mortality rates than the traditional methods, with an average mortality rate of 64.17%.

These results and findings indicate the successful implementation of the IoT-based and controlled environment nursery. The system shows the optimum lumen

needed to germinate garlic and also shows high success in germinating garlic compared to traditional methods. Thus, this validates the effectiveness of the system in germinating garlic through monitoring and controlling the nursery.

Conclusions

The development of an IoT-based and controlled environment nursery for germinating garlic made a positive finding that represents a significant impact on agricultural technology advancement.

Utilizing the web application, mobile application, and LCD display monitoring allows the user to control and monitor the environment of the nursery. Additionally, the system is automated to ensure a precise and accurate environmental requirement for the germination and growth of garlic.

The determined optimum lumen and the environmental requirements for garlic germination are faster, more effective, and healthier, which gives farmers and researchers an advantage in farming. Furthermore, this innovative approach addresses the critical issue of high mortality rates in garlic germination by providing an automated and controlled environment, thus increasing the chances of successful seedling development.

In conclusion, this IoT-based solution not only boosts productivity but also contributes to the broader goal of sustainable agriculture by optimizing the use of resources such as light, and energy ensuring that only the necessary amounts are used

and maximizing crop yields. This project sets a precedent for future technological applications in agriculture, demonstrating the profound impact of IoT and automation on improving crop production efficiency and resilience.

Recommendation

Based on the results obtained from the findings and conclusions of the study, the researchers have the following recommendations:

1. It is recommended that the system utilize an automated sprinkler and soil moisture monitoring for a more precise amount of water needed.
2. It is recommended that the system should go through a bulb phase to further determine the system's ability to produce garlic bulb.
3. It is recommended that the system be equipped with solar power to reduce cost of electricity.

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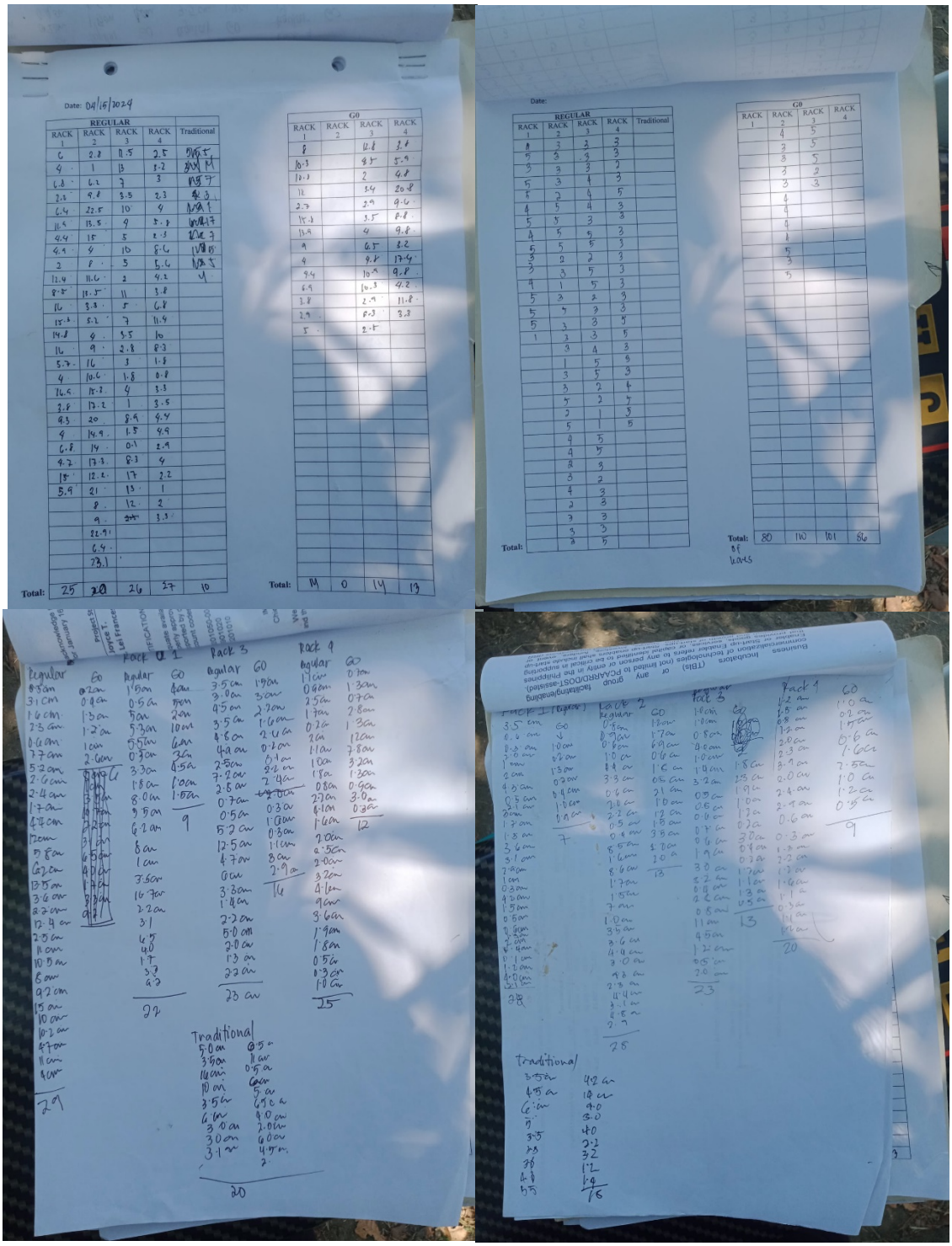
APPENDICES

Appendix A. Result

A 1. Actual Result of the IoT-based vs Traditional

A 2. Raw Data



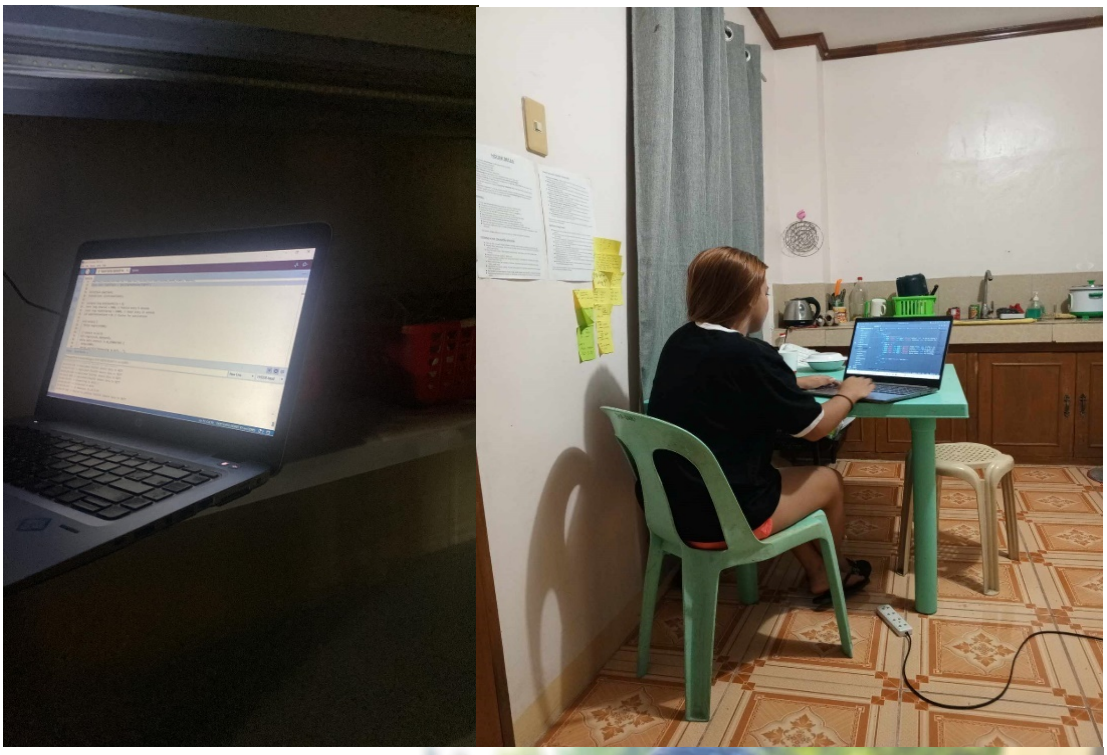
Appendix B. Documentation

B 1. Presentation of Thesis Proposal

B 2. Location Visit

B 3. Documentation on Hardware Development

B 4. Documentation on Software Development



B 5. System Testing

B 6. Consultation with the Statistician

B 7. Preparation and Planting

B 8. Panel Consultation and Visit

B 9. Data Gathering

B 10. Thesis Defended!


NOTICE
CAUTION


OLLEGE OF NGINEERING

APPENDIX C. CODES

C 1. Server Code

```
from flask import Flask
import requests
import datetime
import time
import threading
from pymongo import MongoClient

app = Flask(__name__)

# MongoDB configuration
mongo_client =
MongoClient("mongodb+srv://iotgarlic:garlicg
reenhouse2023@garlicgreenhouse.s6eknyu.m
ongodb.net")
mongodb_db =
mongo_client.GarlicGreenhouse

# Endpoint for setting temperature
temperature_endpoint =
"http://10.40.4.163/set?temp="

def time_until_target(target_time):
    current_time = datetime.datetime.now()
    time_difference = target_time - current_time
    return time_difference.total_seconds()

def send_http_request():
    while True:
        # Get the current time
        current_time = datetime.datetime.now()

        # Retrieve the schedule document from
MongoDB
        schedule_document =
mongodb_db.schedule.find_one()

        if schedule_document:
            # Extract off time and end temperature
from the schedule document
            time_off_start_str =
schedule_document.get('time_off_start',
'00:00')
            end_temperature =
schedule_document.get('end_temperature', 0)
            time_off_start =
datetime.datetime.strptime(time_off_start_str,
'%H:%M')

            # Set the target time to the off time
extracted from the schedule document for
today
            target_time =
current_time.replace(hour=time_off_start.hour
, minute=time_off_start.minute, second=0,
microsecond=0)

            # Calculate the time remaining until
target_time
            time_remaining =
time_until_target(target_time)

            # If the target time has already passed
for the current day, set it for the next day
            if time_remaining < 0:
                target_time +=
datetime.timedelta(days=1)
                time_remaining =
time_until_target(target_time)

            # Sleep until the target time
            time.sleep(time_remaining)

            try:
                # Send HTTP request to set
temperature
                response =
requests.get(f"{temperature_endpoint}{end_te
mperature}")
                print("HTTP Request sent to",
temperature_endpoint, "at",
datetime.datetime.now())
                if response.status_code == 200:
                    print("Temperature set
successfully.")
                # You can add further processing of
response here if needed
            except Exception as e:
                print("Error sending HTTP
request:", e)
```

```
        else:
            print("No schedule document found.")

def start_http_sender():
    sender_thread =
threading.Thread(target=send_http_request)
    sender_thread.daemon = True
    sender_thread.start()

@app.route('/')
def index():
    # Retrieve the first schedule document from
MongoDB
    schedule_document =
mongodb_db.schedule.find_one()

    if schedule_document:
        # Extract off time from the schedule
document
        time_off_start_str =
schedule_document.get('time_off_start',
'00:00')
            return jsonify({'success': False,
'message': 'Authentication required'}), 401
        # For HTML requests, redirect to the
login page
        return redirect(url_for('main_login'))
        # If user is logged in, proceed to the
requested route
        return route_function(*args, **kwargs)
    return decorated_function

def handle_ac_control(current_temperature):
    # Make sure the current_temperature is
within the desired range
    if 17.0 <= current_temperature <= 30.0:
        # Craft the URL with the ESP32 IP and
the current temperature
        url =
f"http://{ac_ip}/set?temp={int(current_temper
ature)}"
        try:
            # Send the HTTP GET request
            response = requests.get(url)
            if response.status_code == 200:
                print("HTTP request sent
successfully:", url)
            else:
                print("Failed to send HTTP
request:", response.status_code)
        except Exception as e:
            print("Error while sending HTTP
request:", str(e))
    else:
        print("Temperature out of range for AC
control")

        # Hash the new password
        hashed_password =
generate_password_hash(new_password).deco
de('utf-8')

        # Update the password in the database
        mongodb_db.users.update_one({"email":
email}, {"$set": {"password":
hashed_password}})

        # Redirect to a success page or login page
        return redirect(url_for('main_login'))

def generate_otp():
    return str(random.randint(100000, 999999))

@app.route('/forgot_password',
methods=['GET', 'POST'])
def forgot_password():
    if request.method == 'POST':
        email = request.form['email']

        # Check if the email exists in the users
collection
        user =
mongodb_db.users.find_one({"email": email})
        if not user:
            flash('Email not found. Please enter a
registered email address.', 'error')
            return
render_template('forgot_password.html')

        # Generate OTP
        otp = generate_otp()

        # Send OTP via email
        msg = Message('Your One-Time
Password', recipients=[email])
        msg.body = f'Your OTP is: {otp}'
        mail.send(msg)

        # Update user document in the users
collection to include OTP
        mongodb_db.users.update_one({"email":
email}, {"$set": {"otp": otp}})
```

```
        # Redirect to OTP page with email as
parameter
        return redirect(url_for('otp',
email=email))

    return
render_template('forgot_password.html')

@app.route('/front')
def front():
    return render_template('front.html')

@app.route('/login', methods=['GET', 'POST'])
def login():
    if request.method == 'POST':
        # If the request is made with JSON data
        if request.is_json:
            data = request.get_json()
            email = data.get('email')
            password = data.get('password')
        else:
            # If the request is made with form data
(HTML form submission)
            email = request.form.get('email')
            password =
request.form.get('password')

        # Check if email matches a user in the
MongoDB collection
        user =
mongodb_db.users.find_one({"email": email})

        if user and
bcrypt.check_password_hash(user.get('passwo
rd', ''), password):
            # Store user ID, email, and name in the
session
            session['user_id'] = str(user.get('_id'))
            session['email'] = email
            session['name'] = user.get('name')

            # Perform login logic if needed
            if request.is_json:
                return jsonify({'success': True})
            else:
                # Redirect to the index route on
successful login
                return redirect(url_for('index'))
        else:
            error_message = "Invalid email or
password. Please try again."
            if request.is_json:
                return jsonify({'success': False,
'message': error_message})
            else:
                # Render the login template with the
error message
                return render_template('main_login',
error_message=error_message)

    # If it's a GET request, render the login
template
    return render_template('login.html')

@app.route('/')
def default():
    # Redirect to the /login route
    return redirect(url_for('main_login'))

@app.route('/turn_on/<int:relay_num>',
methods=['GET'])
def turn_on_relay(relay_num):
    # Determine the appropriate IP based on the
relay number
    if relay_num in [1, 2]:
        ip_address = '10.40.1.21'
    elif relay_num in [3, 4]:
        ip_address = '10.40.0.176'
    else:
        return f'Relay number {relay_num} is not
supported', 400

    # Constructing the URL based on the IP and
relay_num and sending the HTTP request
    url =
f'http://{ip_address}:80/turn_on/{relay_num}'
    response = requests.get(url)

    if response.ok:
        # Update the relay state in MongoDB
        light_state_collection.update_one(
            {'relay_num': relay_num},
            {'$set': {'state': True}},
            upsert=True  # Create a new document
if it doesn't exist
        )

        # Get user's name from the session email
        name = None
        if 'email' in session:
            email = session['email']
            user =
users_collection.find_one({'email': email})
```

```
        if user:
            name = user.get('name')

    # Insert document into light_toggle
collection
    light_toggle_collection.insert_one({
        'rack_number': relay_num,
        'action': 'turn_on',
        'timestamp':
datetime.now().strftime('%Y-%m-%d
%I:%M:%S %p'),
        'controlled_by': name if name else
'Unknown'  # Use user's name or 'Unknown' if
not found
    })

    return f'Relay {relay_num} turned on
successfully', 200
  else:
    return f'Failed to turn on relay
{relay_num}', 500

@app.route('/turn_off/<int:relay_num>',
methods=['GET'])
def turn_off_relay(relay_num):
  # Determine the appropriate IP based on the
relay number
  if relay_num in [1, 2]:
    ip_address = '10.40.1.21'
  elif relay_num in [3, 4]:
    ip_address = '10.40.0.176'
  else:
    return f'Relay number {relay_num} is not
supported', 400

  # Constructing the URL based on the IP and
relay_num and sending the HTTP request
  url =
f'http://{ip_address}:80/turn_off/{relay_num}'
  response = requests.get(url)

  if response.ok:
    # Update the relay state in MongoDB
    light_state_collection.update_one(
      {'relay_num': relay_num},
      {'$set': {'state': False}},
      upsert=True  # Create a new document
if it doesn't exist
    )

    # Get user's name from the session email
    name = None
    if 'email' in session:
      email = session['email']
      user =
users_collection.find_one({'email': email})
      if user:
        name = user.get('name')

    # Insert document into light_toggle
collection
    light_toggle_collection.insert_one({
      'rack_number': relay_num,
      'action': 'turn_off',
      'timestamp':
datetime.now().strftime('%Y-%m-%d
%I:%M:%S %p'),
      'controlled_by': name if name else
'Unknown'  # Use user's name or 'Unknown' if
not found
    })

    return f'Relay {relay_num} turned off
successfully', 200
```

C 2. Web Application Code

```
.text{
  display: flex;
  flex-direction: column;
}
.dashboard-table-wrapper {
  max-height: 800px;
  overflow-y: auto;
}

.dashboard-table-wrapper::-webkit-scrollbar-
        thumb {
  background-color: #0E4BF1;
}

.delete-container {
  margin-top: 20px;
  background: #f9f9f9;
  padding: 20px;
  border-radius: 8px;
  box-shadow: 0 0 10px rgba(0, 0, 0, 0.1);
}
.delete-container h2 {
  color: #12612b;
  margin-bottom: 10px;
```

```
}

.delete-container p {
    margin-bottom: 20px;
    color: #555;
}

.delete-container input[type="password"] {
    width: 100%;
    padding: 10px;
    margin: 10px 0;
    border: 1px solid #ccc;
    border-radius: 4px;
}

.delete-container button {
    padding: 10px 20px;
    margin: 10px 5px;
    border: none;
    border-radius: 4px;
    cursor: pointer;
}

.delete-container .confirm-btn {
    background-color: #d9534f;
    color: white;
}

.delete-container .back-btn {
    background-color: #5bc0de;
    color: white;
}

@media screen and (max-width: 768px) {
    .container{
        width: 100%;
        grid-template-columns: 1fr;
        padding: 0 var(--padding-1);
    }

    aside{
        position: fixed;
        background-color: var(--color-primary);
        width: 15rem;
        z-index: 3;
        box-shadow: 1rem 3rem 4rem var(--
            color-light);
        height: 100vh;
        left: -100%;
        display: none;
        animation: showMenu 0.4s ease
            forwards;
    }

    aside .sidebar{
        display: flex;
        flex-direction: column;
        background-color: var(--color-white);
        box-shadow: var(--box-shadow);
        border-radius: 15px;
        height: 893px;
        position: relative;
        top: 1.5rem;
        transition: all 0.3s ease;
        width: 217px;
        margin-left: -7px;
    }

    @keyframes showMenu {
      to{
        left: 0;
      }
    }

    aside .logo{
        margin-left: 1rem;

    }

    aside .logo h2{
        display: inline;
    }

    aside .sidebar h3{
        display: inline;
    }

    aside .sidebar a{
        width: 100%;
        height: 3.4rem;
    }

    aside .sidebar a:last-child{
        position: absolute;
        bottom: 5rem;
    }

    aside .Logo .close{
        display: inline-block;
        cursor: pointer;
    }

    main{
        margin-top: 8rem;
```

```
    padding: 0 1rem;
}

main .header h2{
    margin-left: -2%;
    font-family: "Poppins", sans-serif;
    font-size: 45px;
    font-weight: bold;
    color: #12612b;
}

main .new-users .user-list .user{
    flex-basis: 35%;
}

main .recent-orders{
    position: relative;
    margin: 3rem 0 0 0;
    width: 100%;
}

main .recent-orders table{
    width: 100%;
    margin: 0;
}

.right-section{
    width: 94%;
    margin: 0 auto 4rem;
}

.right-section .nav{
    position: fixed;
    top: 0;
    left: 0;
    align-items: center;
    background-color: var(--color-white);
    padding: 0 var(--padding-1);
    height: 4.6rem;
    width: 100%;
    z-index: 2;
    box-shadow: 0 1rem 1rem var(--color-
        light);
    margin: 0;
}

.right-section .nav .dark-mode{
    width: 4.4rem;
    position: absolute;
    left: 66%;
}

    .right-section .profile .info{
        display: none;
    }

    .right-section .nav button{
        display: inline-block;
        background-color: transparent;
        cursor: pointer;
        color: var(--color-dark);
        position: absolute;
        left: 1rem;
    }

    .right-section .nav button span{
        font-size: 2rem;
    }

    .right-section .user-profile {
        margin-top: 0rem;
        display: flex;
        justify-content: center;
        align-items: center;
    }

    .action-buttons{
        margin-top: 0px;
    }

}
@media screen and (max-width: 414px) {
    .dashboard-table-wrapper{
        margin-left: -15px;
    }
}


@import
        url('https://fonts.googleapis.com/css2
        ?family=Poppins:wght@300;400;500
        ;600;700;800&display=swap');

:root{
    --color-primary: #ffffff;
    --color-danger: #FFC000;
    --color-success: #1B9C85;
    --color-warning: #F7D060;
    --color-white: #12612b;
    --color-info-dark: #7d8da1;
    --color-dark: #363949;
    --color-light: rgba(132, 139, 200, 0.18);
    --color-dark-variant: #677483;
    --color-background: #f6f6f9;
```

```
    --card-border-radius: 2rem;
    --border-radius-1: 0.4rem;
    --border-radius-2: 1.2rem;

    --card-padding: 1.8rem;
    --padding-1: 1.2rem;

    --box-shadow:  0 4px 8px rgba(0, 0, 0,
            0.467);
}

.dark-mode-variables{
    --color-background: #181a1e;
    --color-white: #202528;
    --color-dark: #edeffd;
    --color-dark-variant: #a3bdcc;
    --color-light: rgba(0, 0, 0, 0.4);
    --box-shadow: 0 2rem 3rem var(--color-
            light);
}

*{
    margin: 0;
    padding: 0;
    outline: 0;
    appearance: 0;
    border: 0;
    text-decoration: none;
    box-sizing: border-box;
}

html{
    font-size: 14px;
}

body{
    width: 100vw;
    height: 100vh;
    align-items: center;
    gap: 0.6rem;
}



.table {
    width: 100%;
    border-collapse: collapse;
    color: #000;
    font-family: 'Lato', sans-serif;
    border: 1px solid #DDD;
}

.table th {
    background-color: #12612b;
    color: whitesmoke;
    padding: 10px;
    text-align: left;
    font-size: 15px;
}
.table tbody tr {
    border-bottom: 1px solid #DDD;
}

.table tbody tr:nth-of-type(even) {
    background-color: #f3f3f3;
}
/* Specific widths for each th and td */
.table th:nth-child(1),
.table td:nth-child(1) {
    width: 10%; /* Adjust as needed */
}
.table th:nth-child(2),
.table td:nth-child(2) {
    width: 20%; /* Adjust as needed */
}
.table th:nth-child(3),
.table td:nth-child(3) {
    width: 20%; /* Adjust as needed */
}
.table th:nth-child(4),
.table td:nth-child(4) {
    width: 20%; /* Adjust as needed */
}
.table th:nth-child(5),
.table td:nth-child(5) {
    width: 20%; /* Adjust as needed */
}
.table th:nth-child(6),
.table td:nth-child(6) {
    width: 10%; /* Adjust as needed */
}

.table td:first-child {
    border-left: 1px solid #DDD;
}
.table td {
    padding: 10px;
    color: #000;
    font-size: 15px;
}

/* Profile image styling */
.profile-image {
    display: block;
```

```
    max-width: 100%;
    height: auto;
    border: 3px solid gray;
    border-radius: 5px;
}


.profile-image {
    display: block;
    max-width: 100%;
    height: auto;
    border: 3px solid gray;
    border-radius: 5px;
}

.text{
    display: flex;
    flex-direction: column;
}
.dashboard-table-wrapper {
    max-height: 800px;
    overflow-y: auto;
}

.dashboard-table-wrapper::-webkit-scrollbar-
            thumb {
    background-color: #0E4BF1;
}

.action-buttons {
    display: flex;
    gap: 10px;
    margin-top: 30px;
}
.button {
    display: flex;          /* Use flexbox */
    justify-content: center;  /* Center
            horizontally */
    align-items: center;      /* Center vertically
            */
    padding: 20px;
    cursor: pointer;
    border: none;
    border-radius: 10px;
    text-align: center;
}

.edit-button {
    background-color: #4CAF50;
    color: white;
}
.delete-button {
    background-color: #f44336;
    color: white;
}
/* Modal styling */
.modal {
    display: none;
    position: fixed;
    z-index: 1;
    left: 0;
    top: 0;
    width: 100%;
    height: 100%;
    overflow: auto;
    background-color: rgba(0, 0, 0, 0.4);
    padding-top: 60px;
    font-family: 'Arial', sans-serif;
}

.modal-content {
    background-color: #ffffff;
    margin: 5% auto;
    padding: 20px;
    border: 1px solid #888;
    width: 80%;
    max-width: 500px;
    border-radius: 10px;
    box-shadow: 0 5px 15px rgba(0, 0, 0, 0.3);
    animation: fadeIn 0.5s ease-in-out;
}

@keyframes fadeIn {
    from { opacity: 0; }
    to { opacity: 1; }
}

.close {
    color: #aaa;
    float: right;
    font-size: 28px;
    font-weight: bold;
}

.close:hover,
.close:focus {
    color: #000;
    text-decoration: none;
    cursor: pointer;
}

h2 {
    text-align: center;
    color: #333;
```

```
    margin-bottom: 20px;
}

.form-elements {
    display: flex;
    flex-direction: column;
    gap: 15px;
}

.form-group {
    display: flex;
    flex-direction: column;
    gap: 5px;
}

label {
    font-weight: bold;
    color: #555;
}

input[type="text"],
input[type="email"],
input[type="file"],
select {
    width: 100%;
    padding: 10px;
    margin: 5px 0;
    border: 1px solid #ccc;
    border-radius: 5px;
    box-sizing: border-box;
    font-size: 16px;
}

input[type="file"] {
    padding: 5px;
}

.save-button {
    background-color: #4CAF50;
    color: white;
    padding: 10px 20px;
    border: none;
    border-radius: 5px;
    cursor: pointer;
    font-size: 16px;
    margin-top: 20px;
}

.save-button:hover {
    background-color: #45a049;
}
```

```
@media screen and (max-width: 768px) {
    .container{
        width: 100%;
        grid-template-columns: 1fr;
        padding: 0 var(--padding-1);
    }

    aside{
        position: fixed;
        background-color: var(--color-primary);
        width: 15rem;
        z-index: 3;
        box-shadow: 1rem 3rem 4rem var(--
            color-light);
        height: 100vh;
        left: -100%;
        display: none;
        animation: showMenu 0.4s ease
            forwards;
    }

    aside .sidebar{
        display: flex;
        flex-direction: column;
        background-color: var(--color-white);
        box-shadow: var(--box-shadow);
        border-radius: 15px;
        height: 893px;
        position: relative;
        top: 1.5rem;
        transition: all 0.3s ease;
        width: 217px;
        margin-left: -7px;
    }

    @keyframes showMenu {
      to{
        left: 0;
      }
    }

    aside .logo{
        margin-left: 1rem;

    }

    aside .logo h2{
        display: inline;
    }

    aside .sidebar h3{
        display: inline;
```

```
}

aside .sidebar a{
    width: 100%;
    height: 3.4rem;
}

aside .sidebar a:last-child{
    position: absolute;
    bottom: 5rem;
}

aside .Logo .close{
    display: inline-block;
    cursor: pointer;
}

main{
    margin-top: 8rem;
    padding: 0 1rem;
}

main .header h2{
    margin-left: -2%;
    font-family: "Poppins", sans-serif;
    font-size: 45px;
    font-weight: bold;
    color: #12612b;
}

main .new-users .user-list .user{
    flex-basis: 35%;
}

main .recent-orders{
    position: relative;
    margin: 3rem 0 0 0;
    width: 100%;
}

main .recent-orders table{
    width: 100%;
    margin: 0;
}

.right-section{
    width: 94%;
    margin: 0 auto 4rem;
}

.right-section .nav{
    position: fixed;
    top: 0;
    left: 0;
    align-items: center;
    background-color: var(--color-white);
    padding: 0 var(--padding-1);
    height: 4.6rem;
    width: 100%;
    z-index: 2;
    box-shadow: 0 1rem 1rem var(--color-
        light);
    margin: 0;
}

.right-section .nav .dark-mode{
    width: 4.4rem;
    position: absolute;
    left: 66%;
}

.right-section .profile .info{
    display: none;
}

.right-section .nav button{
    display: inline-block;
    background-color: transparent;
    cursor: pointer;
    color: var(--color-dark);
    position: absolute;
    left: 1rem;
}

.right-section .nav button span{
    font-size: 2rem;
}

.right-section .user-profile {
    margin-top: 0rem;
    display: flex;
    justify-content: center;
    align-items: center;
    margin-left: 140px;
}

.action-buttons{
    margin-top: 0px;
}

}
@media screen and (max-width: 414px) {
    .dashboard-table-wrapper{
        margin-left: -15px;
```

```
    }
    .action-buttons{
        margin-top: 0px;
    }
}



@import
            url('https://fonts.googleapis.com/css2
            ?family=Poppins:wght@300;400;500
            ;600;700;800&display=swap');

body {
    font-family: Poppins, sans-serif;
   text-align: center;
    margin: 20px;
}

#calendar-container {
margin-top: 20px;
position: relative;
}

#calendar-input {
width: 200px;
padding: 5px;
}

#calendar-dropdown {
width: 200px;
padding: 5px;
border: 1px solid #ccc;
position: absolute;
background-color: #fff;
display: none;
z-index: 1;
}

#calendar-dropdown button {
cursor: pointer;
background-color: #12612b;
color: white;
padding: 5px 10px;
border: none;
border-radius: 5px;
}

.icon {
    margin-top: 5px;
    margin-right: 5px;
    color: white;
}
```

```
<!DOCTYPE html>
<html lang="en">

<head>
    <meta charset="UTF-8">
    <meta name="viewport"
            content="width=device-width, initial-
            scale=1.0">
    <link
            href="https://fonts.googleapis.com/ic
            on?family=Material+Icons+Sharp"
            rel="stylesheet">
    <link rel="stylesheet"
            href="https://fonts.googleapis.com/cs
            s2?family=Material+Symbols+Outlin
            ed:opsz,wght,FILL,GRAD@24,400,0
            ,0" />
    <link rel="stylesheet"
            href="../static/styles/about_us/style_a
            boutus.css">
    <title>ResearchDirectorate</title>
</head>

<body>

    <div class="container">
        <!-- Sidebar Section -->
        <aside>

            <div class="Logo">
                <div class="logo">
                    <img src="../static/images/LOGO-
                MMSU.webp">
                    <h2 style="color:
                darkgreen;">G0<span
                class="danger">Nursery</span></h2
                >
                </div>
                <div class="close" id="close-btn">
                    <span class="material-icons-
                sharp">
                        close
                    </span>
                </div>
            </div>

            <div class="sidebar">
                <a href="dashboard" >
```

```
    <span class="material-icons-
sharp">
        monitor
    </span>
    <h3>Dashboard</h3>
 </a>

 <a href="control">
    <span class="material-icons-
sharp">settings_remote</span>
    <h3>Control</h3>
 </a>

 <a href="feed">
```

```
    <span class="material-icons-sharp
live-icon">
        live_tv
    </span>
    <h3>Feed</h3>
 </a>

 <a href="alerts">
    <span class="material-symbols-
outlined">
        notifications
        </span>
    <h3>Scheduler</h3>
    <span class="message-
count">1</span>
```

C 3. Mobile Application Code

```
<?xml version="1.0" encoding="utf-8"?>
<androidx.constraintlayout.widget.ConstraintL
ayout
xmlns:android="http://schemas.android.com/a
pk/res/android"

xmlns:app="http://schemas.android.com/apk/r
es-auto"

xmlns:tools="http://schemas.android.com/tool
s"
   android:layout_width="match_parent"
   android:layout_height="match_parent"
   android:orientation="vertical"
   tools:context=".MainActivity">

   <androidx.cardview.widget.CardView
      android:id="@+id/firstpage"
      android:layout_width="0dp"
      android:layout_height="0dp"
      android:visibility="gone"
      app:cardCornerRadius="25dp"

app:layout_constraintBottom_toBottomOf="@
+id/guideline4"

app:layout_constraintEnd_toEndOf="@+id/gu
ideline2"

app:layout_constraintStart_toStartOf="@+id/g
uideline1"

app:layout_constraintTop_toTopOf="@+id/gu
ideline3">


<androidx.constraintlayout.widget.ConstraintL
ayout
        android:layout_width="match_parent"

android:layout_height="match_parent">

        <TextView
           android:id="@+id/backtologin"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
           android:layout_marginTop="16dp"

android:drawableStart="@drawable/baseline_
arrow_back_24"

android:fontFamily="@font/oswald_semibold
"
           android:letterSpacing=".1"
           android:gravity="center"
           android:text="Back To Sign In"
           android:textSize="24dp"
           android:textStyle="bold"

app:layout_constraintEnd_toEndOf="parent"

app:layout_constraintHorizontal_bias="0.209"
```

```
app:layout_constraintStart_toStartOf="parent"

app:layout_constraintTop_toTopOf="parent"
/>

        <ImageView
            android:id="@+id/image1"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:layout_marginTop="32dp"
            android:scaleX="2"
            android:scaleY="2"

android:src="@drawable/verification_code_35
"

app:layout_constraintBottom_toTopOf="@+id
/words3"

app:layout_constraintEnd_toEndOf="@+id/gu
ideline6"

app:layout_constraintStart_toStartOf="@id/gu
ideline5"

app:layout_constraintTop_toTopOf="@+id/gu
ideline7" />

        <TextView
            android:id="@+id/words3"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:gravity="center"
            android:letterSpacing="0.12"
            android:text="Please Enter Your
Email Address To\n Receive a Verification
Code"
            android:textSize="18dp"
            android:textStyle="bold"

app:layout_constraintEnd_toEndOf="@+id/gu
ideline6"

app:layout_constraintStart_toStartOf="@+id/g
uideline5"

app:layout_constraintTop_toBottomOf="@+id
/image1"

app:layout_constraintBottom_toTopOf="@+id
/emailtextview"
            />

        <TextView
            android:id="@+id/emailtextview"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:alpha="0.7"
            android:text="Email"
            android:textSize="18dp"
            android:textStyle="bold"

app:layout_constraintBottom_toTopOf="@id/
user_email"

app:layout_constraintEnd_toEndOf="@+id/gu
ideline6"

app:layout_constraintHorizontal_bias="0.058"

app:layout_constraintStart_toStartOf="@+id/g
uideline5"

app:layout_constraintTop_toBottomOf="@+id
/words3" />

        <EditText
            android:id="@+id/user_email"
            android:layout_width="0dp"

android:layout_height="wrap_content"

android:background="@drawable/edittext_bg"

android:drawableEnd="@drawable/baseline_c
ontact_mail_24"
            android:inputType="text"
            android:padding="6dp"
            android:textSize="20dp"

app:layout_constraintBottom_toTopOf="@+id
/getOtp"

app:layout_constraintEnd_toEndOf="@+id/gu
ideline6"
```

```
app:layout_constraintHorizontal_bias=".58"

app:layout_constraintStart_toStartOf="@+id/guideline5"

app:layout_constraintTop_toBottomOf="@+id/emailtextview" />

        <Button
            android:id="@+id/getOtp"

android:layout_width="wrap_content"

android:layout_height="wrap_content"

android:backgroundTint="@color/green"
            android:text="Send"
            android:textSize="24dp"

app:layout_constraintBottom_toBottomOf="@+id/guideline8"

app:layout_constraintEnd_toEndOf="@+id/guideline6"

app:layout_constraintStart_toStartOf="@+id/guideline5"

app:layout_constraintTop_toBottomOf="@+id/user_email" />


<androidx.constraintlayout.widget.Guideline
            android:id="@+id/guideline5"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:orientation="vertical"

app:layout_constraintGuide_percent="0.05" />


<androidx.constraintlayout.widget.Guideline
            android:id="@+id/guideline6"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:orientation="vertical"

app:layout_constraintGuide_percent=".95" />


<androidx.constraintlayout.widget.Guideline
            android:id="@+id/guideline7"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:orientation="horizontal"

app:layout_constraintGuide_percent=".15" />


<androidx.constraintlayout.widget.Guideline
            android:id="@+id/guideline8"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:orientation="horizontal"

app:layout_constraintGuide_percent=".90" />


<androidx.constraintlayout.widget.Group

android:layout_width="wrap_content"

android:layout_height="wrap_content"

app:constraint_referenced_ids="words3,emailtextview,user_email,getOtp" />

</androidx.constraintlayout.widget.ConstraintLayout>
    </androidx.cardview.widget.CardView>

    <!--
////////////////////////////////////////////////////////////////////-->
    <androidx.cardview.widget.CardView
        android:id="@+id/secondpage"
        android:layout_width="0dp"
        android:layout_height="0dp"
        android:visibility="gone"
        app:cardCornerRadius="25dp"

app:layout_constraintBottom_toBottomOf="@+id/guideline4"
```

```
app:layout_constraintEnd_toEndOf="@+id/guideline2"

app:layout_constraintStart_toStartOf="@+id/guideline1"

app:layout_constraintTop_toTopOf="@+id/guideline3">


<androidx.constraintlayout.widget.ConstraintLayout
        android:layout_width="match_parent"

android:layout_height="match_parent">

        <TextView

android:id="@+id/backtoemailinput"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:layout_marginTop="16dp"

android:drawableStart="@drawable/baseline_arrow_back_24"

android:fontFamily="@font/oswald_semibold"
            android:letterSpacing=".1"
            android:text="Verify Email"
            android:textSize="24dp"

            android:textStyle="bold"

app:layout_constraintEnd_toEndOf="parent"

app:layout_constraintHorizontal_bias="0.209"

app:layout_constraintStart_toStartOf="parent"

app:layout_constraintTop_toTopOf="parent" />

        <ImageView
            android:id="@+id/image2"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:scaleX="2"
            android:scaleY="2"

android:src="@drawable/verification_code_35"

app:layout_constraintBottom_toTopOf="@+id/textView4"

app:layout_constraintEnd_toEndOf="@+id/guideline10"

app:layout_constraintStart_toStartOf="@id/guideline9"

app:layout_constraintTop_toTopOf="@+id/guideline11" />

        <TextView
            android:id="@+id/textView4"

android:layout_width="wrap_content"

android:layout_height="wrap_content"

            android:gravity="center"
            android:letterSpacing="0.12"
            android:text="Please Enter Your Verification Code"
            android:textSize="18dp"
            android:textStyle="bold"

app:layout_constraintBottom_toTopOf="@+id/otptextview"

app:layout_constraintEnd_toEndOf="@+id/guideline10"

app:layout_constraintHorizontal_bias="0.555"

app:layout_constraintStart_toStartOf="@+id/guideline9"

app:layout_constraintTop_toBottomOf="@+id/image2"


app:layout_constraintStart_toStartOf="@+id/guideline9" />


<androidx.constraintlayout.widget.Guideline
```

```
            android:id="@+id/guideline9"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:orientation="vertical"

app:layout_constraintGuide_percent="0.05" />


<androidx.constraintlayout.widget.Guideline
            android:id="@+id/guideline10"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:orientation="vertical"

app:layout_constraintGuide_percent=".95" />


<androidx.constraintlayout.widget.Guideline
            android:id="@+id/guideline11"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:orientation="horizontal"

app:layout_constraintGuide_percent=".15" />


<androidx.constraintlayout.widget.Guideline
            android:id="@+id/guideline12"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:orientation="horizontal"

app:layout_constraintGuide_percent=".90" />


<androidx.constraintlayout.widget.Guideline
            android:id="@+id/middle"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:orientation="horizontal"

app:layout_constraintGuide_percent=".55" />

</androidx.constraintlayout.widget.ConstraintLayout>
   </androidx.cardview.widget.CardView>
   <!--
////////////////////////////////////////////////////////////////////
-->
   <androidx.cardview.widget.CardView
      android:id="@+id/thirdpage"
      android:layout_width="0dp"
      android:layout_height="0dp"
      android:visibility="gone"
      app:cardCornerRadius="25dp"

app:layout_constraintBottom_toBottomOf="@+id/guideline4"

app:layout_constraintEnd_toEndOf="@+id/guideline2"

app:layout_constraintStart_toStartOf="@+id/guideline1"

app:layout_constraintTop_toTopOf="@+id/guideline3">


<androidx.constraintlayout.widget.ConstraintLayout
         android:layout_width="match_parent"

android:layout_height="match_parent">

         <ImageView
            android:id="@+id/imageview"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
               android:scaleX="2"
               android:scaleY="2"
               app:tint="@color/deep_blue"

android:src="@drawable/baseline_lock_person_24"

app:layout_constraintEnd_toEndOf="@+id/guideline14"

app:layout_constraintStart_toStartOf="@id/guideline13"
```

```
app:layout_constraintTop_toTopOf="@+id/guideline15"

app:layout_constraintBottom_toTopOf="@+id/words"
            />

        <TextView
            android:id="@+id/words"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:gravity="center"
            android:letterSpacing="0.11"
            android:text="Your New Password Must be Different\n From Previous Password"
            android:textSize="18dp"
            android:textStyle="bold"

app:layout_constraintEnd_toEndOf="@+id/guideline14"

app:layout_constraintStart_toStartOf="@+id/guideline13"

app:layout_constraintTop_toBottomOf="@+id/imageview"

app:layout_constraintBottom_toTopOf="@id/newpass1textview"
            />

        <TextView
app:layout_constraintTop_toBottomOf="@+id/newpass1"

app:layout_constraintBottom_toTopOf="@+id/newpass2"
            />

        <EditText
            android:id="@+id/newpass2"
            android:layout_width="0dp"

android:layout_height="wrap_content"
            android:layout_marginTop="8dp"

android:background="@drawable/edittext_bg"

android:drawableEnd="@drawable/baseline_contact_mail_24"
            android:padding="6dp"
            android:textSize="20dp"
            android:inputType="text"

app:layout_constraintEnd_toEndOf="@+id/guideline14"

app:layout_constraintHorizontal_bias="1.0"

app:layout_constraintStart_toStartOf="@+id/guideline13"

app:layout_constraintTop_toBottomOf="@+id/newpass2textview"

app:layout_constraintBottom_toTopOf="@+id/changepass_btn"
            />

        <Button
            android:id="@+id/changepass_btn"

android:layout_width="wrap_content"

android:layout_height="wrap_content"

android:backgroundTint="@color/green"
            android:text="Save"
            android:textSize="24dp"

app:layout_constraintBottom_toBottomOf="@+id/guideline16"

app:layout_constraintEnd_toEndOf="@+id/guideline14"

app:layout_constraintStart_toStartOf="@+id/guideline13"

app:layout_constraintTop_toBottomOf="@+id/newpass2" />


<androidx.constraintlayout.widget.Guideline
            android:id="@+id/guideline13"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
```

```
            android:orientation="vertical"

app:layout_constraintGuide_percent="0.05" />


<androidx.constraintlayout.widget.Guideline
            android:id="@+id/guideline14"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:orientation="vertical"

app:layout_constraintGuide_percent=".95" />


<androidx.constraintlayout.widget.Guideline
            android:id="@+id/guideline15"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:orientation="horizontal"

app:layout_constraintGuide_percent=".15" />


<androidx.constraintlayout.widget.Guideline
            android:id="@+id/guideline16"

android:layout_width="wrap_content"

android:layout_height="wrap_content"
            android:orientation="horizontal"

app:layout_constraintGuide_percent=".98" />

</androidx.constraintlayout.widget.ConstraintLayout>
   </androidx.cardview.widget.CardView>



<androidx.constraintlayout.widget.Guideline
      android:id="@+id/guideline1"
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
      android:orientation="vertical"

app:layout_constraintGuide_percent=".025" />


<androidx.constraintlayout.widget.Guideline
      android:id="@+id/guideline2"
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
      android:orientation="vertical"

app:layout_constraintGuide_percent=".975" />


<androidx.constraintlayout.widget.Guideline
      android:id="@+id/guideline3"
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
      android:orientation="horizontal"

app:layout_constraintGuide_percent=".15" />


<androidx.constraintlayout.widget.Guideline
      android:id="@+id/guideline4"
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
      android:orientation="horizontal"

app:layout_constraintGuide_percent=".70" />
</androidx.constraintlayout.widget.ConstraintLayout>
<?xml version="1.0" encoding="utf-8"?>
<androidx.drawerlayout.widget.DrawerLayout
xmlns:android="http://schemas.android.com/apk/res/android"

xmlns:app="http://schemas.android.com/apk/res-auto"

xmlns:tools="http://schemas.android.com/tools"
   android:id="@+id/drawer_layout"
   android:layout_width="match_parent"
   android:layout_height="match_parent"
   tools:context=".Main_page">

   <androidx.appcompat.widget.Toolbar
      android:id="@+id/toolbar"
      style="@style/WhiteTextToolbarStyle"
      android:layout_width="match_parent"

android:layout_height="50dp"></androidx.appcompat.widget.Toolbar>

   <FrameLayout
```

```
        android:id="@+id/fragment_container"
        android:layout_width="match_parent"
        android:layout_height="match_parent" />


<com.google.android.material.navigation.NavigationView
        android:id="@+id/navigation_view"
        android:layout_width="wrap_content"
        android:layout_height="match_parent"
        android:layout_gravity="start"

app:headerLayout="@layout/header_menu"
        app:menu="@menu/main_menu">


</com.google.android.material.navigation.NavigationView>

</androidx.drawerlayout.widget.DrawerLayout>
<?xml version="1.0" encoding="utf-8"?>
<androidx.constraintlayout.widget.ConstraintLayout

lineChart.getDescription().setEnabled(false); // Disable chart description
                XAxis xAxis = lineChart.getXAxis();
                xAxis.setEnabled(false);
                xAxis.setDrawLabels(true); // Enable X-axis labels
                xAxis.setGranularity(1f); // Ensure only integer labels are shown on X-axis

xAxis.setPosition(XAxis.XAxisPosition.BOTTOM); // Set X-axis position
                YAxis yAxis = lineChart.getAxisLeft();

lineChart.setGridBackgroundColor(Color.RED);

lineChart.getAxisRight().setEnabled(false); // Disable right Y-axis
                lineChart.invalidate(); // Refresh chart data
            }
        });
    }
  }
```

```
  private void updateSpinner(List<String> datesList) {
      if (requireContext() != null){
          // Create an ArrayAdapter using the string array and a default spinner layout
          ArrayAdapter<String> spinnerAdapter = new ArrayAdapter<>(requireContext(),
                  R.layout.spinner_design,
                  datesList);
          // Specify the layout to use when the list of choices appears

spinnerAdapter.setDropDownViewResource(android.R.layout.simple_spinner_dropdown_item);
          // Apply the adapter to the spinner

spinnerDate.setAdapter(spinnerAdapter);

spinnerDate.setSelection(listDates.size()-1);
      }
  }
  private void handleDateSelection(String selectedDate) {
      Document document = dataMap.get(selectedDate);

      if (document != null) {
          Object temperature = document.get("averageTemperature");
          Object humidity = document.get("averageHumidity");
          Object lumens1 = document.get("averageLumens1");
          Object lumens2 = document.get("averageLumens2");
          Object lumens3 = document.get("averageLumens3");
          Object lumens4 = document.get("averageLumens4");


      } else {
          Log.e("Selected Data", "No data found for the selected date");
      }
  }

}
package com.example.garlicapp;
//Create new User
```

```
import android.content.Intent;
import android.os.Bundle;
import android.util.Log;
import android.view.View;
import android.widget.Button;
import android.widget.EditText;
import android.widget.TextView;
import android.widget.Toast;

import
androidx.appcompat.app.AppCompatActivity;

import
com.google.android.gms.auth.api.signin.GooglSignIn;
import
com.google.android.gms.auth.api.signin.GooglSignInAccount;
import
com.google.android.gms.auth.api.signin.GooglSignInClient;
import
com.google.android.gms.auth.api.signin.GooglSignInOptions;
import
com.google.android.gms.tasks.OnCompleteListener;
import com.google.android.gms.tasks.Task;

import org.bson.Document;
import org.bson.types.ObjectId;

import java.time.Instant;
import java.time.ZoneId;
import java.time.ZonedDateTime;
import java.util.Date;


public class SetUsername extends
AppCompatActivity {
   EditText getUser, getPassword, getEmail,
getIncCode;
   TextView welcomemessage;
   GoogleSignInOptions gso;
   private String email;
   GoogleSignInClient gsc;
   private Button confirm_btn;
   boolean empty = false;


   @Override
   protected void onCreate(Bundle
savedInstanceState) {
      super.onCreate(savedInstanceState);

setContentView(R.layout.activity_set_username);
      gso = new
GoogleSignInOptions.Builder(GoogleSignInOptions.DEFAULT_SIGN_IN).requestEmail().build();
      gsc = GoogleSignIn.getClient(this, gso);
      GoogleSignInAccount acc =
GoogleSignIn.getLastSignedInAccount(this);
      String inviteCode = "G49glis12!3#";
      welcomemessage =
findViewById(R.id.welcomemessage);

      getUser = findViewById(R.id.getUser);
      getEmail = findViewById(R.id.getEmail);
      getPassword =
findViewById(R.id.getPassword);
      getIncCode =
findViewById(R.id.getInvCode);
      if (acc != null) {
         welcomemessage.setText("Welcome,
"+acc.getDisplayName());
         getEmail.setText(acc.getEmail());

getUser.setText(acc.getDisplayName());
      }


      confirm_btn =
findViewById(R.id.confirm_btn);
      confirm_btn.setOnClickListener(new
View.OnClickListener() {


            if (getemail.trim().isEmpty()) {
               empty = true;
               getEmail.setError("This field is
required");
            }
            if (getuser.trim().isEmpty()) {
               empty = true;
               getUser.setError("This field is
required");
            }
            if (getpass.trim().isEmpty()) {
               getPassword.setError("This field
is required");
               if (getpass.length() < 8){
```

```
getPassword.setError("Password Must Be Greater Than 8 Characters");
                    empty = true;
                }
            }

Realm.init(getApplicationContext());
            AppConfiguration appConfiguration = new AppConfiguration.Builder(getString(R.string.App_id)).build();
            App app = new App(appConfiguration);

app.loginAsync(Credentials.anonymous(), it -> {
                if (it.isSuccess()) {
                    User user = app.currentUser();
                    if (user != null) {
                        MongoDatabase mongoDatabase = user.getMongoClient(getString(R.string.servicename)).getDatabase(getString(R.string.databaseNameUser));
                        String collectionname = "users";

MongoCollection<Document> collection = mongoDatabase.getCollection(collectionname);

collection.find().iterator().getAsync(result -> {
                            if (result.isSuccess()) {
                                boolean isnamepresent = false;
                                for (MongoCursor<Document> its = result.get(); its.hasNext(); ) {
                                    Document document = its.next();
                                    email = document.getString("email");
                                    if (getemail.equals(email)) {
                                        isnamepresent = true;
                                        break;
                                    }
                                }
                                if (isnamepresent && empty) {
                                    Toast.makeText(getApplicationContext(), "Email Taken", Toast.LENGTH_LONG).show();

getEmail.setError("This Email" + getemail + " exists!");
                                } else {
                                    if (!getinv.equals(inviteCode)) {

getIncCode.setError("Invitation Code Do not Match!");
                                    } else if (getinv.trim().isEmpty()) {

getIncCode.setError("This field is required");
                                    } else if (getpass.length()<8) {

getPassword.setError("Password Must Be Greater Than 8 Characters");
                                    } else {


addUserToCollection(user, getuser, getemail, getpass);

Toast.makeText(getApplicationContext(), "Account Created", Toast.LENGTH_LONG).show();
                                    }

                                }

                            }
                        });
                    }
                } else {
                    Log.e("EXAMPLE", "Failed to LogIn: " + it.getError().getErrorMessage());
                }
            });
        }
    });
  }

   private void addUserToCollection(User user, String username, String email, String password) {
      MongoDatabase mongoDatabase = user.getMongoClient(getString(R.string.servic
```

```
ename)).getDatabase(getString(R.string.databa
seNameUser));
        String collectionname = "users";
        MongoCollection<Document> collection
=
mongoDatabase.getCollection(collectionname)
;
        ObjectId randID = new ObjectId();

        // Use java.time to handle date and time
        Instant instant = Instant.now();
        ZonedDateTime zonedDateTime =
instant.atZone(ZoneId.of("Asia/Manila"));
        Date dateformat =
Date.from(zonedDateTime.toInstant());

        // Create a new user document
        Document newUserDocument = new
Document()
                .append("_id", randID)
                .append("name", username)
                .append("email", email)
                .append("password",
BCrypt.withDefaults().hashToString(12,
password.toCharArray()))
                .append("imagesource", "null")
                .append("filename", "null")
                .append("registration_date",
dateformat);

        // Insert the new user document

collection.insertOne(newUserDocument).getA
sync(result -> {
            if (result.isSuccess()) {
                Log.v("EXAMPLE", "Inserted new
user: " + username);
                Intent intent = new
Intent(getApplicationContext(),
IntroActivity.class);
                intent.putExtra("email_extra_users",
email);
                startActivity(intent);ssss
            } else {
                Log.e("EXAMPLE", "Failed to insert
new user: " +
result.getError().getErrorMessage());
            }
        });
    }

    void signout() {
gsc.signOut().addOnCompleteListener(new
OnCompleteListener<Void>() {
            @Override
            public void onComplete(Task<Void>
task) {
                finish();
                startActivity(new
Intent(getApplicationContext(),
MainActivity.class));
            }
        });
    }
}
package com.example.garlicapp;

import io.realm.mongodb.Credentials;
import io.realm.mongodb.User;
RoundedCornersTransformation(70, 0)
```