RMIT University

Engineering Capstone Project Part B - OENG1185

OENG1185/COSC2503 Capstone Project Part B / Programming Project 2

FINAL REPORT

Smart Irrigation System for a Community Garden

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Table of Contents

List of Figures

List of Tables

I. EXECUTIVE SUMMARY

The Calico capstone team has fulfilled all the requested deliverables from our industry partner since the built system runs justifiable and receive good feedback in the SSET showcase 2024. RMIT Sustainability has requested SSET final-year students to create a "Smart Watering System" as a 2024 capstone project to promote sustainable gardening practices in RMIT's sustainable garden, the Aloe Garden. The watering system should have a water-saving function, and innovative setup that can assist garden participants in reducing stress during its use. The system combines sensor-based and schedule-based watering methods, allowing users to adjust the irrigation based on real-time soil moisture levels or adjusting to their personalized schedules.

This report by the Calico capstone team proposes solutions for RMIT Sustainability, including project context, literature review, and market research. In the market research session, our team conducted an extensive literature review to explore existing smart irrigation systems, sensor technologies, and water-saving practices. Additionally, market research helped us identify trends, available components, and potential theoretical backups for our project. Given the scope of the project in this second phase, and the limitation for storage in RMIT Sustainability, Calico team successfully deal with industry partner to scale down the prototype to demonstrate it in the Engineering capstone. Although the system prototype is smaller size compared to the full-scale design in Capstone A. The smart watering system still combines several key components:

- Irrigation System and the controller function: Modular and pre-installed for ease of setup, featuring a centrifugal pump, water pipes, solenoid valves, and adjustable sprinklers. The system uses sensors to monitor soil moisture and control watering based on real-time data.

- Water Shooting Range: Designed for user engagement and stress relief, featuring a water gun, targets, and a closed-loop system to ensure no water wastage with 2 separate water tanks setup

- Water Tanks: A small tank collects water from the shooting range, while a larger tank serves as the primary reservoir for the project. The tanks are reinforced with acrylic sheets, glue and with the designed in joint joining techniques to prevent deformation and leakage.

The smart watering system's key functionalities include a user-friendly web interface connected to a Raspberry Pi, enabling users to monitor schedules, review sensor data, and switch between automatic and manual watering modes. Additionally, soil moisture monitoring with adaptive adjustments ensures efficient water management. The waterproofing features for all the electronics components, while maintaining the right output water volume was also focused to fulfill the project deliverables.

The project encountered challenges such as issues with sensor data accuracy, hardware problems with the Raspberry Pi, and the need for improved waterproofing and durability. Addressing these issues is crucial for enhancing system performance and reliability.

The "Smart Watering System" project successfully developed a functional prototype that demonstrates the potential for advanced irrigation solutions in garden management of RMIT Sustainability. Improvements on system reliability, user experience, and long-term performance should be more concentrated on if the project carried on to the next phase after handing over for the customer. Project has showed the prototype at Engineering Capstone 2024, presented the system to 35 booth participants with the direct testing of 7 participants for the shooting prototype, and received good feedback.

II. PROJECT BACKGROUND AND PROBLEM STATEMENT

This report outlines the finalized result for Team Calico's Smart Watering System for a Community Garden Using a Water Shooting Gun. It builds on the progress from Capstone Project A and covers key areas: Project Description, Problem Statement, Literature review and market research, Solution Design, Result Analysis and discussion.

1. Project Description

The project's scope has shifted from a comprehensive system to a scaled-down prototype, retaining core functionalities. This prototype will demonstrate water and energy efficiency through an automated watering model, integrating sensors for real-time control. While the real-world system requires extended operation, the demonstration schedule is condensed for efficiency.

2. Problem Statement

RMIT Sustainability aims to create a community garden that encourages sustainable living. However, traditional watering methods may be inefficient or labor-intensive for the around 40 m^2 garden at RMIT Building 9. There is a need for a system that not only optimizes water use but also engages students and staff in garden maintenance, making it a more interactive and educational experience. Three key challenges correspond to the pillars of sustainability **- People, Planet, and Profit:**

- **People**: The garden lacks sufficient human resources due to an underdeveloped volunteering culture in Vietnam. The solution should involve a water gun shooting range that triggers the watering mechanism, engaging students and staff in a fun, interactive way while addressing the labor shortage.
- **Planet:** The garden faces uneven watering due to an underground electrical system that releases heat, particularly affecting plants on the right side, causing them to weaken and die. The system must efficiently water a diverse range of plants (vegetables, fruits, and medicinal plants) and address the heat-related challenges.
- **Profit:** The system must be easy to maintain and maximize water efficiency. An irrigation plan that includes pumps, sensors, and automatic water refilling will ensure optimal water management and reduce long-term costs.

This smart watering system will enhance the garden’s sustainability while encouraging community involvement.

3. Key Deliverables

- **Automated Watering Model:** Adjusted for demonstration but keeps sensor integration.
- Water Shooting System (Rescale to a smaller model after verifying with Stakeholder): Merging two tasks (shooting range target and water gun volume monitoring) into a single detailed CAD design for the prototype.
- **Irrigation System:** Originally planned for a real-scale garden, it is now designed for an exhibition area prototype, including nozzle plans, pipes, and storage layout based on plant needs. The Calico team has included testing results for different plants, and how the system works with different types of plants.
- **Water Storage and Pipe Network:** The storage and pipe layout consider plant requirements and ensure efficient water delivery.
- **Budget and Communication:** A detailed resource analysis remains unchanged.

The adjusted scope aims to maintain project alignment while preparing for demonstration and exhibition, which is also called SSET capstone showcase 2024. The showcase would happen on 12th September 2024.

III. LITERATURE REVIEW AND MARKET RESEARCH

1. Recap from Progress Report and Completion Plan

A few pertinent techniques, designs, and technologies from the articles and research papers were included in the Progress Report. Planter arrangements for garden design, rain barrels for watering, irrigation rate calculations for watering requirements, and irrigation systems for garden watering are just a few examples. Utilizing Zigbee technology to keep an eye on routine maintenance and garden system hardware. According to the Completion Plan, the team project's task scope involved reducing the prototype's size because it was moved to Building 10 for display rather than the actual garden, and it also involved somewhat modifying the system to accommodate the prototype's new conditions:

- Develop and refine an automated prototype for water and energy efficiency.
- Build a working model of the water system based on water shooting.
- Plan the location and coverage of irrigation systems.
- Design a nozzle plan, pipe, and storage components' location map for irrigation system.
- Prepare a project budget and maintain communication with stakeholders.

The sensors offer real-time data for automatic adjustments, and the user can set watering periods. Monitoring the water level prevents overflow. A user-activated manual watering function. A minimum of one day will be the duration of the scheduling function in the real-world system. To achieve the requirements of the demonstration, the team must shorten the porotype's lengthy interval period. The team needs a technique to use plants to demonstrate the effectiveness of the system because some plants need less regular watering than others.

From the Progress Report, the project was compared with Maka Wi-Fi enabled automatic watering system using Solenoid valve and Rain Bird ESP-TM2 Outdoor Automatic Irrigation Controller. Although the Maka system is simple to use, zone management for individual plants in the garden is limited. Since the product did not include this feature, the team had to interface the irrigation system with sensors and modify the watering schedule depending on data in order to conserve water. Additionally, the schedule can only be manually altered. With features like zone management with four distinct channels and weather-based modification, Rain Bird ESP-TM2 is a more sophisticated product. Yet, the cost is high, and the project need was not entirely met in exchange. To encourage more individuals to adopt a sustainable lifestyle, the team planned to combine the irrigation system with shooting. For the Rain Bird ESP-TM2 to monitor the water within the firing range, it is necessary to connect the controller to a water level sensor. This is because the Rain Bird ESP-TM2 is limited to specifically designed sensors.

2. Updated Literature Review and Market Research

When developing, testing and researching, there are quite some changes in the project design and adjustment for solving problems. The team also discovered some relevant technologies, techniques, and designs:

IoT-Based Smart Irrigation System [1].

The Internet of Things (IoT) is a critical component of contemporary systems, particularly in automation. These systems use Internet of Things architecture to link different parts, gather information, and come to wise judgments. The objective of the case study by G. Sasi Kumar, G. Nagaraju, D. Rohith, and A. Vasudevarao is to build and implement an IoT-based Smart Irrigation system that is affordable, automated, and minimizes the need for human involvement while conserving water. Their design's essential elements are:

- ***Soil Moisture Sensors:*** allows to monitor and detect the changes in soil moisture levels
- ***Node MCU:*** Which is similar to Raspberry Pi, responsible for receiving data from sensors and activating the irrigation motor.
- ***Mobile Alert:*** Allow users to receive notifications about soil moisture levels on the mobile app.

The project's functionality, which deals with a system that autonomously waters plants based on real-time soil moisture data, is very similar. When the soil is completely wet, the DC motor pump switches off. It goes on when the moisture level is low. Their implementation method reduced the problems brought on by over- and under-irrigation by providing the field with the appropriate amount of water. denoting a lack of crop failure danger. This table shows how well their subsequent test performed and was effective.

S. No.	Type of soil	Moisture content (%)	Motor ON/OFF
1	Wet soil	75	OFF
2	Partially Wet soil	55	ON
3	Dry soil	30	ON

Figure 1: Moisture Performance of Subsequent Test [1]

Computer Vision and AI Technologies [2]

Ai Technologies.

In addition to urban and rural agriculture, automated irrigation systems can potentially benefit from the application of artificial intelligence (AI). "Smart Irrigation System in Agriculture: A Systematic Review" states that artificial intelligence (AI) has many different study fields, one of which is machine learning (ML). ML allows computers to learn through algorithms that process datasets and make predictions about them without the need for explicit programming; these algorithms are categorized into sub-fields based on the complexity and type of application.

Another area of AI is fuzzy logic, which Lofti Asker Zadeh first discussed in 1965. It developed as a substitute for standard Boolean logic in situations where it is unable to address problems involving variables that can only take on binary values, which are often represented mathematically by the numbers 0 and 1. Because it uses linguistic variables and IF-Then rules to simulate human decision behavior derived from experience and stimulate human thought processes, fuzzy logic is categorized as an artificial intelligence discipline.

Using a modified version of the PRISMA 2020 technique, AI was used in the review process to screen and filter pertinent articles. After identifying 170 articles in total, they reduced the number of sources to 50 important ones for further examination. The primary areas of application are urban and rural agriculture. The adaptation of smart irrigation systems for Urban Agriculture settings—where resources and space are scarce—is highlighted in the review. Additionally, it discusses its applicability in conventional farming, emphasizing soil-based crops in rural farming. One of the difficulties in using AI is scaling the technologies for broad application in various agricultural settings. In order to develop a coherent smart irrigation system, there is also a requirement for the smooth integration of multiple technologies (AI, IoT, Big Data). Additionally, sustainability refers to how long-term and economically viable the systems are.

Computer Vision.

An inventive method for effectively using water in agriculture is shown in the report article "Automatic Irrigation System Based on Computer Vision and an Artificial Intelligence Technique Using Raspberry Pi" [3]. The suggested system employs a non-contact method for computer vision. Soil is captured in successive photos using a Raspberry Pi camera. Changes in soil color are tracked to assess when irrigation is necessary. Efficiency is increased by minimizing human interference. The experiment was conducted in a home garden over the course of three months, considering the various weather conditions at each time. Leishmaniosis is a neglected tropical illness that is a serious health concern that is spread by sand flies. There were climate elements governing the risk of vector activity in different geographic zones of the country. The system consists of a camera, a relay to regulate the water pump, and a Raspberry Pi to act as the central controller. A power bank prevents disruptions by ensuring a steady power supply. A digital Raspberry Pi 4 with a camera that worked with modules 2, 3, and 4 was set up in the research area at a 45-degree angle, between one and two sample soil types, from one to one and a half meters. Using an image sensor (OV5647) with a resolution of up to 5MP in JPG format, the Pi camera captured photographs on a Raspberry Pi minicomputer with a resolution of 2592 x 1944 pixels.

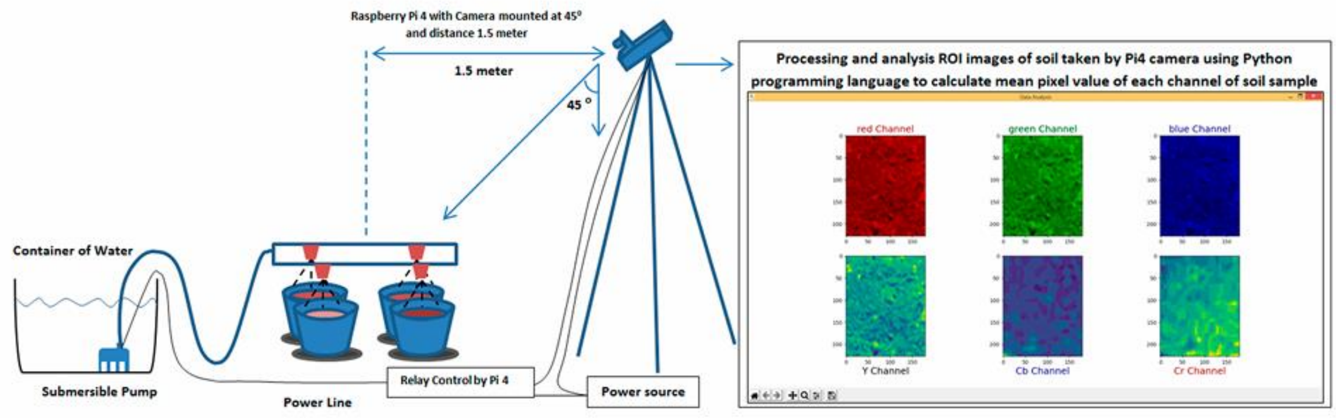

Figure 2: Computer Vision Irrigation System Diagram [3]

The suggested imaging system's experimental setup relies on the observation and analysis of soil color using Python 3.10 computer language methods to process photos. In three distinct weather conditions—dusty, sunny, and cloudy—samples of soil (sand and peat moss soil) were used in the experiment. Each scenario included more than 300 sample photos. There were three different scenarios that were carried out: one with dust, one with clouds, and the final one with sunshine. Using an RPi 4 camera, all experiment photos were captured in real time, and their analysis determined whether irrigation was necessary.

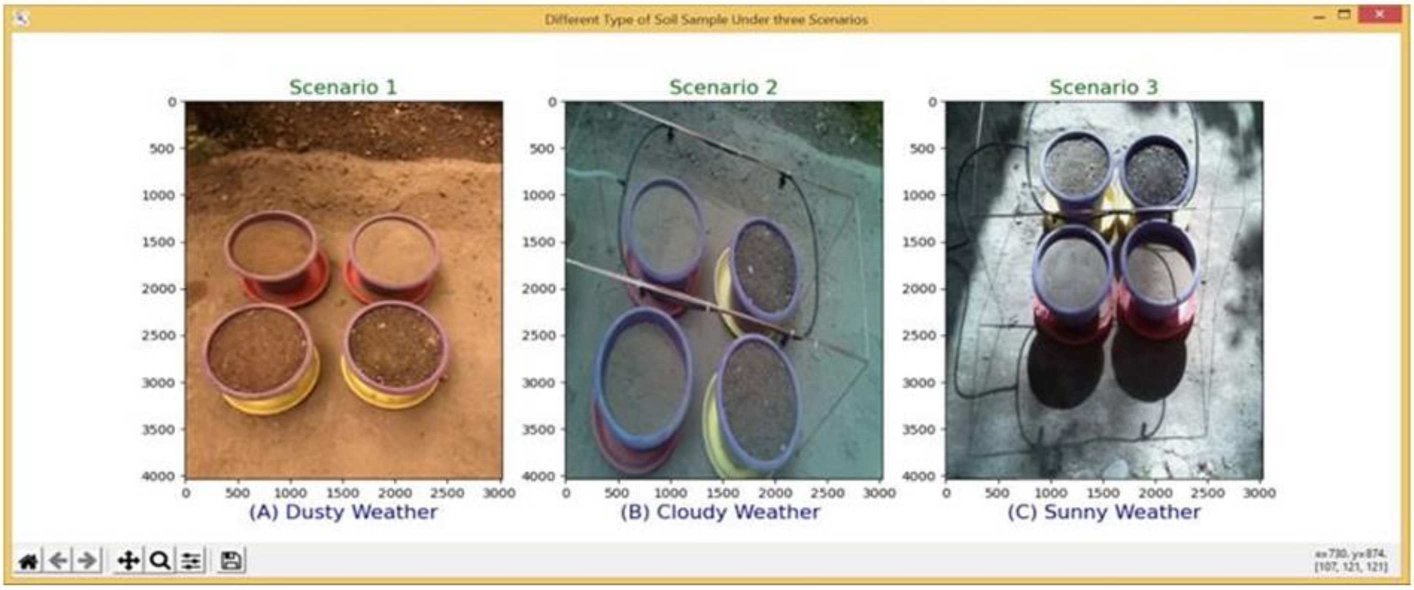

Figure 3: Weather Condition Test Cases [3]

No. of Soil Types per Scenario	Exp. Scenario	Conditions
1, 2	Dusty	Dry
		Wet
1, 2	Cloudy	Dry
		Wet
1, 2	Sunny	Dry
		Wet

Figure 4: Scenarios Data Collection [3]

The system's benefits include lowering water usage, which improves irrigation and avoids overwatering. Reduce labor costs and requirements to allow farmers to concentrate on other duties. Furthermore, it is possible to access and monitor soil conditions and plant health remotely. The system is still having difficulties, though, and new directions are required. optimizing the algorithm to increase the precision of color-based decision-making. modifying the system's scales to accommodate wider farming regions. Real-time weather information is included to improve decision-making through integration with weather data. Overall, this study shows how computer vision and the Raspberry Pi's capability can transform irrigation techniques. It supports sustainable agriculture by limiting human interference and cutting down on water waste.

Communication Protocol

LoRa (Long Range)

Spread spectrum modulation technology known as LoRa was developed from Chirp Spread Spectrum (CSS) technology. Similar to how bats and dolphins communicate, it uses chirp pulses to encode information on radio waves. Long-range reception of LoRa modulated transmission is possible, and it is resistant to disruptions [4]. Applications that transfer small amounts of data at low bit rates might benefit greatly from it. Compared to technologies like Wi-Fi, Bluetooth, or Zigbee, data can be delivered over a great distance. These characteristics may make LoRa appropriate for low-power sensors and actuators [4].

Figure 5: LoRa System [5]

It is possible to use LoRa on license-free sub-gigahertz brands. For instance, 868 MHz, 433 MHz, and 915 MHz at the expense of range, it may operate at 2.4GHz to reach faster data rates than sub-gigahertz. These frequencies belong to ISM brands, which are used for industrial, scientific, and medicinal applications and are protected internationally [4]. The ISM band and SRD band are two distinct regional frequency ranges used in Lora's star-shaped network architecture. These comprise the frequency ranges in Europe between 863MHz and 870MHz and 433.05MHz to 434.79MHz [5]. The frequency ranges of 902MHz to 928MHz in North America are authorized for data transmission. The sensors don't need new batteries to function for many years [5]. Additionally, LoRa has a very long range. Up to 55 kilometers can be bridged between the transmitter and the receiver in sparsely populated areas. Due to construction, the range is just a few kilometers in urban areas; however, good penetration allows for the reach of subterranean sensors [5].

LoRa has a Wide Area Network component called LoRa (WAN). a protocol constructed using LoRa modulation as a foundation. It details message format and how devices use the LoRa hardware. Between devices and gateways, LoRaWAN controls communication. Its remarkable range is achieved at ultra-low power.

- Ultra-low Power: LoRaWAN endpoints are designed to last as long as ten years on a single coin cell battery thanks to their economical operation [4].
- Long Range: In densely populated regions, LoRaWAN gateways can send and receive signals up to 3 kilometers in length, and up to 10 kilometers in rural areas [4].

Cellular Network

Wireless communication between devices is made possible via a sort of telecommunications infrastructure called a cellular network, often known as a mobile network. Its structures create what are known as Cells, which are smaller geographical units. Furthermore, a fixed-location transceiver—also referred to as a base station or cell tower - typically serves each cell [6, 7]. Together, these cells encompass a huge landmass, facilitating smooth connectivity between various locations. There is a hierarchy of cell types inside the cellular network [6]:

- **Femtocells:** Often utilized indoors, in homes and small offices, these minuscule cells have a coverage area of only a few meters.
- **Picocells**: Found in wireless local area networks (WLANs), picocells are slightly larger in size and have a ten-meter coverage range.
- **Microcells:** Located in metropolitan areas, these cells span hundreds of meters and are utilized to facilitate technologies such as Personal Communication Service (PCS).
- **Macrocells**: The largest cells, and they span several kilometers. cater to urban regions.
- ***Megacells:*** They are used in conjunction with satellite communication and cover entire countries.

A base station is a component of every cell that connects to mobile devices inside its coverage region. In order for devices (like mobile phones) to connect to the network and make voice calls or access the internet, the base station receives and broadcasts radio signals.

Advantages [6]:

- It allows both stationery and mobile users to connect. Services for data and voice are also offered, possesses enhanced capacity and is easy to maintain.
- Equipment can be easily upgraded, and less energy is used.
- Because it is wireless, it is used in locations where wires cannot be installed.
- Primarily utilize all public and private networks' features and functionalities.
- Able to be dispersed over a wider area of coverage.

Disadvantages [6]:

- Offers a lesser data rate than DSL and fiber optic networks, which are wired networks. Depending on the wireless technology—GSM, CDMA, LTE, etc. The data rate varies.
- Multipath signal loss affects macrophage cells.

- Limited capacity to serve clients, which varies depending on the channels and various methods of access.
- There are security concerns because the link is wireless.

Design Consideration

It is crucial to remember that while technology can improve the automated irrigation system's efficiency, a well-thought-out design layout is also necessary to further boost the system's effectiveness and aesthetic appeal. There are a few things to consider while creating an automated irrigation system, including:

- **Placement of the sensor:** it's important to put moisture sensors correctly. It is important to arrange sensors so that they represent various fields of view.
- **Decision Algorithms:** It is crucial to create reliable algorithms that take crop kind, soil properties, and weather forecasts into account.
- **Communication Protocol:** Selecting the appropriate communication protocol (LoRa, Zigbee, or Wi-Fi) for data transmission between sensors and controllers.
- **Energy Efficiency:** Solar panels and sensors that run on batteries can assist in cutting down on energy use.
- **Pump control:** Using effective pump control techniques to maximize the supply of water.

3. Market Research and Comparison.

Compare Netro Sprite Smart Sprinkler Controller to The Project [8]

The Netro Controller offers good water efficiency since it adjusts irrigation schedules based on soil moisture levels and real-time meteorological data. For the most part, it is quite easy to set up and use for first time users. Using the Netro App, it enables management and control. The project prototype is primarily intended for community gardens, where zone control on a wide scale is necessary for each individual plant, and status information must be displayed on a monitor or app. This is the Netro Controller's deficiency because it only has 8 zones and is only appropriate for smaller yards; also, it lacks a touchscreen and is primarily dependent on apps.

Compare RainPoint Smart Wi-Fi 2-Zone Sprinkler Timer to The Project [8]

The RainPoint Timer design is perfect for balconies or tiny spaces. It is easy to set up and install, much like Netro Controller. For users, it is incredibly affordable. As RainPoint Timer is only intended for two zones, it does not have the big zone management that the Project Porotype requires to function in a community-scale garden. Additionally, the RainPoint Timer lacks some capabilities due to its simplistic designs and functionalities, but the Project prototype has many more features because it operates based on sensors. This makes the RainPoint Timer a no-frills alternative for users.

IV. SOLUTION DESIGN

Scope of Work

The previous report furnished a thorough elucidation of our work. Given that the scope of work remains unaltered, I shall recapitulate it with the following table for your convenience.

Table 1: Scope of Work

Scope	Deliverables
Develop and refine an automated prototype model for water and energy efficiency.	Water saving & energy efficiency prototype model - automation function
Create detailed CAD drawings for the shooting range target	Technical drawing - Water gun model, shooting range target
Design a water gun system with volume monitoring	Diagram, component schematics, and assembly drawing of the shooting range
Plan the location, investment phases, and coverage of the irrigation system.	Irrigation system - location plan, phase of investment plan, coverage radius
Design the nozzle plan, pipe, and storage components' location map of the irrigation system.	Irrigation system - nozzle plan, pipe plan, and storage plan
Prepare a project budget and maintain communication with stakeholders.	Budget and stakeholders contact
Fulfil all reports, presentation and evaluations from SSET Capstone course	Reporting and updating results with stakeholders
Identify project risks and manage the budget accordingly.	Risk management and budget plan

A more detailed explanation will be included in the following Appendix section.

1. Design Overview

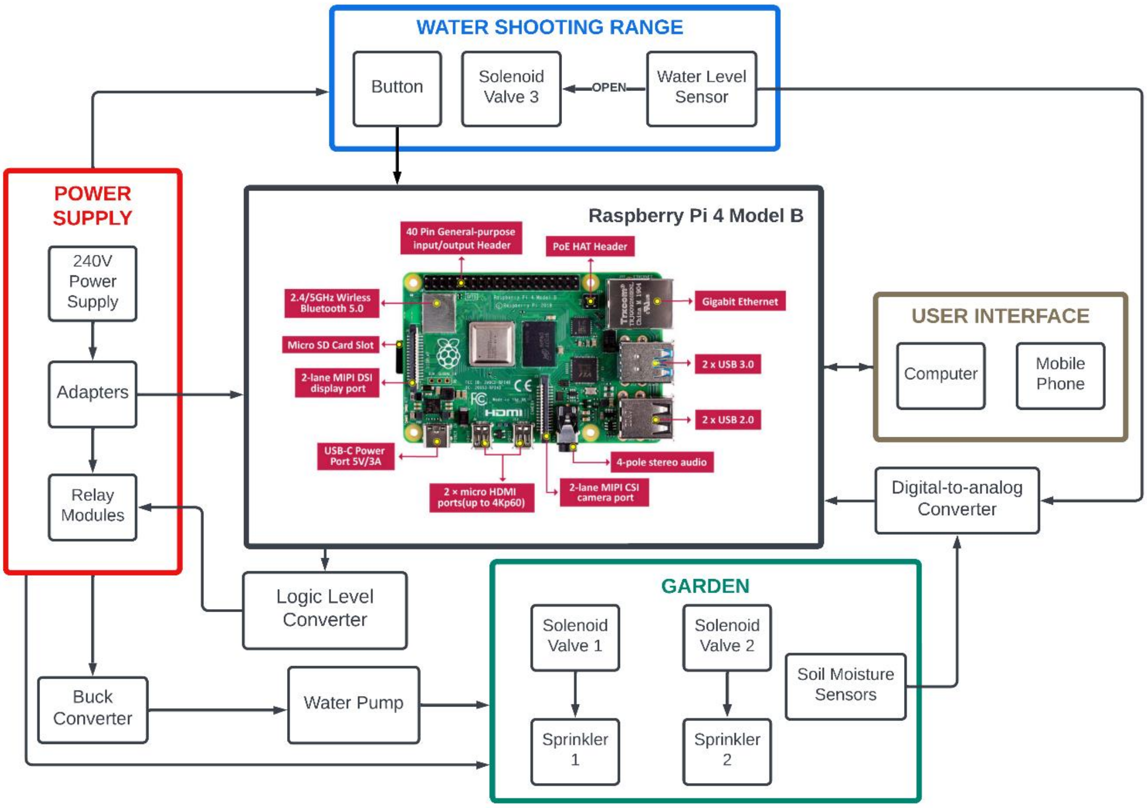

Figure 6: Prototype implementation overview

Figure 7: Overview of the irrigation system

Figure 8: Main water tank underneath

The group decided to purchase additional equipment and accessories outside of the Bill of Materials (BOM). These extra components were not initially planned, but they were necessary to meet the technical requirements for outdoor use. These items would be more convenient to purchase outside of the BOM, because they can be bought immediately without waiting for approval, allowing for easier testing of new concepts and part fixes.

2. Controller Function

In the context of this automated watering system, the controller, typically a microcontroller or a single-board computer like the Raspberry Pi, functions as the central processing unit, orchestrating the various components to achieve autonomous irrigation based on real-time sensor data and user-defined schedules.

Key Functionalities:

- User Interface: The controller facilitates interaction with the user, allowing for schedule adjustments, mode selection (schedule-based vs. sensor-based), and system monitoring through a connected PC, laptop, or smartphone.
- Sensor Data Acquisition & Processing: It interfaces with soil moisture sensors to gather real-time data about the soil's hydration levels.
- Decision-Making & Control: Based on programmed schedules and sensor inputs, the controller determines the appropriate watering actions and prevents overflows by monitoring water levels in the storage.

In the last report, the team includes a feature that enables users to press the button to trigger the water flow manually but after reconsidering the team decides to exclude it from the deliverables.

Furthermore, it is imperative to highlight the system's inherent flexibility in accommodating diverse user preferences through the provision of two distinct watering methodologies:

Irrigation Modes:

- Mode 1 (Threshold-Based): If soil moisture falls below a predefined "dry threshold," the Raspberry Pi will activate the pump and valve to irrigate the plant until the moisture level reaches a "wet threshold."
- Mode 2 (Schedule-Based): In addition to threshold-based watering, a watering schedule can be implemented. The Raspberry Pi will activate irrigation at scheduled intervals, adjust the duration based on user setup.

The threshold-based watering will be the best option if the sensor works properly. The plants will always be in the perfect soil status to raise and maintain healthy. However, if the soil moisture does not work very well, or some plants need to be watered frequently, the system can be changed to schedule based.

The system architecture will be shown as the following diagram:

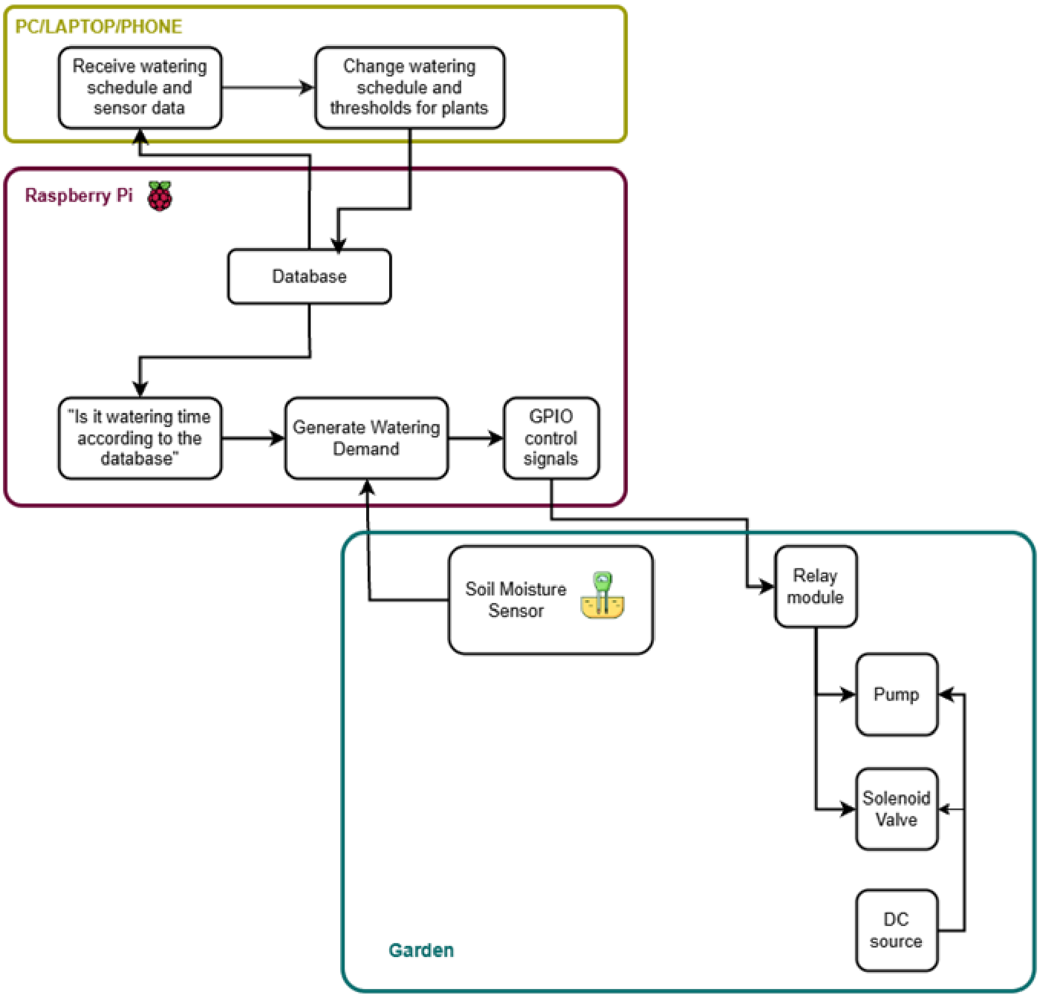

Figure 9: System Architecture of Controller

This diagram depicts an automated irrigation system facilitated by a user interface (UI) accessible via PC, laptop, or phone. The UI enables the configuration of watering schedules and moisture thresholds, which are subsequently stored within a database residing on a Raspberry Pi. The Raspberry Pi, acting as the system's central controller, retrieves the selected watering method (schedule-based or sensor-based) and proceeds to evaluate the corresponding criteria. If watering is deemed necessary, the Raspberry Pi transmits control signals to a relay module. This module, in turn, governs the operation of a pump and solenoid valve, thereby initiating the irrigation process within the designated garden area.

The UI serves as the primary interface, enabling users to seamlessly monitor and control the system. It provides a visual representation of real-time data, configuration options, ensuring intuitive and efficient management of the irrigation process.

The User Interface encompasses four primary functionalities:

1. **Watering Schedule Configuration**:
   Mode Selection: Independently configure each section's watering mode (sensor-based or schedule-based) as detailed in the "Irrigation Modes" section previously mentioned.
   Manual Watering: Initiate watering manually via the web application, specifying the duration and target section.

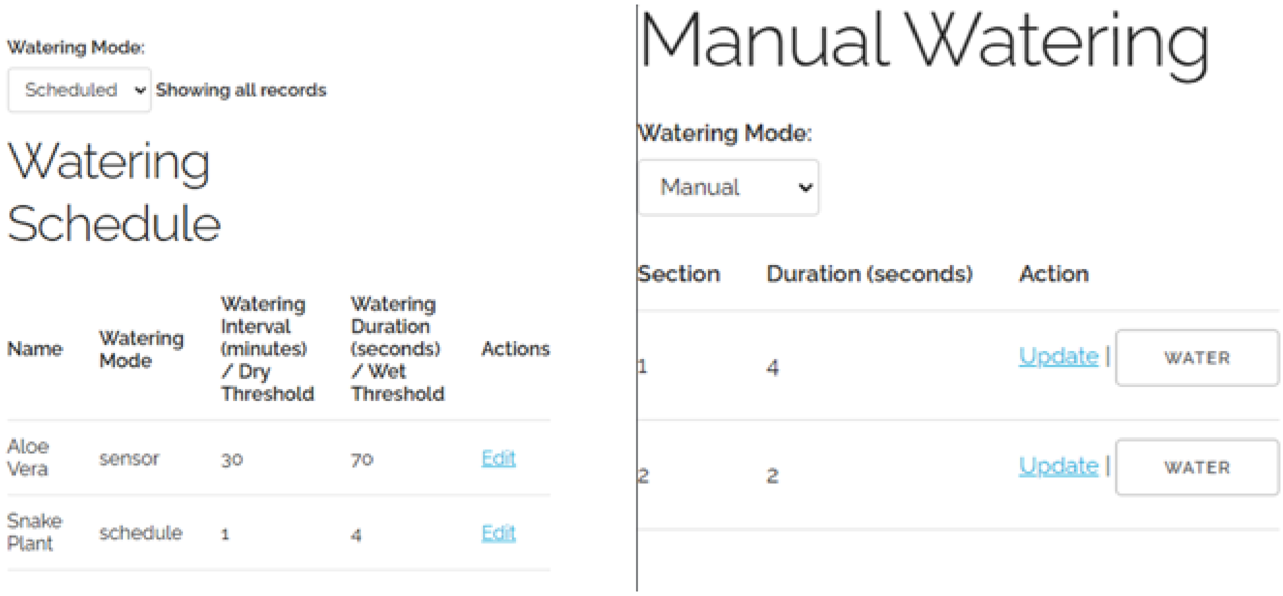

Figure 10: UI of Scheduling the Watering

2. **Current sensor data**: Display real-time sensor readings within the application [9]

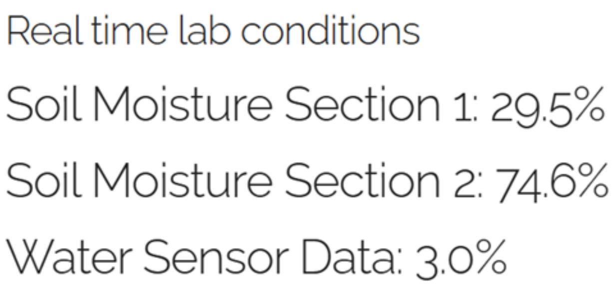

Figure 11: UI of current sensor data

3. **Watering History.**
   After each time of watering, the system will store the records in the database, accessible through the web app.
   Demo picture in the Appendices. (Figure 46)
4. **Sensor Data History**: Display historical sensor data via the web app.
   Demo picture in the Appendices. (Figure 47)

In parallel, the Circuit Design establishes the physical connections between the controller and the system's components. It governs the transmission of signals and power, allowing the controller to effectively communicate with and control the pump, valves, and sensors, thus translating user commands into concrete actions. The team has developed a PCB to interface all peripheral components with the Raspberry Pi for professional applications.

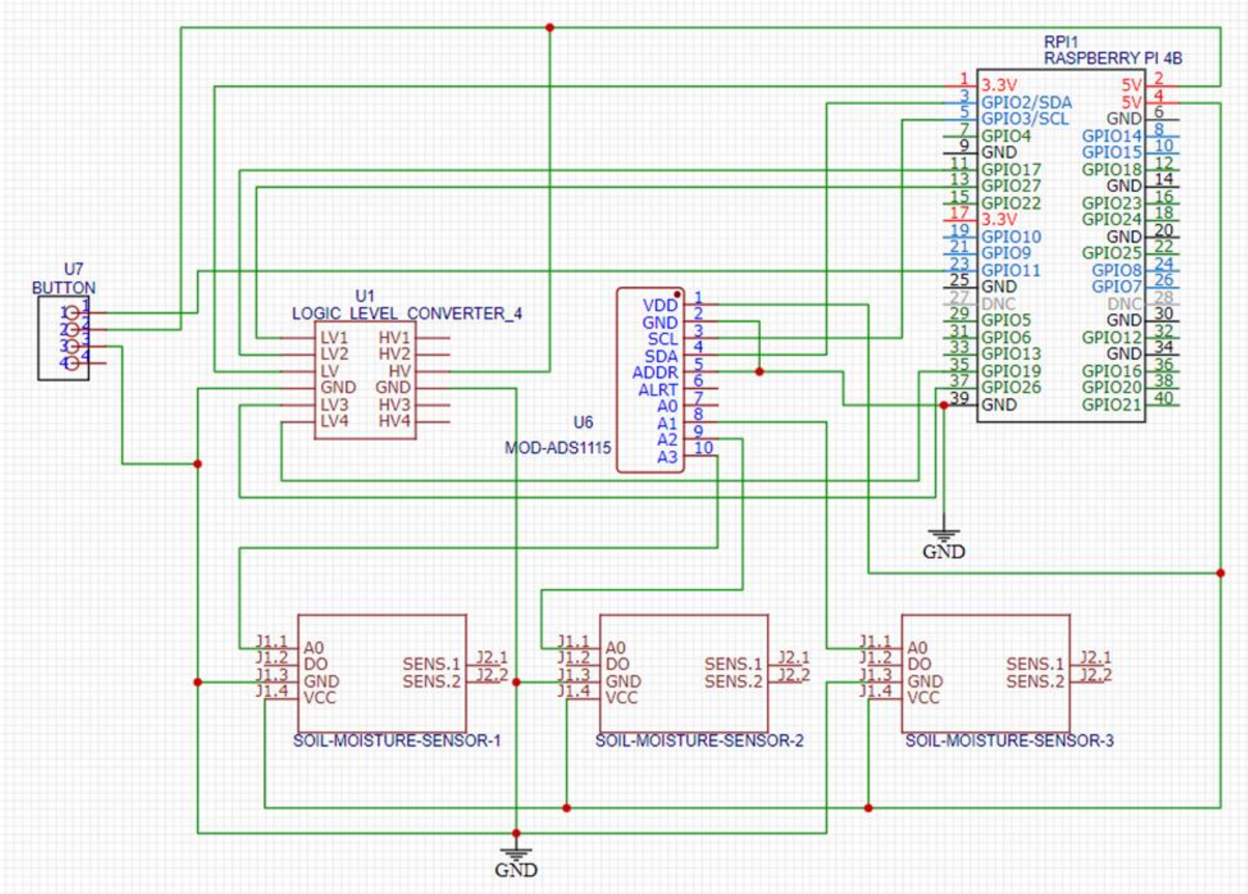

Figure 12: Circuit Design of the system

This circuit design might look complicated, but it only features 2 main things:

- Analog-to-Digital Conversion: An external ADS1115 module is employed to convert analog sensor data to digital values for Raspberry Pi processing [10]. Three soil moisture sensors are connected to the ADC's analog input channels (A1-A3), with I2C communication established between the ADC and Raspberry Pi [11].
- Logic Level Conversion: A logic level converter boosts the Raspberry Pi's 3.3V GPIO output to 5V, ensuring sufficient voltage to trigger the relay module. Four GPIO pins, controlling one pump and three valves, are connected to the converter's low-voltage inputs [12].

The circuit diagram illustrating the control of the pump via a relay using logic voltage signals, as previously provided, has been included in the Appendices for reference. (Figure 48)

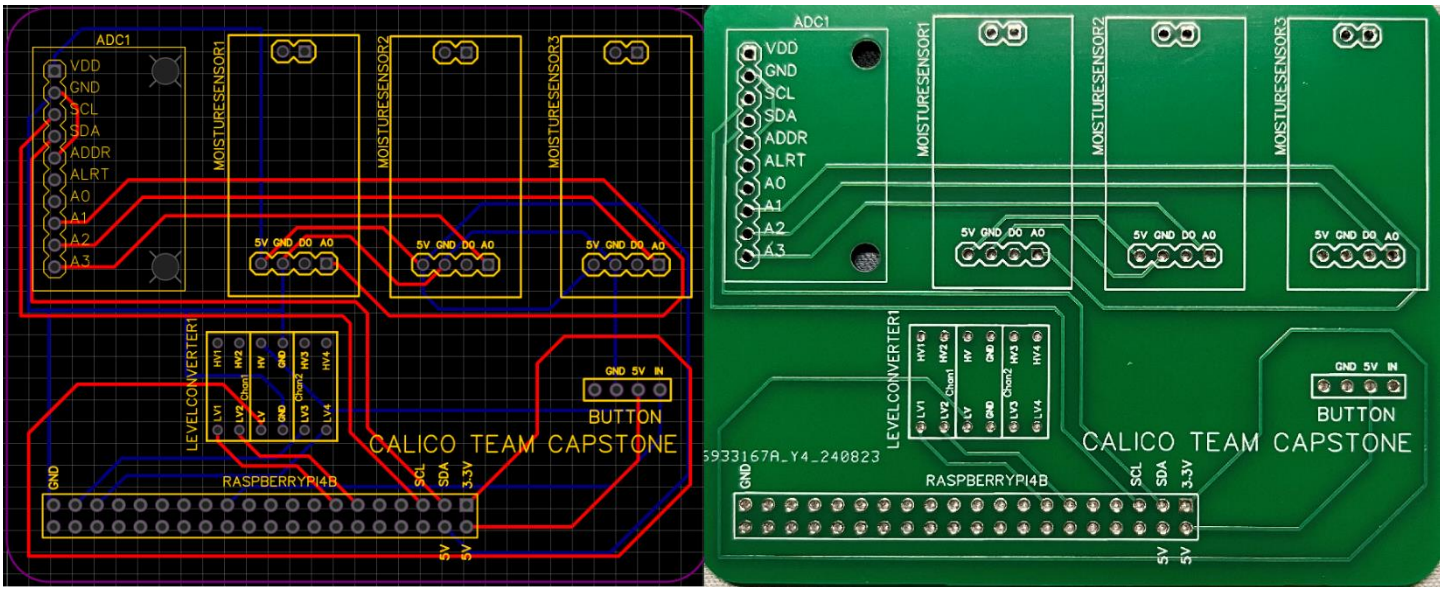

Figure 13: PCB design

The final product is a waterproof electric box:

Figure 14: Final electric box

Upon receiving the PCB, female pins were soldered to enable mounting on the Raspberry Pi and peripheral components, including the ADS1115, sensors, logic converter were then integrated. There is a buck converter used to monitor the voltage input (9V to 14V) for the pump so that the pressure of the pump is controlled. Final assembly involves securing all wiring to components within a conduit to protect them from external stress or wire pulling.

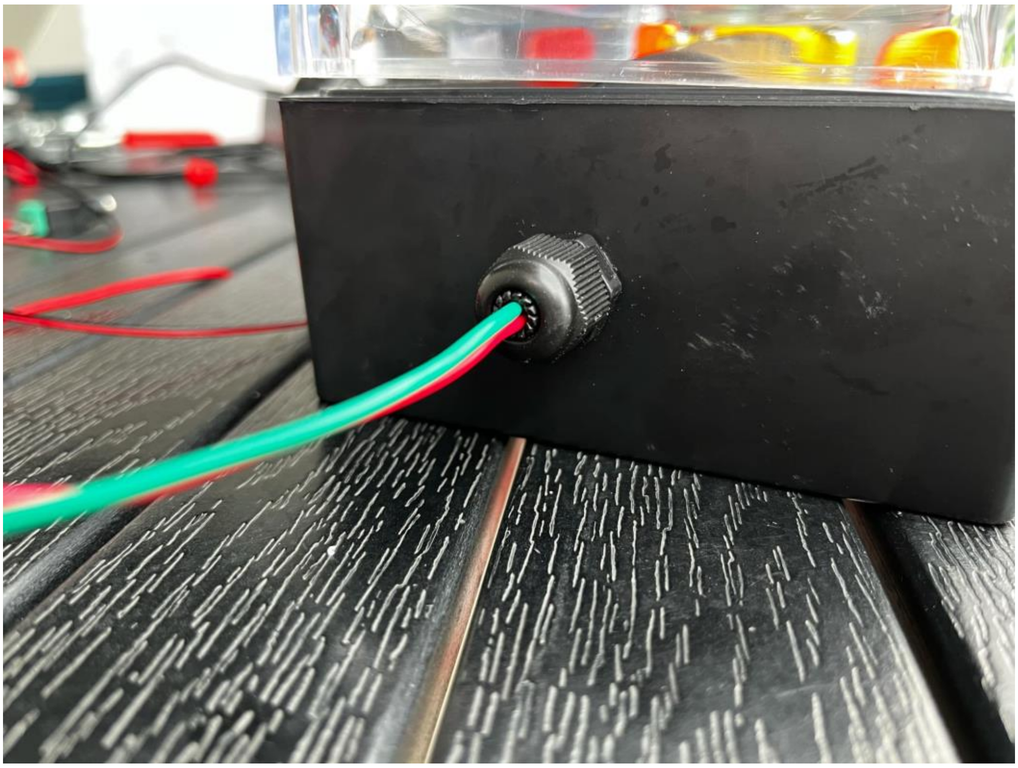

Figure 15: Electric conduit

This is an electric conduit designed to allow the passage of wires while maintaining water resistance. It ensures a tight seal around the wires, applying pressure to prevent them from being dislodged by external forces, thus preserving both functionality and safety.

3. Irrigation Plan

Description: The community garden will feature various types of plants, and their watering schedule will depend on the plant's needs. To ensure optimal irrigation, the system will provide two modes of operation: schedule watering mode and sensor watering mode, which can be switched or modified from the user-friendly user interface. The garden will be separated into several parts, each representing a group of plants with similar water requirements. A series of solenoid valves will be placed to control water flow to each area independently and precisely to the plants that need it, provide minimum water wastage and maintain uniform watering.

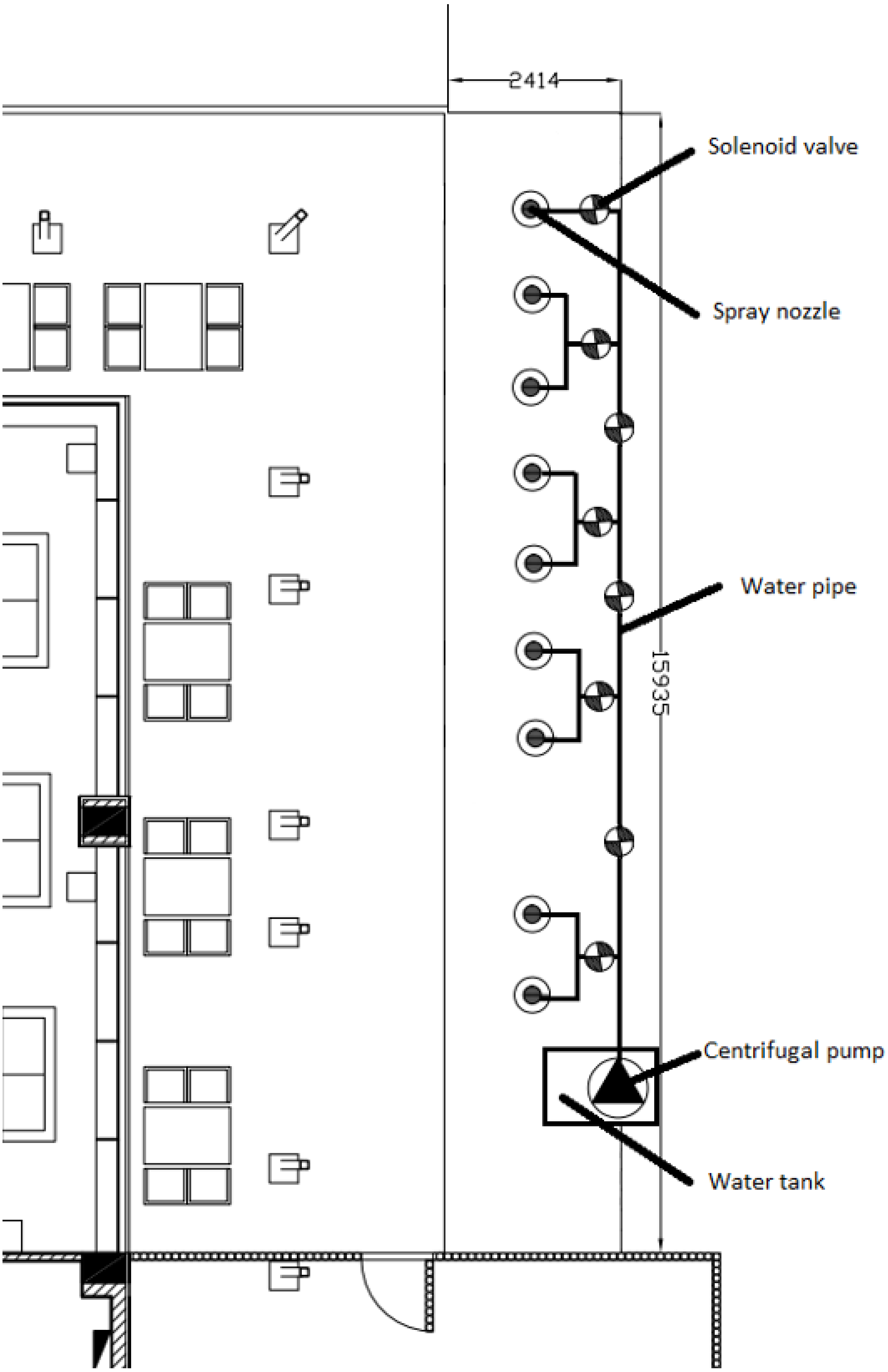

Figure 16: Irrigation plan for pipes and solenoid valves

Figure 17: Garden’s watering system prototype

Technologies: The watering system for the community garden will include a main large water tank that is automatically replenished by the RMIT water supply. The tank’s water level is regulated by a floating ball valve, guaranteeing that the tank is always full, even without manual involvement. To effectively distribute water around the garden, the system uses a centrifugal pump to pressurize the water, ensuring a consistent flow across all sections. After that, a sequence of solenoid valves can be adjusted to open or close, directing water flow to the desired sections. Once a solenoid valve is open, the pressurized water can flow to the sprinkler nozzles, which have adjustable spray patterns, with a coverage radius ranging from 1 to 1.5 meters, designed to cover the garden's width of 2.4 meters.

Figure 18: Water pump

The centrifugal water pump is contained within a durable, water-resistant ABS housing designed to protect the pump from external environmental elements such as rain and dirt while also minimizing operational noise. Due to an improper fit between the Maka pipe and the pump's intake and output connections, a smaller pipe is inserted as a cushion and tightly secured with clamps to prevent leakage. In case of any potential leakage inside the box, a drainage hole is drilled at the bottom plate of the box.

Figure 19: Main tank and the pump to deliver water garden

All necessary pipe connections for the irrigation system, including water pipes, thread converters, fittings, and sprinklers, are conveniently available at Maka Store. Purchasing all irrigation supplies from a single supplier ensures component compatibility, simplifying both installation and future maintenance. Finally, ordering from the same store reduces delivery costs and eliminates the need to wait for multiple vendors.

Figure 20: Irrigation supplies from Maka store

Required resources:

- **Centrifugal pump:** A 12V DC pump with a maximum flow rate of 800l/h and a lift capacity of 3-5m. Its small size and simple design make it economical to maintain and operate. This pump is effective at moving big volumes of fluid because it raises the water's pressure and velocity [13].
- **Water pipes:** Water pipes with an outer diameter of 16mm, made of PVC. They are sturdy, flexible, and suitable for use in all weather conditions. Furthermore, it is anti-algae and UV resistant, which will increase its longevity.
- **Water pipe fittings:** These are 16mm-diameter pipe connections for water pipelines. Water pipes can be joined together securely and impenetrably with the help of these connectors.
- **Solenoid Valve:** An electromagnetic valve that responds to controller inputs to close and open. This enables the system to distribute water differently throughout each section.
- **Sprinkler:** The sprinkler head Bs7000 plus will be used because it can vary the watering radius and flow and requires only 1 bar of water pressure (600L/h). This nozzle also boasts great precision and durability.
- **Automatic water level control valve:** An automatic water level control valve will automatically refill the main tank when the water level falls and stop supplying water when it raises to the water limit line.

4. Water shooting range

Description: The water shooting range is the attraction feature to help reducing stress of the garden participants. Utilize a water gun to release stress from shooting at the cute targets with auto reset mechanism. The shooting range will require minimum maintenance, no wastage of water, and offer participants endless fun without supervision.

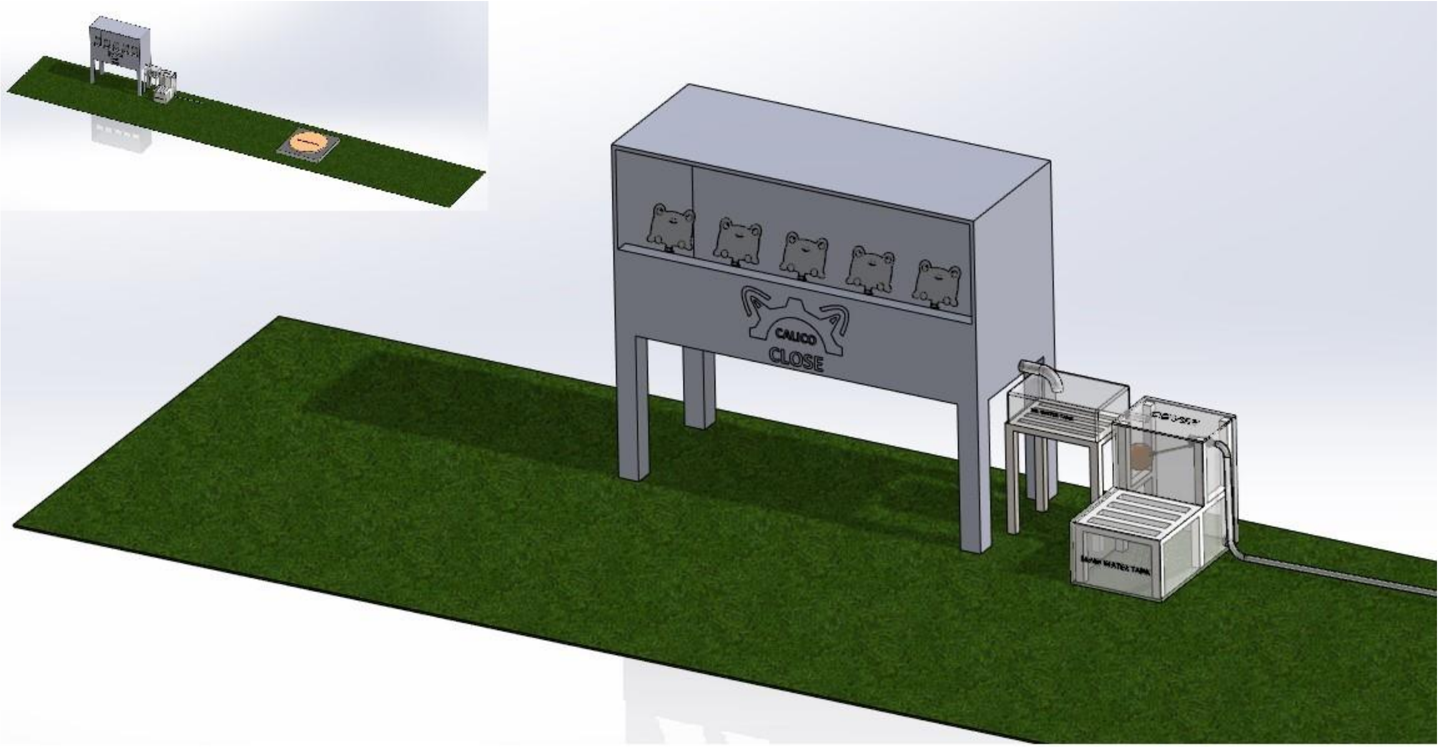

Figure 21: 3D model of the Water shooting range in SolidWorks

Technologies:

The water gun can be refilled with water from the main tank top and use to shoot down the five targets in the shooting range box. All the water shot in will be held in a 20L water tank with a water level sensor, placed next to the shooting range. When it is full, this water tank will automatically release 20 liters of water by opening the solenoid valve and letting gravity pull the water down to the main tank. The time it discharges will be recorded and added together to determine the total amount of water collected from the shooting range. The water was then transferred to the main large tank, where it would be utilized to irrigate the garden plants. Because of the closed-loop system this produces, no water will be wasted.

Figure 22: Participant trying out the Water shooting range

The high-tech water gun features dual nozzles, allowing it to draw water from one nozzle while shooting from the other nozzle. It has an amazing range of up to 10 meters and a 1-liter water capacity. The water gun is powered by a rechargeable battery that provides up to 30 minutes of continuous operation, ensuring longer playtime. Recharging is simple and convenient, as the battery can be easily replenished via a USB cable. The charging socket has a waterproof rubber ring to offer durability and protection, especially in outdoor or wet locations. This water gun's cutting-edge functionality and durability make it an excellent choice for both casual and more intense water-based activities.

Figure 23: Water gun

Figure 24: Water gun's shooting and refilling nozzles

The upper nozzle is where the water will be shot out, while the lower nozzle is where the water will be pumped in.

Two rechargeable lithium battery is stored inside a tightly sealed compartment, tighten with a screw.

Figure 25: Water gun's battery compartment

The targets are designed as cute frogs, made from acrylic sheets. They are mounted on hinges that serve as pivot points, allowing them to move back and forth when struck by a water stream. When pushed by a water stream and knocked down, the targets are immediately reset to an upright posture by a counterweight at the bottom of the targets.

Figure 26: Shooting range's targets

Reset mechanism: The force that causes the target to turn about a hinge pivot point is called the moment of a force [14]. For the system to reset, the moment from the counterweight must be greater than the moment from the target's weight. Moreover, the differences must be small enough for the targets to be knocked down by water force and slower the target reset time as desired.

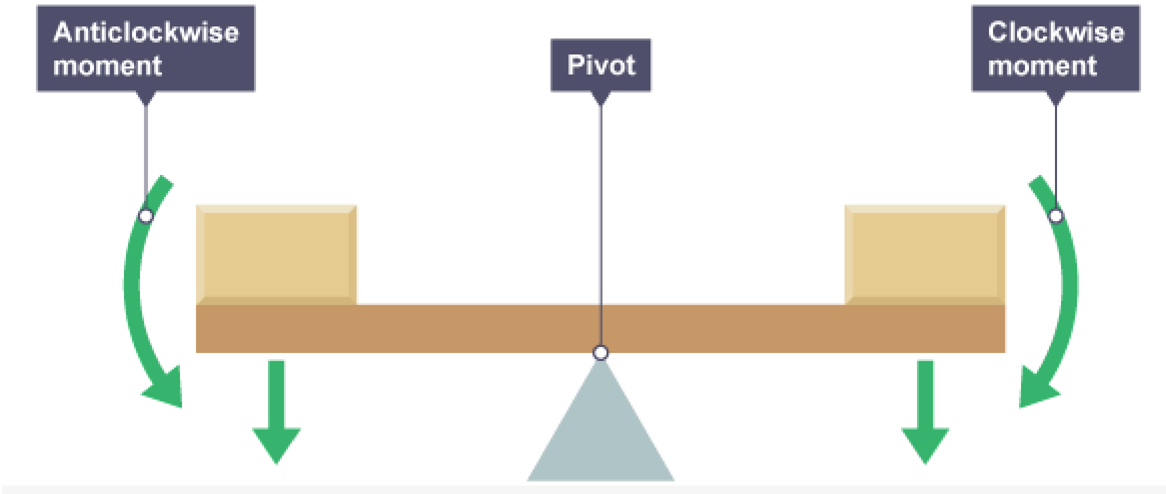

Figure 27: Moments act about a pivot in clockwise and counterclockwise directions [13]

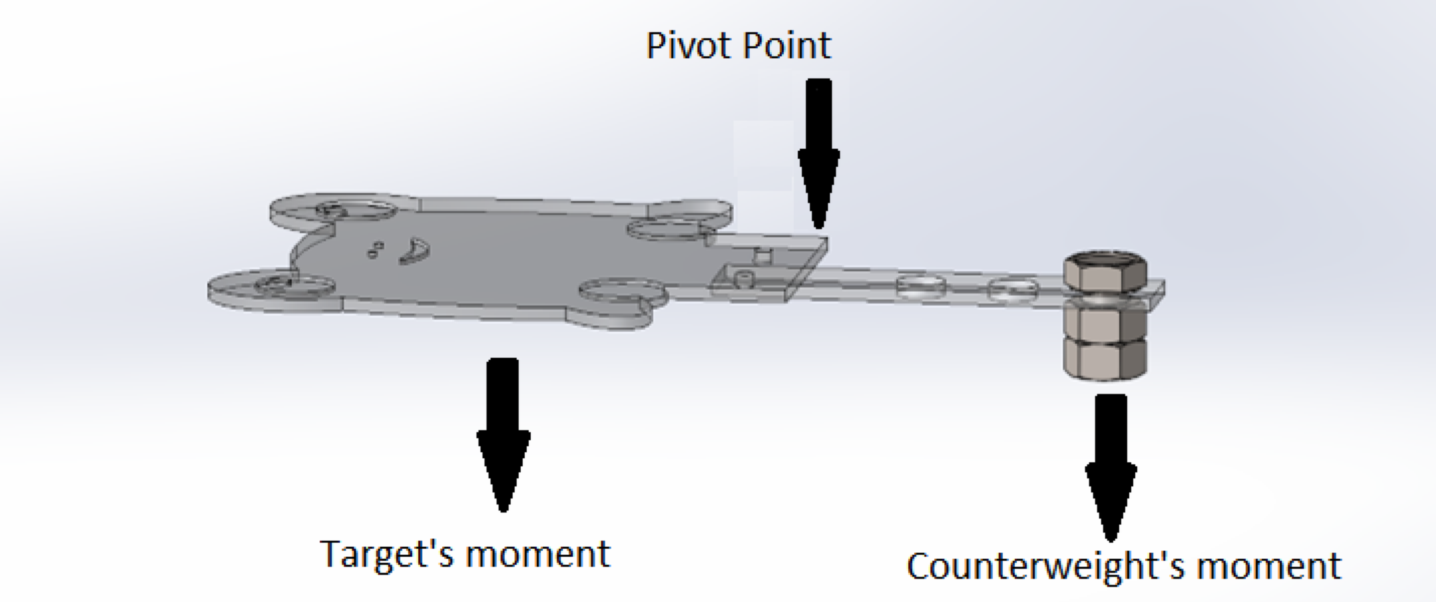

Figure 28: Target's moment and Counterweight's moment act about the hinge pivot point

- **Calculate the target's moment:**

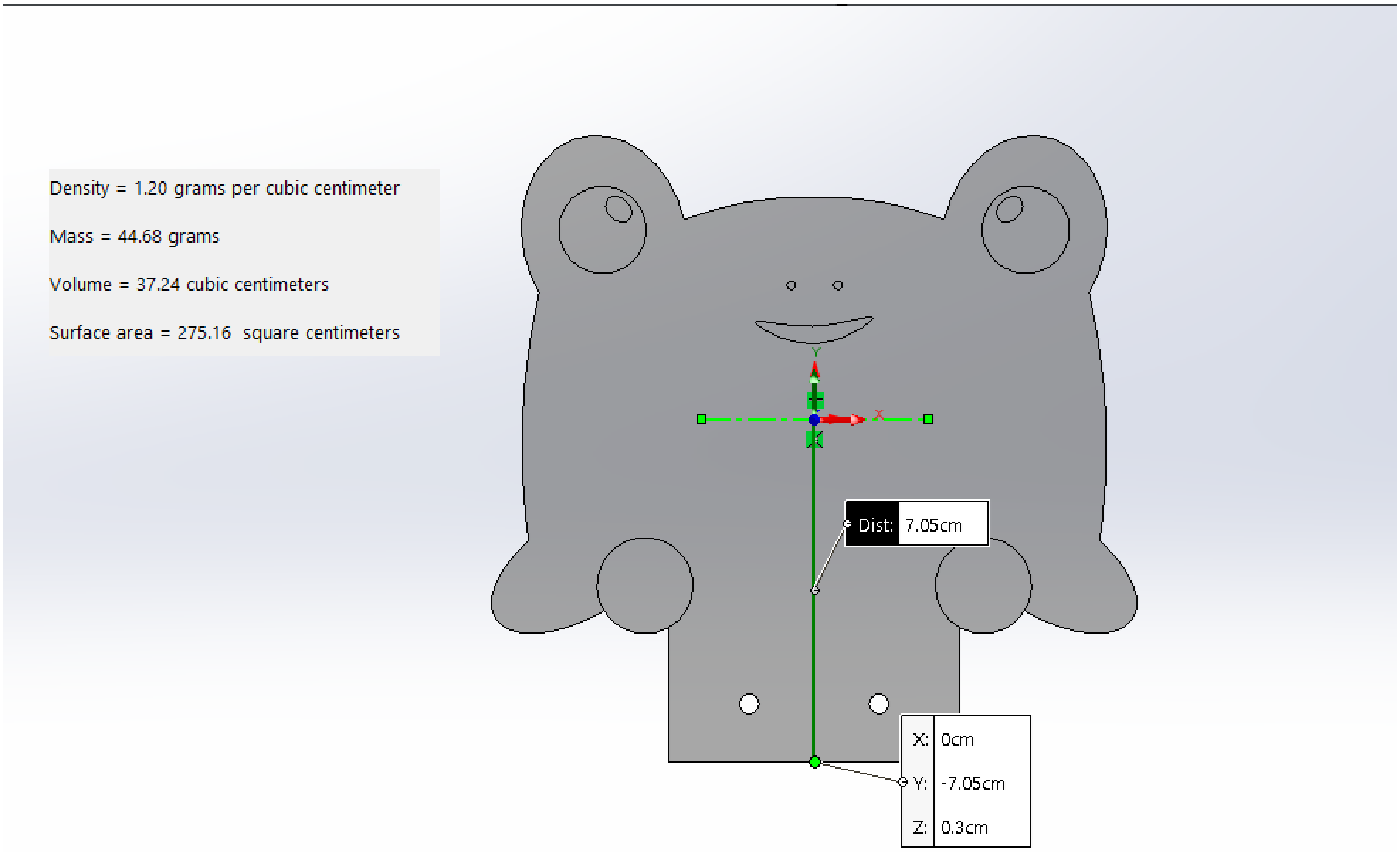

Figure 29: Target's parameters

Each target weight 44.68 grams and the distance from its center of mass to the hinge pivot point is about 7.05 cm. The target's moment can be calculated using the equation:

$$M = m_{target} * g * r_{target}$$

$$M_{target} = 0.04468(\text{kg}) * 9.81(\text{m}/s^2) * 0.0705(\text{m})$$

$$M_{target} = 0.309(\text{N/m})$$

- **Calculate the counterweight's moment:**

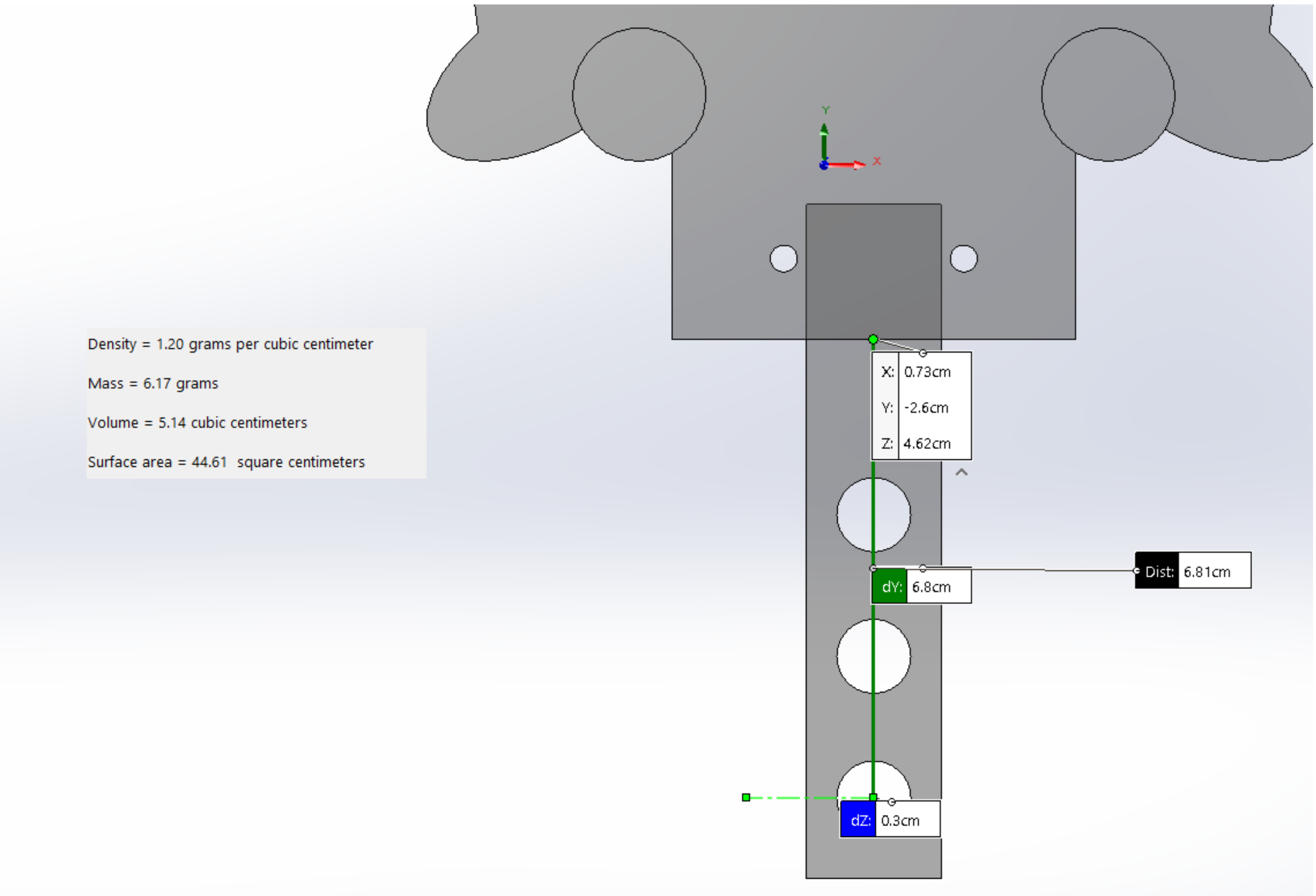

Figure 30: Counterweight holder dimensions

Each target is counterweighted by 52 grams of a hex bolt M10x20 (22 grams), 2 nuts (12 grams), and a thin acrylic sheet (6 grams) [15]. Attached at the bottom of the targets away from the hinge pivot point is 6.81 cm. The counterweight's moment can be calculated using the equation:

$$M_{counterweight} = m_{counterweight} * g * r_{counterweight}$$

$$M_{counterweight} = 0.052(\text{kg}) * 9.81(\text{m}/s^2) * 0.0681(\text{m})$$

$$M_{counterweight} = 0.0347(\text{N/m})$$

- **Fine-tuning the reset mechanism:**

To slow down the target reset time, the counterweight's moment should be larger than the target's moment by a small amount. To do this, the weight of the counterweight can be reduced or move it closer to the pivot point.

$$M_{counterweight} = 0.0347(\text{N/m}) > M_{target} = 0.309(\text{N/m})$$

Required resources:

- **Water gun:** a high-tech water gun that is made from ABS plastic and runs on rechargeable battery through USB charger. The water gun has its own water storage compartment of about 1L capacity. It can be refilled by dipping the nozzle into water, or directly pouring water into the gun storage from the top hole. The accurate range is estimated to be around 5-10 meters.

- **Shooting Range:** a box assembled from many acrylic sheets to minimize weight and cost. It includes a small platform to attach the targets on, a drainage hole on the side to release all the water into a 20L water tank beside.
- **Targets:** The targets are cute-designed frogs, used to attract players and release stress for them. The target is laser cut from acrylic sheets, designed on SolidWorks. It is a lightweight and durable material, making the target resist water damage and light enough to be moved by a water stream and counterweight by a few bolts.
- **Counterweight:** The counterweight consists of 2 nuts and a hex bolt M10x20. The nuts and bolt will be screwed onto a hole of a thin acrylic sheet 3 cm wide and 10 cm long. The thin acrylic will then glue to the bottom of target to create a counterweight.
- **Small water tanks:** a small water tank assembled from many acrylic sheets.
- **Solenoid valve:** This solenoid valve requires zero pressure to flow, unlike the solenoid valves for irrigation system.

5. Water Tanks

Initially, the real scale irrigation system includes 2 water tanks: a 20L small tank to collect the water from shooting range and a 130L big tank as the main water source for watering the plants. However, in this project, only a smaller scale prototype can be made due to budget limits. In the original plan, the water tanks will be made acrylic clear sheets 5mm thick, but RMIT does not allow these to be fabricated from an external vendor. The team is permitted to use the university's manufacturing workshop to cut the acrylic sheets for free, but they are limited to 3mm thick which was weaker than expected and potentially deform during testing. To compensate for this, the team leader Huy designed an extra support structure inside the big water tank to prevent deformation. By using super glue and silicon sealant, these water tanks could store huge amounts of water without deformation and leakage. Moreover, the student Nhan provided the team with water-resistant wallpaper to fully wrap the outside of these water tanks for extra reinforcement and increasing aesthetic.

Thus, the water tanks' sizes are reduced significantly as shown in below:

Small Water Tank:

Overall, the small water is shown as below, with a dimension of 200mm in length, 150mm in width and 120mm in height. Compensating for the acrylic sheets thickness, the actual size inside the tank that contains water is 194x147x120mm accordingly, which could contain approximately 3.4L of water.

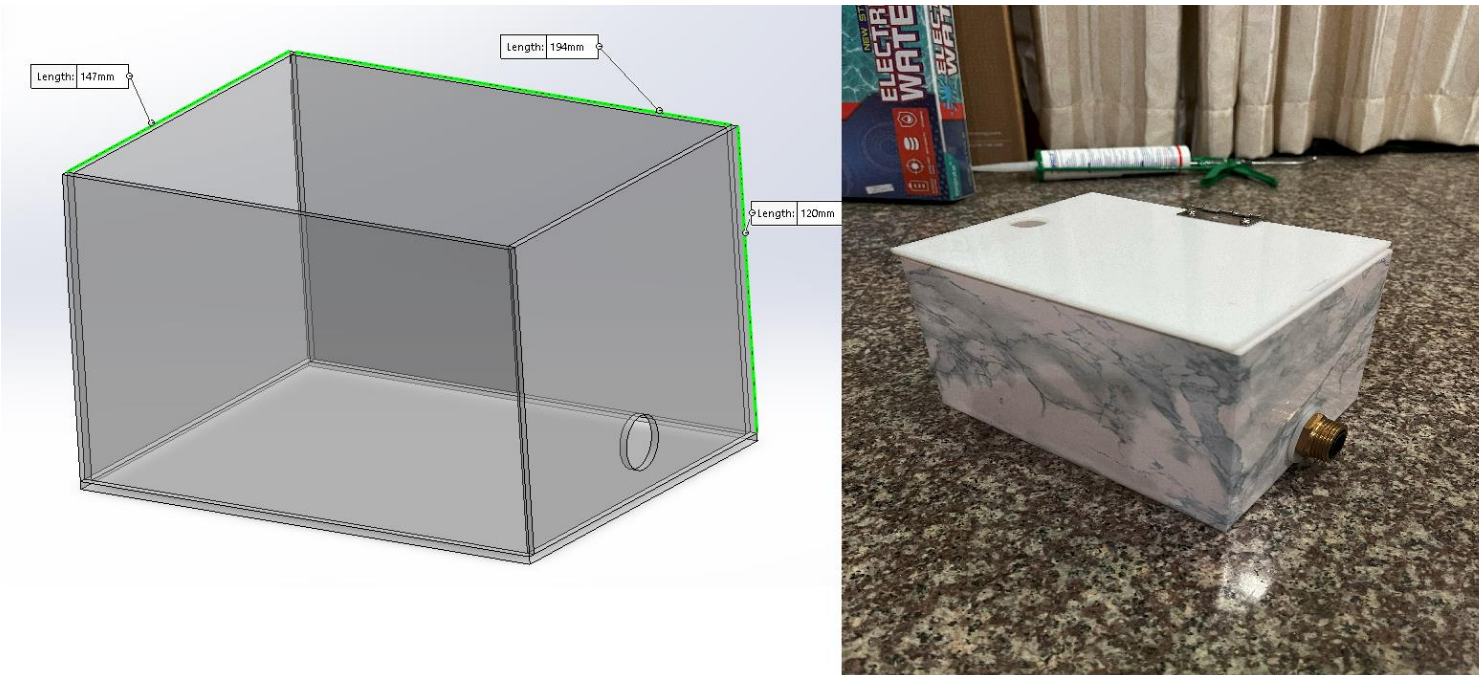

Figure 31: Small water tank in 3D design and in real life

Figure 32: Small water tank lid

The lid is attached with a simple latch for easier actuation, covering the water tank from dust and insects. The round hole on the right side is where the water flows from the shooting range via a plastic tube, and the rectangular hole on the left is where the water level sensor will be inserted. The drainage hole on the side is installed with a thread adapter and is connected to a solenoid valve. When the water level reaches the sensor, it will open the valve and release the water back into the big water tank.

Before the tank was fabricated and built, a stress analysis was done using SolidWorks software to ensure the tank could withstand the water pressure acting on each side without much deformation or breakdown. The tank is 120mm or 0.12m high, the pressure acting on each side of the tank can be calculated as shown [16]:

$$P = \rho * g * h = 1000 * 9.81 * 0.12 = 1177.2\ N/m^2$$

Where: ρ is the density of water = 1000kg/m^3

g is the gravitational acceleration = 9.81 m/s^2

h is the height of water inside the tank

The calculated pressure represents the maximum pressure exerted on the bottom plate. The water pressure applied to the sides will vary with height, decreasing as the water level rises. Therefore, if the structure at the lowest point can withstand the pressure, the upper sections will be adequately supported as well.

Although the test showed the tank could hole the water at a certain level, this result should be regarded as a reference point since there are several factors that could potentially alter the actual outcome, such as the quality of the material, human error during assembly, and particularly the strength of the connections of the acrylic sheets at each side.

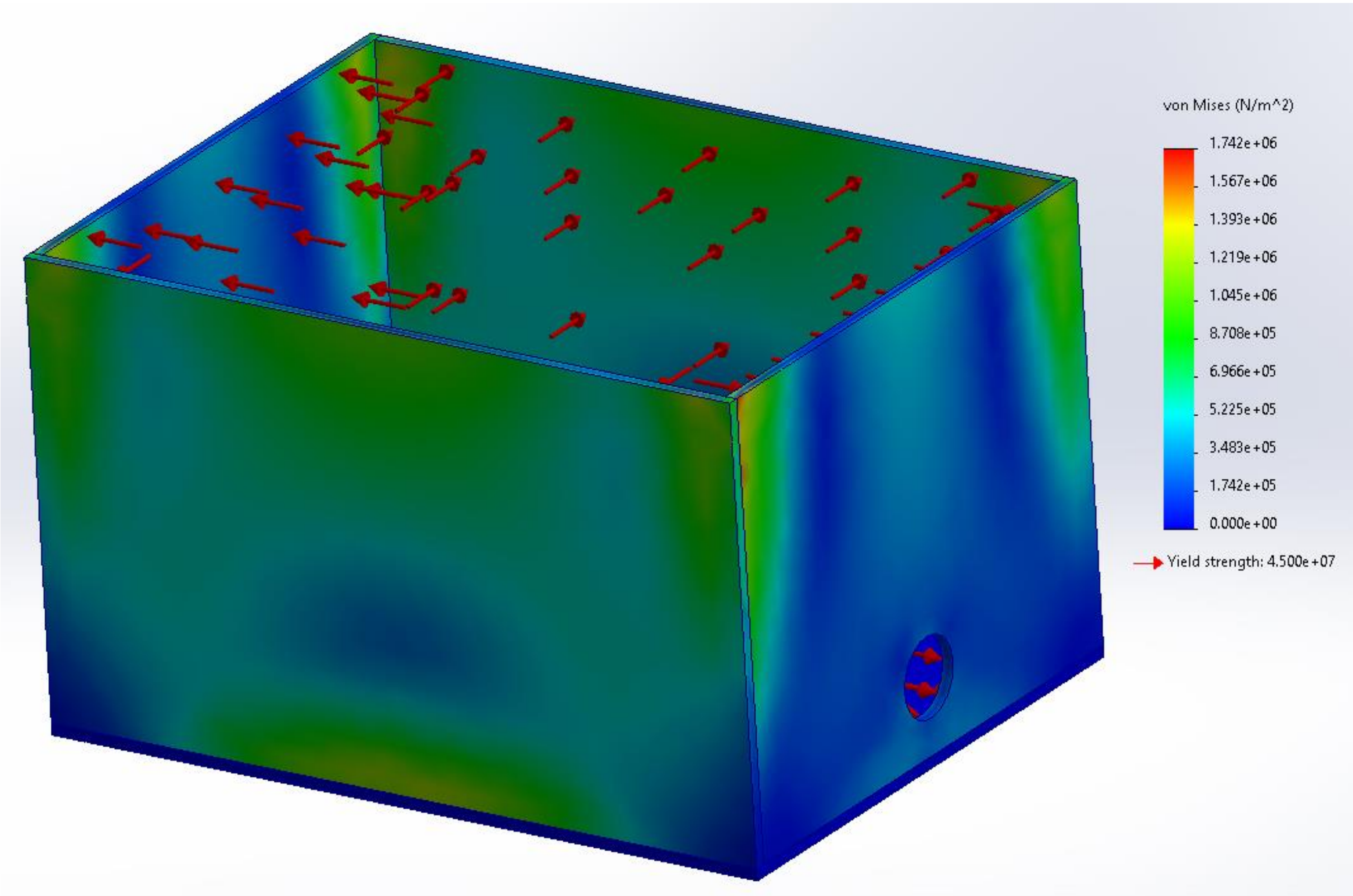

Figure 33: Stress analysis on the small water tank tested on Solidworks

Big Water Tank:

Overall, the big water is shown as below, with a dimension of 350mm in heigh, 350mm in depth and 250mm in width. Compensating the thickness of the acrylic sheets and the support structure inside, the total volume of water that this tank could store is approximately 18.5L.

The big water tank is designed into a chair-shaped tank for aesthetic purposes based on the client’s requirement. This increases the overview appearance of the water tank compared to the typical water barrel and serves a chair purpose apart from being a water container.

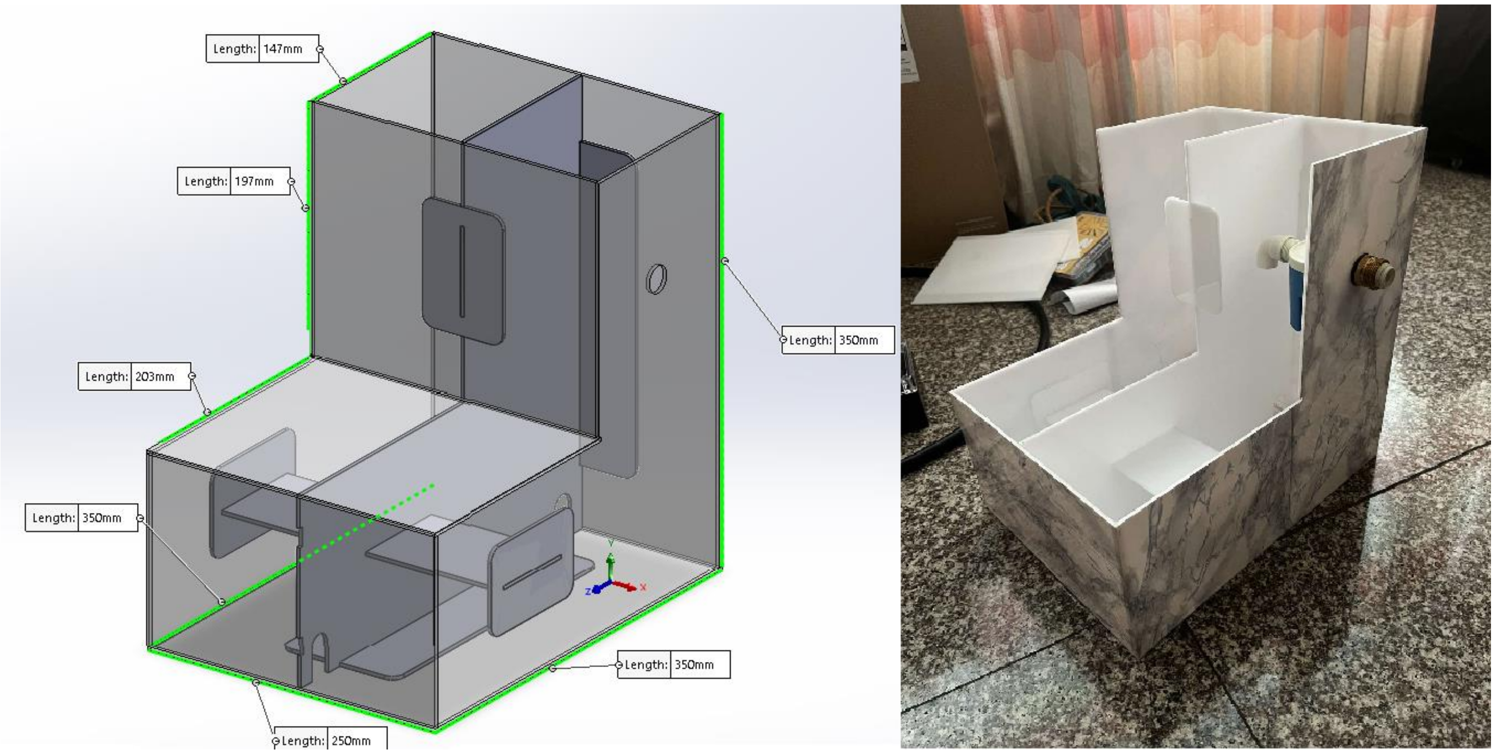

Figure 34: Big water tank in 3D design and in real life

The big water tank should have a similar lid with a latch like the small water tank as well, however, it was not installed to show the internal structure for showcase purpose.

In the project proposal, the team suggested a metal inner-frame as the support structure for the big tank, but the team could not find a proper fabrication vendor to manufacture such frame. So, a plastic one is created. In small scale, this structure could withstand external forces from damaging the integrity of the water tank. Yet, on a bigger scale model, the thickness of the acrylic sheets could be greater and provides stronger foundation for the tank.

On the top right side of the tank, an automatic water level control valve is installed. The outer side will be connected to the water supply via a tube, while the water will be automatically refilled in the tank and maintained at a specific level.

Figure 35: Automatic water level control valve

Basically, when this valve is connected with the water supply, the supply will always fill the valve with water and the water fills the tank. The valve operates based on the principle of hydraulic pressure. It consists of a control valve mechanism connecting to a float buoy. When the water level reaches the valve, the buoy will float and push against the control valve, shutting the water flow and preventing the tank from overflowing. When the water is used, more water will be refilled, and the tank will always be full. The water level can be modified by adjusting the position of the valve along the tank's side [17].

Similarly, the tank is 350mm or 0.35m high, the pressure acting on each side of the tank can be calculated as shown:

$$P = \rho * g * h = 1000 * 9.81 * 0.35 = 3433.5\ N/m^2$$

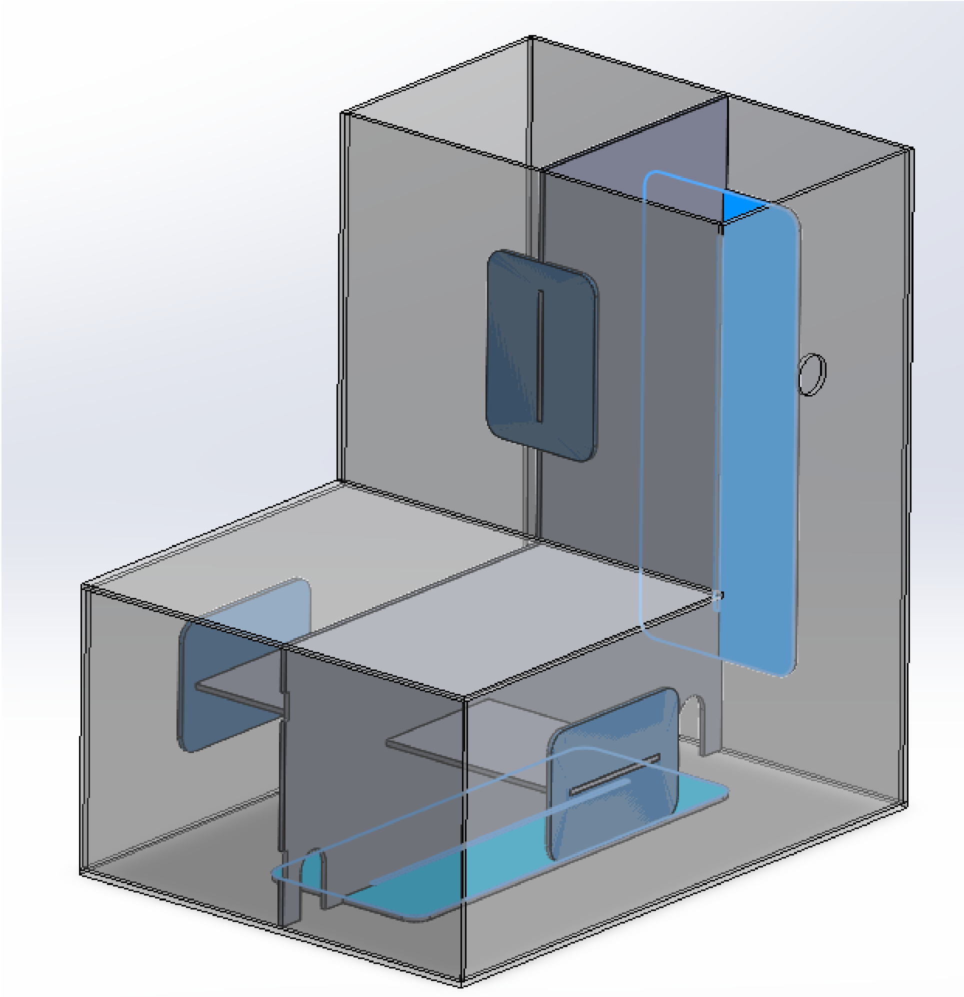

Figure 36: Supported pads highlighted blue

The blue-highlighted support pads are connected to the structural framework, increasing the total contact area adhering to the sides of the water tank. This design enhances the ability to act against shear stress, increases stability, as both super glue and sealant are used in the tank's assembly.

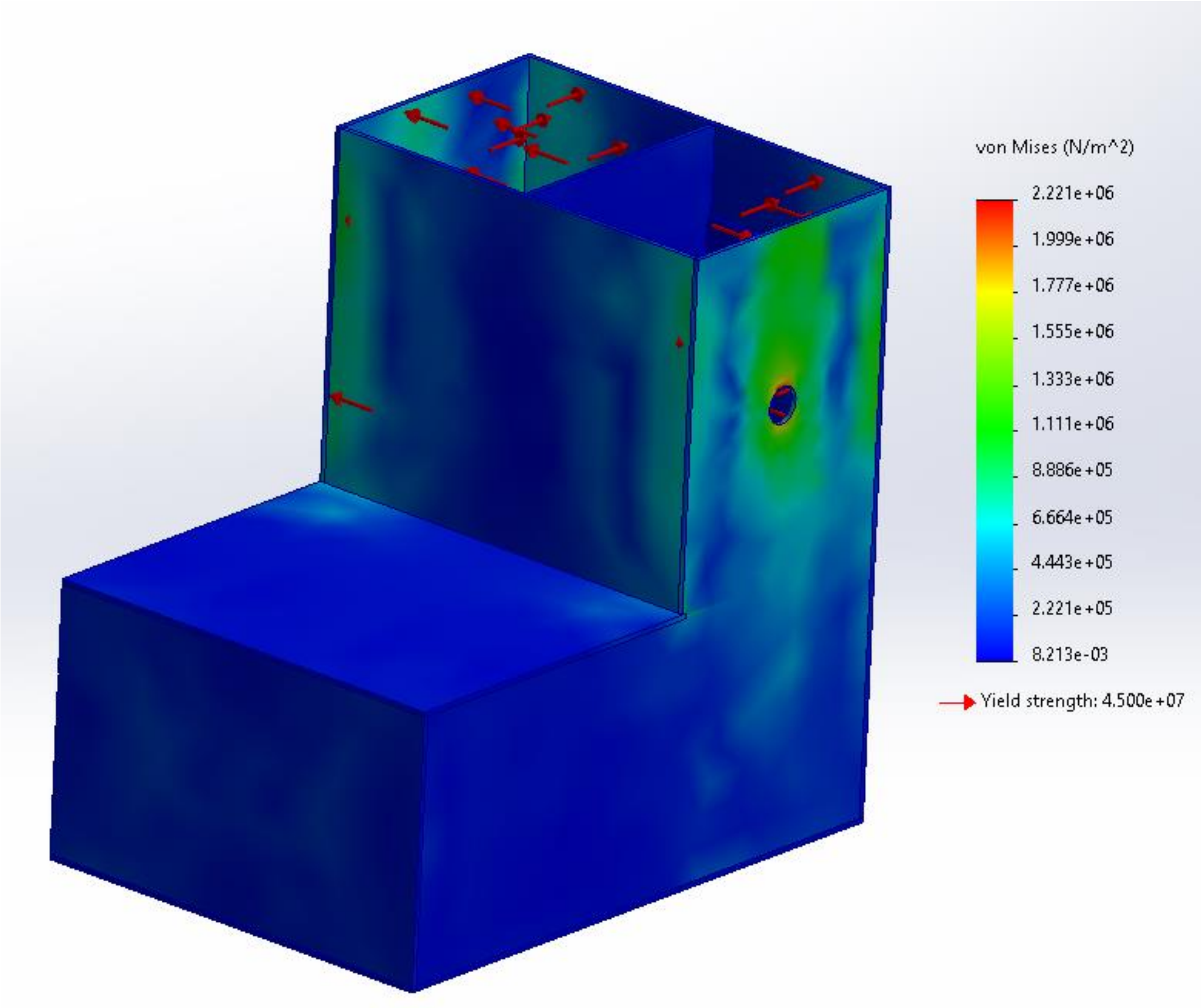

Figure 37: Stress analysis on the big water tank tested on Solidworks

V. RESULT ANALYSES AND DISCUSSIONS

1. Project Showcase Setup

Figure 38: Irrigation System complete setup

Each section of the project such as the electrical box, shooting range, sprinklers with pipes and so on, is modular and pre-installed, so the installation process is quite easy and simple. Basically, the garden and irrigation are the main objective of the project and will be displayed at the front. The water shooting will be located behind the garden so the water splash will not spill everywhere, and it is put onto a 20cm tall stand while the small water tank is put at table level. The reason for this is to allow gravity assists the work and let the water from the shooting range flow into the small water tank. The big water tank will be on the ground to collect the water from the small tank above, with the pump connected right next to it, and the water will be pumped back to the garden. The electrical box could be placed anywhere depending on the length of the electrical wires.

Operation:

After everything is settled, plug in the adapters and turn on the Raspberry Pi first to connect with the laptop or smartphone through Wi-Fi at a specific IP address. Once the connection is secured, users can access the web application. They can firstly review the sensor's data history or watering history. Then, users can actively monitor the current status of the soil by referring to the "Current Sensor Data" tab. This tab will provide a clear visualization of the moisture levels present in both section 1 and section 2 of the designated area. Additionally, it will also display the current status of the water level within the small tank, allowing for comprehensive monitoring.

To ensure optimal functionality, the system can be rigorously tested using the water scheduling task. This task offers two distinct options for watering methods, catering to different needs and preferences.

The first option is sensor-based watering. When this method is selected, users are granted the flexibility to modify the dry threshold. This threshold acts as the trigger that initiates the watering process. Similarly, users can also adjust the wet threshold, which serves as the point at which the watering process will be terminated.

The second option available is schedule-based watering. This method shares similarities with the sensor-based approach, but instead of relying on sensor readings, users modify the watering interval and duration. Once the desired modifications have been made, they can be submitted for confirmation. The system will diligently check this schedule at one-minute intervals. It's important to note that any modifications will not be applied if the previous watering process has not yet reached completion, ensuring a seamless and efficient watering cycle.

In the case of sensor-based watering, testing the sensor's accuracy can prove challenging when it is buried within the soil. This is because the soil may not dry out at a rapid pace, making it difficult to observe the sensor's response to dry conditions. To effectively demonstrate the dry status, the sensors can be temporarily removed from the soil. When the intention is to halt the watering process in section 1 or section 2, the sensor can be strategically placed back into that section's wet soil. Furthermore, it's worth noting that when both valves controlling the two sections are in the closed position, the pump responsible for supplying water will also be deactivated, promoting water conservation.

For the scheduling mode, the system operates with a methodical approach. It will first check the predefined interval to determine whether it is the appropriate time to initiate watering based on the set schedule. If the conditions are met, the system will proceed to water the designated section for the duration specified in the watering duration parameter stored within the database. Once the watering process is complete, the system will then deactivate the watering mechanism.

In scenarios where the system is not watering based on the schedule or sensor inputs, users can switch to manual watering mode. This mode empowers users to take direct control of the watering process. They can choose the desired duration of watering for each individual section and then simply press the corresponding button to manually initiate watering for that specific section.

Figure 39: The system is running, and the plants are watered

The system runs flawlessly, with the sprinklers' water radius being lowered to reduce spilling during the showcase.

Figure 40: Two sensors are plugged in wet soil

After plugging the first sensor into the wet soil, one valve closes, and the sprinkler stops watering. Then, the second sensor is plugged into the soil and the remaining sprinkler stops watering.

2. Discussion

Controller Function:

Discussion about Key Functionalities:

- **User Interface:** The controller provides a stable web server interface for users to manage watering schedules. However, enhancements to the web application's interface are recommended for improved user experience. A new feature such as a recommendation list of how to water the common plants can be added so that users can have a direct reference in the app. Furthermore, the current connection method, which requires obtaining the Raspberry Pi's IP address and accessing the web application through it, could be optimized. Developing a dedicated mobile application that seamlessly connects users to the system upon joining the same network as the Raspberry Pi would offer greater convenience and accessibility.
- **Sensor Data Acquisition & Processing:** The Raspberry Pi successfully establishes communication with soil moisture sensors, facilitating the collection of real-time data on soil hydration levels. However, challenges persist in the data acquisition process that require further investigation and resolution. There is a problem with collecting the data. Due to the operational characteristics of the ADS1115 module, specifically its 9ms conversion time, concurrent data requests from multiple threads can result in identical values across all channels. Therefore, if we implement the system to check the sensor data hourly, this inconsistency poses a challenge for accurate watering, as erroneous readings could potentially be missed.
  To mitigate this issue and ensure the system's reliability, continuous data retrieval is imperative. By constantly fetching sensor values, the system can promptly identify and correct errors, thereby preventing missed watering opportunities and maintaining optimal irrigation.
- **Decision-Making & Control:** Based on the programmed schedules and sensor inputs, the controller can monitor the pump and valves. There is some room for improvement in the connection between the Raspberry Pi and external components. The current PCB design exhibits certain limitations that, due to time constraints during development, could not be addressed. Notably, the water sensor connections rely on female pins and jumper wires, a configuration that is inherently susceptible to instability and potential disconnections. Integrating dedicated terminals directly onto the PCB for the water sensor would significantly enhance the robustness and reliability of this connection.
  Furthermore, the current design necessitates the use of a breadboard and external wiring to accommodate the two relay modules. Incorporating these modules onto the PCB itself would streamline the overall design, eliminating the need for external components and connections, thus resulting in a more compact and integrated solution.

Issues when completing the project:

Problem with the Raspberry Pi:

- The SD card slot of Raspberry Pi appears to be non-functional. The Raspberry Pi cannot detect the SD card upon startup. There is a software-related solution for this problem, but it needs to be done before the SD card slot goes wrong. The developer can update Bootloader Eeprom so that the Raspberry Pi will boot from bootable USB first then the SD card [18].
- Another Raspberry Pi encounters with IC short circuit. This problem occurs mainly when the user touches the GPIO pins of or the soldering bridge on the back of the Raspberry Pi. To mitigate this problem, a protective cover has been applied to the rear of the Raspberry Pi.

Waterproofing Solution

In future project iterations, the electrical enclosure should be built from more robust materials and securely mounted to a wall. Additionally, all power adapters should be neatly organized and connected within the enclosure, promoting a more streamlined and professional appearance while also minimizing the risk of accidental disconnections or damage. An example of this kind of electrical box is as follows:

Figure 41: Example of Future Electric Box

Estimated Future Power Consumption.

Figure 42: Map of garden

- Aloe Vera: Aloe vera is a succulent and prefers its soil to dry out completely between waterings. Generally, watering once every 2-3 weeks is sufficient.
- Basil, Lolot pepper, Polyscias fruticosa, Perilla: These are herbs that prefer consistently moist but not soggy soil. They typically require watering every 1-2 days, especially during hot weather.
- Flowers: The proposed flowers are the kind that need less water. The average watering interval is about every 4-5 days.

The last report estimated the garden's total water requirement at 70L per watering. Based on plant watering intervals, this 70L will last approximately 4 days.

Power consumption calculation (per month):

1. Raspberry Pi Consumption:
   Total Energy Consumption = 4.5 Watts * 24 hours/day * 30 days = 3240Wh= 3.24kWh
2. Pump Consumption:
   The flow rate of the pump is 6 liters/minute. Therefore, it takes about 70/6 = 12 minutes. And the pump is using a 12V 4A power source.
   Total Energy Consumption = 48 Watts * 12/60 * 30/4 cycles = 72Wh = 0.072kWh
3. Valve Consumption:
   Total Energy Consumption = 24 Watts * 12/60 * 2 quantities * 30/4 cycles = 72Wh = 0.072kWh

⇒ Power Consumption Per Month: 3.384kWh. This is just estimated power consumption. It can vary depending on the final design of plants in the garden. And we do not have the chance to test the pressure of the pump for the real garden to see if it is enough to provide water to the whole garden.

Irrigation plan:

- **Pipe plan**: Since all irrigation parts are supplied by the same provider, they all fit together flawlessly and do not leak. However, because the pump's discharge and suction nozzles are only 12mm in diameter, connecting the pump to the water pipe is challenging. Since this is significantly smaller than the Maka 16mm pipe, the team chose to use clamps to hold the connection and insert a smaller pipe to make the nozzle bigger. For implementation, the pump nozzles size should be compatible with water pipes and all connections should have sealing material to prevent any leakage and wasting water.
- **Solenoid valve:** The solenoid valves are functioning properly in response to the controller inputs from the Raspberry Pi. However, since the current valves are not rated for waterproofing, the team has temporarily used heat shrink tubing to provide some protection. For implementation, investing in a higher quality and waterproof solenoid valve is essential for the system's long-term operation and safety. Moreover, the prototype system only uses two valves to water two sections, the implemented system will have an additional valve between each section to prevent water from flowing to the end point before the sprinkler can water. By investing in solenoid valves, it will make the implemented irrigation system more efficient and robust.

- **Sprinklers:** The current sprinkler system is performing well for the project's requirements, delivering water at the necessary pressure range of 1 to 3 bar, and distributing it evenly within a radius of 0.1 to 0.65 meters. However, for the final implementation, the team plans to upgrade to BS 7000 Plus sprinklers, which offer a larger and adjustable watering radius of 0.8 to 4 meters. These sprinklers are not only more versatile but also more durable, with a 5-year warranty, making them a more robust alternative for long-term use [19].
- **Watering radius:** although the system could water the plant correctly to its functionality, the sprinkler coverage radius becomes inconsistent when one valve is closed. Since the pump operates at a constant pressure, it initially divides the pressure equally between the two branches of the pipe. However, when one valve is closed, all the pressure is directed to the remaining sprinkler, increasing its watering radius. This could be problematic in a real-world system as the purpose of having separate sprinklers is to control the water volume for each section of the garden independently, providing the appropriate amount of water for different types of plants. For instance, Over-watering could occur, potentially harming the plants. To address this, pressure relief valves could be installed at each sprinkler to regulate water pressure and prevent over-watering, or a more advanced piping system could be designed to better distribute the water pressure.
- **Pump:** The pump used by the team has the capacity to deliver up to 8 bars of pressure, this is more than enough for the sprinklers used in the prototype system which require only 1 bar – 3 bars of pressure to operate. However, running the pump at maximum power is unnecessary for the irrigation system and may result in excessive pressure, leading to unnecessary energy consumption, greater risk of leakage, and potential wear on the pump and valves. To improve performance and longevity, a voltage regulator is used to regulate the pump's output based on the system's current requirements. The irrigation system will be implemented using a centrifugal pump, which is more effective at managing huge volumes of water at moderate pressure levels and delivering steady water flow [13].

Issues when completing the project:

Problem with the pump:

- The team originally requested a 12V 3A pump adapter, but the vendor delivered a 12V 3.3A pump instead. Using the 3A adapter with this pump would cause the adapter to overheat, as the pump requires more current than the adapter can provide. To address this issue, the team opted to purchase a new 12V 4A adapter, which ensures adequate power for the pump. This solution is more cost-effective than replacing the pump itself and ensures safe, reliable operation.
- The pump at full power produces high water pressure, making it difficult to test the system because the pipes need to be easily disassembled and not yet securely connected. To enable testing and adjusting the sprinkler radius, the team understood the importance of controlling the pump's power output. After considering various options, the team decided to use an adjustable buck converter with a digital display, providing precise voltage control and enhanced visualization for more accurate adjustments. This solution allows for easier testing and ensures better control of the system's performance.

Water Tanks:

Figure 43: Water tanks filled with water

The water tanks could store the water without any leakage or deformation, and they are durable after several impacts without damaging. Nevertheless, there are two major problems with the current products:

- Aesthetics: white acrylic sheet is the only option available in RMIT Workshop, while these water tanks are intended to be crystal-clear to easily observe the water level inside the tank.
- Durability: the current tank design is not optimal, as the sheets are directly bonded using super glue and sealant, which are neither professional nor reliable. This issue could be addressed by incorporating a snap-fit feature or a stud-and-tube connection, similar to the LEGO design, to provide initial structural support to the sheets. Additionally, the design could be reinforced with L-shaped metal plates at the corners.

Water shooting range

The team purchased a cheap water gun to reduce costs. While functional, a higher-quality gun would offer enhanced material durability, multiple shooting modes for an improved user experience, and USB-based rechargeable capabilities. While the current model battery is in a tightly sealed compartment, every time the users need to recharge, the cover needs to be removed, and a screwdriver is required to remove the tighten screw, which may not always be convenient for users.

Figure 44: Image of the support structure being modified

The shooting range functions as intended; however, the mechanism is relatively simple, and several design flaws are present. For example, the support structure added later obstructs the path of the middle target, requiring modifications to parts of the structure. This compromise negatively impacts the overall aesthetic. Additionally, the placement of the drainage hole on the side of the range is not optimal due to the thickness of the conduit ring, which raises the hole above the bottom plate. As a result, the water could not fully drain out, creating a favorable environment for insects' reproduction. This could easily be fixed by relocating the drainage hole to the bottom of the range. Such a modification would allow a small water tank to be placed beneath the system as well.

Figure 45: Image of the drainage hole's position

Overall, the project successfully meets the client's requirements and performs as expected. With improvements to the identified system flaws, the project would be well-positioned for implementation on a larger scale, allowing its full potential to be harnessed. Additionally, this project is relatively more economical compared to similar products currently available on the market. The detailed breakdown of material costs is provided as follow:

Table 2: Calico Team bill of materials for the irrigation system

NO	COMPONENTS NAME	QUANTITY	VENDORS	PRICE (in VND)
1	Raspberry Pi 4 Model B 4Gb	1	Shopee Vietnam	2,000,000
2	Adapter for Raspberry Pi 4 (US)	1	Shopee Vietnam	310,000
3	Solenoid valve Male 21mm	2	Nshop	282,000
4	Pump 12V (DC) Power output Female Pipe output 10mm	1	Shopee Vietnam	99,000
5	Adapter male (12V 3A)	1	Shopee Vietnam	75,000
6	Relay (5V)	2	Nshop	91,000
7	Jack DC 5.5 *(3 Female, 3 Male)*	6	Nshop	20,000
8	Jumper Wire 30cm (3 Female-Female, 3 Female-Male, 3 Male-Male)	9	Nshop	15,900
9	PH wire (PH2-2P)	40	Nshop	40,000
10	Soil Moisture Sensor	2	Nshop	140,000
11	Water Level Sensor	1	Shopee Vietnam	7,000

12	Water Pipe LDPE 16MM METZER	5 meters	Maka.vn	75,000
13	Water Gun (blue)	1	Shopee Vietnam	435,000
14	T-Connector 16MM ANTELCO	1	Maka.vn	10,000
15	Thread Converter 21 to 27	6	Maka.vn	60,000
16	Internal Thread Connector 27MM to 16MM Pipe ANTELCO	6	Maka.vn	180,000
17	360° Sprinklers ELGO MFB-360	2	Maka.vn	110,000
18	Anti-Fold Soft Hose Cord 1m Phi 22	1 meter	Shopee Vietnam	45,000
19	Rubber tube rolled	2	Shopee Vietnam	6,000
20	Silicon Glue Tube	1	Shopee Vietnam	25,200
21	Glue Gun (green without troughs)	1	Shopee Vietnam	32,000
22	Inox Latch (4F)	4	Shopee Vietnam	14,000
23	Bolts and nuts	10	Shopee Vietnam	11,000
24	Electric welding torch - Bá Quang (40W straight)	1	Shopee Vietnam	92,000
25	Lead roll VINACHI	1	Shopee Vietnam	15,000
26	Anti-Overflow Mechanical Float JUNY (SIZE: Φ21)	1	Shopee Vietnam	59,000
27	Black tube (Phi 25mm)	4 meters	Shopee Vietnam	280,000
28	Assembled basin with legs	1	Shopee Vietnam	339,000
29	MICA Sheets for Water tanks and Shooting Range	-	Makerstore	Estimated 2.650.000
30	Hose clamp (phi 25)	2	Shopee Vietnam	5,700
31	Delivery Fee	-	-	Estimated 500,000
32	Electronic Junction box 250x160x80mm	1	Nshop	72,000
33	Electronic Junction box 200x120x75mm	1	Nshop	50,000
34	Electric tape	1	Shopee Vietnam	3,600
35	Heat shrinks tubes	1 box	Nshop	43,000
TOTAL	7,440,400			

VI. SUMMARY AND REFLECTION

The Smart Watering System capstone project has been a significant learning experience, highlighting both successes and areas for improvement. Calico team also successfully completed all scope of work, and deliverables requested by Sustainability department, our industry partners.

1. Achievements

System Integration: The modular design, incorporating the Raspberry Pi, sensors, and sprinklers, successfully met the objectives of the project. The website application effectively managed and monitored the watering process.

***Prototype Performance**:* Testing confirmed that both sensor-based and schedule-based watering methods functioned as intended, delivering water accurately to designated areas. Calico team tested & demonstrated our latest version of the system at the SSET showcase day and lots of people loved it. We have around 35 people coming over to out booth, and 7 out of 35 participants tested the water shooting function real-time in the showcase area. All 7 participants enjoyed the shooting testing. The list of participants is attached in the Appendices. Calico team received feedback from all participants, including ones tested the software functions, and ones tested the shooting. Calico team only recorded the participants did one of the testing functions, for participants that only came to hear about the system the capstone team did not record data of those.

Showcase result: Project team got invited to another exhibition for doing the prototype demonstration

2. Challenges

Sensor Accuracy: Data consistency issues due to the ADS1115 module's limitations affected moisture readings. Continuous data retrieval was necessary to maintain accuracy.

***Hardware Problems**:* Issues with Raspberry Pi components, such as SD card slot failures and IC short circuits, highlighted the need for robust hardware design and pre-implementation testing.

Tank Design: The water tanks faced aesthetic and durability issues. The reliance on acrylic sheets and super glue, while functional, lacked professional quality and reliability.

3. Learnt Lessons

Thorough Testing: Comprehensive testing of both hardware and software is essential to identify and address issues early. Iterative testing and feedback improve system reliability.

Component Integration: Ensuring compatibility and proper integration of all components is crucial. Detailed planning and validation are necessary before final assembly.

Continuous Improvement: Implementing feedback and making iterative improvements based on testing results enhance system performance and user experience.

4. Future Considerations

Data Handling: Improve real-time data processing to enhance sensor accuracy. Explore alternative modules or methods for better data acquisition. This is also the feature that our team decided to enhance for the Green Economy Forum & Exhibition (GEFE) 2024, the next exhibition that the engineering capstone team got invited to.

Hardware Design: Focus on robust and durable hardware. Ensure all components, including connectors and enclosures, are reliable and well-tested. Considering adding in the decal stickers for all components to make a consistent and professional appearance for the devices.

User Experience: Enhance the user interface and interaction methods. Enhancing the testing function, and reliability of testing water gun shooting in a showcase area while considering all safety control policy of the organizers. Adding the mentioned user-friendly features will improve overall usability.

5. Recommendations for stakeholders

Our recommendation includes regular maintenance, purchasing the quality components, and comprehensive planning while finalizing the land location. Establishing a maintenance schedule and quality components to address component vulnerability and update software would resolve emerging issues. Finally, the most recent, and recurring challenge for our stakeholder is that RMIT Sustainability needs to finalize the land location approvals and the permits. This would include presentation of our smart watering system for the high leaderboard of RMIT. Sustainability might need to fill in some RMIT templates for the safety control, pet control, local legacy, and permit to operating system. As far as Calico team know, in the second phase we could not test our prototype in the garden area is because that area is under construction for Building 9 renovation, and both industry partner and Calico team did not have right to test the system there yet.

In sum, the Smart Watering System project has achieved key milestones and key deliverables while working on the improvement for. Addressing these challenges and incorporating lessons learned will lead to a more effective and reliable irrigation solution.

VII. REFERENCES

[1] G. S. Kumar, G. Nagaraju, D. Rohith, and A. Vasudevarao, "Design and Development of Smart Irrigation System Using Internet of Things (IoT) - A Case Study," *Nature Environment and Pollution Technology*, vol. 22, no. 1, pp. 523–526, Mar. 2023, doi: 10.46488/nept.2023.v22i01.052.

[2] D. Vallejo-Gómez, M. Osorio, and C. A. Hincapié, "Smart Irrigation Systems in Agriculture: A Systematic Review," *Agronomy*, vol. 13, no. 2, p. 342, Jan. 2023, doi: 10.3390/agronomy13020342.

[3] M. Oudah, A. Al-Naji, T. Y. Al-Janabi, D. S. Namaa, and J. Chahl, "Automatic Irrigation System Based on Computer Vision and an Artificial Intelligence Technique Using Raspberry Pi," Automation, vol. 5, no. 2, pp. 90–105, May 2024, doi: 10.3390/automation5020007.

[4] "What are LoRa and LoRaWAN?," *The Things Network* (Mar. 19, 2024). Accessed: May 14, 2024 [Online]. Available: https://www.thethingsnetwork.org/docs/lorawan/what-is-lorawan/

[5] P. Gebhardt, "What Is LoRa? A Beginner's Guide #1," *Paessler* (Mar. 29, 2022). Accessed: May 14, 2024 [Online]. Available: https://blog.paessler.com/what-is-lora-a-beginners-guide-part-1

[6] GeeksforGeeks, "Cellular Networks," *GeeksforGeeks*, (Nov. 23, 2023) Accessed: May 14, 2024 [Online]. Available: https://www.geeksforgeeks.org/cellular-networks/

[7] P. Axell, "Cellular Network: Understanding what are Cellular Networks," *PBE Axell*, (Jun. 17, 2024). Accessed: May 14, 2024 [Online]. Available: https://pbeaxell.com/about/glossary/what-is-a-cellular-network

[8] G. Taylor, "The Best Smart Sprinkler Controllers Today," *Bob Vila*, (Jun. 15, 2023). Accessed: May 14, 2024 [Online]. Available: https://www.bobvila.com/articles/best-smart-sprinkler-controller/

[9] METER Group, Inc. USA. "What is Soil Moisture? The Science Behind the Measurement." METER Group. Accessed: Aug 1, 2024. [Online]. Available: https://metergroup.com/measurement-insights/what-is-soil-moisture-the-science-behind-the-measurement/

[10] Texas Instruments. "ADS1113, ADS1114, ADS1115 Low-Power, I2C-Compatible, 860-SPS, 16-Bit ADCs with Internal Reference and Oscillator." Datasheet. Accessed: Aug 1, 2024. [Online]. Available: https://www.ti.com/lit/ds/symlink/ads1114.pdf?ts=1590897534760

[11] Pinout.xyz. "Raspberry Pi GPIO Pinout." Accessed: May 14, 2024. [Online]. Available: https://pinout.xyz/

[12] Raspberry Pi Foundation. "BCM2711 Peripherals." Datasheet. Accessed: Jun 14, 2024. [Online]. Available: https://datasheets.raspberrypi.com/bcm2711/bcm2711-peripherals.pdf

[13] Michael Smith engineers, "Useful information on centrifugal pumps," Michael Smith engineers. Accessed: Sep. 15, 2024 [Online]. Available: https://www.michael-smith-engineers.co.uk/resources/useful-info/centrifugal-pumps#:~:text=A%20centrifugal%20pump%20is%20a

[14] “Turning effect - Moment of a force - CCEA - GCSE Physics (Single Science) Revision - CCEA,” BBC Bitesize. Accessed: Sep. 15, 2024 [Online]. Available: https://www.bbc.co.uk/bitesize/guides/zkwxgwx/revision/1

[15] “Bolt weight and quantity — Fasteners Calculator,” MetalGuide. Accessed: Sep. 15, 2024. [Online]. Available: https://en.metcalc.info/calc-fasteners/bolt/

[16] GeeksforGeeks, "Water Pressure Formula," (Sep. 12, 2023). Accessed: Sep. 17, 2024 [Online]. Available: https://www.geeksforgeeks.org/water-pressure-formula/.

[17] “Automatic Water Level Control Valve”, CannonWater. Accessed: Aug 1, 2024. [Online]. Available: https://cannonwater.com/water-treatment-equipment/water-control-valve/automatic-water-level-control-valve/#:~:text=The%20valve%20operates%20based%20on,automatic%20water%20level%20control%20valves?\

[18] A. KL, "Three Different Ways to Boot a Raspberry Pi from a USB Drive". LinkedIn. Accessed: Aug 15. [Online]. Available: https://www.linkedin.com/pulse/three-different-ways-boot-raspberry-pi-from-usb-drive-arun-kl

[19] “Béc BS 7000 Plus,” vuonnhietdoi. Accessed: Sep. 15, 2024. [Online]. Available: https://vuonnhietdoi.vn/san-pham/bec-bs-7000-plus

[20] “Blynk IoT Smart farming using water pump”. Techatronic. Accessed: May 14, 2024. [Online]. Available: https://techatronic.com/blynk-iot-smart-farming-using-water-pump.

VIII. APPENDICES

Watering History

Watering Time	Plant ID	Is Watered
2024-09-15 09:46:02	2	False
2024-09-15 09:46:01	1	True
2024-09-15 09:29:02	2	True
2024-09-15 09:29:01	1	True
2024-09-15 09:22:02	2	True
2024-09-15 09:22:01	1	True

Figure 46 46: UI of Watering History

2024-09-12 07:00:01	68.12
2024-09-12 08:00:01	77.00
2024-09-12 09:00:01	74.42
2024-09-12 10:00:01	84.01

Figure 4747: UI of Sensor Data History

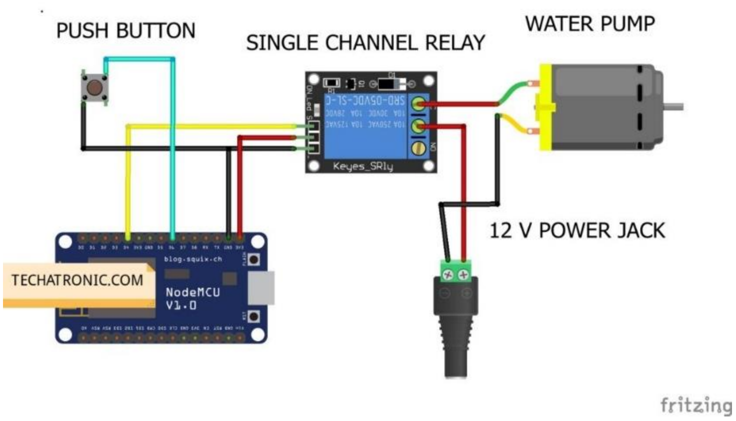

Figure 4848: Connection between microcontroller and water pump or valve diagram [20]

Showcase booth participants" in [Calico Team Wiki](), where we manage all of our activities.

No.	Participant Name	Role / Occupation	Tested water gun	Feedback	Note
1	Ms. Van Anh	Staff - Lecturer		Like the system	
2	Mr. Huy	Lecturer			
3	Dr. Alex	Lecturer, Academic Supervisor		The set up has done well. The parts are well set up together and he can see some improvements comparing to the previous meetings	
4	Mr. Son	Lecturer			
5	Mr. Son Dao	Lecturer		The system cna be enhanced more	
6	Lecturer 1	Staff			
7	Lecturer 2	Staff			
8	Ngoc	Sustainability Ambassadors		"I think I can use this system for my home garden"	
9	Sang	Sustainability Ambassadors			
10	Dan	Sustainability Ambassadors			
11	Vy	Sustainability Ambassadors			
12	Capstone team student - booth 18	Student		The purpose for the shooting range is not related to egineering . It is just for entertaining purpose	
13	SCD student 1 (that taking sustainability course)	Student	x	The water shooting is satisfying	
14	SCD student 2 (that taking sustainability course)	Student	x	The water shooting range can be used after class to have some fun	
15	SCD student 3 (that taking sustainability course)	Student		I can't shoot water out of this gun	He used the adapted small water gun, not the big water gun we wanted to use for our system. So this can't be counted as a tester
16	Ms. Nguyen - SSET Admin 1	Staff			
17	Ms. Huong - SSET Admin 2	Staff			
18	SSET Admin 3	Staff			
19	SSET Admin 4	Staff			
20	SSET Admin 5	Staff			
21	Matthew	Director of Capital Work, Sustainability			
22	Tram	Sustainability Ambassadors		I cna see how is it connect to sustsinability	
23	Tram's Friends	Sustainability Ambassadors			
24	Dr. Byron	Lecturer, Academic Supervisor		The team did well in setting up the parts in the showcase day	
25	Engineering Student 1	Student	x	The shooting is fun, and the water gun can shoot far	
26	Engineering Student 2	Student			
27	Engineering Student 3	Student			
28	Engineering Student 4	Student			
29	Engineering Student 5	Student			
30	Industry Partner 1	Industry Partner	x		
31	Industry Partner 2	Industry Partner	x		
32	Industry Partner 3	Industry Partner			
33	Quynh Anh	Student		I like the shooting part, I think the system is suitable for bulding 9 area	
34	An	Sustainability Ambassadors	x		
35	Minh Anh	Sustainability Ambassadors	x		

Figure 4949: List of Booth participants and their feedback

IX. MEETING JOURNALS

Calico Capstone Team
Weekly Meeting Minutes

Introduction to Calico team Weekly meeting minutes.

Calico Capstone Team meeting minute Summary

Here is a summary of all Calico Capstone team meetings within Semester 2, 2024. Every week the capstone would have at least one internal meeting on Wednesday from 8:30am to 10:am to discuss the focuses of the week and prepare for the meetings with their lecturers. Overall, from Week 3, the academic supervisors and capstone team decided to have a weekly meeting on Friday morning, however, there will still be some weeks that there were no meetings hosted because there were not enough testing results, and progress to update with the academic supervisors.

In this report, the Calico capstone team will present all meeting minutes with different supervisors, and some samples of Calico's internal meeting minutes for weekly tasks.

List of meetings

First, let's take a look at all meetings Calico teams had, and the focuses for each meeting.

Table 3: Summary of Meetings in Semester 2 2024

No.	Week	Date & Time	Location	Focus of the week	Attendants
1	W1	10:00 - 11:00, Fri 5th July 2024	Online via Teams	Discuss resizing the Capstone project, Budget request proposal finalization, Bill of Material process	Capstone team, Dr. Alex, Dr. Byron (Academic supervisors)
2	W2	13:00 - 13:30, Mon 8th July 2024	Online via Teams	Confirm expectations, resizing, storage, soil provider, and other needs	Capstone team, Phuong, Mr. Tam, Mr. Hoc (Industry supervisors)
3	W2	16:00 - 17:00, Wed 10th July 2024	Online via Teams	Final review of Bill of Material; lecturers lent equipment to the Capstone team	Capstone team, Dr. Alex, Dr. Byron (Academic supervisors)
4	W4	11:00 - 12:00, Fri 26th July 2024	B2.4.26	Design & Bill of Materials; received a small version of the printed Shooting Range	Capstone team, Dr. Alex, Dr. Byron (Academic supervisors)
5	W6	10:00 - 11:00, Fri 9th August 2024	Boost Juice	No clear memory of the meeting (possibly skipped due to illness)	Capstone team, Dr. Alex, Dr. Byron (Academic supervisors)
6	W7	11:00 - 12:00, Fri 16th August 2024	Boost Juice	Discussed the pump and made suggestions; lecturers reviewed the small tank and possibilities	Capstone team, Dr. Alex, Dr. Byron (Academic supervisors)
7	W8	11:00 - 12:00, Fri 23rd August 2024	Boost Juice area, B2	Lecturer attended demonstration; discussed leaking	Capstone team, Dr. Alex, Dr. Byron (Academic supervisors)

				and overall project plan	
8	W10	11:00 - 12:00, Fri 6th September 2024	B2.4.26	Showed demo video and prepared for showcase presentation	Capstone team, Dr. Alex, Dr. Byron (Academic supervisors)
9	W3	8:30 – 10:00 am ,17th July 2024 Wednesday	B2.4.40	Break down the Capstone B timeline	Capstone team
10	W5	8:30 – 10:00 am Wednesday,3rd August 2024	B2.4.40	PCB arrival and Report writing division	Capstone team
11	W11	10:00 am - 12:00 pm Wednesday,11th September 2024	B2.4.40	Showcase presentation and final testing of the system	Capstone team

Meeting with Stakeholders

Meeting No. 1 Details

Date	**Friday, 5th July 2024**
Time	10:00 AM - 11:00 AM
Attendees	All Calico team members, Dr. Alex, Dr. Byron (Academic Supervisors)
Apologies	Phuong Trinh, Hoc Tran, Tam Le (Sustainability team could not join the meeting due to a clashed schedule, and the meeting was announced quite urgently). So, we planned a catch-up meeting with sustainability team in Week 2
Copy To	N/A

Information /Decision

Item No.	Discussion Summary
1	Discussed resizing the Capstone project to better align with resources and timeline.
2	Reviewed the budget request process and emphasized streamlining approvals.
3	Late for BOM submission challenge break down
4	Discussed improving the Bill of Material (BOM) process to avoid delays in procurement.

Action Items

No	Item	Who	By
1.1	Capstone team to revisit project scope and propose a resized version.	Capstone Team	12th July 2024
1.2	Dr. Alex to draft revised budget approval guidelines for faster processing.	Dr. Alex	19th July 2024
1.3	Dr. Byron to consult with procurement team regarding Bill of Material process improvements.	Dr. Byron	26th July 2024

Meeting No.2 Details

Date:	**8th July 2024**
Time:	1:00 PM - 1:30 PM
Attendees:	All Calico team members, Phuong, Mr. Tam, Mr. Hoc (Industry Supervisors)
Apologies	N/A
Copy To	N/A

Information /Decision

Item No.	Discussion Summary
1	Confirmed expectations regarding the resized Capstone project and required deliverables.
2	Discussed storage requirements for materials and equipment related to the project.
3	Identified potential soil providers and assessed their suitability for the project.
4	Reviewed additional needs for the project, including timeline adjustments and logistical support.
5	*Q&A on using soil, electrical hazard, safety protocols, build prototype…*

Action Items

No	Item	Who	By
2.1	Capstone team to finalize resized project plan and present to supervisors.	Capstone Team	15th July 2024
2.2	Phuong to secure storage space for project materials.	Phuong	12th July 2024
2.3	Mr. Tam and Mr. Hoc to follow up with potential soil providers and confirm arrangements.	Mr. Tam, Mr. Hoc	19th July 2024

Meeting No.3 Details

Date:	**Wednesday, 10th July 2024**
Time:	4:00 PM - 5:00 PM
Attendees:	Dr. Alex, Dr. Byron (Academic Supervisors), All Calico team members
Apologies	N/A
Copy To	N/A

Information /Decision

Item No.	Discussion Summary
1	Final review of the Bill of Material (BOM) to ensure all items are listed and approved for procurement.
2	Confirmed the equipment lent by lecturers to the Capstone team for use in the project.
3	Request a quick check on the Bill of materials list before submission for procurement
4	Feedback on how the components type should be listed
5	Update on the team current status

Action Items

No	Item	Who	By
3.1	Capstone team to submit the final version of the Bill of Material for approval.	Capstone Team	12th July 2024
3.2	Dr. Alex and Dr. Byron to arrange the handover of lent equipment to the Capstone team.	Dr. Alex, Dr. Byron	14th July 2024

Meeting No.4 Details

Date	**Friday, 26th July 2024**
Time	**11:00 AM - 12:00 PM**
Location	**B2.4.26**
Attendees	All Calico team members**, Dr. Alex, Dr. Byron (Academic Supervisors)**
Apologies	N/A
Copy To	N/A

Information /Decision

Item No.	Discussion Summary
1	Reviewed the design and finalized key components of the project.
2	Discussed updates to the Bill of Materials (BOM) based on the design changes, mostly for PCB order.
3	Received a small 3D-printed version of the Shooting Range for initial testing and feedback.
4	Possible location for components storage
5	Estimated showcase area for the project, which could affect the final size of the prototype
6	Borrow the school equipment for implementation

Action Items

No	Item	Who	By
4.1	Capstone team to update the Bill of Materials to reflect new design modifications.	Capstone Team	1st August 2024
4.2	Dr. Alex and Dr. Byron to review and provide feedback on the 3D-printed Shooting Range.	Dr. Alex, Dr. Byron	2nd August 2024

Meeting No.5 Details

Date	**Friday, 9th August 2024**
Time	**10:00 AM - 11:00 AM**
Location	**Boost Juice**
Attendees	All Calico team members**, Dr. Alex, Dr. Byron (Academic Supervisors)**
Apologies	N/A
Copy To	N/A

Information /Decision

Item No.	Discussion Summary
1	The leaking in the small water tank
2	Discussion how to add waterproof features to the microcontroller, & other electric components
3	Discussion on how water tanks are assembled to ensure integrity and prevent leakage
4	Update on the team current status

Action Items

No	Item	Who	By
5.1	Follow up with Capstone team and supervisors to confirm if any actions were missed or need review.	Capstone Team	16th August 2024
5.2	Testing the components and the new pipe to see the leaking rate of it	Capstone team	16th August 2024

Meeting No.6 Details

Date	**Friday, 16th August 2024**
Time	**11:00 AM - 12:00 PM**
Location	**Boost Juice**
Attendees	All Calico team members**, Dr. Alex, Dr. Byron (Academic Supervisors)**
Apologies	N/A
Copy To	N/A

Information /Decision

Item No.	Discussion Summary
1	Discussed the pump specifications and made suggestions for improvements or adjustments.
2	Lecturers reviewed the small tank and explored possibilities for its integration into the project.
3	Check and feedback on prototype of water tank and circuit
4	Discussion on how water tanks are assembled to ensure integrity and prevent leakage
5	Update on the team current status

Action Items

No	Item	Who	By
6.1	Capstone team to implement suggested changes to the pump and present updates.	Capstone Team	23rd August 2024
6.2	Dr. Alex and Dr. Byron to further assess the feasibility of the small tank in the design.	Dr. Alex, Dr. Byron	23rd August 2024
6.3	Designing the poster, cover page, and demonstration video to submit	Capstone team	25th August 2024

Meeting No.7 Details

Date	**23rd August 2024**
Time	11:00 AM - 12:00 PM
Attendees	All Calico team members, Dr. Alex, Dr. Byron
Apologies	N/A
Copy To	N/A

Information /Decision

Item No.	Discussion Summary
1	Lecturers attended the project demonstration to observe progress.
2	Identified issues with leaking and discussed potential solutions to address it.

3	Reviewed the overall project plan and discussed the next steps moving forward.
4	Review the project poster & project cover page

Action Items

No	Item	Who	By
7.1	Capstone team to resolve leaking issues and update supervisors on the fix.	Capstone Team	30th August 2024
7.2	Dr. Alex and Dr. Byron to provide feedback on the revised project plan.	Dr. Alex, Dr. Byron	30th August 2024
7.3	Re-submit the project poster and project cover page to SSET	Chenin	30th August 2024

Meeting No.8 Details

Date	**6th September 2024**
Time	11:00 AM - 12:00 PM
Location	B2.4.26
Attendees	All Calico team members, Dr. Alex, Dr. Byron
Apologies:	N/A
Copy To:	N/A

Information /Decision

Item No.	Discussion Summary
1	Capstone team presented a demo video showcasing the progress of the project.
2	Discussed preparations for the upcoming showcase presentation, including final touches and delivery.

Action Items

No	Item	Who	By
8.1	Capstone team to finalize the showcase presentation materials and rehearse.	Capstone Team	13th September 2024
8.2	Dr. Alex and Dr. Byron to review the outline of the showcase presentation and provide feedback.	Dr. Alex, Dr. Byron	13th September 2024
8.3	Dr. Alex and Dr. Byron review the software feedback issues, and provide recommendation	Dr. Alex, Dr. Byron	6th September 2024

Internal Meeting (Additional)

Other than the meetings with stakeholders like our academic supervisors, and industry supervisors, the Calico team also has our internal meetings, it usually happens on Wednesday every week, however, we didn't write meeting minutes for all of the meetings since those meeting carried only discussion on previous meeting's focuses. There have been three weeks that the discussion was separate and was significant enough to make separate meeting minutes. For all of the internal meetings, all members of Calico team were present, and no one was absent during those meetings.

Meeting No.9 Details

W3 – Internal Meeting of Capstone

Date	Wednesday, Week 3 17th July 2024
Time	8:30 AM - 10:00 AM

Attendees	All Calico team members: Huy, Minh, Nhan, Tuan, Tung.
Apologies	N/A
Copy To	N/A

Information /Decision

Item No.	Discussion Summary
1	Reviewed the current progress of the project.
2	Discussed the tasks to be completed by each team member.
3	Identified any issues or blockers and discussed potential solutions.

Action Items

No	Item	Who	By
9.1	Team members to complete their assigned tasks and report progress in the next meeting.	Capstone Team	Next Meeting

Meeting No.10 Details

W5 – Internal Meeting of Capstone

Date	Wednesday, Week 5 3rd August 2024
Time	8:30 AM - 10:00 AM
Attendees	All Calico team members: Huy, Minh, Nhan, Tuan, Tung.
Apologies	N/A
Copy To	N/A

Information /Decision

Item No.	Discussion Summary
1	Checking and planning the soldering & completion plan of the project capstone B
2	Task division for the whole report writing
3	PCB arrival and task division for soldering electronics

Action Items

No	Item	Who	By
10.1	First two parts of the report	Chenin	16th September 2024
10.2	Literature review	Tung, Chenin (proofreading)	16th September 2024
10.3	Solution design (excluding sprinklers)	Tuan, Minh	16th September 2024
10.4	Sprinkler design	Chenin	16th September 2024
10.5	Result analysis	Tuan, Minh	16th September 2024

10.6	Soldering the electronics Components	Minh, Tung	10th August 2024

Meeting No.11 Details

W11 – Internal Meeting of Capstone

Date	Wednesday, Week 11 11th September 2024
Time	10:00 AM – 12:00 PM
Attendees	All Calico team members: Huy, Minh, Nhan, Tuan, Tung.
Apologies	N/A
Copy To	N/A

Information /Decision

Item No.	Discussion Summary
1	Timeline and things to share in the showcase.
2	Presentation for showcase structure, and the professional dress code for the team
3	Dividing the tasks

Action Items

No	Item	Who	By
1	Bring all equipment that the members keeping at home	All members	12th September
2	Preparing the presentation video	Chenin	18th September
3	Upload all photos and videos of demonstration	Huy, Chenin, Tuan	18th September