



AquaCycle: Design and Implementation of a Plastic Bottle-to-Water Recycling System

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CHAPTER I

INTRODUCTION

1.1 Rationale

Plastic pollution presents a formidable threat to the environment, particularly impacting oceans and ecosystems due to the extensive accumulation of plastic waste. In the Philippines alone, approximately 2.7 million tons of plastic are discarded annually, with less than 10 percent recycled; the rest is dumped, incinerated, or mismanaged, causing significant ecological damage to marine and terrestrial habitats (Climate.gov.ph, 2024). The consequences of plastic pollution are extensive and detrimental to marine ecosystems and human health. Ocean plastic debris damages marine life and habitats, disrupts ecological processes, and results in significant economic losses for fisheries and tourism sectors (Beaumont et al., 2019). Moreover, plastic pollution threatens human health through ingesting contaminated seafood and water and exposure to microplastics via inhalation and ingestion (Smith et al., 2019). Additionally, the lifecycle of plastics, from production to disposal, contributes to climate change by releasing greenhouse gases, further linking plastic pollution to global environmental challenges (Ford et al., 2022).

Each year, vast amounts of plastic waste, estimated in the millions of metric tons, flow into the oceans, with over 1,000 rivers responsible for most of this pollution (Meijer et al., 2021). This issue is especially pressing in Bangladesh, as inadequate waste management has made the country rivers major contributors to marine plastic pollution (Hossain et al., 2021). These challenges highlight the urgent need for coordinated global efforts to manage plastic waste more effectively. The United Nations Environment Programme (2021) noted that several strategies have already been introduced, including

national recycling initiatives to curb plastic waste. Meanwhile, innovative approaches that combine recycling with essential services, like exchanging plastic bottles for clean drinking water, offer dual benefits. Such solutions not only promote environmental sustainability but also help address water scarcity, especially in underserved communities (Huang et al., 2021).

In the Philippines, solid waste management continues to be a complex challenge. According to Coracero et al. (2021), inconsistent waste collection, segregation, and processing contribute significantly to the problem. They further describe that municipal solid waste in the country comprises various materials, including sewage sludge, scraps, domestic refuse, and yard waste, primarily driven by overproduction and consumerism. The authors emphasize that the multi-stage processes involved in waste management—collection, transport, processing, recycling, disposal, and monitoring—pose significant difficulties for local government units.

According to Macusi et al. (2019), the province of Mindanao, the second-largest island in the Philippines, grapples with its share of environmental and social challenges, including plastic pollution and access to clean water. Introducing a plastic bottle-to-water exchange program in Mindanao has the potential to not only reduce plastic waste but also improve water accessibility, particularly in marginalized communities. Moreover, such initiatives can empower residents to actively participate in environmental conservation efforts while fostering community solidarity and resilience.

1.2 Purpose and Project Description

The project goal is to set up a system at Davao Oriental State University to exchange plastic bottles for water. The system encourages people to recycle their plastic bottles by giving them clean water or points for every bottle they recycle. Offering clean drinking water as a prize for each bottle turned in is part of the Plastic Bottle-to-Water Exchange, which encourages people to collect and recycle plastic bottles. Students, teachers, staff, and community members will all be involved in the project, which aims to promote a sense of responsibility and care for the environment.

1.3 Objectives of the Study

This project aims to reduce plastic trash in schools by encouraging people to act in environmentally friendly ways, rewarding recycling, providing clean water, implementing monitoring systems to track recycling, and getting students involved in projects that care about the environment. Its stated goals are to;

1. Develop a web-based interface for users and administrators to track the number of plastic bottles deposited and assign points accordingly.
2. Implement a user profile system and integrate it with the hardware for participation tracking.
3. Allow users to select their preferred reward, either clean drinking water or points that can be redeemed.

1.4 Significance of the Study

This study aims to address the issue of incorrectly disposed of water bottles, which cause pollution and health risks. The study addresses plastic pollution and its consequences for ecosystems and human health. Many people are unaware of the adverse effects of improper disposal. Davao Oriental State University, a recycling system for plastic waste, evolved as an innovative way to manage plastic bottles. This system was developed to make clear water more accessible while collecting and reducing plastic waste. The project encourages people to recycle plastic bottles, which reduces the adverse effects caused by plastic waste on the environment, especially near the ocean.

In places where clean water can be hard to come by, the system reward method of giving clean drinking water in exchange for plastic bottles meets an important need. The goal of this project is to promote recycling exercises and general health.

The project encourages engagement among the university community, including students, faculty, and staff, by giving them a reason to participate in conservation efforts. This group effort builds a sense of duty and makes people in the school more aware of environmentally friendly practices.

The project supports the ideas of a circular economy by reusing and repurposing the collected plastic bottles, which lowers the need for new plastic output and reduces waste.

1.5 Scope and Limitations

The scope of the study “AquaCycle: Design and Implementation of a Plastic Bottle-to-Water Recycling System” includes the development, integration, and evaluation of a recycling system that exchanges plastic bottles for reward points or clean water. The study focuses on bottle detection, user interaction, and reward mechanisms, while addressing limitations such as accepting only clean, empty plastic bottles within specific weight ranges and requiring users to bring their tumblers.

The scope of the study was:

- Develop a mechanism that can detect, count, and measure the weight of plastic bottles to classify them into sizes (Small, Medium, Large, Extra Large, and Extra Extra Large) for Point Assignment System.
- Link student profiles to recycling activities and reward points.
- Admin interface for complete administrative control
- User Interface for registration, points balance, and reward offering.
- Allow user to physically verify their points with an administrator before redeeming their chosen rewards.

However, the system has the following limitations:

- Users are required to deposit only plastic bottles.
- Users are required to deposit only empty plastic bottles without caps.
- Users are required to deposit only clean plastic bottles.
- The system only accepts plastic bottles within specific weight ranges of 5g to 80g.
- Users must bring their tumbler to receive the water incentive.

1.6 Concept Framework

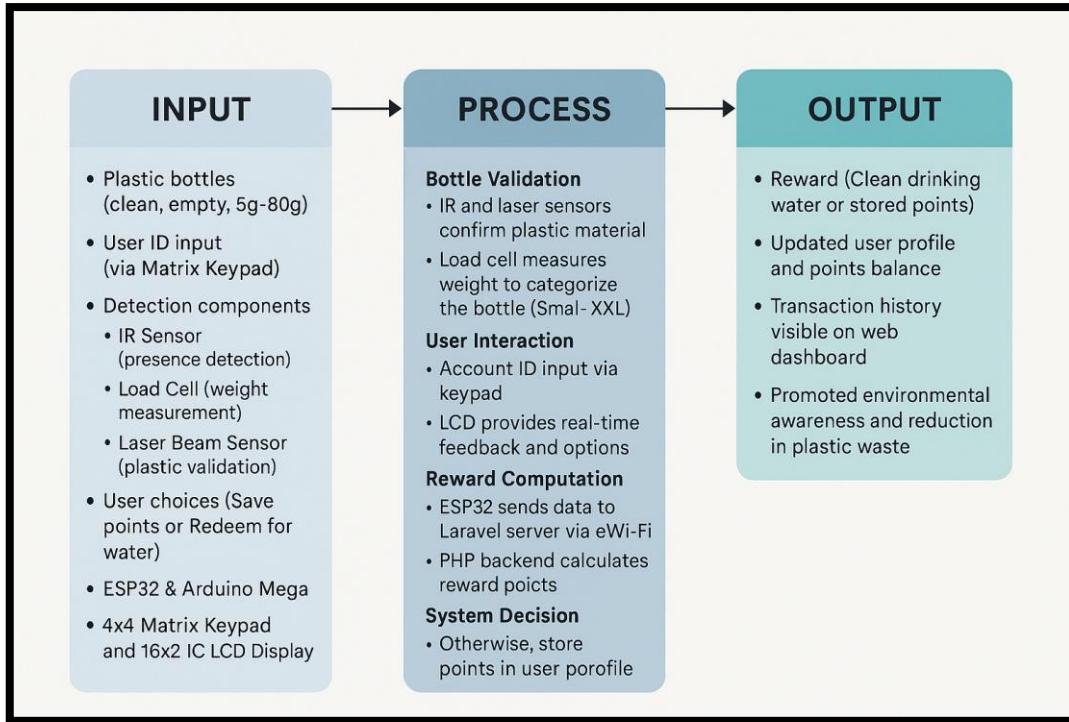


Figure 1.1 Conceptual Framework

This study utilized the Input-Process-Output (IPO) model (see Figure 1.1) to visually illustrate the logical structure of the AquaCycle. The inputs include the collection of plastic bottles that are clean, empty, and within a specified weight range, as well as user interaction through account ID input and selection of reward preferences. It also encompasses the integration of key hardware components such as the IR sensor, load cell, laser beam sensor, ESP32, Arduino Mega, keypad, and LCD.

The processes involve validating the material through sensors, measuring weight for size classification, computing reward points, and facilitating real-time interaction with the user. Data is processed and transmitted through the ESP32 to a web-based platform using

PHP and Laravel. The system then decides whether to dispense water or store points based on the user's choice and available balance.

The outputs of the system are the dispensing of clean drinking water, the updating of user profiles and points balance, real-time transaction logging, and increased environmental awareness. Ultimately, the system promotes sustainable practices through the integration of technology with environmental conservation efforts.

1.7 Definition of Terms

AquaCycle	Is the name of the system or project.
ESP32 Microcontroller	A small, powerful computer used to control the system. It manages sensors, displays, and communication between the hardware and the web interface.
IR Sensor	A sensor that detects the presence of objects by using infrared light. It helps the system know when a bottle is placed in the machine.
Load Cell	A sensor that measures the weight of the bottle. It helps calculate how many points the user will earn based on the bottle's weight.
Relay Module	A device that acts as a switch to control the water pump. It allows the system to turn the pump on or off when needed.

Water Pump	When the user redeems their reward points, a device dispenses clean water.
16x2 LCD Display	A screen that shows information to the user, such as the points balance and current system status.
Matrix Keypad	Users press buttons to log in, input their account ID, and choose rewards.
PHP and Laravel	PHP is a programming language used to create websites, and Laravel is a framework that helps build those websites. Both manage user accounts, transactions, and reward systems.
MySQL Database	A system used to store and manage data, including user data profiles, transactions, and points information.
Arduino IDE	A software application used to write, compile, and upload code to Arduino microcontroller boards for hardware programming.
Visual Studio	Microsoft integrated development environment (IDE) used to write, debug, and develop software applications in various programming languages.
Points System	A method used to reward users for recycling bottles. These points can be exchanged for rewards like clean water.
Reward Redemption	The process by which users exchange their points for rewards, such as clean water or other prizes.

CHAPTER II

REVIEW OF RELATED LITERATURE

2.1. Technical Background

The system developers employed a range of programs when creating it, including:

2.1.1 PHP

PHP (Hypertext Preprocessor) is a widely used open-source server-side scripting language designed for web development. It enables the creation of dynamic web pages by embedding code within HTML, interacting with databases, and handling server-side logic. PHP's ease of use, extensive libraries, and strong community support make it a popular choice for building websites and web applications (PHP.net, 2024). In AquaCycle, PHP is used to handle backend processes, manage user accounts, process bottle deposit data sent from the ESP32, and update user points and rewards in real time.

2.1.2 Bootstrap

Bootstrap is a free, open-source front-end framework used for designing responsive and mobile-first websites. It provides a collection of CSS and JavaScript-based design templates for typography, forms, buttons, navigation, and other interface components. Developed by Twitter, Bootstrap simplifies web design and ensures that websites adapt to different screen sizes, improving user experience across devices. It is highly customizable, offering pre-designed themes

and tools to make the development process faster and more efficient. With its grid system and reusable components, Bootstrap helps developers create modern, professional-looking interfaces with minimal effort (Bootstrap, 2024). In AquaCycle, Bootstrap is used to create a responsive and user-friendly interface that allows users and administrators to interact with the system across various devices.

2.1.3 Arduino IDE

The Arduino Integrated Development Environment (IDE) is an open-source software platform for writing and uploading code to Arduino boards. It supports C/C++ programming languages and provides an intuitive interface for developers to create code and interface with hardware components such as sensors, actuators, and other peripherals. The IDE simplifies hardware programming by providing tools for debugging, compiling, and uploading code directly to the microcontroller. The Arduino IDE supports a variety of microcontroller boards, and its large community of developers creates extensive libraries and resources for building electronics projects (Arduino, 2024). In AquaCycle, the Arduino IDE is used to program the Arduino Mega to interface with hardware components such as sensors, servos, and the keypad, enabling the detection and classification of plastic bottles.

2.1.4 MySQL Database

MySQL is a popular, open-source relational database management system (RDBMS) known for its reliability, scalability, and high performance. It uses

Structured Query Language (SQL) manages and manipulates table data. As one of the most widely used databases in web development, MySQL supports large-scale data storage, complex queries, and data integrity constraints. It is highly optimized for web applications and integrates seamlessly with programming languages like PHP and Python. MySQL supports transactional and non-transactional storage engines and provides a robust solution for applications requiring efficient and secure data handling (MySQL, 2024). In AquaCycle, MySQL stores all data related to user profiles, bottle deposits, points earned, and rewards redeemed, forming the core of the system's data management.

2.1.5 Visual Studio

Visual Studio is a powerful integrated development environment (IDE) created by Microsoft, widely used for developing applications in various programming languages, including C#, C++, Python, and more. It provides tools for debugging, testing, and deploying applications, along with an intuitive interface for coding, managing projects, and integrating version control systems like Git. Visual Studio supports a variety of plugins and extensions, enhancing its functionality and versatility. Developers use it to build everything from simple desktop applications to complex enterprise-level solutions. NET-based ecosystems. Visual Studio offers advanced features like code completion, IntelliSense, and a built-in debugger, making it an indispensable tool for software development (Microsoft, 2024). In AquaCycle, Visual Studio is used for managing and testing scripts and system modules.

2.1.6 Laravel

Laravel is a modern, open-source PHP framework that follows the Model-View-Controller (MVC) architectural pattern. It simplifies web application development by providing elegant syntax, built-in tools for routing, authentication, database management (via Eloquent ORM), and security features. Laravel accelerates development and improves code maintainability, making it a preferred framework for scalable and robust PHP applications (Laravel, 2024). In AquaCycle, Laravel manages user authentication, reward logic, and routing of the web application, ensuring smooth communication between the frontend and backend.

2.1.7 ESP32 Microcontroller

The ESP32 is a low-cost microcontroller with built-in Wi-Fi and Bluetooth, designed by Espressif Systems. It features a dual-core processor running up to 240 MHz, multiple GPIO pins, ADC/DAC channels, and supports various communication protocols like SPI and I²C. Known for its low power consumption and strong security features, the ESP32 is widely used in IoT devices, smart home applications, and embedded systems (Espressif Systems, 2024). In AquaCycle, the ESP32 receives sensor data from the Arduino Mega, sends it to the web server over Wi-Fi, and displays user points and messages via the LCD, enabling real-time data transfer and system control.

2.1.8 Arduino Mega

The Arduino Mega 2560 is a microcontroller development board based on the ATmega2560 chip. It offers 54 digital input/output pins, including 15 PWM outputs, 16 analog inputs, and 256 KB of flash memory for program storage. With a 16 MHz clock speed, it supports complex projects requiring numerous I/O

connections, such as 3D printers, robotics, and home automation systems. Its compatibility with the Arduino IDE makes it accessible for beginners and professionals alike (Arduino, 2024). In AquaCycle, the Arduino Mega processes input from hardware sensors, controls the servo motors for sorting bottles, and communicates validated data to the ESP32.

2.1.9 Load Cell

A load cell is a sensor that converts mechanical force, such as weight or pressure, into an electrical signal. It uses strain gauges that deform under load, changing their electrical resistance proportionally. This change is measured and converted into a voltage output, which can be calibrated to represent the applied force. Load cells are essential in weighing scales, industrial automation, and material testing due to their high precision and durability (Omega Engineering, 2024). In AquaCycle, the load cell measures the weight of each bottle, enabling the system to categorize the bottle size and assign the appropriate number of points.

2.1.10 Water Pump

A water pump is a mechanical device used to move water from one location to another by creating pressure or suction. Electric water pumps are commonly used in irrigation systems, water supply networks, and cooling systems. They vary in design, including centrifugal and diaphragm types, and are selected based on flow rate, pressure requirements, and power consumption (Grundfos, 2024). In AquaCycle, the water pump dispenses clean drinking water to users who redeem their points as a reward.

2.1.11 Relay

A relay is an electrically controlled switch that uses an electromagnet to open or close contacts, enabling a low-power circuit to control a high-power load safely. Relays provide electrical isolation between control and load circuits and are widely used in automation systems, motor control, and safety devices to switch lights, motors, and other electrical equipment (Schneider Electric, 2024). In AquaCycle, a 12V relay controls the activation of the water pump based on system commands to ensure safe and efficient dispensing.

2.1.12 IR sensor

An IR (infrared) sensor detects infrared radiation emitted or reflected by objects. It typically consists of an IR LED that emits infrared light and a photodiode or phototransistor that senses the reflected light. IR sensors are commonly used in applications such as proximity sensing, object detection, line following robots, and remote control systems because they are inexpensive and reliable in detecting nearby objects (Robu.in, 2024). In AquaCycle, the IR sensor detects the presence of a plastic bottle placed into the system, initiating the validation process.

2.1.13 16x2 LCD Display

A 16x2 LCD has 16 columns and two rows, which allows it to show 16 characters in each row. These displays are widespread in electronics projects and devices because they are easy to use and provide a way to display simple information. For example, they might be used in clocks, temperature sensors, and other systems where you need to show text or numbers. The display is controlled by sending data through specific pins that manage the characters shown on the

screen (Electronics For You, 2024). In AquaCycle, the LCD displays prompts, instructions, and feedback to users, such as their account status, points earned, and reward confirmation.

2.1.14 Ultrasonic Sensor

Ultrasonic sensors operate on the principle of sound wave emission and reflection. These sensors emit sound waves at frequencies above human hearing (typically around 40 kHz) and measure the time it takes for the sound to reflect from an object. This time delay is used to calculate the distance to the object.

Ultrasonic sensors are commonly used in various fields such as robotics, object detection, and distance measurement due to their accuracy and ability to operate in environments where optical sensors may be ineffective (MaxBotix, 2024). In AquaCycle, the ultrasonic sensor monitors the fill level of the internal plastic bin and alerts the system when the bin is full to prevent overflow.

2.1.15 Matrix Array 12 Key

A 12-key matrix keypad is a type of input device used in many systems where users need to enter data. The keypad consists of 12 keys arranged in a 3x4 grid. Each key in the grid corresponds to a unique combination of rows and columns, and when a key is pressed, the system detects the specific combination. These keypads are useful in devices like calculators, alarm systems, and even in embedded electronics where space is limited, and multiple keys are needed (Scribd, 2024). In AquaCycle, the matrix keypad allows users to input their account ID and interact with the system to confirm deposits or select rewards.

2.1.16 Servo Motor

A 12V servo motor is an electromechanical device that provides precise angular control of mechanical components. Operating at 12 volts, these servos deliver higher torque and faster response compared to lower voltage models. They incorporate a feedback sensor to maintain position accuracy, making them ideal for robotics, automation, and remote-controlled vehicles where precise motion control is critical (Pololu, 2024). In AquaCycle, servo motors control the sorting and dispensing mechanism, ensuring plastic bottles are directed appropriately based on their validation results.

2.2 Related Literature

Collecting documents and publications related to the investigation will be invaluable in carrying out this research. These are the additional research projects that are connected to this one.

Plastic pollution is a significant environmental issue that has garnered increased attention in recent years due to its adverse impacts on ecosystems and human health. The extensive use of plastic water bottles, in particular, has raised concerns regarding their production, consumption, and disposal practices (Karagöz et al., 2019). Plastic pollution is a global challenge that requires collective action to minimize its adverse environmental effects (Pierau et al., 2022). Despite plastics' convenience and affordability, the environmental risks associated with improper management have become increasingly evident (Negrete-Cardoso et al., 2022).

Kibria et al. (2023) argue that while numerous countries have implemented waste management frameworks, many still struggle with enforcement and public participation. Their research highlights the potential of local-scale solutions, such as reverse vending machines, to complement national waste strategies and engage citizens directly. Efforts to combat plastic pollution and encourage sustainable AquaCycle systems introduce a novel concept to tackle environmental challenges associated with plastic waste, specifically plastic bottles, by implementing a Plastic Bottle-to-Water reverse vending machine (RVM) (Sinaga & Irawan, 2020). Reverse vending machines, like the one proposed in AquaCycle, are crucial for waste management by encouraging the return of beverage containers, such as plastic bottles and cans, for recycling (Tur et al., 2019). These machines efficiently sort waste, reducing waste and promoting recycling practices.

Research has explored the use of Deposit–Refund Systems (DRS) for water bottles in closed-loop recycling systems. In this approach, consumers are incentivized to return empty bottles to RVMs for recycling into new PET bottles (Jadayil, 2023). This approach promotes recycling and emphasizes rewarding consumers for engaging in sustainable practices.

In the context of plastic bottle-to-water exchange systems, initiatives such as biobased and biodegradable materials have emerged as promising solutions to reduce the environmental impact of plastic use (Negrete-Cardoso et al., 2022). These alternatives aim to alleviate the harmful effects of traditional plastics by providing more sustainable options that can be effectively managed in the global environment (Negrete-Cardoso et al., 2022).

According to Moshhood et al. (2022), although plastic materials, with their numerous make-ups and manufacturing costs, are of high quality, it is of great concern if this plastic

material can be appropriately managed in our society. While plastics have become highly valued for their long-lasting functional use, many perspectives on plastics-related environmental hazards and energy crises have recently been raised. Plastics are popular because they provide people with less financial cost for what they want.

Consumers are, however, now more aware of the harmful environmental effects of plastics. Therefore, because it can be sustained and handled in the global environment, bio-based and biodegradable polymeric materials are one of the most appropriate means to realize.

Moreover, implementing recycling machine systems and adopting sustainable practices play a crucial role in mitigating the health concerns associated with plastic pollution (Burciaga et al., 2019). By empowering communities and individuals to make informed choices and embrace eco-friendly alternatives, it is possible to alleviate the environmental burden of plastic waste (Pierau et al., 2022). Empowering and educating communities and citizens to collaborate to minimize plastic pollution and use alternative options for plastics must be promoted and enforced. Plastic pollution is a global concern that must be addressed collectively with the utmost priority (Kumar, 2021).

In addition, today, this article aims to provide a comprehensive understanding of plastic pollution's origins, ramifications, and potential remedies by synthesizing research studies, reports, and articles. It will examine policy interventions, regulations, circular economy approaches, technological innovations, and case studies from various regions to promote sustainable alternatives to traditional plastics (Akande, 2023).

2.3.1 Related Systems

F&N and Singapore's NEA collaborated on the RecycleNSave project, which promotes recycling by allowing users to return used bottles via reverse vending machines and receive discount coupons in return. Although it is a huge step in the right direction, it mostly functions in commercial environments and provides few incentives without monitoring user participation over time (National Environment Agency [NEA], 2023). AquaCycle, on the other hand, expands on this concept and allows users to exchange plastic bottles for points or clean drinking water, making it more practical and fulfilling, particularly in communities and schools where water access is important. Additionally, it has a web-based system to monitor user behaviour and encourage sustained involvement.

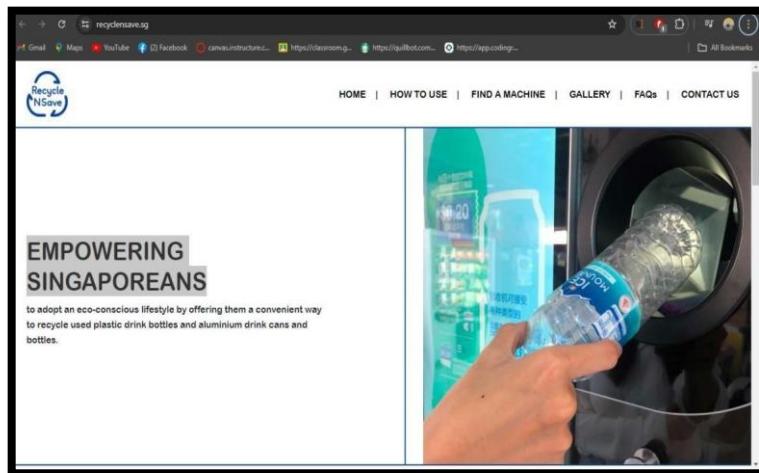


Figure 2.1: RecycleNSave Website Homepage

2.3.2 WEIMI

A top producer of intelligent vending machines in China, WEIMI provides a variety of automated systems, such as those for drinks and other consumer goods. Their equipment, which usually serves commercial and retail settings, prioritizes

efficiency, intelligent technology, and user convenience. However, WEIMI systems are largely profit-driven and do not specifically address environmental objectives such as community awards or the reduction of plastic waste (WEIMI, 2024). AquaCycle differentiates itself by utilizing intelligent automation for sustainability rather than sales, turning recycling into a fun activity by trading plastic bottles for points or clean water. AquaCycle encourages community involvement and environmental responsibility in contrast to WEIMI's commercial vending strategy, particularly in schools and underprivileged regions where access to water and waste reduction is crucial.



Figure 2.2: WEIMI Website Homepage

2.3.3 Climate Action

In order to promote recycling, climate action programs, like Iceland bottle return program in the UK, provide tiny cash vouchers. Hundreds of thousands of bottles have been returned, demonstrating how successful this strategy is in

engaging customers. However, because it depends on financial incentives that might not be available or effective in all communities, its influence is frequently restricted to places with retail access (Iceland Supermarket, 2022). AquaCycle expands on this idea by providing a more useful and long-lasting incentive—clean drinking water or points, particularly in places like rural villages or schools. Through a computerized tracking and reward system, AquaCycle provides customers with an immediate, necessary benefit in lieu of cash while encouraging long-term environmental awareness.

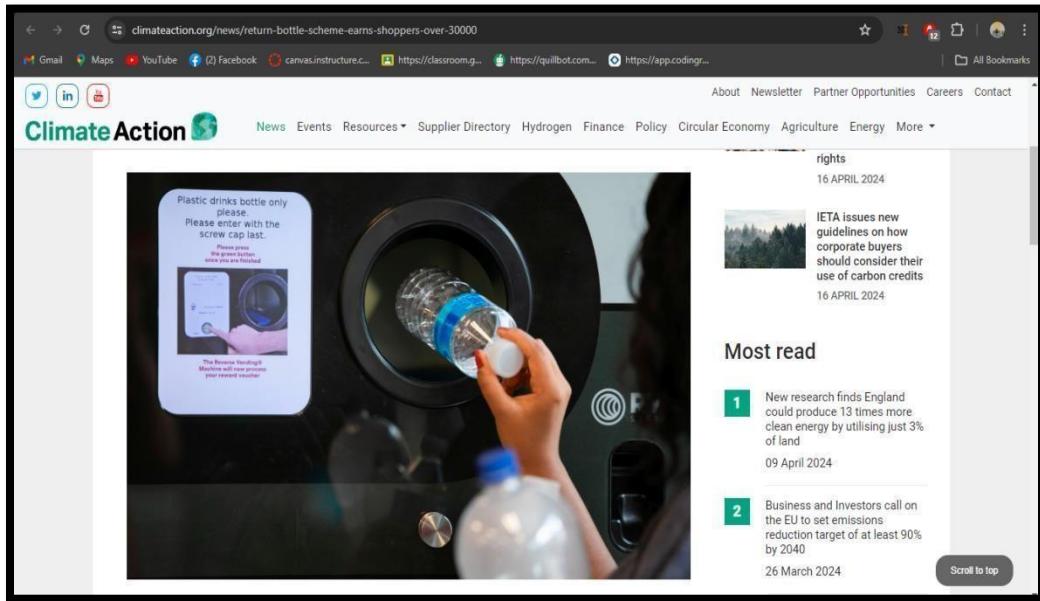


Figure 2.3: Climate Action Website Homepage

2.4 Synthesis

Relevant research on the use of plastic water bottles and their effects on the environment emphasizes how urgent it is for people to take action against plastic pollution as a group.

The literature review highlights the growing environmental concerns surrounding plastic pollution, particularly from plastic water bottles. Plastic waste has reached alarming levels globally, contributing significantly to marine pollution and ecosystem degradation (Zhang et al., 2023). Countries like the Philippines face significant challenges in solid waste management due to inconsistent collection, lack of proper segregation, and inadequate processing infrastructure (Coracero et al., 2021). Regions like Mindanao are also impacted by plastic pollution and lack of access to clean water (Macusi et al., 2019).

Innovative solutions like plastic bottle-to-water exchange programs have emerged to address these issues. These initiatives incentivize individuals to collect and return used plastic bottles in exchange for clean drinking water (Gambino et al., 2020). Such programs help reduce plastic waste and improve water accessibility, making them particularly valuable in water-scarce areas.

The literature emphasizes the urgency of transitioning towards more sustainable waste management practices and circular economy approaches (Negrete-Cardoso et al., 2021; Aguilar-Morales et al., 2023). Alternatives like biobased and biodegradable plastics show promise as environmentally-friendly substitutes that can be effectively managed (Negrete-Cardoso et al., 2022; Moshhood et al., 2022). Moreover, empowering communities through education, policy interventions, and technological innovations is crucial to fostering behavioral change and mitigating plastic pollution's health and environmental impacts (Kumar et al., 2021; Pierau et al., 2022; Akande, 2023). Collective action, involving stakeholders from various sectors, is necessary to implement comprehensive solutions and drive a shift towards more sustainable practices.

It is important to consider the health hazards that may arise when harmful substances seep into water stored in bottles subjected to temperature fluctuations (Ahmed et al., 2021). We require thought-out plans that include policy changes, technological advancements, and real-life examples to encourage the adoption of eco alternatives to conventional plastics (Akande, 2023; Kumar et al., 2021).

CHAPTER III

MATERIALS AND METHODS

3.1 Software Methodology

In software development, methodologies act as roadmaps for planning and managing the development process. This study involved a series of observations and experiments across various development areas. The goal was to streamline the process by identifying and removing unnecessary steps and optimizing the sequence based on importance. This would allow the researchers to implement their study more efficiently.

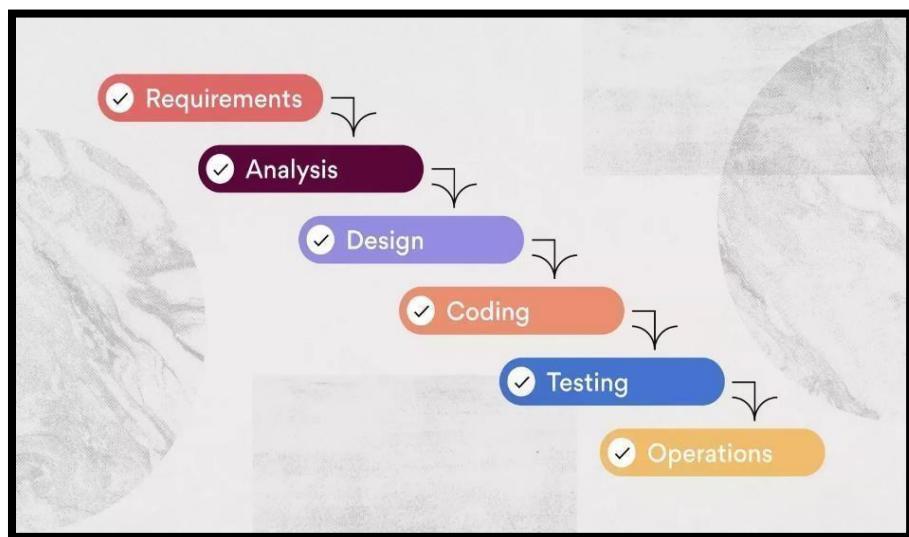


Figure 3.1: Waterfall Methodology (Laoyan, 2025)

In software development, methodologies act as roadmaps for planning and managing the development process. This study involved a series of observations and experiments across various development areas. The goal was to streamline the process by identifying and removing unnecessary steps and optimizing the sequence based on importance. This would allow the researchers to implement their study more efficiently.

The researchers adopted the waterfall methodology, a popular choice in software development, to manage the study development process. This linear approach involves distinct phases or stages that must be completed sequentially. The researchers progressed through these phases one by one.

The researchers began with the **Discovery Phase**, where they meticulously gathered a comprehensive list of requirements for the entire project. Documenting all these requirements was crucial to ensure the project delivers the desired outcome. This phase also involved researching references and selecting the most suitable technologies for the application.

Following the Discovery Phase, the researchers moved on to the **Design Phase**. Here, they focused on how the application would be built and function. This involved creating mockups and wireframes and choosing appropriate programming languages, databases, and other essential technologies.

In the **Coding Phase**, the heart of the development process, the researchers brought the project to life. This involved programming the application and integrating the chosen technologies into a cohesive whole.

Next came the **Testing Phase**. The researchers meticulously examined the entire codebase to identify and eliminate any bugs or inconsistencies. The project underwent rigorous testing to ensure it functioned as intended, with a focus on finding and fixing defects. This initial testing is often referred to as Alpha testing. Following this, Beta testing would involve releasing the application to a broader audience to gather real-world user feedback and recommendations. Upon successful completion of testing, the project was ready for

deployment. The **Deployment Phase** involved releasing the application to the general public or the client, depending on the project's purpose.

The final phase, Maintenance, is an ongoing process that may or may not be required. In this phase, the researchers would provide ongoing support, address any lingering bugs, and potentially release new features and updates to enhance the application.

3.2 Requirements Analysis

3.2.1 Documentation of the Current System

The system was created because the current ways of dealing with plastic trash are minimal and mainly depend on people sorting and recycling by hand. These physical methods are inefficient, take much time, and may not lead to proper disposal, which worsens environmental problems like plastic pollution. The current method also does not give people enough reason to recycle their plastic waste properly. Because of these problems, the system wants to make recycling easier by getting people to trade their plastic bottles for clean water or other prizes. This method automatically collects plastic bottles, which cuts down on the need for manual labor, raises the recycling rate, and encourages people to act in ways that are good for the environment.

3.3 Requirements Documentation

3.3.1 System Architecture

The system architecture integrates hardware and software components to ensure the smooth operation of the plastic bottle-to-water exchange process. At

the heart of the system is the ESP32 microcontroller, which manages the interaction between sensors, the display, and the web-based platform.

The ESP32 microcontroller controls the core functions of the system. It communicates with the IR sensor to detect when a plastic bottle is inserted into the system and with the load cell to measure the weight of the bottle. Based on the weight data, the system categorizes the bottle and assigns corresponding reward points. The relay module controls the water pump, dispensing the correct amount when the user selects the water redemption option. The 16×2 LCD provides real-time feedback to the user, displaying messages such as successful bottle deposits, available rewards, and the current points balance. The matrix keypad allows the user to input their account ID for login and select reward options. The system is powered by a 12V power supply, which powers the ESP32 and other components.

On the software side, the system uses a web-based interface built with PHP and Laravel. This interface allows users to track their plastic bottle deposits, view transaction histories, check available rewards, and monitor their points balance in real-time. Users can log in using their account credentials, and the system will display detailed information about their recycling activities. The Laravel framework is used to handle backend operations, such as user authentication, transaction management, and reward calculations.

The ESP32 communicates with the web-based platform using HTTP requests. When a user deposits a plastic bottle, the ESP32 sends the relevant data (e.g., bottle weight and classification) to the Laravel backend. The backend processes the data, calculates the reward points, and updates the user's account

in the MySQL database. All transaction records and user profiles are stored securely in the database, ensuring that the data is consistent and accessible across devices. The system logic, written in Arduino code for the ESP32, handles tasks such as detecting bottle deposits, calculating rewards, and controlling the water pump. The logic ensures that bottles are categorized correctly based on weight and that the corresponding reward is dispensed accurately.

The system's modular architecture allows for easy updates and expansion. The ESP32 ensures the system is compact, efficient, and scalable, while the PHP and Laravel platforms provide a robust and flexible backend for managing user data and transactions.

3.4 Requirement Specification

3.4.1 Product Perspective

The system is designed to address two major environmental issues: plastic waste and water scarcity. The system combines hardware and software to make recycling more efficient and easier to use. The system lets people put plastic bottles into a reverse vending machine (RVM) to get clean drinking water in return. The system does not bring in new technologies but puts together existing, reliable ones to create a fresh solution for waste management and clean water distribution. The system is designed to make collecting plastic and giving out rewards easier and more automated, providing a smooth experience for users.

3.4.2 Product Features

The system includes several features aimed at improving user experience and supporting environmental sustainability. It has a hardware setup that collects and processes plastic bottles, and it also features a software application to manage user data and rewards.

3.4.2.1 Hardware Device

The hardware system is designed to efficiently collect and process plastic bottles using a combination of essential sensors and modules. However, due to the system current limitations, it cannot differentiate between plastic and other materials. As a result, users are restricted to depositing only plastic bottles. The system cannot detect or filter out other types of objects, so it is crucial to emphasize this limitation in the usage guidelines.

An IR sensor detects the presence of the plastic bottle as it is inserted into the system. This sensor ensures that the system knows when a bottle is being deposited, triggering the next steps of the process. A weight sensor works in tandem with the IR sensor to measure the weight of the bottle, allowing the system to classify the bottle (e.g., small, medium, large) and calculate the corresponding reward. The weight sensor ensures that the classification is accurate and that the user receives the appropriate reward based on the weight of the bottle. Relay modules control the water dispensing system, allowing the system to deliver clean drinking water to the user after a valid bottle has been deposited.

Once the reward is calculated and the bottle is verified, the relay ensures that the pump activates to provide the water. This process is automated and helps ensure a seamless user experience.

An integrated 16×2 LCD Display provides real-time feedback to the user. This display shows the system's current status, such as whether the bottle has been successfully deposited, if the system is processing, or if there is an issue (e.g., invalid bottle). It also guides users during deposit and updates them on their reward options. The display is the primary visual interface, ensuring the user understands what happens at each process stage.

This hardware setup enables smooth, reliable recycling operations and rewards distribution. The focus remains on efficient bottle detection, accurate reward calculation, and smooth user interaction.

3.4.2.2 Software System

The software component of the system is a web-based platform that facilitates real-time interaction between users and administrators. This platform enables users to track their recycling activities, monitor their rewards, and engage with the system via an intuitive dashboard.

On the user side, the dashboard provides an overview of their recycling history, displaying details about the number of bottles deposited, the points earned, and the rewards available for redemption. Users can view their available points balance and select rewards based on their accumulated points. The system allows users to choose from rewards like

clean drinking water or other eco-friendly items like stationery. The user profile also provides a way to update personal information and preferences, helping to tailor the experience to individual needs.

The administrator's side of the platform is managed through the admin dashboard, where administrators can track system activity, user statistics, bottle recycling totals, and reward distribution. The admin dashboard allows administrators to manage user accounts, update reward settings, handle any issues or disputes, and monitor the health and performance of the system. This provides administrators with complete control over system operations, ensuring that everything runs smoothly and efficiently.

The software also includes a redemption feature that allows users to select and claim rewards via the web interface. Once a reward is chosen, the system automatically updates the user's points balance, reflecting the deduction of points used for the reward. This ensures that the reward process is streamlined and the points balance is always up to date.

3.4.3 User Classes and Characteristics

This project is intended for the students, faculty, and staff of Davao Oriental State University, as the system was created specifically for their involvement in campus recycling initiatives.

3.4.3.1 General Users

Both students and faculty at Davao Oriental State University utilize the AquaCycle system. People can interact with the system by dropping off plastic bottles and receiving rewards like drinking water. All users need to register in the system so we can monitor everything and provide updates regarding their participation and rewards.

3.4.3.2 Administrator

Administrators are responsible for managing the system. They manage how the hardware works, keep track of recycling stats, and make sure everything is running well. Admins can add or remove users, handle rewards, and monitor the system health. The admin dashboard gives a clear view of the system performance, making it easier to manage and fix issues.

3.5 Operating Environments

The researchers worked on the project using different tools and technologies. These technologies helped us create a system combining hardware and software components effectively.

3.5.1 Software Specifications

The software components of the system consist of a web-based application designed for Android users. The system is built with PHP and Laravel, where PHP handles the server-side logic and Laravel, a PHP framework, simplifies user

authentication, routing, and database management. The back-end processes user inputs, manages bottle deposits, and tracks reward redemptions. It ensures real-time synchronization of user data, transaction logs, and system performance metrics through interactions with a MySQL database. The database securely stores user actions such as bottle deposits and points balances, providing up-to-date information to users instantly. The web-based interface is optimized for Android devices, enabling users to easily log their deposits, check their points balance, and redeem rewards. The system has undergone thorough testing to ensure smooth interactions and quick load times on Android browsers.

3.5.2 Hardware Specifications

The system relies on several hardware components to detect plastic bottles and provide rewards. Each part plays an important role in ensuring everything runs smoothly. These are the main components:

Arduino Mega 2560: The Arduino Mega handles sensor data acquisition and preprocessing. It interfaces with high-precision detection components (laser sensors and photoelectric switches) and transmits processed data to the ESP32 via UART serial communication. Its extensive I/O capabilities support simultaneous management of multiple sensors.

ESP32 Microcontroller: The ESP32 serves as the central processing unit, handling reward calculations, user interface control, and cloud communication. It receives sensor data from the Arduino Mega; computes reward points based on

bottle weight, manages the LCD/keypad interactions, and transmits transaction data to the web server via Wi-Fi.

IR Sensor (Infrared Sensor): The IR sensor detects when a plastic bottle is placed in the system. It uses infrared light to sense the bottle and triggers the system to process the deposit.

Load Cell: The load cell measures the weight of the plastic bottle. The system calculates the reward points the user will receive based on weight. Larger bottles are rewarded with more points.

Relay Module: The relay module acts like a switch to control the water pump. When the user chooses to redeem their points for water, the relay triggers the pump to dispense the water.

Water Pump: The water pump is responsible for dispensing clean drinking water as a reward. When the user redeems points, the pump is activated to provide the water.

16x2 LCD Display: The LCD shows important information to the user, like their points balance, the status of the bottle deposit, and available rewards. It provides real-time updates and guidance throughout the process.

Matrix Keypad: The keypad allows users to input their account ID and choose their actions. Users press the buttons to log in, confirm their bottle deposit, or select rewards.

3.5.3 Hardware Constraints

The AquaCycle system combines hardware and software to automate plastic bottle recycling and reward distribution. However, there are a few important hardware constraints.

First, the system sensors, including the infrared sensor, laser sensor, and load cell, are designed to detect and measure bottles, but they can't perfectly identify the material of every object. The laser sensor checks if its beam passes through the object: if the beam is blocked, the system assumes the object is not plastic. But this method is not foolproof- some plastics might block the beam, and some non-plastics might let it through. So, the system relies on users to only insert clean, empty plastic bottles.

The load cell is another key part of the hardware. In the code, it's calibrated for typical plastic bottle weights. If a bottle is much heavier or lighter than expected, the reading might not be accurate, which could affect how many points the user earns. Consistency in bottle size and weight is important for the system to work as intended.

Regarding dispensing rewards, the relay-controlled water pump is programmed to release a fixed amount for each transaction. This makes the system reliable and straightforward, but users cannot choose a custom amount of water as a reward.

User input is handled through a matrix keypad. The code waits for users to enter their account ID and make selections using the keypad. While this is

straightforward, it can be less intuitive for new users and might slow down the process if someone is not familiar with the system.

Finally, the system's performance depends on everything being properly aligned and connected. If a sensor is out of place or a wire comes loose, the code might not be able to detect bottles or dispense rewards correctly. Regular maintenance and calibration are needed to keep the system running smoothly.

3.6 User Documentation

The system team is creating detailed user documentation to help users understand how to use the system's features. The documentation has clear guides that show users how to scan bottles, check their points, and claim rewards, making it easy for them to use the system. A section just for administrators explains how to handle users, set up configurations, and create reports. You can find the documentation in the system, and there is a digital help section you can check out whenever you need it. Feel free to contact support if you have any problems or need clarification. This way, everyone can find the system easy to use, whether just starting or having some experience.

3.7 Other Non-Functional Requirements

The system incorporates various non-functional requirements to ensure that the system operates efficiently and securely, meeting the needs of both users and administrators.

3.7.1 Safety Requirements

To ensure the safety of users and the environment, the researchers ensured that the system components were designed and installed in a way that avoids any potential hazards. The water dispensing unit is fitted with safety features to prevent contamination and ensure the water quality remains safe for consumption. All electronic components are also enclosed in protective casings to prevent water damage and electrical hazards, reducing the risk of malfunction or accidents.

3.7.2 Security Requirements

The system is designed with strong security measures to safeguard user data and maintain system integrity. User accounts and transaction details are securely stored using PHP and Laravel, with authentication and data encryption features to protect sensitive information. Additionally, the system implements session-based login and logout protocols to prevent unauthorized access. These security measures ensure that only authorized users can access private data, preserving user privacy and the system's integrity.

3.8 Software Quality Attributes

The system has been developed to meet standards of software quality, ensuring that the system is reliable, user-friendly, and efficient.

3.8.1 Functionality

The AquaCycle system was designed to ensure the proper tracking of plastic bottle deposits and the accurate dispensing of clean drinking water or points as rewards. The system uses a laser sensor, a photoelectric switch, an infrared sensor to detect bottle deposits, and a load cell to measure their weight. Once a bottle is detected and classified, it triggers a reward based on the weight category. Users can easily track their points and rewards through the web-based interface, which provides real-time updates on their recycling activity.

3.8.2 Reliability

The system is designed to ensure reliable performance in a variety of conditions. It uses real-time data processing to verify bottle deposits and dispense rewards accurately. Built-in fail-safes are integrated into the hardware and software to prevent data loss or incorrect reward dispensing. Users can rely on transaction logs for temporary system interruptions to ensure their data is intact and recoverable.

3.8.3 Portability

The AquaCycle system is designed to be portable, allowing it to be deployed in various locations with minimal setup. The compact design of the hardware components, including the Arduino Mega, ESP32 microcontroller, sensors, and water pump, makes it easy to transport and install in different environments. The web-based interface adds to the portability by enabling users

to access the system from any device with an internet connection, making it adaptable in different settings, such as schools, universities, or public spaces.

3.8.4 Usability

The system is designed with usability as a top priority. The interface for users and administrators is simple to navigate, ensuring a smooth interaction for all involved. Users can easily register, deposit bottles, view rewards, and redeem points with minimal effort. The mobile-optimized web interface allows users to access the system from their smartphones, streamlining the recycling and reward process.

3.8.5 Efficiency

The system operates efficiently, processing bottle deposits and dispensing rewards swiftly. The Arduino Mega and ESP32 microcontroller ensure smooth coordination between the sensors and the web interface, enabling near-instantaneous updates of points and rewards. The automated water dispensing process also runs quickly and accurately, delivering the appropriate amount based on the users' accumulated points.

3.8.6 Security

Security is a critical component of the AquaCycle system. The web-based platform ensures secure user authentication; all transactions are encrypted to protect user data. The MySQL database securely stores user profiles, transaction histories, and reward balances, preventing unauthorized access. Additionally,

admin access is protected with login credentials, ensuring only authorized personnel can manage the system.

3.8.7 Compatibility

The AquaCycle system is compatible with Android devices, ensuring accessibility for many users. The web-based platform is optimized to work across different mobile browsers, allowing users to track their recycling progress and rewards on various Android smartphones. The system hardware is designed to accommodate standard plastic bottle sizes, and future upgrades can improve compatibility with more recyclable materials.

3.8.8 Maintainability

The AquaCycle system is designed for easy maintenance and updates. The modular architecture allows the individual components (hardware and software) to be replaced or upgraded without significant system downtime. The web-based platform includes an admin dashboard for monitoring system health, ensuring any issues can be quickly identified and addressed. Regular system updates and maintenance procedures are in place to ensure long-term performance.

3.9 Use Case Diagram

The diagram presented below illustrates the actors and processes involved in the system. The actors include the User and the Administrator, each with distinct roles and responsibilities. The processes, represented within ellipse shapes, highlight the specific

functionalities that the system provides. These functions are performed based on the roles assigned to the actors, ensuring a seamless interaction between users and the system.

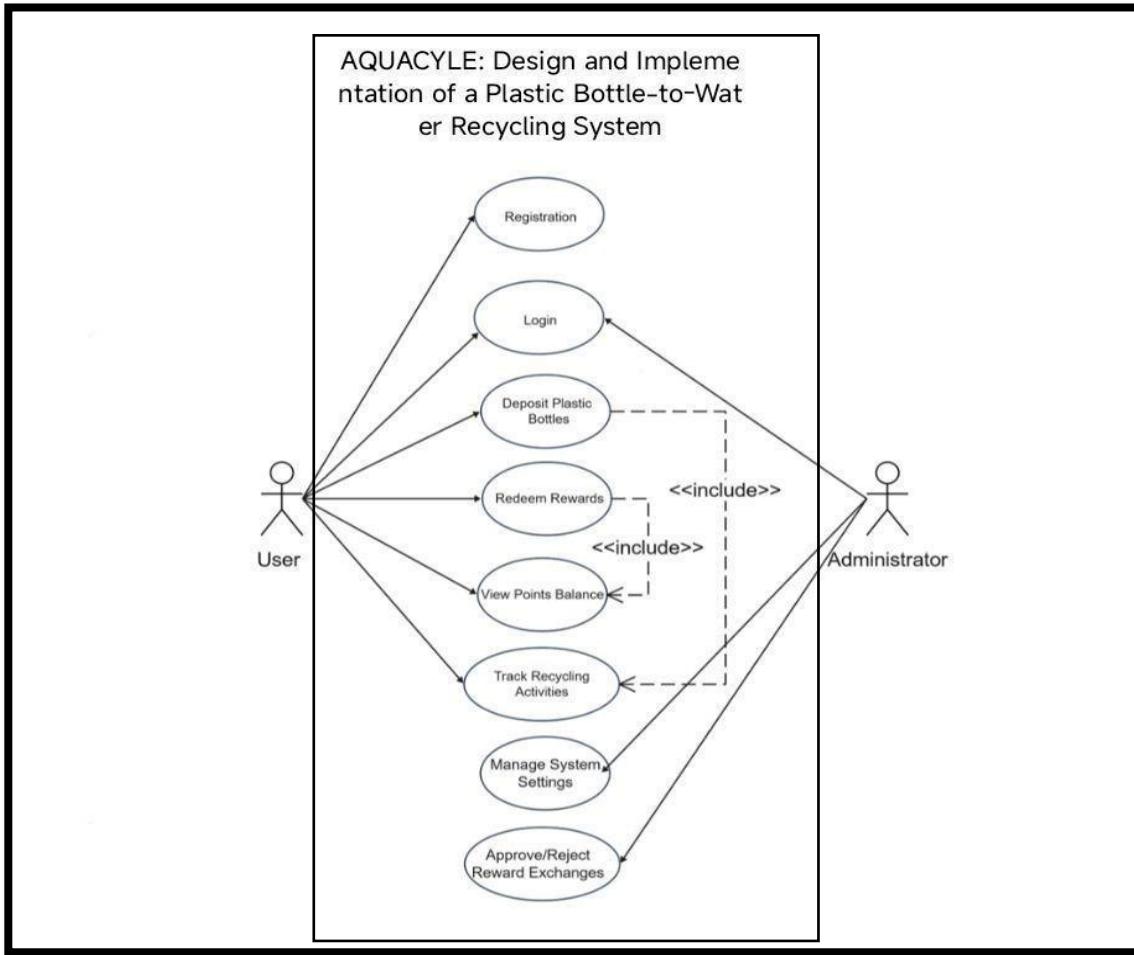


Figure 3.2 Use Case Diagram

3.9.1 Use Case Diagram Description

The table below shows the description of the Use Case Diagram used by the Proponents.

Table 3.1 Registration/Login Use Case

Registration/Login	
Actors	General User
Description	Allows users to register or log in to their accounts to access system features.
Data	User credentials such as email and password.
Stimulus	User inputs their registration or login details.
Response	The system validates credentials and either registers the user or logs them in.
Comments	

Table 3.2 Deposit Plastic Bottles Use Case

Deposit Plastic Bottles	
Actors	General User
Description	Users deposit plastic bottles into the system to gain points for rewards.
Data	Bottle size and weight.
Stimulus	The user places a plastic bottle into the system.
Response	The system scans the bottle, weighs it, and updates the user's points balance accordingly.
Comments	Only clean, empty plastic bottles within specific weight ranges are accepted.

Table 3.3 View Points Balance Use Case

View Points Balance	
Actors	General User
Description	Allows users to view their accumulated points balance.
Data	User profile and points balance.
Stimulus	The user navigates to the dashboard to check their balance.
Response	The system displays the current points balance in real-time.
Comments	Ensure accurate and immediate updates after every bottle deposit.

Table 3.4 Redeem Rewards Use Case

Redeem Rewards	
Actors	General User
Description	Users can redeem their accumulated points for rewards such as clean drinking water.
Data	Reward options, points required, and the user's available points.
Stimulus	The user selects a reward from the system.
Response	The system deducts points from the user's balance and provides the selected reward.
Comments	Ensure reward availability is updated frequently to avoid redemption issues.

Table 3.5 Track Recycling Activities Use Case

Track Recycling Activities	
Actors	General User
Description	Users can track their recycling activities, including the number of bottles deposited and rewards earned.
Data	User profile, recycling history, and points balance.
Stimulus	The user navigates to the history section on their dashboard.
Response	The system displays detailed recycling activity history, including dates and earned rewards.
Comments	Historical data should be securely stored and accessible for user reference.

Table 3.6 Manage System Settings Use Case

Manage System Settings	
Actors	Administrator
Description	Admins can manage system configurations, user accounts, and reward settings.
Data	System settings, user profiles, and reward options.

Stimulus	Admin modifies settings or updates configurations through the admin dashboard.
Response	The system applies updates and reflects changes in real-time.
Comments	Changes made by admins should be logged for accountability and troubleshooting.

Table 3.7 Approve/Reject Reward Exchanges Use Case

Approve/Reject Reward Exchanges	
Actors	Administrator
Description	Admins review and approve or reject users' reward exchange requests.
Data	Exchange requests, user points balance, and reward inventory.
Stimulus	Admin selects an exchange request from the dashboard.
Response	The system updates the request status and notifies the user.
Comments	Ensure inventory levels are updated to reflect approved exchanges.

3.9.2 Schematic Diagram

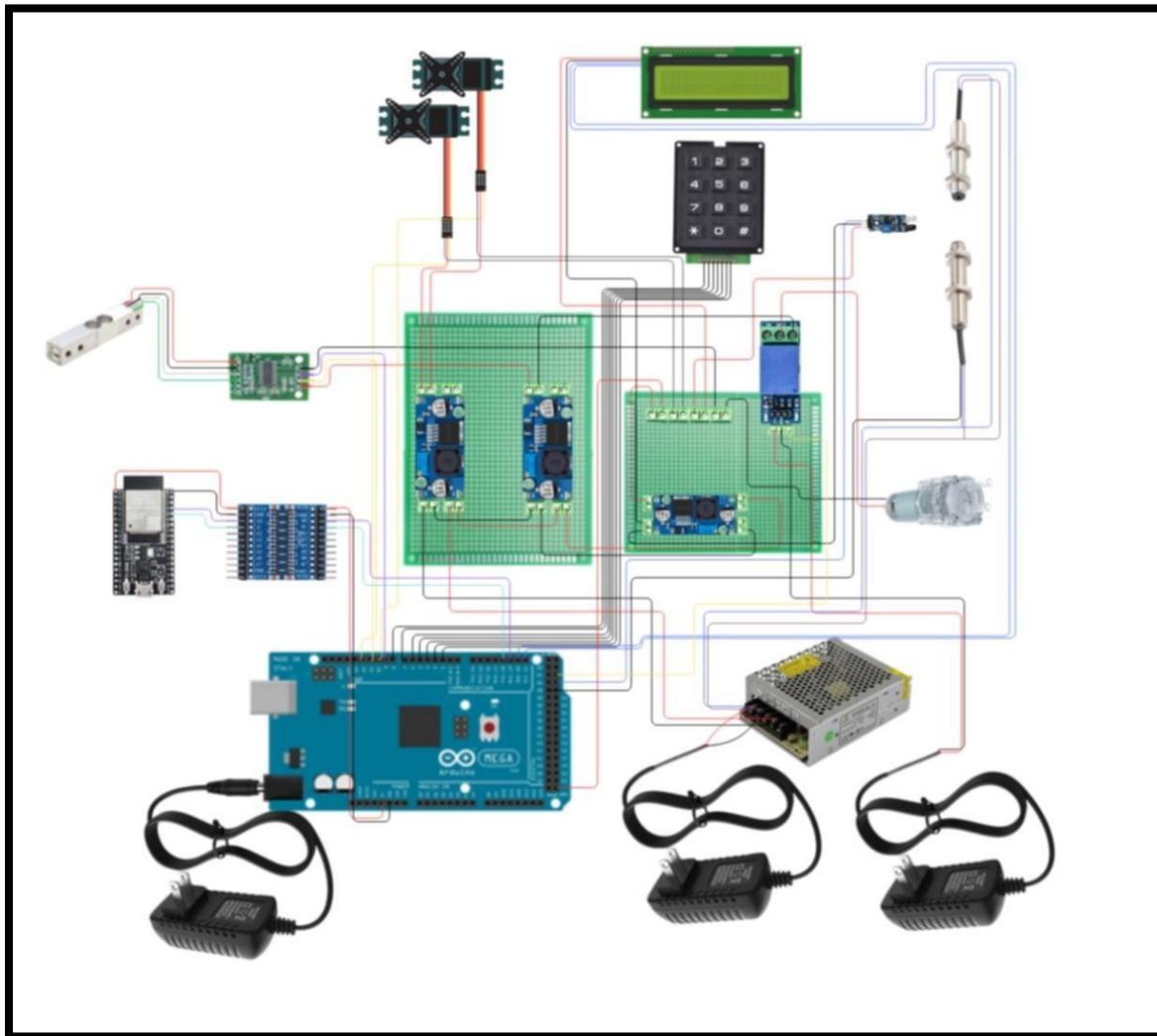


Figure 3.3 Schematic Diagram

Figure 3.5.2: *Schematic diagram developed by the researchers Aqua Cycle System.* The diagram shows the integration of various components, including the Arduino Mega microcontroller, ESP32 module, load cell with HX711 amplifier, infrared barrier sensors, laser beam sensors, a 4x4 keypad, 16x2 LCD with I2C interface, and a water pump dispenser. Servo motors are used for sorting mechanisms, powered by

LM2596 buck converters. A relay module controls the water pump. The system is powered through regulated 12V DC power supplies. The ESP32 handles Wi-Fi connectivity and communicates with the Arduino Mega via a logic level converter. This design ensures synchronized hardware interaction, user input management, object validation, and reward dispensing functionality.

3.10 GUI Design

This is the GUI design created by the developers for the Administrator and User Interface.

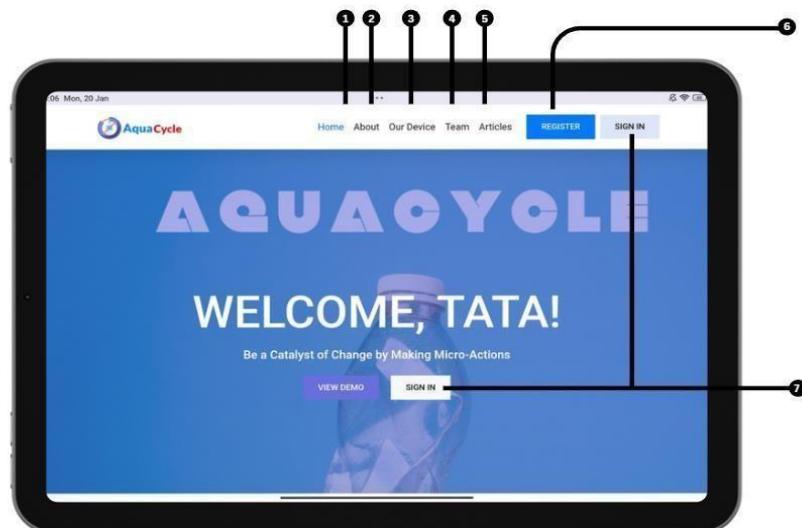


Figure 3.4 User Home Page

Table 3.8 User Home Page

No.	Component Name	Description
1	Home Button	Navigates the user to the application homepage.
2	About Button	Provides information about the organization or project.
3	Our Device Button	Displays details and features of the device offered by the platform.

4	Reviews Button	Links to user reviews or testimonials about the service.
5	Team Button	Displays information about the team members involved in the project.
6	Register Button	Redirects users to a registration form to create an account.
7	Sign In Button	Allows existing users to log in to their accounts.



Figure 3.5 User Login page

Table 3.9 Login Page

No.	Component	Description
1	Email Input Field	A text field with placeholder text "Enter your Email" for user authentication is positioned at the top of the login form, with a dark gray background.
1	Password Input Field	A secure input field with placeholder text "Enter your Password" allows users to enter account credentials and features password masking for security.
2	Log In Button	Red-colored action button labeled "Log In" that processes the user's credentials and enables access to the account.

3	Registration Link	The "Register Now" link is in red, allowing new users to navigate to the registration page.
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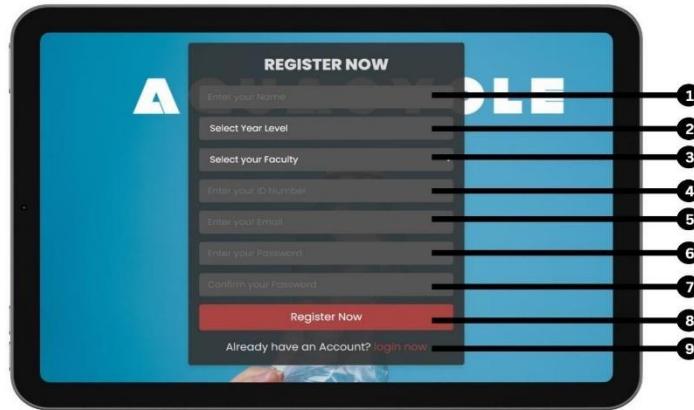


Figure 3.6 User Register page

Table 3.10 Register Page

No.	Component	Description
1	Name Input Field	A text field where new users enter their full name during registration.
2	Year Level Selector	Dropdown menu for selecting the users academic year level.
3	Faculty Selector	Dropdown menu for selecting the users Faculty.
4	ID Number Input	Field for entering a unique identification number assigned to the user.
5	Email Input Field	A text input field where users enter their email address for login or registration.
6	Password Input Field	A secure input field with masked characters is used to enter the account password.

7	Confirm Password Field	Secondary password input to verify and confirm the chosen password.
8	Register Now Button	Primary action button that submits registration information.
9	Account Status Links	The "Login Now" link is in red, allowing new users to navigate to the login page.

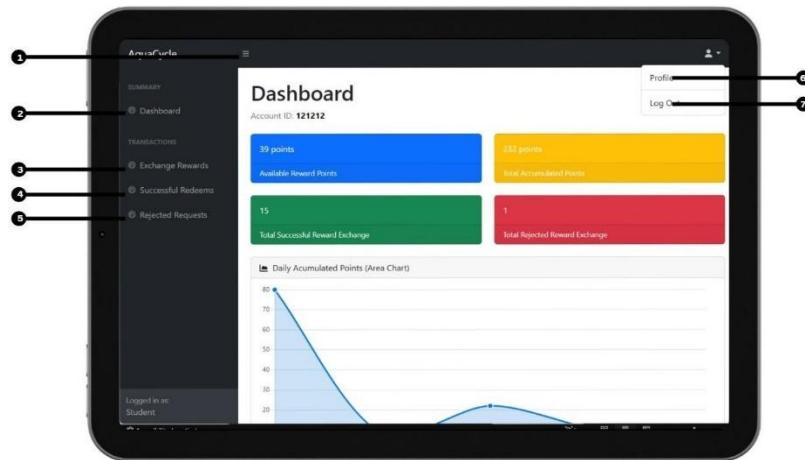


Figure 3.7 User Dashboard page

Table 3.11 User Dashboard Page

No.	Component	Description
1	Hamburger Menu Bar	An icon for opening the sidebar navigation menu, typically positioned in the top-left corner.
2	Dashboard Menu	The primary navigation item highlights the current dashboard view.
3	Exchange Rewards	Menu option for viewing and managing reward exchange activities.
4	Successful Redemeems	Navigation item showing completed reward redemptions.

5	Rejected Requests	Menu item displaying declined or rejected reward exchange requests.
6	Profile	The user profile access link is in the top-right corner.
7	Log Out	Button to securely end the current user session.

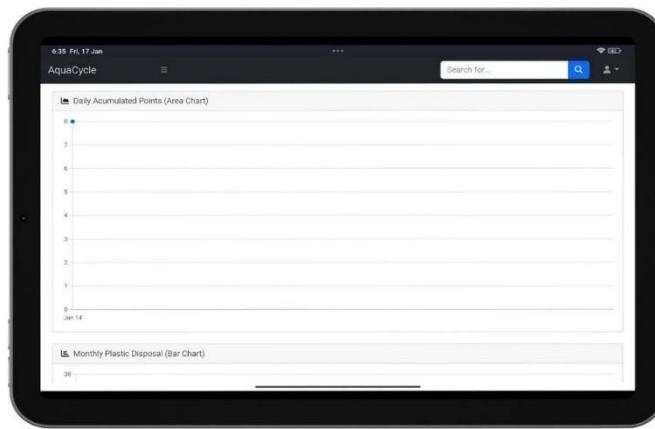


Figure 3.8 User Graph chart

Figure 3.8 shows the data visualization, featuring an Area Chart for Daily Accumulated Points and a Bar Chart for Monthly Plastic Disposal. Each chart is neatly organized with clear axis labels and grid lines for easy reading.

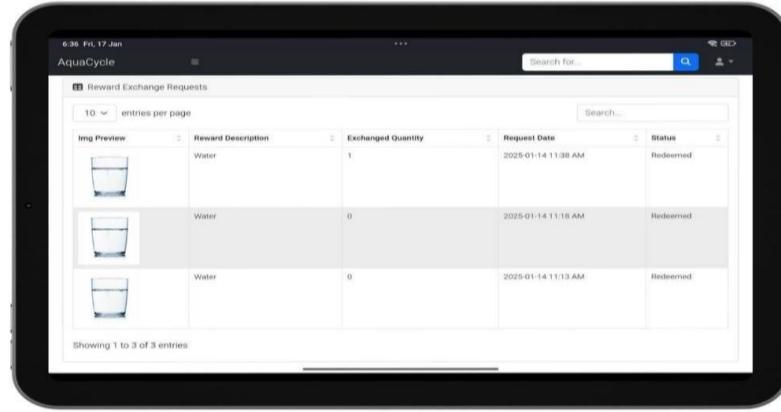


Figure 3.9 Dashboard page

Figure 3.9 shows the table that tracks reward exchange items. This table efficiently displays product images, descriptions, quantities exchanged, timestamps, and redemption statuses.

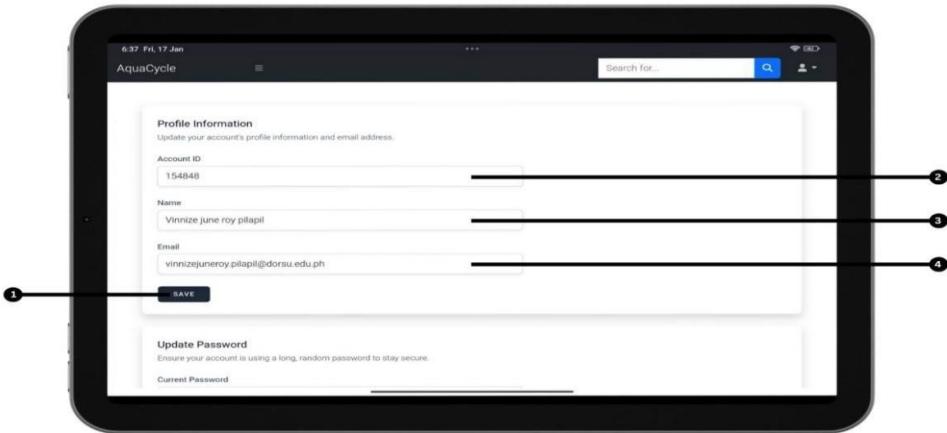


Figure 3.10 User Profile page

Table 3.12 User Profile Page

No.	Component	Description
1	Save Button	An action button that stores any changes made to the profile information.

2	Account ID Field	Read-only field displaying the user's unique identifier.
3	Name Field	Text input showing the user's full name.
4	Email Field	Text input containing the user's institutional email address.

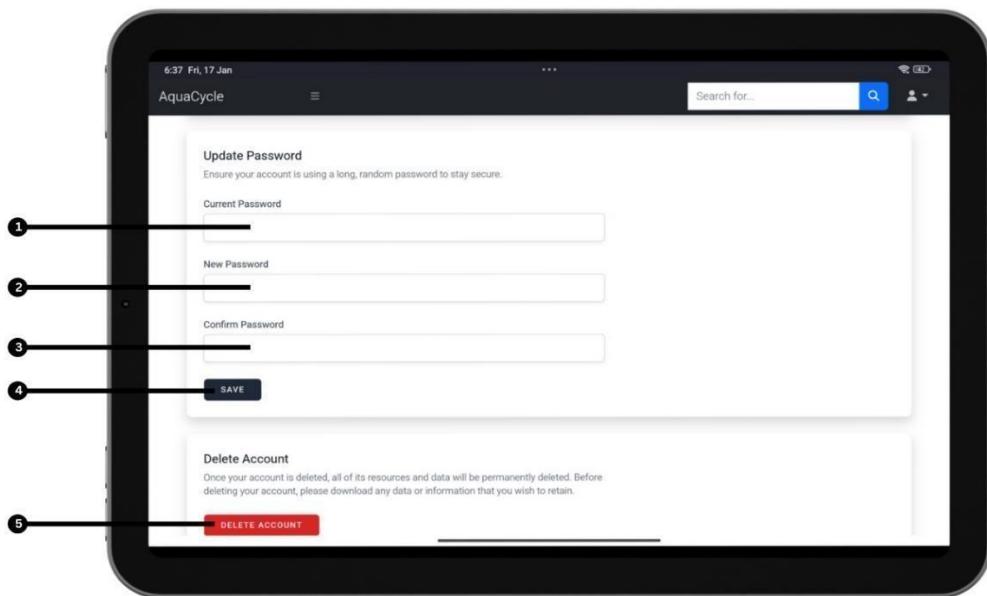


Figure 3.11 User Password page

Table 3.13 User Password Page

No.	Component	Description
1	Current Password Field	Input field where users enter their existing password for verification.
2	New Password Field	Text input where users enter their desired new password.
3	Confirm Password Field	Field to re-enter the new password to ensure accuracy.

4	Save Button	Blue button that saves the password changes when clicked.
5	Delete Account Button	Red button that initiates the account deletion process with a warning about permanent data loss.

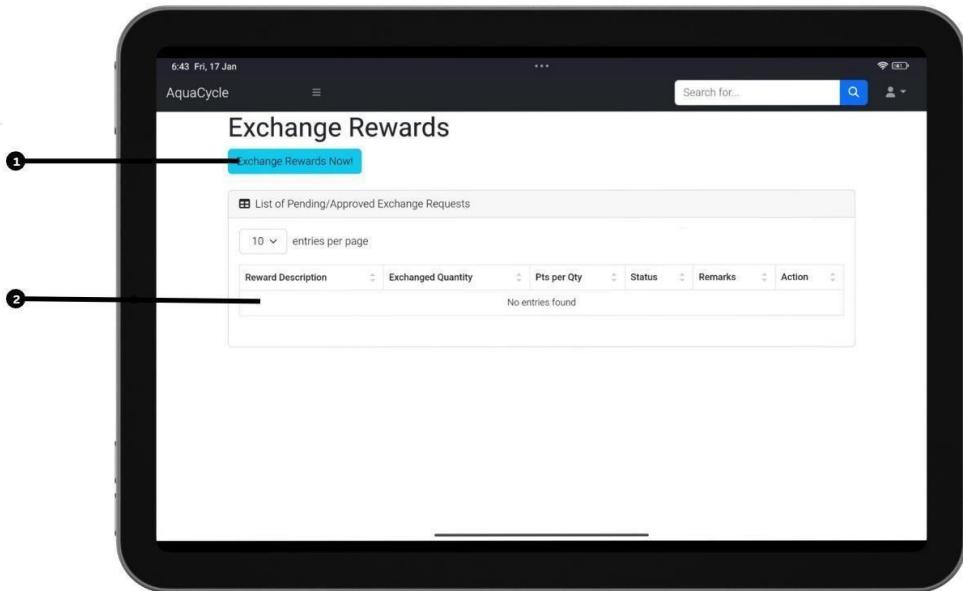


Figure 3.12 User Exchange rewards list page

Table 3.14 User Exchange Rewards List Page

No.	Component	Description
1	Exchange Rewards Now! Button	A blue button that allows users to initiate the process of exchanging their accumulated rewards.
2	Rewards Exchange Table	A data table displaying the list of pending and approved exchange requests with columns for Reward Description, Exchanged Quantity, Points per Quantity, Status, Remarks, and Action.

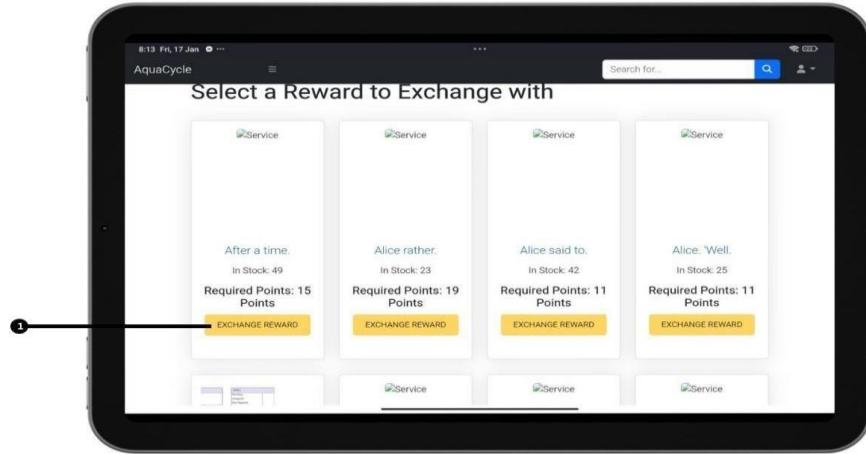


Figure 3.13 User Exchange rewards page

Table 3.15 User Exchange Rewards Page

No.	Component	Description
1	Exchange Reward Button	A yellow button located beneath each reward card that allows users to initiate the exchange process for the selected reward.

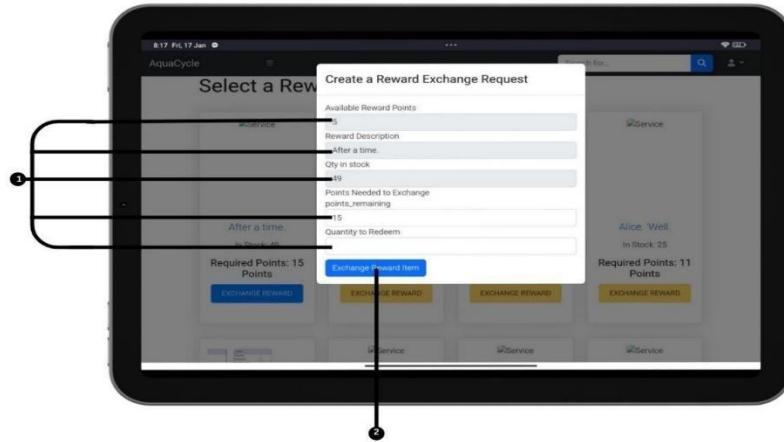


Figure 3.14 User Exchange rewards page

Table 3.16 User Exchange Rewards Page

No.	Component	Description
1	Exchange Request Form Fields	A set of form fields displaying reward information, including: - Available Reward Points - Reward Description - Quantity in stock - Points Needed to Exchange - A field for entering the Quantity to redeem
2	Exchange Reward Item Button	A blue button at the bottom of the form finalizes and submits the reward exchange request once the quantity is specified.

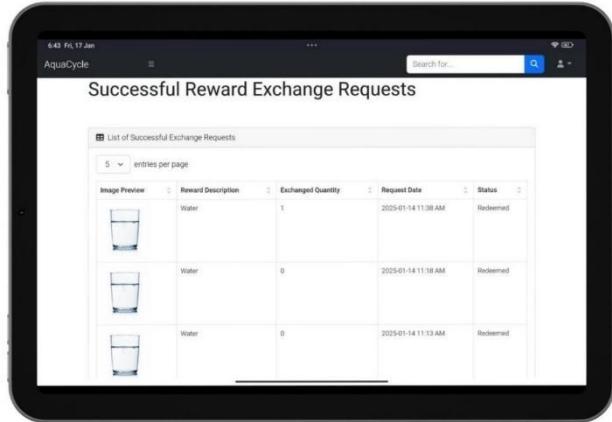


Figure 3.15 User Successful Exchange interface

Figure 3.15 shows the table listing all successful reward exchanges. This table efficiently displays product images, descriptions, quantities exchanged, timestamps, and redemption statuses.

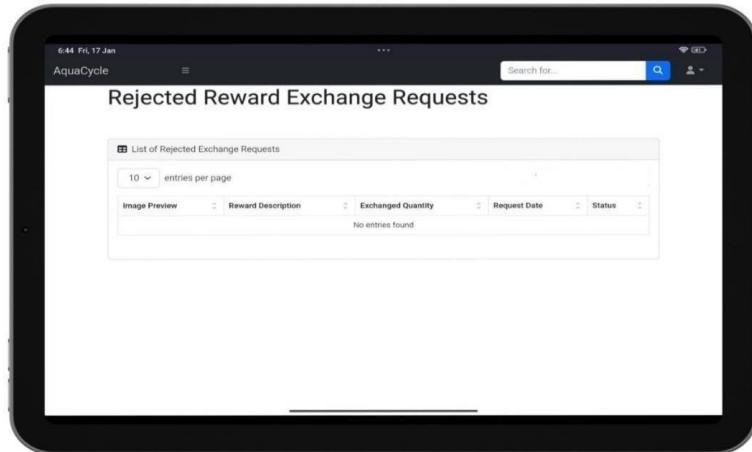


Figure 3.16 User Rejected Exchange page

Figure 3.16 shows the table listing all rejected reward exchange items. This table efficiently displays product images, descriptions, quantities exchanged, timestamps, and redemption statuses.

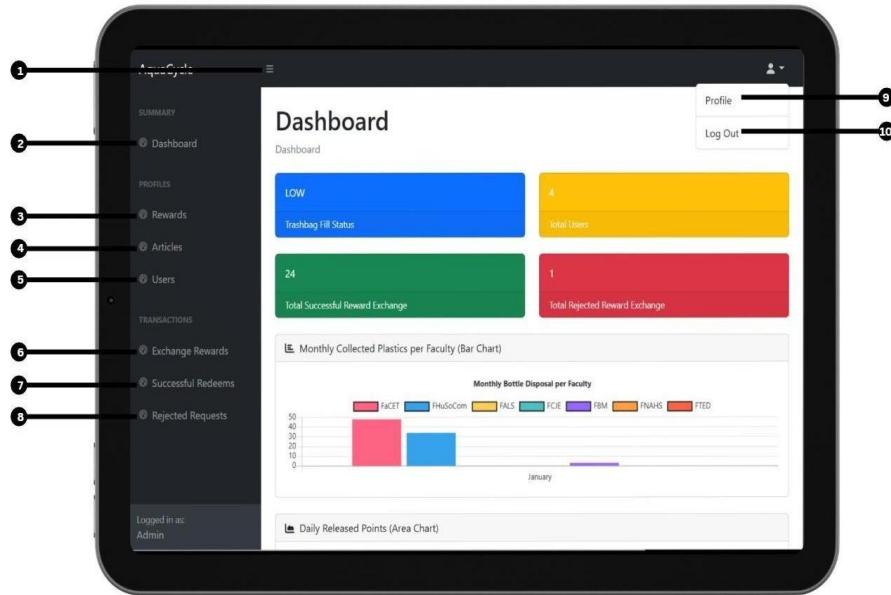


Figure 3.17 Admin dashboard

Table 3.17 Admin Dashboard page

No.	Component	Description
1	Hamburger Menu	Expands and collapses the left-hand navigation menu, providing access to the various sections of the admin dashboard.
2	Dashboard	Displays an overview of key metrics, including Trash-bag Fill Status, Total Users, Total Successful Reward Exchanges, and Total Rejected Reward Exchanges.
3	Rewards	Enables the admin to view, manage, and process user reward exchanges.
4	Articles	Provides access to documentation, resources, and articles related to the platform.
5	Users	Allows the admin to view and manage user accounts and activity.
6	Exchange Rewards	Let the admin review and process pending reward exchange requests.
7	Successful Redemeems	Shows a history of completed reward exchanges.

8	Rejected Requests	Displays information about rejected reward exchange requests.
9	Profile	Allows the admin to manage their account profile and settings.
10	Log Out	Provides a way for the admin to log out of the dashboard.

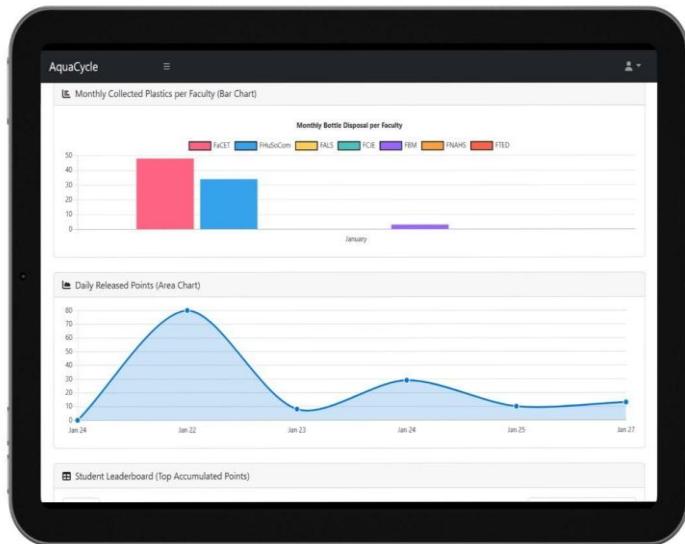


Figure 3.18 Admin dashboard Chart

Figure 3.18 shows the data visualization, featuring both an Area Chart for Daily Released Points and a Bar Chart for Monthly Collected Plastics for each faculty. Each chart is neatly organized with clear axis labels and grid lines for easy reading.

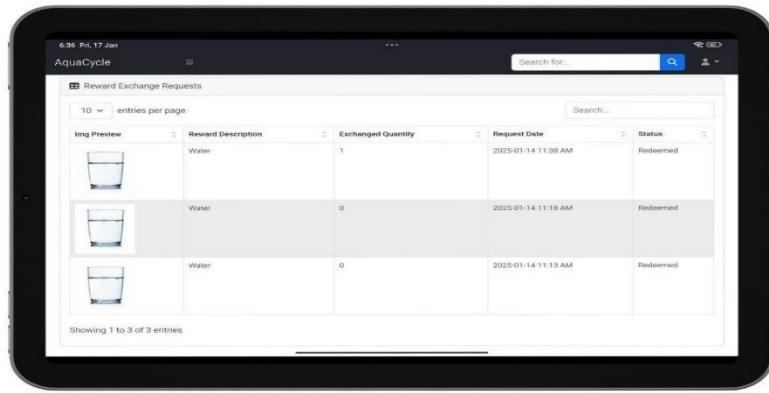


Figure 3.19 Admin exchange request interface

Figure 3.19 shows the table that tracks reward exchanges Request. This table efficiently displays product images, descriptions, quantities exchanged, timestamps, and redemption statuses.

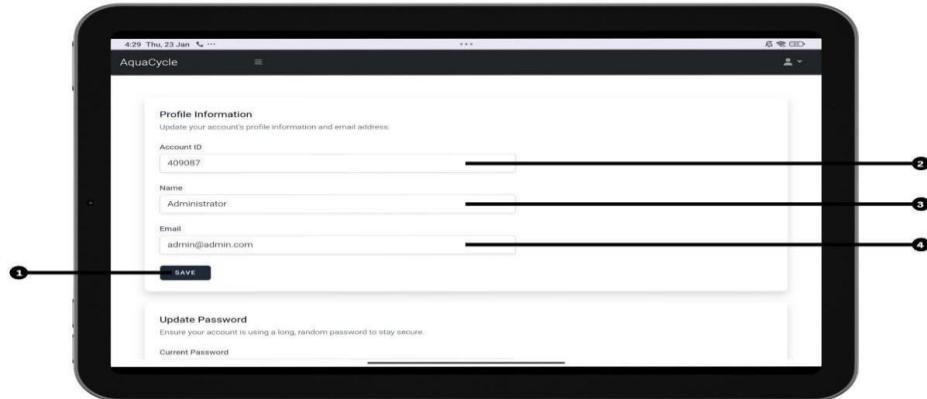


Figure 3.20 Admin Profile page

Table 3.18 Profile Page

No.	Component	Description
1	Save Button	An action button that stores any changes made to the profile information.

2	Account ID Field	Read-only field displaying the admin unique identifier.
3	Name Field	Text input showing the admin full name.
4	Email Field	Text input containing the admin institutional email address.

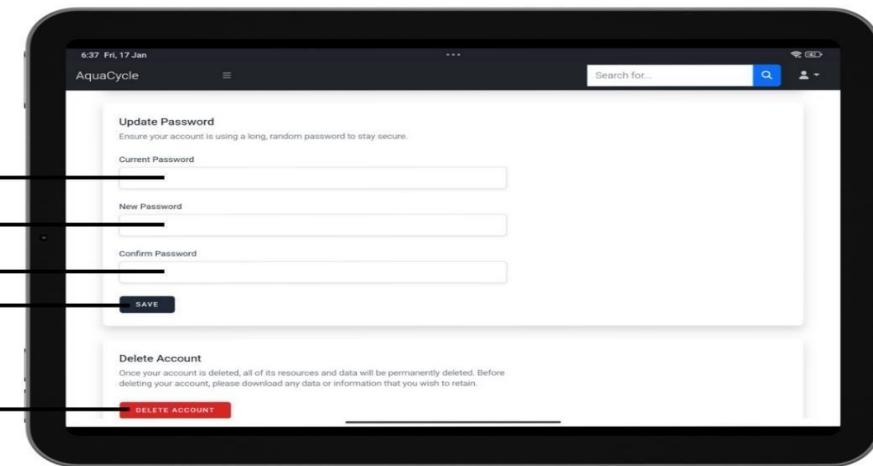


Figure 3.21 Admin Update Password page

Table 3.19 Update Password Page

No.	Component	Description
1	Current Password Field	Input field where users enter their existing password for verification.
2	New Password Field	Text input where users enter their desired new password.
3	Confirm Password Field	Field to re-enter the new password to ensure accuracy.
4	Save Button	Blue button that saves the password changes when clicked.
5	Delete Account Button	Red button that initiates the account deletion process with a warning about permanent data loss.

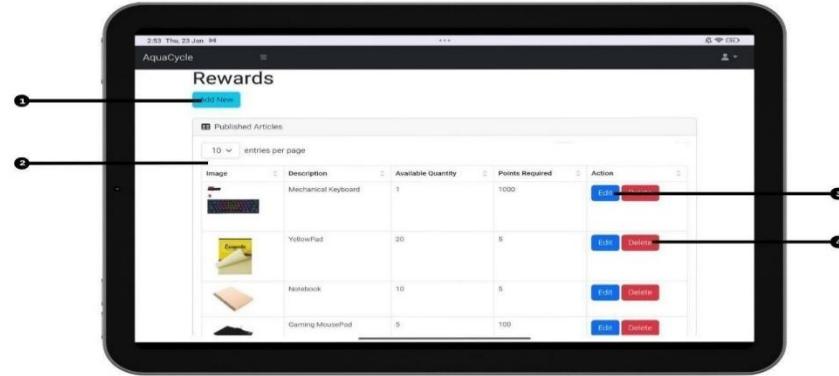


Figure 3.22 Admin Reward Management page

Table 3.20 Admin Reward Management Page

No.	Field	Description
1	Add New	Button to add a new reward to the list.
2	Reward List	Displays a table containing the list of rewards with their details.
3	Edit Button	Allows editing the details of the selected reward.
4	Delete Button	Deletes the selected reward from the list.

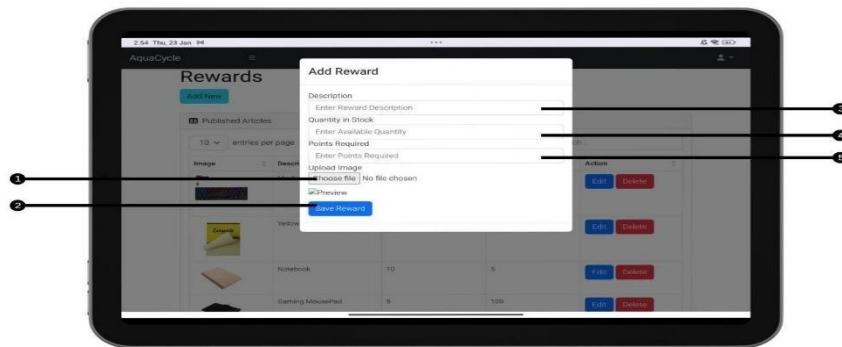


Figure 3.23 Admin Add Reward Management page

Table 3.21 Admin Add Rewards Management Page

No.	Field	Description
1	Description	Field displaying the description of the reward.
2	Quantity in Stock	Field to input the total quantity of the reward available.

3	Points Required	Field to specify the number of points needed for the reward.
4	Upload Image	Option to upload an image for the reward.
5	Save Reward	Button to save the reward details.

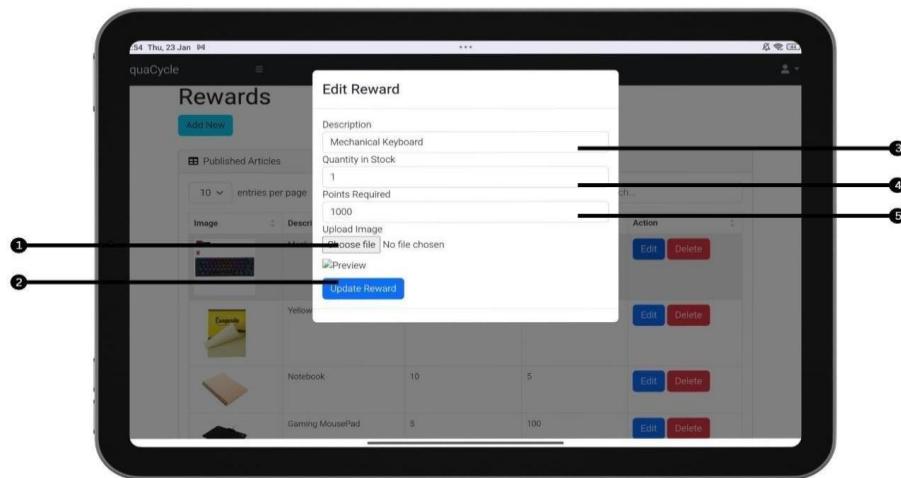


Figure 3.24 Admin Edit Reward Management page

Table 3.22 Admin update Reward Management Page

No.	Field	Description
1	Description	Field displaying the description of the reward.
2	Quantity in Stock	The field is used to input the total quantity of the reward available.
3	Points Required	Field to specify the number of points needed for the reward.
4	Upload Image	Option to update an image for the reward.
5	Update Reward	Button to save the updated reward details.

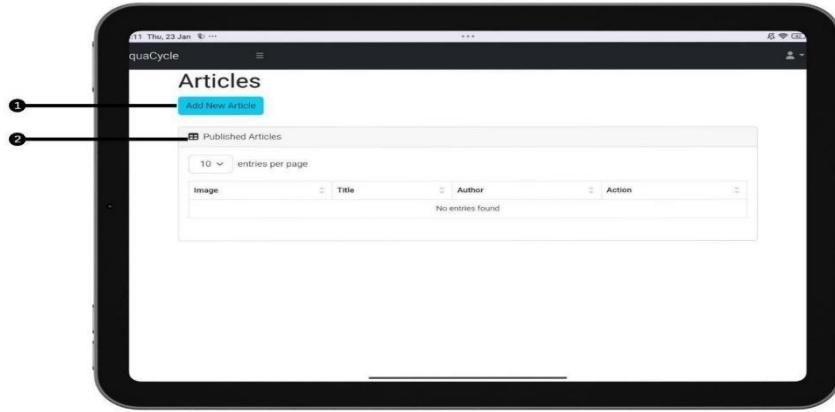


Figure 3.25 Admin Add Article page

Table 3.23 Admin Add Article Page

No.	Field	Description
1	Add New Article	Button to create and add a new article to the list.
2	Published Articles	Displays a table of all published articles with details like image, title, author, and actions.

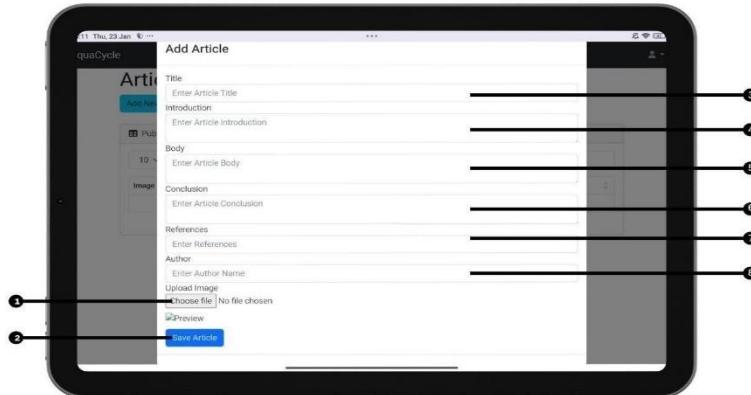


Figure 3.26 Admin Add Article Content page

Table 3.24 Admin Add Article Content Page

No.	Field	Description
1	Upload Image	The field is used to upload an image related to the article.

2	Save Article	Button to save the newly added article.
3	Title	Field to enter the title of the article.
4	Introduction	The field provides a brief introduction to the article.
5	Body	Field for the main content or body of the article.
6	Conclusion	Field to enter the conclusion of the article.
7	References	Field to add references or sources used for the article.
8	Author	Field to enter the author's name.

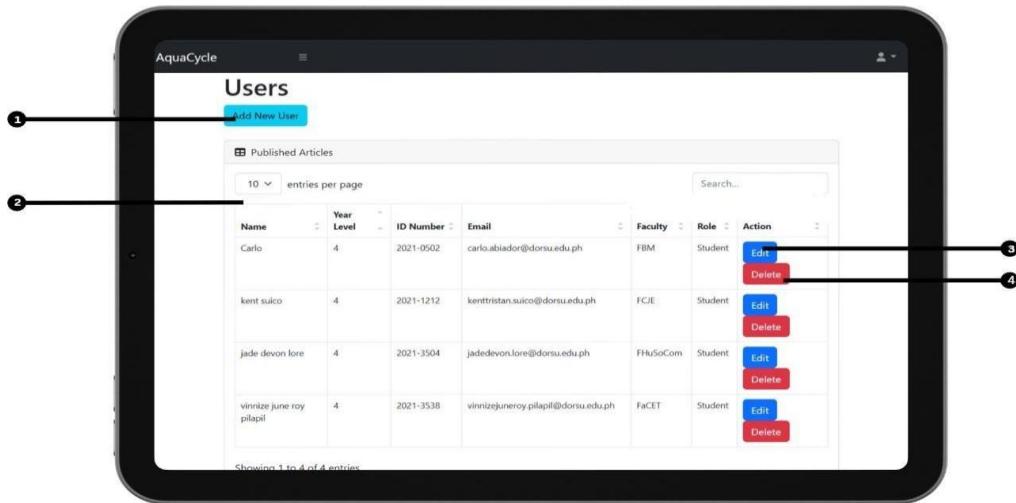


Figure 3.27 Admin User Management page

Table 3.25 Admin user management Page

No.	Field	Description
1	Add User	Button to add a new user to the list.
2	User table	Displays a table containing the list of rewards with their details.
3	Edit Button	Allows editing the details of the selected reward.
4	Delete Button	Deletes the selected reward from the list.

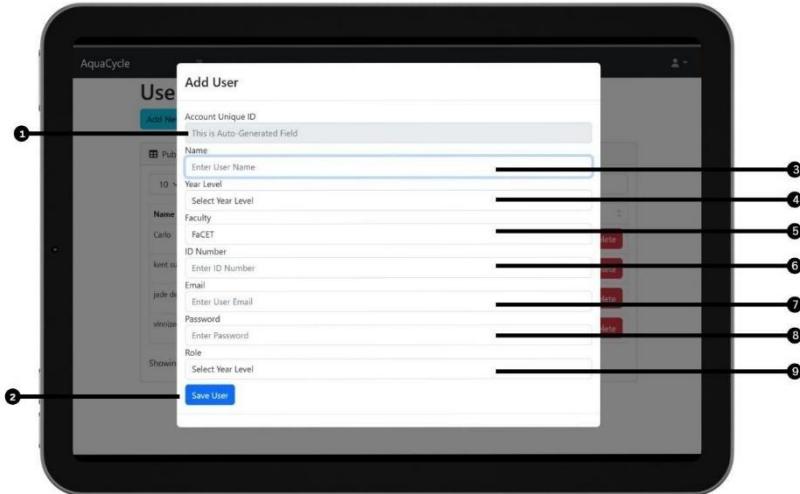


Figure 3.28 Admin Add user manually page

Table 3.26 Admin Add User Manually Page

No.	Component	Description
1	Account ID Field	Auto-generate user account ID
2	Name Input Field	Text field where to add a new user to enter their full name.
3	Save User Button	Primary action button that submits registration information.
4	Year Level Selector	A dropdown menu for selecting the user's academic year level.
5	Faculty Selector	Dropdown menu for selecting the users Faculty.
6	ID Number Input	Field for entering a unique identification number assigned to the user.
7	Email Input Field	Text input field where the admin enters the users email address for registration.
8	Password Input Field	A secure input field with masked characters is used to enter the account password.
9	Confirm Password Field	Secondary password input to verify and confirm the chosen password.

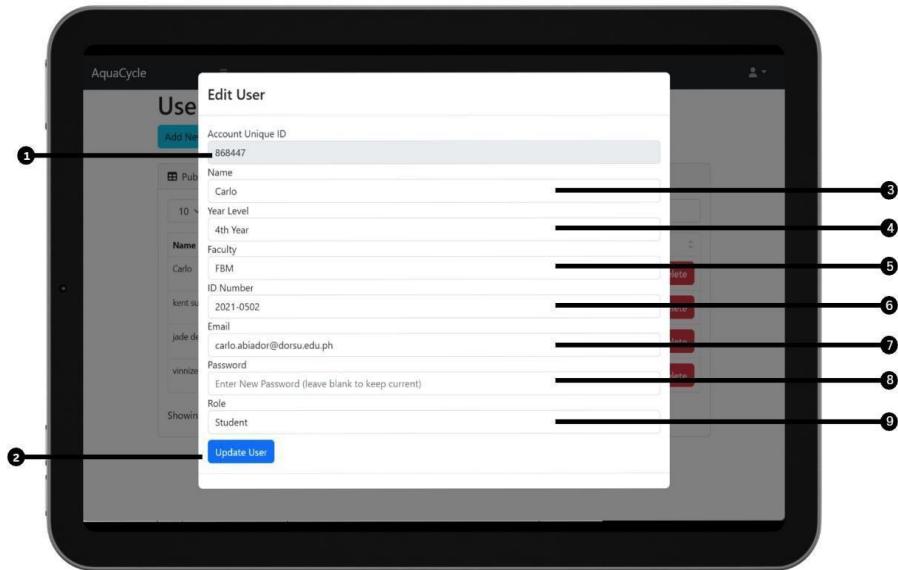


Figure 3.29 Admin Edit User Management page

Table 3.27 Admin Edit User management Page

No.	Component	Description
1	Account ID Field	Read-only field displaying the admin unique identifier.
2	Update User Button	Primary action button that submits registration information.
3	Name Input Field	Text field where to add a new user to enter their full name.
4	Year Level Selector	A dropdown menu for selecting the user academic year level.
5	Faculty Selector	Dropdown menu for selecting the user Faculty.
6	ID Number Input	Field for entering a unique identification number assigned to the user.
7	Email Input Field	Text input field where the admin enters the users email address for registration.
8	Password Input Field	A secure input field with masked characters is used to enter the account password.
9	Confirm Password Field	Secondary password input to verify and confirm the chosen password.

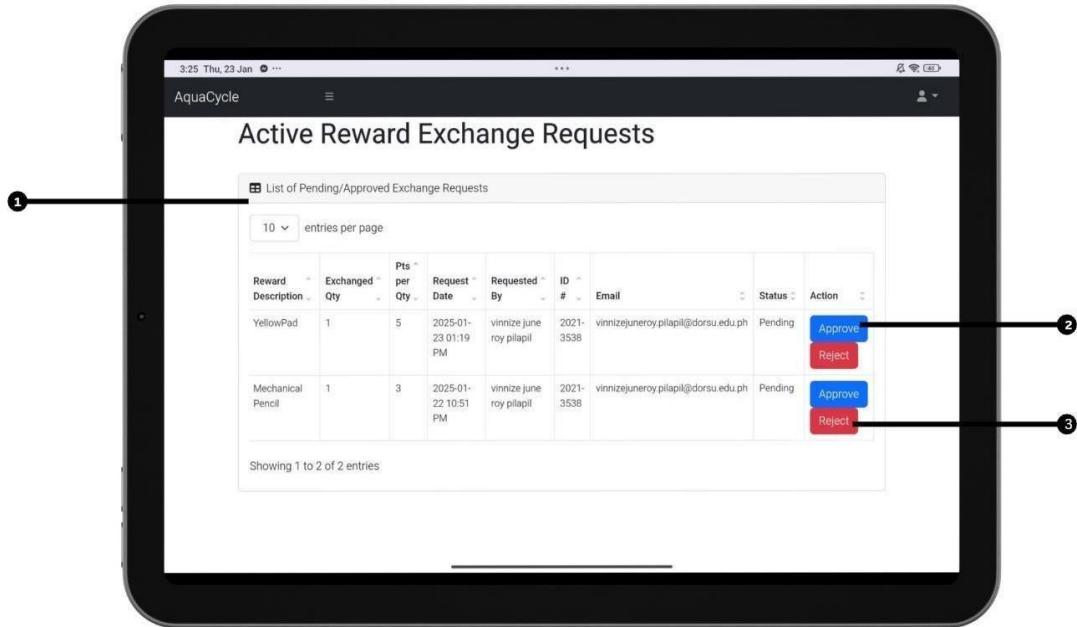


Figure 3.30 Admin pending Reward page

Table 3.28 Admin pending Reward Page

No.	Component	Description
1	Entries Selector	Dropdown to select the number of entries displayed per page.
2	Approve Button	An action button to approve a specific reward exchange request.
3	Reject Button	An action button to reject a specific reward exchange request.

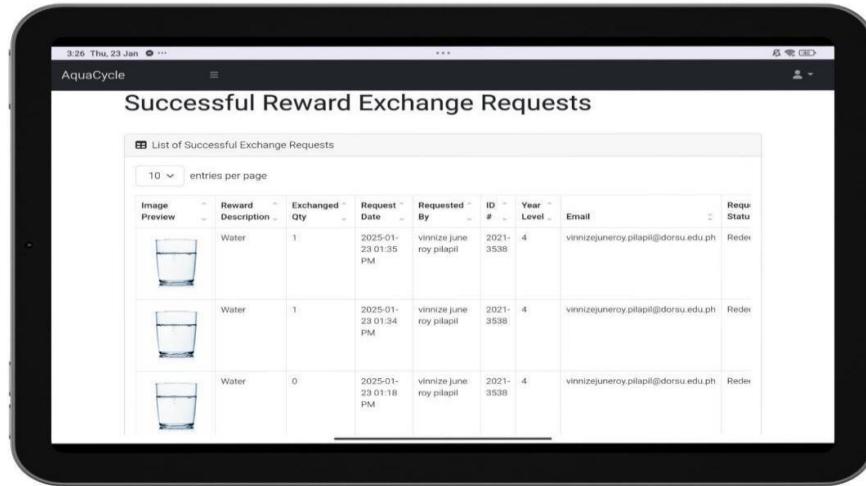


Figure 3.31 Admin Successful Reward page

Figure 3.31 shows the table of all successful reward exchanges. This table efficiently displays product images, descriptions, quantities exchanged, timestamps, and redemption statuses.

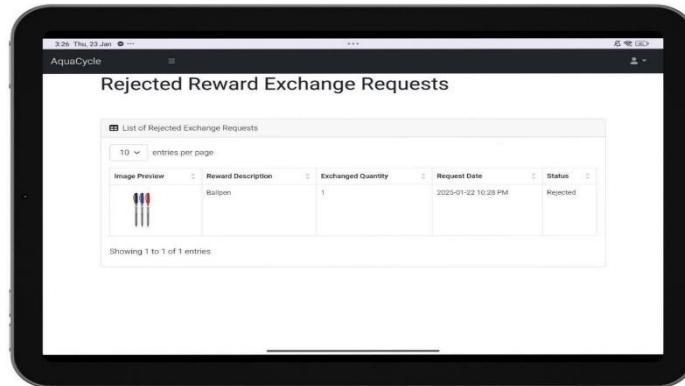


Figure 3.32 Admin Rejected Reward page

Figure 3.32 shows the table of all rejected reward exchange requests. This table efficiently displays product images, descriptions, quantities exchanged, timestamps, and redemption statuses.

3.11 Points Calculation

3.11.1 Economic Framework for Sustainable Reward System

This section details the economic framework implemented in our Reverse Vending Machine (RVM) system to ensure long-term financial sustainability. The framework establishes equilibrium between the monetary value of collected recyclable materials and the cost of dispensed rewards.

3.11.2 Valuation of Recyclable Materials

Our system's economic foundation is based on current market rates for recyclable plastics in the local region. Research across multiple recycling facilities established that plastic bottles are purchased at PHP 10-12 per kilogram, with our operational baseline set at PHP 11 per kilogram.

Different bottle types vary in weight and, consequently, in recycling value. After analyzing these variables, we determined that each point in our system represents approximately PHP 0.22 in actual recycling value.

3.11.3 Point Assignment System

To create a user-friendly experience while maintaining economic viability, we established the following standardized point values:

Table 3.29: Point Allocation Framework for Plastic Bottle

Bottle Type (Grams)	Points Awarded
Small Plastic Bottle(5-15g)	1
Medium Plastic Bottle(15-30g)	2
Large Plastic Bottle(30-45g)	3
Extra Large Plastic Bottle(45-60g)	4
EEX Plastic Bottle(60-80g)	5

3.11.4 Reward Valuation Methodology

To maintain system sustainability, rewards are priced according to their actual cost divided by the point-to-value conversion factor:

$$\text{Points Required} = \text{Reward Cost (PHP)} \div 0.22 \text{ PHP/point}$$

Example calculation: Notebook (14 PHP) = $14 \div 0.22 = 63.64 \approx 64$ points

This formula ensures the system maintains positive cash flow while providing meaningful incentives to users.

3.11.5 Implemented Reward Structure

Based on our valuation methodology, the following reward structure has been implemented:

Table 3.30: Reward Offering

Reward Item	Retail Value (PHP)	Points Required
Notebook	14.00	64
Bond Paper (3 pieces)	2.00	9
Bond Paper (whole ream)	260.00	1,182
Yellow Paper	48.00	218
Ballpen	10.00	45
Pencil	10.00	45

3.11.6 Water Dispensing Subsystem Analysis

The water dispensing feature represents a key incentive in our system and has been specifically calibrated for optimal sustainability:

- **Water Supply Unit Cost:** PHP 25 per gallon
- **Users Served per Gallon:** 250 individual dispensing operations
- **Cost per Dispensing Operation:** PHP 0.10

Table 3.31: Warter Conversion

Parameter	Value
Points Required per Dispensing Operation	1 point
Material Value Recovered per Point	PHP 0.22
Cost of Water per Dispensed	PHP 0.10
Net Positive Value per Transaction	PHP 0.12

3.12 Development and Testing

The Aqua Cycle project was created to encourage recycling by allowing users to exchange plastic bottles for clean water. The team followed the Waterfall Methodology, which divides the development into clear steps: gathering requirements, designing the system, coding, testing, deploying, and maintaining it.

The hardware components, including the Arduino Mega, ESP32 microcontroller, IR sensor, laser sensor, photoelectric switch, infrared, load cell, and water pump, were assembled to work together smoothly. The software was developed using PHP, Laravel, and MySQL to allow users to track bottles, earn points, and redeem rewards. Feedback from early prototypes helped improve the system design. To test the system, the team

followed several steps. Alpha testing identified and fixed issues during the development stage. Beta testing allowed a small group of users, such as students and staff, to try the system and provide feedback. Hardware stress testing ensured the sensors and pumps worked reliably, even continuously. Integration testing checked if the hardware and software worked together as expected. Finally, user acceptance testing gathered feedback from the target audience to confirm that the system met their needs.

3.12.1 Data Analysis Plan

The evaluation of the AquaCycle system focused on assessing its functionality, usability, and effectiveness in achieving its goals of incentivizing recycling and promoting environmental sustainability. The proponents adopted the ISO 25010 Model to ensure the system met software quality standards and aligned with user needs. The analysis concentrated on various quality attributes.

Functional suitability was assessed by evaluating the accuracy and efficiency of bottle detection, weight classification, and reward calculation. The system performance efficiency was measured through response times during bottle deposits, reward redemption, and data updates, ensuring a seamless and efficient process. Usability was evaluated by gathering user feedback on the web-based interface's clarity, ease of navigation, and intuitiveness, focusing on key areas such as the dashboard, registration process, and reward selection.

Reliability was tested by observing the hardware and software ability to perform consistently over time, monitoring uptime, and detecting potential malfunctions. Security measures were assessed by testing account authentication protocols, encryption methods, and resistance to unauthorized access.

Maintainability was evaluated by reviewing the system's modular design to ensure it could be easily updated and troubleshooted. Portability was tested by deploying the system in different locations within the university campus to confirm adaptability and stable operation in various environments.

Feedback and evaluation were gathered from students and staff who participated in the program. The proponents developed a Likert scale-based questionnaire to capture user perceptions, with responses ranging from 1 (strongly disagree) to 5 (strongly agree). The data collected was analyzed using the weighted arithmetic mean to identify areas of strength and those needing improvement.

CHAPTER IV

RESULTS AND DISCUSSIONS

4.1 Achievement per Objective

This shows the objectives that the developers have solved, including photo documentation on how they achieved those particular objectives.

4.1.1 Develop a web-based interface for users and administrators to track the number of deposited plastic bottles and assign points.

The primary goal of creating an accessible and user-friendly web-based interface for users and administrators has been effectively accomplished. This interface enables seamless monitoring of plastic bottle deposits and efficient point management.

Below are screenshots showcasing the results of this objective.

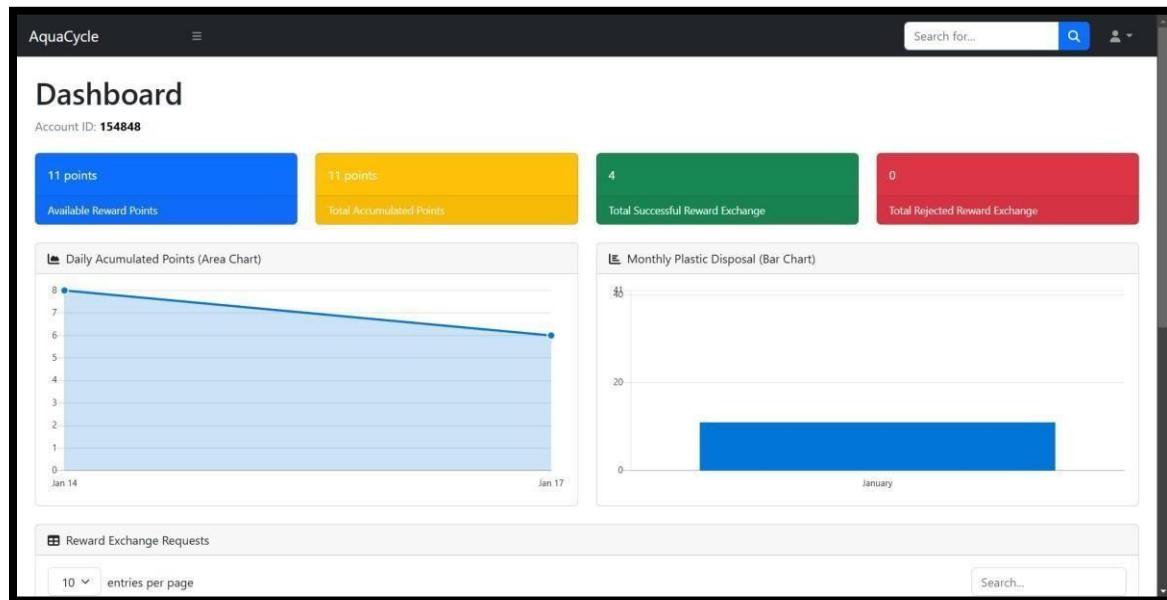


Figure 4.1: User Dashboard Page

Figure 4.1 illustrates the user dashboard page, where individuals can summarize their recycling activities. Key details include the total number of plastic bottles deposited, points accumulated over time, and recent transactions.

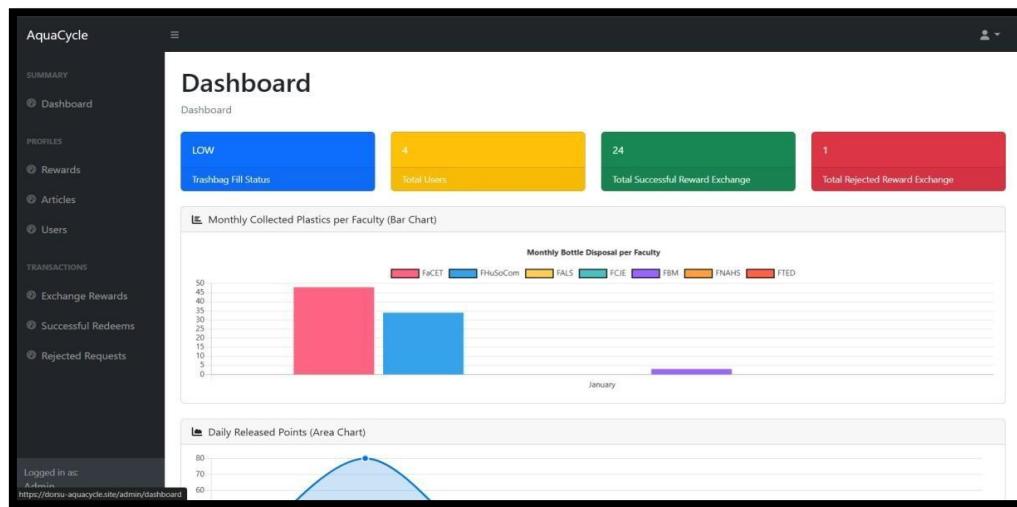


Figure 4.2: Admin Dashboard Page

Figure 4.2 highlights the admin dashboard, designed to provide a comprehensive overview of system operations. Administrators can oversee total deposits, manage user activities, and analyze participation statistics to maintain system efficiency.

4.1.2 Implement a user profile system to track participation and integrate it with the hardware system.

The following figure shows that the developers achieved the project objectives. This system helps users track their recycling activities, points, and

contributions to sustainability. The profiles are linked to the hardware system, updating automatically whenever users participate.

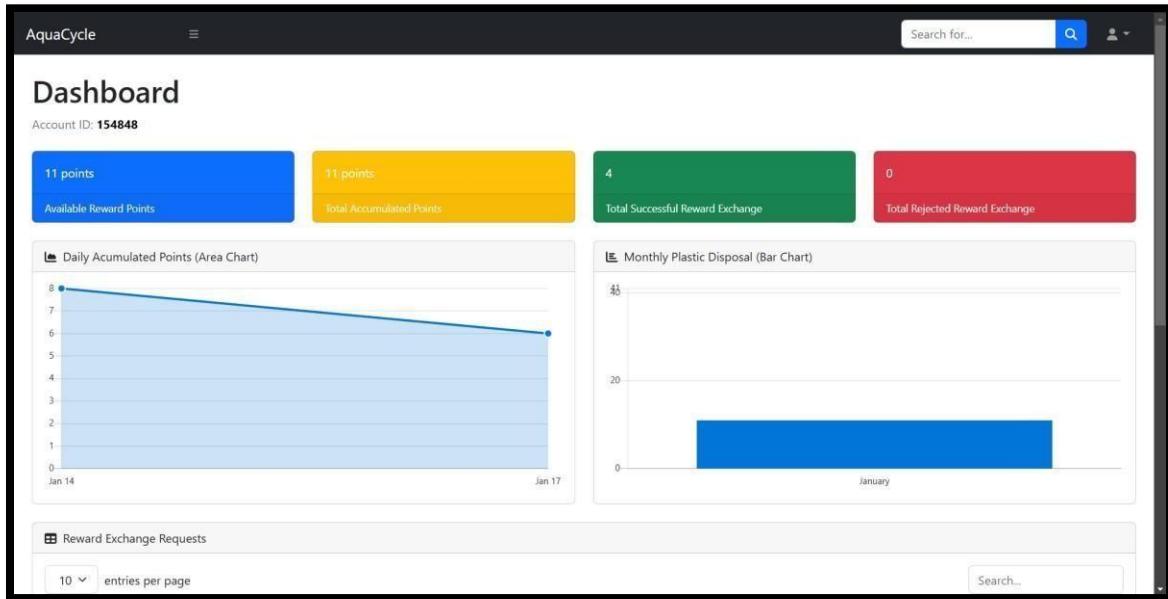


Figure 4.3: User Profile

Figure 4.3 shows detailed insights into individual recycling activities, including transaction history, points balance, and contributions.



Figure 4.4: User Profile link

Figure 4.4 shows how user profiles are connected to the hardware system, allowing real-time updates whenever users interact with it.

4.1.3 Allow users to select their preferred reward, either clean drinking water or points that can be redeemed.

The figure below shows that the developer achieved the third objective: to allow users to choose between clean drinking water or redeemable points as rewards for depositing plastic bottles.

The system was designed to automatically process the deposited bottles and provide the chosen reward by integrating hardware components. Once a bottle is deposited, the system uses a combination of sensors and a load cell to process the input and deliver the reward.



Figure 4.5: Hardware Setup

Figure 4.4 shows the hardware system, which includes the components responsible for detecting plastic bottles, measuring their weight, and dispensing rewards such as water.

4.2 Evaluation of the System

In evaluating the AquaCycle system, the respondents used a survey questionnaire based on ISO/IEEE 25010 standards. The approved survey form was distributed to 20 respondents. Following data collection, the researchers utilized the Weighted Arithmetic Mean to calculate and analyze the gathered data.

Table 4.1: Weighted Arithmetic Mean

Range	Interpretation
4.51 – 5.00	Strongly Agree
3.51 – 4.50	Agree
2.51 – 3.50	Neutral
1.51 – 2.50	Disagree
1.50 below	Strongly Disagree

Table 4.2: AquaCycle Evaluation Results

Indicators	Respondents	Average Mean	Interpretation
Functional Suitability	20	4.57	Strongly Agree
Performance Efficiency	20	4.35	Agree
Compatibility	20	3.91	Agree
Usability	20	4.37	Agree
Reliability	20	3.99	Agree
Security	20	3.78	Agree
Maintainability	20	3.46	Agree
Portability	20	4.05	Agree
Overall	20	4.06	Agree

Table 4.2 shows the performance of the AquaCycle system based on various evaluation criteria, including functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability. Each criterion was rated on a scale of 1 to 5, with 5 being the highest score. The weighted mean was calculated to provide an overall assessment.

The first indicator, functional suitability, yielded a mean of 4.57, which is interpreted as strongly agreeing. This result signifies that the respondents found the system effective in fulfilling its intended functions and accurately achieving its objectives.

The second indicator, performance efficiency, received a weighted mean of 4.35, indicating agreement. This suggests that the system efficiently responds to user interactions and optimizes resource usage within acceptable performance standards.

The system attained a mean of 3.91 for compatibility, which falls under the agree interpretation. This result indicates that AquaCycle is compatible with various hardware and software environments, ensuring seamless integration and operation.

Usability scored a mean of 4.37, reflecting user satisfaction with the system interface and ease of navigation. Respondents agreed that AquaCycle is intuitive, user-friendly, and facilitates smooth user interactions.

Reliability obtained a mean score of 3.99, which is interpreted as agree. This suggests that the system consistently performs its functions as expected, even under prolonged usage or varied conditions.

Security was rated with an average of 3.78, indicating agreement. This result implies that the system provides adequate security measures to protect user data and prevent unauthorized access.

Maintainability, with a mean of 3.46, also received an interpretation of agree. This suggests the system can be modified and updated efficiently to address potential improvements or issues.

Portability scored 4.05, which is also interpreted as agree, indicating that.

AquaCycle can be used across different devices and operating environments with ease.

Overall, the system achieved a weighted mean of 4.06, indicating that the respondents agreed on its effectiveness and functionality. These results demonstrate that AquaCycle meets essential software quality attributes, making it a viable and reliable solution for recycling and reward-based water distribution.

4.3 Implementation Plan

Table 4.3: AquaCycle Implementation Plan

Strategy	Activity	Persons Involved	Duration
Approval from the users	Letter for the users	Researchers, User	1 Day
Information Distribution	Manuals	Researchers, Users	1 Days
System Testing	User testing and bug fixing	Researchers, Users	2 Days

To implement the AquaCycle system, the researchers first sought approval from the users by submitting a formal letter, which took one day. Once approval was granted, information was distributed to the users as manuals to ensure they understood the system's functionalities and processes.

The system underwent user testing, during which selected student respondents interacted with it to ensure its functionality and ease of use. This phase lasted for two days,

allowing researchers to address any issues before the full deployment of the system. The implementation strategies involved collaboration between the researchers and users to ensure a smooth transition and effectively utilize the AquaCycle system.

CHAPTER V

Summary, Conclusion, and Recommendation

5.1 Summary

The growing global issue of plastic pollution and limited access to clean drinking water has spurred the development of innovative solutions. The AquaCycle project addresses these challenges through a plastic bottle-to-water exchange system implemented at Davao Oriental State University. This system incentivizes recycling by allowing users to exchange plastic bottles for clean drinking water or redeemable points.

Key components of the system include hardware such as the Arduino Mega, ESP32, IR sensors, load cells, and a water pump, integrated with a web-based platform for real-time tracking and reward management. The system user-friendly design fosters students, faculty, and staff participation while promoting environmental sustainability.

During testing, the system effectively demonstrated its ability to collect, process, and reward the recycling of plastic bottles. The results validated its potential to reduce plastic waste and improve water accessibility within the campus community.

5.2 Conclusion

The AquaCycle project achieved its objectives by demonstrating a sustainable and efficient method for managing plastic waste and promoting recycling. The system hardware and software components worked seamlessly to provide a smooth user experience and encourage environmentally responsible behavior.

The following conclusions can be drawn:

- The system effectively integrates hardware and software to streamline the recycling process and reward mechanism.
- It fosters environmental awareness and responsibility among the university community.
- The modular design allows for scalability, enabling the system to be replicated in other institutions and communities.

While the system achieved its goals, certain limitations, such as the inability to distinguish plastic from non-plastic materials and the reliance on user compliance with bottle cleanliness, highlight opportunities for further improvement.

5.3 Recommendations

The AquaCycle system was developed aligned with its objectives, scope, and limitations. To enhance its functionality and broaden its impact, the following recommendations are proposed:

- Enhanced Detection Capabilities: Upgrade the system to detect non-plastic materials and prevent errors in bottle identification.
- Incorporate Renewable Energy: Use solar or other renewable energy sources to power the system, ensuring sustainability.
- Long-Term Testing: Conduct extended testing to assess the system long-term stability and reliability under varied conditions.

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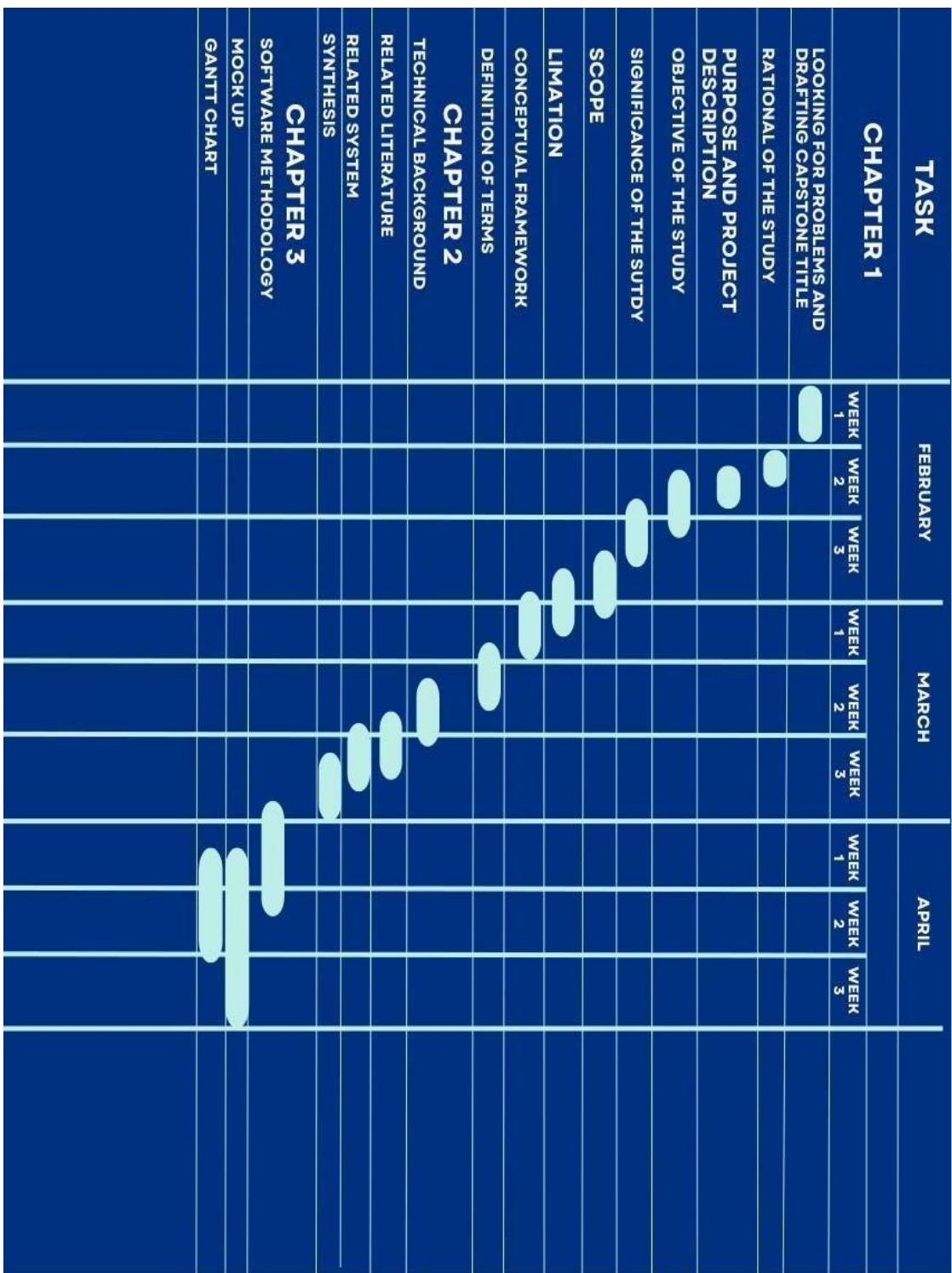
Appendices

Appendix A

Gantt Chart

Capstone Project Manuscript Development GANTT CHART

ANITA
MAX
WAYNEEE

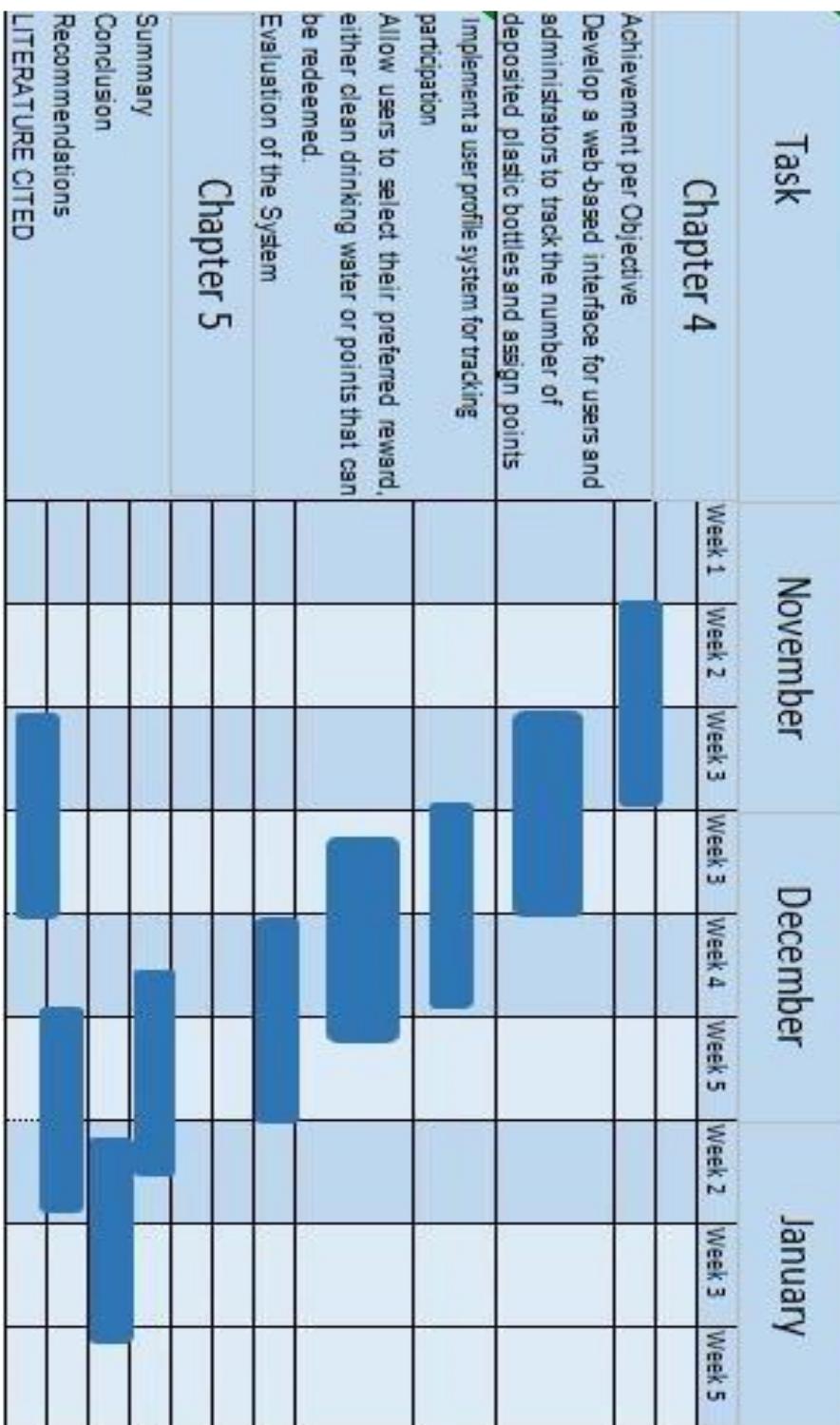


Capstone Project

Manuscript Development

ANITA
MAX
WAYNEEE

Gantt Chart



Appendix B

Advisory agreement

**DAVAO ORIENTAL
STATE UNIVERSITY**
"A University of excellence, innovation, and inclusion"



Document Code No.			
FM-DOrSU-ODI-24			
Issue Status	Rev No.	Effective Date	Page No.
01	00	07.22.2022	1 of 1

ADVISORY AGREEMENT

Institute of Faculty of Computing, Data Sciences, Engineering, and Technology

Date: 06/05/2024

We, the undersigned, hereby agree and formally expresses our commitment to constitute the Advisory Committee of Vinnize June Roy P. Pilapil, Rhoscbrian Jamisola, Zen Rae A. Candia in her/his/their pursuance to complete the requirements of the course, Undergraduate Thesis/SP/FS/Capstone Project, effective immediately upon approval by concerned authorities this semester/summer, SY 2023 to 2024.

Advisory Committee:

Jhon O. Inoco

Thesis Adviser

Wilkin F. Simo

Chair of the Panel

April Joy B. Dy

Panel Member

Clint Laurence M. Dueñas

Panel Member

This duly signed composition of the Advisory Committee is hereby endorsed and approved and shall be enforced until the completion of the study unless sooner revoked or terminated.

Endorsed by:

CINDY A. LASCO

Thesis Coordinator

Approved by:

EMMANUEL D. BARBAS, ENGR.D

Dean

Date

Date

Noted:

CINDY A. LASCO

Program Head

Date

Appendix C

Routing Slip

Appendix D

Experts Validation

**DAVAO ORIENTAL
STATE UNIVERSITY**

"A University of excellence, innovation, and inclusion"



Dear Mrs. Lanie B. Laureano,

We are currently creating a capstone project titled "**AquaCycle: Design and Implementation of a Plastic Bottle-to-Water Recycling System**". This method uses a unique recycling process to repurpose used plastic bottles, accordingly solving two significant environmental concerns: plastic pollution and water scarcity. To guarantee that the water generated satisfies high quality criteria and is fit for a variety of applications, including drinking, the system includes advanced removing and cleansing ways. We are to undergo user testing with a survey form. This survey contains 8 domains (Functional Suitability, Performance Efficiency, Compatibility, Usability, Reliability, Security, Maintainability, & Portability) with 5 items in the first domain, 5 items in the second, 5 items in the third, 5 items in the fourth, 5 items in the fifth, 5 items in the sixth, 5 items in the seventh, and 5 items in the eighth domain, totaling 40 items.

We need your expert judgement on the degree of relevance and degree of clarity of each item to the measured domains. Please be guided on the use of the following rating scales:

Numerical Rating	Degree of Relevance	Degree of Clarity
4	The item is highly relevant to the measured domain	The item is very clear
3	The item is quite relevant to the measured domain	The item is clear but need some minor revision
2	The item is somewhat relevant to the measured domain	The item needs some revision
1	The item is not relevant to the measured domain	The item is not clear

Thank you. More power and God bless.

Respectfully yours,

VINNIZE JUNE PILAPIL

ZEN RAFA A. CANDIA

RHOSEBRIAN JAMISOLA

Proponents

Mrs. Lanie B. Laureano
Expert's Name & Signature

Noted by:

Jhon O. Inoco
 Capstone Adviser

Date Signed

**DAVAO ORIENTAL
STATE UNIVERSITY**

"A University of excellence, innovation, and inclusion"



Dear Mr. Clint Laurence M. Duenas,

We are currently creating a capstone project titled "**AquaCycle: Design and Implementation of a Plastic Bottle-to-Water Recycling System**". This method uses a unique recycling process to repurpose used plastic bottles, accordingly solving two significant environmental concerns: plastic pollution and water scarcity. To guarantee that the water generated satisfies high quality criteria and is fit for a variety of applications, including drinking, the system includes advanced removing and cleansing ways. We are to undergo user testing with a survey form. This survey contains 8 domains (Functional Suitability, Performance Efficiency, Compatibility, Usability, Reliability, Security, Maintainability, & Portability) with 5 items in the first domain, 5 items in the second, 5 items in the third, 5 items in the fourth, 5 items in the fifth, 5 items in the sixth, 5 items in the seventh, and 5 items in the eighth domain, totaling 40 items.

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Thank you. More power and God bless.

Respectfully yours,

VINNIE JUNE PILAPIL

ZEN RAE A. CANDIA

RHOSEBRAIN JAMISOLA

Proponents

CLINT LAURENCE DUENAS

Expert's Name & Signature

Noted by:

Jhoh O. Inoco
Capstone Adviser

Date Signed

Appendix E

**User Testing/ Evaluation
Form (With User
Assessment)**

<p>Data Privacy Act – RA 10173</p> <p>We value your privacy and are committed to protecting your personal information. The data collected through this questionnaire will be used solely for research and evaluation purposes related to improving our mobile quiz application. All responses will be anonymized, and any personal information provided will be kept confidential and secure.</p> <p>Dear App User/Respondent,</p> <p>Thank you for using 'AquaCycle: Design and Implementation of a Plastic Bottle-to-Water Recycling System'. We request your time to evaluate the developed mobile application based on your experience as part of the development process. The suggestions and comments received during this evaluation will be utilized to drive future system development. Thank you for your support. Best wishes!</p> <p>- Developer</p> <p>PERSONAL PROFILE</p> <p>Name: (Optional) _____ Signature: </p> <p>Age: <u>25</u> Gender: <input type="checkbox"/> Male <input checked="" type="checkbox"/> Female</p> <p>I. APP EVALUATION</p> <p>Direction: Please indicate a check mark (✓) under the column that best describes your level of agreement for each item about 'AquaCycle: Design and Implementation of a Plastic Bottle-to-Water Recycling System'.</p> <p>Please use the rating below.</p> <p>5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree</p> <p>5 – Strongly Agree: The statement is fully accepted and seen as highly relevant. 4 – Agree: The statement is generally accepted but with less certainty. 3 – Neutral: No strong agreement or disagreement with the statement, showing uncertainty. 2 – Disagree: The statement is mostly not accepted or considered relevant. 1 – Strongly Disagree: The statement is completely rejected and seen as irrelevant.</p> <p>F. Security</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>24. The system reliably records and saves all my transaction data without errors?</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>25. I trust the system to function reliably and functionally.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>26. I trust the system to effectively safeguard my personal information, and I know that the system is accessible to administrators and staff.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>27. The system provides clear and transparent privacy settings.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>28. I have full confidence in the security of my account and recycling data.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>29. The system employs strong security measures to prevent unauthorized access.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>30. I am assured that my recycling data is maintained with strict confidentiality.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> </table> <p>G. Maintainability</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>31. I am informed about updates or maintenance related to the system.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>32. The system is regularly maintained and kept up to date, with notifications provided via email.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>33. I have encountered issues needing maintenance or fixes.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>34. The system is easy to update or upgrade without affecting its functionality.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>35. The system can easily be improved in the future.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> </table> <p>H. Portability</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>36. The system is easy to use on different devices like phones, tablets, and computers.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>37. The system works the same across all devices.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>38. The system avoids problems with platform compatibility.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>39. The system works well on different operating systems like Android and iOS.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>40. The system works reliably in different places and setups.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> </table>	24. The system reliably records and saves all my transaction data without errors?	✓				25. I trust the system to function reliably and functionally.	✓				26. I trust the system to effectively safeguard my personal information, and I know that the system is accessible to administrators and staff.	✓				27. The system provides clear and transparent privacy settings.	✓				28. I have full confidence in the security of my account and recycling data.	✓				29. The system employs strong security measures to prevent unauthorized access.	✓				30. I am assured that my recycling data is maintained with strict confidentiality.	✓				31. I am informed about updates or maintenance related to the system.	✓				32. The system is regularly maintained and kept up to date, with notifications provided via email.	✓				33. I have encountered issues needing maintenance or fixes.	✓				34. The system is easy to update or upgrade without affecting its functionality.	✓				35. The system can easily be improved in the future.	✓				36. The system is easy to use on different devices like phones, tablets, and computers.	✓				37. The system works the same across all devices.	✓				38. The system avoids problems with platform compatibility.	✓				39. The system works well on different operating systems like Android and iOS.	✓				40. The system works reliably in different places and setups.	✓				<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="5" style="text-align: center;">ITEM INDICATOR</th> </tr> <tr> <th></th> <th style="text-align: center;">5</th> <th style="text-align: center;">4</th> <th style="text-align: center;">3</th> <th style="text-align: center;">2</th> <th style="text-align: center;">1</th> </tr> </thead> <tbody> <tr> <td>A. Functional Suitability</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>1. The system accurately tracks the number of plastic bottles I deposit through the system.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>2. The rewards I receive for recycling are clearly communicated.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>3. I can easily access my transaction history and points balance.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>4. The system meets my needs for recycling and obtaining rewards.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>5. The system functions as I expected it to.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>B. Performance Efficiency</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>6. The system processes my bottle deposits quickly.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>7. I do not experience delays when redeeming my rewards.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>8. The system updates my points immediately after I deposit bottles.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>9. The system performs well during busy times without slowdowns.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>10. Overall, the performance of the system is satisfactory.</td> <td style="text-align: center;">✓</td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> <td style="text-align: center;"></td> </tr> <tr> <td>C. 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The suggestions and comments received during this evaluation will be utilized to drive future system development. Thank you for your support. Best wishes!</p> <p>- Developer</p> <p>PERSONAL PROFILE</p> <p>Name: (Optional) _____ Signature: </p> <p>Age: <u>22</u> Gender: <input type="checkbox"/> Male <input checked="" type="checkbox"/> Female</p> <p>I. APP EVALUATION</p> <p>Direction: Please indicate a check mark (✓) under the column that best describes your level of agreement for each item about 'AquaCycle: Design and Implementation of a Plastic Bottle-to-Water Recycling System'.</p> <p>Please use the rating below.</p> <p>5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree</p> <p>5 – Strongly Agree: The statement is fully accepted and seen as highly relevant. 4 – Agree: The statement is generally accepted but with less certainty. 3 – Neutral: No strong agreement or disagreement with the statement, showing uncertainty. 2 – Disagree: The statement is mostly not accepted or considered relevant. 1 – Strongly Disagree: The statement is completely rejected and seen as irrelevant.</p>	ITEM INDICATOR						5	4	3	2	1	A. Functional Suitability	✓					1. The system accurately tracks the number of plastic bottles I deposit through the system.	✓					2. The rewards I receive for recycling are clearly communicated.	✓					3. 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1. The system accurately tracks the number of plastic bottles I deposit.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
2. The rewards I receive for recycling are clearly communicated through the system.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
3. I can easily access my transaction history and points balance.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
4. The system meets my needs for recycling and obtaining rewards.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
5. The system functions as I expected it to.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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6. The system processes my bottle deposits quickly.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
7. I do not experience delays when redeeming my rewards.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
8. The system updates my points immediately after I deposit bottles.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
9. The system performs well during busy times without slowdowns.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
10. Overall, the performance of the system is satisfactory.		✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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11. The system works well across different types of devices (mobile, tablet, desktop).			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
12. I can easily access the system from various platforms.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
13. The system integrates smoothly with other digital recycling or reward apps.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
14. I have been able to use the system without any compatibility issues across different browsers.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
15. The system performs consistently across different operating systems.		✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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16. The interface is user-friendly and easy to navigate.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
17. I can easily find information about my rewards and points.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
18. The instructions provided by the system are clear and helpful.		✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
19. I can navigate the system without any confusion.		✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
20. The system offers valuable guidance whenever I encounter an error.		✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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21. The system operates without errors most of the time.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
22. I have not experienced crashes or malfunctions while using the system.			✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
23. The system accurately and consistently displays information about my plastic bottle deposits and reward balances?		✓																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											

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All responses will be anonymized, and any personal information provided will be kept confidential and secure.</p> <p>Dear App User/Respondent, Thank you for using "AquaCycle: Design and Implementation of a Plastic Bottle-to-Water Recycling System". We request your time to evaluate the developed mobile application based on your experience as part of the development process. The suggestions and comments received during this evaluation will be utilized to drive future system development. Thank you for your support. Best wishes!</p> <p>- Developer</p> <p>PERSONAL PROFILE Name: (Optional) _____ Signature:  Age: <input checked="" type="checkbox"/> 22 Gender: <input type="checkbox"/> Male <input type="checkbox"/> Female</p> <p>I. APP EVALUATION Direction: Please indicate a check mark (✓) under the column that best describes your level of agreement for each item about "AquaCycle: Design and Implementation of a Plastic Bottle-to-Water Recycling System". 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The suggestions and comments received during this evaluation will be utilized to drive future system development. Thank you for your support. Best wishes!</p> <p>- Developer</p> <p>PERSONAL PROFILE</p> <p>Name: (Optional) <u>Tommy</u> Signature: </p> <p>Age: <u>21</u> Gender: <input type="checkbox"/> Male <input checked="" type="checkbox"/> Female</p> <p>I. APP EVALUATION</p> <p>Direction: Please indicate a check mark (✓) under the column that best describes your level of agreement for each item about "AquaCycle: Design and Implementation of a Plastic Bottle-to-Water Recycling System".</p> <p>Please use the rating below.</p> <p>5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree</p> <p>5 – Strongly Agree: The statement is fully accepted and seen as highly relevant. 4 – Agree: The statement is generally accepted but with less certainty. 3 – Neutral: No strong agreement or disagreement with the statement, showing uncertainty. 2 – Disagree: The statement is mostly not accepted or considered relevant. 1 – Strongly Disagree: The statement is completely rejected and seen as irrelevant.</p>	ITEM INDICATOR							5	4	3	2	1	A. Functional Suitability	✓					1. The system accurately tracks the number of plastic bottles I deposit through the system.	✓					2. The rewards I receive for recycling are clearly communicated.	✓					3. 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The suggestions and comments received during this evaluation will be utilized to drive future system development. Thank you for your support. Best wishes!</p> <p>- Developer</p> <p>PERSONAL PROFILE</p> <p>Name: (Optional) <u>Banasa</u> Signature: <u>[Signature]</u></p> <p>Age: <u>25</u> Gender: <input checked="" type="checkbox"/> Male <input type="checkbox"/> Female</p> <p>I. 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24. The system reliably records and saves all my transaction data without errors?	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
25. I trust the system to function reliably and functionally.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
26. I trust the system to effectively safeguard my personal information, and I know that the system is accessible to administrators and staff.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
27. The system provides clear and transparent privacy settings.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
28. I have full confidence in the security of my account and recycling data.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
29. The system employs strong security measures to prevent unauthorized access.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
30. I am assured that my recycling data is maintained with strict confidentiality.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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31. I am informed about updates or maintenance related to the system.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
32. The system is regularly maintained and kept up to date, with notifications provided via email.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
33. I have encountered issues needing maintenance or fixes.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
34. The system is easy to update or upgrade without affecting its functionality.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
35. The system can easily be improved in the future.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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36. The system is easy to use on different devices like phones, tablets, and computers.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
37. The system works the same across all devices.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
38. The system avoids problems with platform compatibility.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
39. The system works well on different operating systems like Android and iOS.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
40. The system works reliably in different places and setups.	<input checked="" type="checkbox"/>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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<p>Data Privacy Act – RA 10173</p> <p>We value your privacy and are committed to protecting your personal information. The data collected through this questionnaire will be used solely for research and evaluation purposes related to improving our mobile quiz application. All responses will be anonymized, and any personal information provided will be kept confidential and secure.</p> <p>Dear App User/Respondent,</p> <p>Thank you for using "AquaCycle: Design and Implementation of a Plastic Bottle-to-Water Recycling System". We request your time to evaluate the developed mobile application based on your experience as part of the development process. The suggestions and comments received during this evaluation will be utilized to drive future system development. Thank you for your support. Best wishes!</p> <p>- Developer</p> <p>PERSONAL PROFILE</p> <p>Name: (Optional) _____ Signature: </p> <p>Age: <u>26</u> Gender: <input checked="" type="checkbox"/> Male <input type="checkbox"/> Female</p> <p>I. APP EVALUATION</p> <p>Direction: Please indicate a check mark (✓) under the column that best describes your level of agreement for each item about "AquaCycle: Design and Implementation of a Plastic Bottle-to-Water Recycling System".</p> <p>Please use the rating below.</p> <p>5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree</p> <p>5 – Strongly Agree: The statement is fully accepted and seen as highly relevant.</p> <p>4 – Agree: The statement is generally accepted but with less certainty.</p> <p>3 – Neutral: No strong agreement or disagreement with the statement, showing uncertainty.</p> <p>2 – Disagree: The statement is mostly not accepted or considered relevant.</p> <p>1 – Strongly Disagree: The statement is completely rejected and seen as irrelevant.</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">ITEM INDICATOR</th> <th style="text-align: center;">5</th> <th style="text-align: center;">4</th> <th style="text-align: center;">3</th> <th style="text-align: center;">2</th> <th style="text-align: center;">1</th> </tr> </thead> <tbody> <tr> <td colspan="2">A. 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G. Maintainability		✓	✓	✓	✓	✓	✓
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H. Portability		✓	✓	✓	✓	✓	✓
36. The system is easy to use on different devices like phones, tablets, and computers.		✓	✓	✓	✓	✓	✓
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		✓	✓	✓	✓	✓	✓
F. Security		✓	✓	✓	✓	✓	✓
26. I trust the system to effectively safeguard my personal information, and I know that the system is accessible to administrators and staff.		✓	✓	✓	✓	✓	✓
27. The system provides clear and transparent privacy settings.		✓	✓	✓	✓	✓	✓
28. I have full confidence in the security of my account and recycling data.		✓	✓	✓	✓	✓	✓
29. The system employs strong security measures to prevent unauthorized access.		✓	✓	✓	✓	✓	✓
30. I am assured that my recycling data is maintained with strict confidentiality.		✓	✓	✓	✓	✓	✓
G. Maintainability		✓	✓	✓	✓	✓	✓
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Data Privacy Act - RA 10173

We value your privacy and are committed to protecting your personal information. The data collected through this questionnaire will be used solely for research and evaluation purposes related to improving our mobile quiz application. All responses will be anonymized, and any personal information provided will be kept confidential and secure.

Dear App User/Respondent,

Thank you for using "AquaCycle: Design and Implementation of a Plastic Bottle-to-Water Recycling System". We request your time to evaluate the developed mobile application based on your experience as part of the development process. The suggestions and comments received during this evaluation will be utilized to drive future system development. Thank you for your support. Best wishes!

- Developer

PERSONAL PROFILE

Name: (Optional) _____ Signature: 
Age: 18 Gender: Male Female

I. APP EVALUATION

Direction: Please indicate a check mark (✓) under the column that best describes your level of agreement for each item about "AquaCycle: Design and Implementation of a Plastic Bottle-to-Water Recycling System".

Please use the rating below.

5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree

5 – Strongly Agree: The statement is fully accepted and seen as highly relevant.

4 – Agree: The statement is generally accepted but with less certainty.

3 – Neutral: No strong agreement or disagreement with the statement, showing uncertainty.

2 – Disagree: The statement is mostly not accepted or considered relevant.

1 – Strongly Disagree: The statement is completely rejected and seen as irrelevant.

Appendices F

User Evaluation Result

Indicators	1	2	3	4	5	Weighted Mean
Functional Suitability						
1. The system accurately tracks the number of plastic bottles I deposit.	0	0	1	5	14	4.55
2. The rewards I receive for recycling are clearly communicated through the system.	0	0	0	9	11	4.55
3. I can easily access my transaction history and points balance.	0	0	1	7	12	4.55
4. The system meets my needs for recycling and obtaining rewards.	0	0	2	6	11	4.5
5. The system functions as I expected it to	0	0	0	6	14	4.7
Performance Efficiency						
6. The system processes my bottle deposits quickly.	0	0	0	8	12	4.6
7. I do not experience delays when redeeming my rewards.	0	0	9	2	9	4.35
8. The system updates my points immediately after I deposit bottles.	0	1	4	8	7	4.05
9. The system performs well during busy times without slowdowns.	0	1	3	9	7	4.15
10. Overall, the performance of the system is satisfactory.	0	0	0	8	12	4.6

Compatibility						
11. The system works well across different types of devices (mobile, tablet, desktop).	0	0	6	10	4	3.9
12. I can easily access the system from various platforms.	0	0	3	11	6	4.15
13. The system integrates smoothly with other digital recycling or reward apps.	0	0	9	7	4	3.75
14. I have been able to use the system without any compatibility issues across different browsers.	0	0	6	12	2	3.8
15. The system performs consistently across different operating systems.	0	0	7	7	6	3.95
Usability						
16. The interface is user-friendly and easy to navigate.	0	0	1	8	11	4.5
17. I can easily find information about my rewards and points.	0	0	1	12	7	4.3
18. The instructions provided by the system are clear and helpful.	0	0	2	11	7	4.25
19. I can navigate the system without any confusion.	0	0	2	8	10	4.4
20. The system offers valuable guidance whenever I encounter an error.	0	0	1	10	9	4.4
Reliability						
21. The system operates without errors most of the time.	0	1	6	8	5	3.85
22. I have not experienced crashes or malfunctions while using the system.	0	0	5	13	2	3.85

23. The system accurately and consistently displays information about my plastic bottle deposits and reward balances?	0	0	7	8	5	3.85
24. The system reliably records and saves all my transaction data without errors?	0	0	1	13	6	4.25
25. I trust the system to function reliably and functionally.	0	0	4	9	7	4.15
Security						
26. I trust the system to effectively safeguard my personal information, and I know that the system is accessible to administrators and staff.	1	0	8	9	2	3.55
27. The system provides clear and transparent privacy settings.	0	0	7	8	5	3.9
28. I have full confidence in the security of my account and recycling data.	0	0	8	11	1	3.65
29. The system employs strong security measures to prevent unauthorized access.	0	0	8	8	4	3.8
30. I am assured that my recycling data is maintained with strict confidentiality.	0	0	6	9	5	3.95
Maintainability						
31. I am informed about updates or maintenance related to the system	0	1	6	9	4	3.65
32. The system is regularly maintained and kept up to date, with notifications provided via email.	0	2	7	8	3	3.6

33. I have encountered issues needing maintenance or fixes.	0	6	11	2	1	2.9
34. The system is easy to update or upgrade without affecting its functionality.	1	1	8	7	3	3.5
35. The system can easily be improved in the future.	1	2	5	5	7	3.85
Portability						
36. The system is easy to use on different devices like phones, tablets, and computers.	0	0	4	8	8	4.2
37. The system works the same across all devices.	0	1	4	13	2	3.8
38. The system avoids problems with platform compatibility.	0	0	3	11	6	4.05
39. The system works well on different operating systems like Android and iOS.	0	0	5	8	7	4.1
40. The system works reliably in different places and setups.	0	0	3	12	5	4.1

Appendix G

User Testing

Appendix H

User Manual

Overview

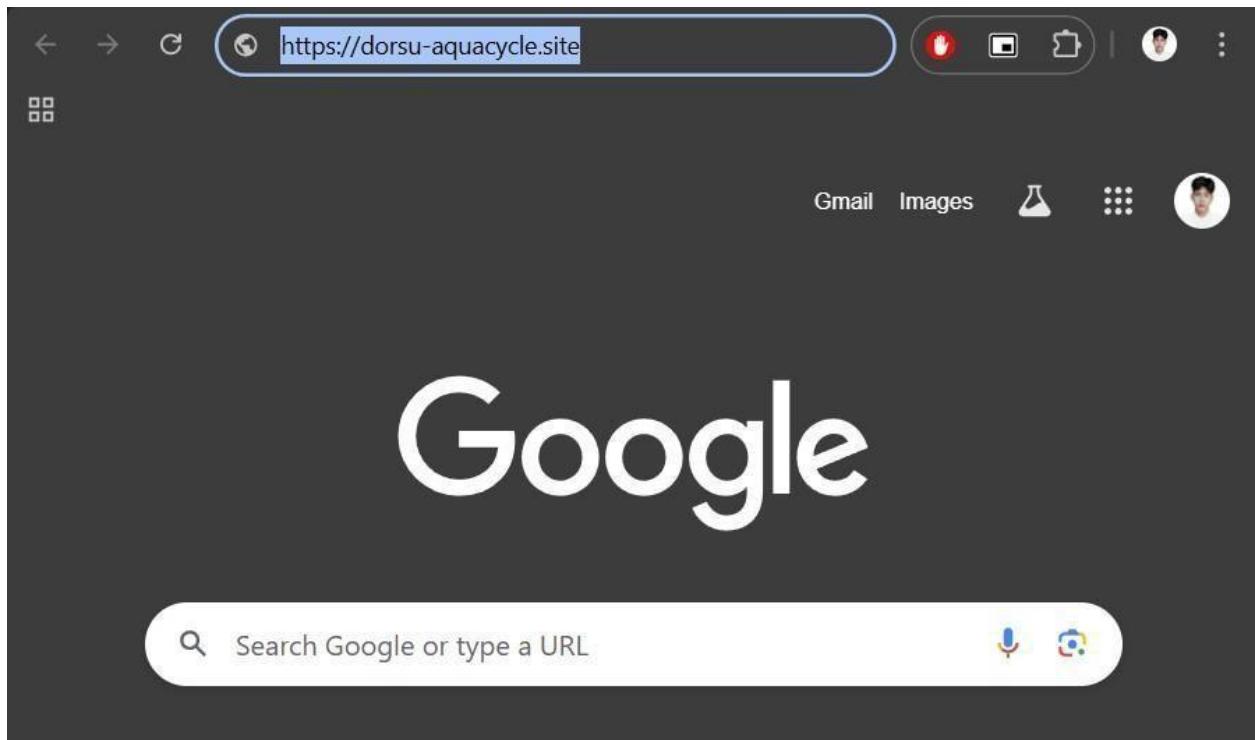
The AquaCycle system is designed to provide a platform for recycling plastic bottles in exchange for points that can be redeemed for rewards like clean drinking water. By combining hardware and software technologies, AquaCycle automates the recycling process and encourages environmentally responsible behavior. This user manual provides step-by-step instructions for accessing and using the AquaCycle system.

User

Accessing the System:

Step 1.1: Open your preferred web browser (e.g., Chrome, Firefox, Safari).

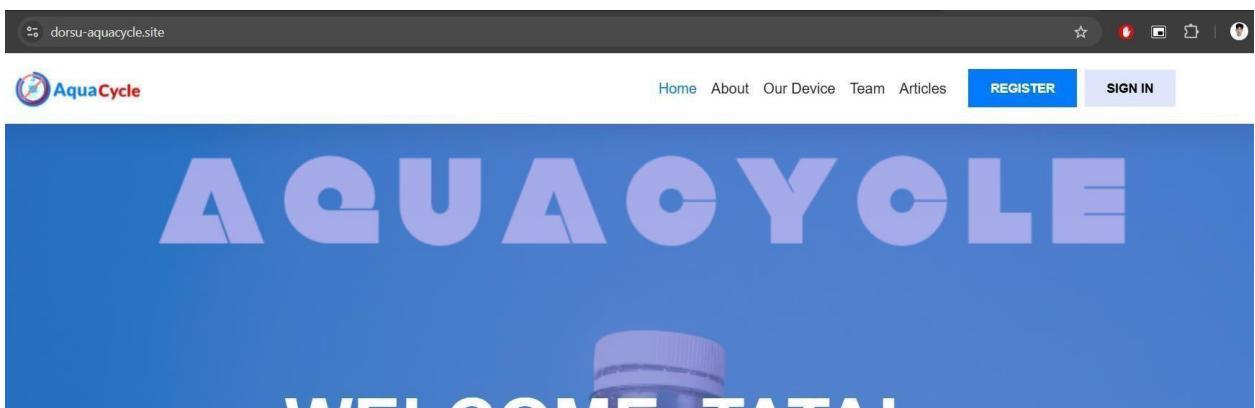
Step 1.2: In the address bar, enter the system's URL to access the AquaCycle application.



Logging In/ Registering:

Step 2.1: Click on the Login or Sign Up button on the homepage to access the login or registration page.

Step 2.2: If you already have an account, select Login and enter your email and password.



Step 2.3: If you are a new user, select **Sign Up** and fill in the required fields, including name, year level, Faculty, ID number, email and password

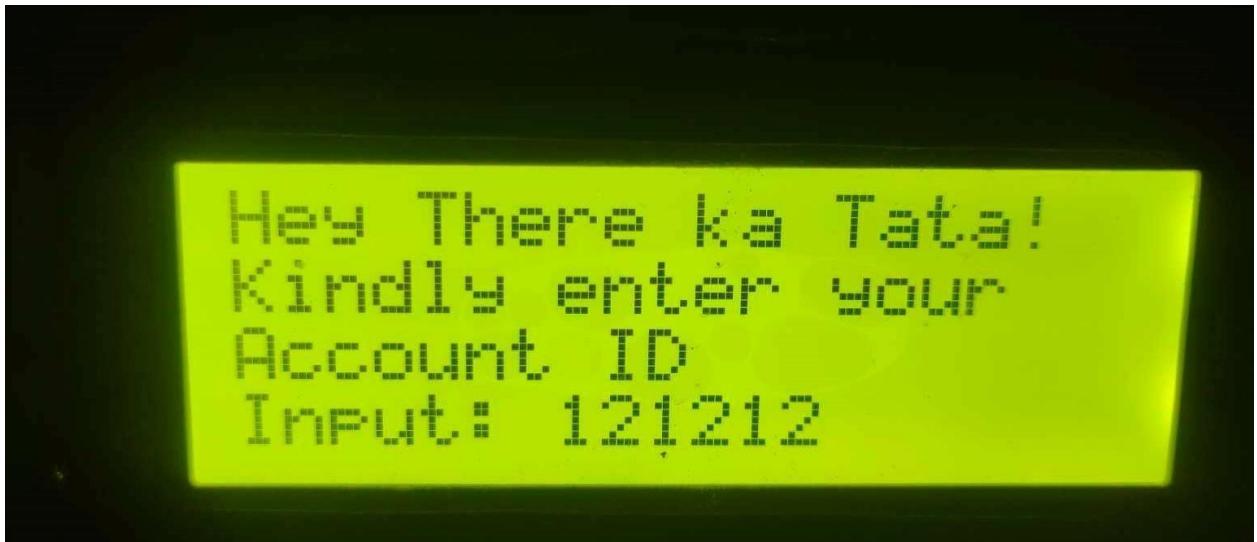
Step 2.4: After entering your information, click **Register** or **Login** to access your dashboard.

Using AquaCycle

Depositing Plastic Bottles:

Step 3.1: Ensure your plastic bottles are clean and empty. Remove caps before depositing.

Step 3.2: Type your ID number to the keypad



Step 3.3: Place the bottle into the designated slot on the AquaCycle machine.

Step 3.4: The system will validate the bottle using sensors and measure its weight to calculate points. (Click # if done)



Step 3.4: You can now see your points balance, Store Points and convert water on the system LCD display after (Clicking # if done).

Step 3.5: Click 1 in the keypad to store the point in your account and exit. Click 2 in the keypad to convert water.

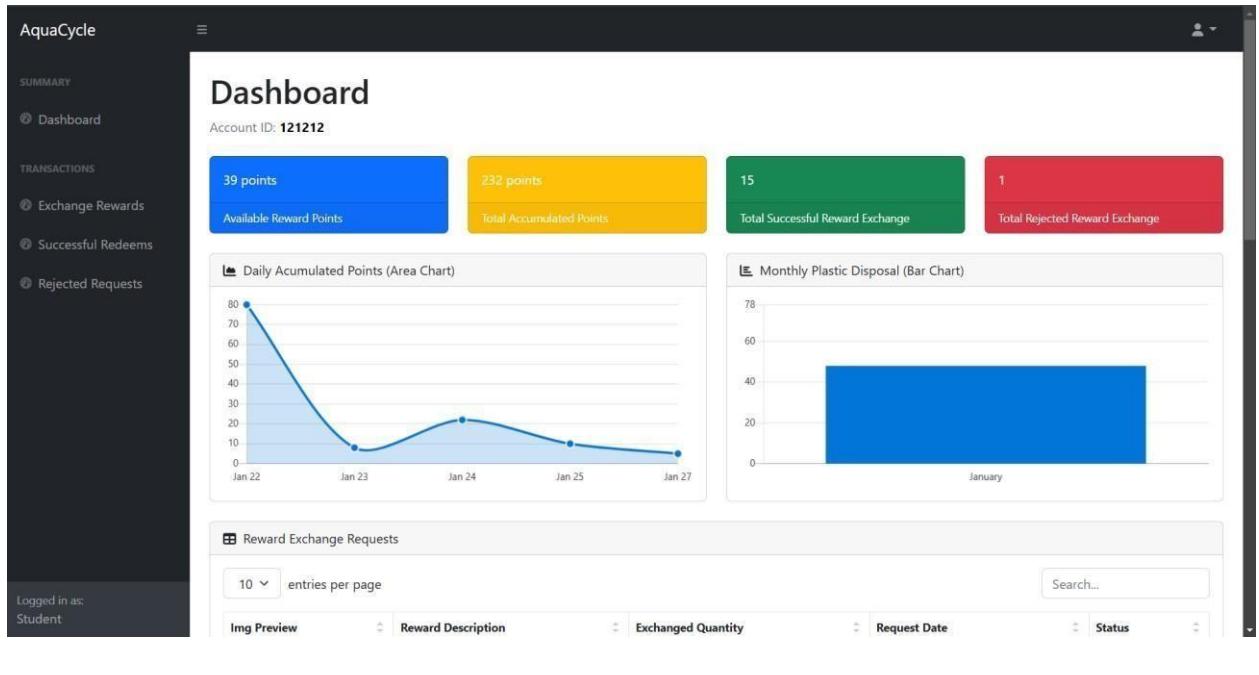


Checking Points Balance:

Step 4.1: Log in to your account via the AquaCycle web URL.

Step 4.2: Navigate to the **Dashboard** section.

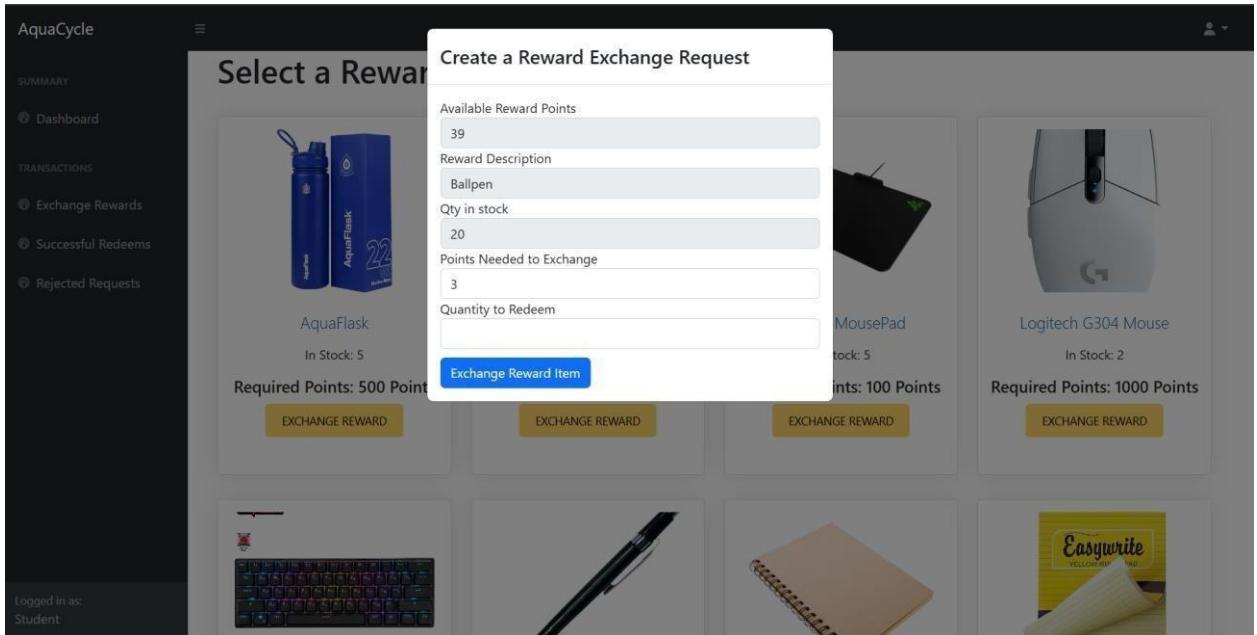
Step 4.3: Now you can view your total accumulated points and recycling history.



Redeeming Rewards:

Step 5.1: Log in to the system and go to the **Exchange Rewards** section and Click “Exchange Reward Now!”.

Step 5.2: Select a reward such Aquaflask, ballpen, etc. products, and confirm your choice.



Step 5.3: If redeeming water, bring your own tumbler to the machine for dispensing.

The water pump will dispense the appropriate amount based on your redeemed points.

Successful and rejected:

Step 6.1: in the Sidebar menu you can view your successful exchange by Clicking “Successful Redemeems”

Step 6.2: in the menu bar you can view your Rejected exchange by Clicking “Rejected Requests”

Logging Out:

Step 7.1: Click on your profile icon in the top-right corner.

Step 7.2: Select **Log Out** to securely end your session.

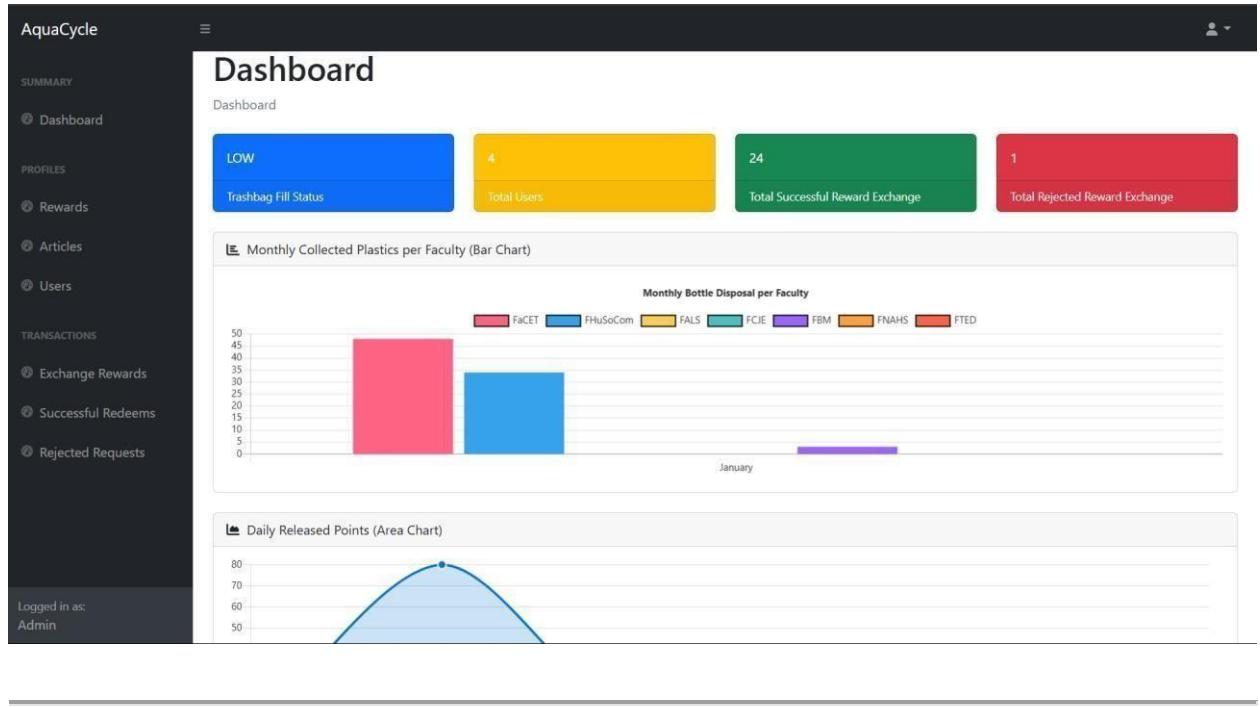
Administrator Manual

Accessing the Admin Dashboard:

Step 1.1: Open your web browser and navigate to the AquaCycle system URL.

Step 1.2: Log in using your administrator credentials (email and password). **Step 1.3:**

After logging in, you will be redirected to the Admin Dashboard.

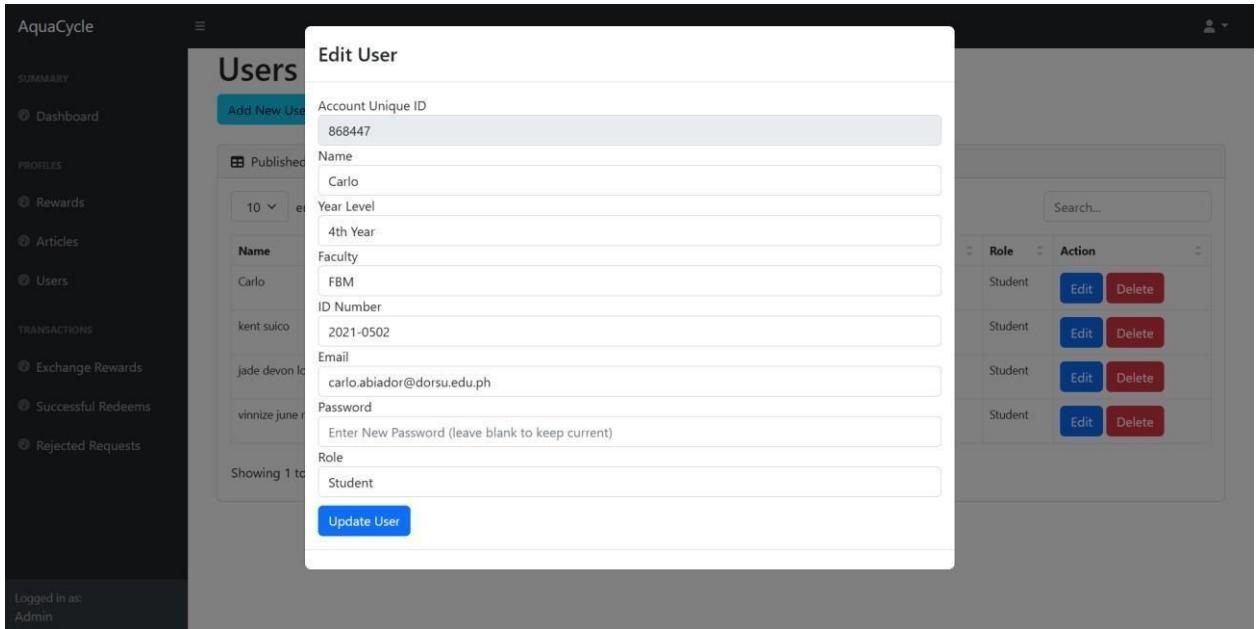


Managing User Accounts:

Step 2.1: On the left sidebar, navigate to the **Users** section to manage it.

Step 2.2: Locate the **User List** table, where all registered users are displayed. **Step 2.3:** You can perform action on user as needed.

- **Delete User**
- **Edit User**
- **Assign User Roles:** Change user roles to Administrator or User from the dropdown menu in the edit section.



Monitoring Recycling Activities:

Step 3.1: From the sidebar, navigate to the **Dashboard** section. **Step 3.2:** View key metrics such as:

- Trash bag Fill status

Total User.

Total Successful Reward exchange.

Total Rejected rewards Exchange.

Step 3.3: Analyze data through charts showing trends in recycling activities, including monthly or daily metrics.

Managing Rewards:

Step 4.1: Navigate to the **Rewards** section from the sidebar to manage it. **Step 4.2:**

Add new rewards:

Click Add Reward.

Fill in the reward details, including description, points required, and stock quantity.

Upload an image of the reward if applicable.

Click Save Reward.

Image	Description	Points Required	Action
	Mechanical Keyboard	100	Edit Delete
	Yellow Notepad	5	Edit Delete
	Notebook	10	Edit Delete
	Gaming MousePad	5	Edit Delete
	Mechanical Pencil	20	Edit Delete

Step 4.3: Edit existing rewards:

Locate the reward in the table.

Click **Edit** to update details, then click **Save Changes**.

The screenshot shows the AquaCycle software interface. On the left, there's a sidebar with navigation links: Dashboard, Rewards, Articles, Users, Exchange Rewards, Successful Redemeers, and Rejected Requests. The main area displays a table of rewards with columns for Image, Description, Quantity in Stock, Points Required, and Action (Edit and Delete buttons). A modal dialog box titled 'Edit Reward' is open, overlaid on the table. The dialog contains fields for Description (Notebook), Quantity in Stock (10), Points Required (30), an Upload Image section with a 'Choose File' button, and an 'Update Reward' button.

Image	Description	Quantity in Stock	Points Required	Action
	Notebook	10	30	Edit Delete
	Yellow			Edit Delete
	Gaming MousePad	5	100	Edit Delete
	Mechanical Pencil	20	3	Edit Delete
	Ballpen	20	3	Edit Delete

Step 4.4: Remove rewards:

Select **Delete** for the specific reward you want to remove.

5. Reviewing Reward Requests:

Step 5.1: Navigate to the **Exchange Requests** section in the sidebar.

Step 5.2: Review pending reward redemption requests. **Step 5.3:** For each request, choose:

Approve: Approve the request and update the user reward status.

Reject: Decline the request and provide remarks if necessary.

The screenshot shows the AquaCycle Admin Dashboard with the title "Active Reward Exchange Requests". The sidebar on the left includes sections for SUMMARY, PROFILES (Rewards, Articles, Users), and TRANSACTIONS (Exchange Rewards, Successful Redemeers, Rejected Requests). The main content area displays a table titled "List of Pending/Approved Exchange Requests" with the following data:

Reward Description	Exchanged Qty	Pts per Qty	Request Date	Requested By	ID #	Email	Status	Action
Gaming MousePad	1	100	2025-01-24 06:01 PM	vinnize june roy pilapil	2021-3538	vinnizejuneroy.pilapil@dorsu.edu.ph	Pending	<button>Approve</button> <button>Reject</button>
YellowPad	1	30	2025-01-23 01:19 PM	vinnize june roy pilapil	2021-3538	vinnizejuneroy.pilapil@dorsu.edu.ph	Pending	<button>Approve</button> <button>Reject</button>
Mechanical Pencil	1	15	2025-01-22 10:51 PM	vinnize june roy pilapil	2021-3538	vinnizejuneroy.pilapil@dorsu.edu.ph	Pending	<button>Approve</button> <button>Reject</button>

Showing 1 to 3 of 3 entries.

Logged in as: Admin
https://dorsu-aquacycle.site/admin/dashboard

6. Manage Article:

Step 6.1:

Step 6.1: Navigate to the **Article** section from the sidebar to manage it. **Step 6.2:** Add new

Article:

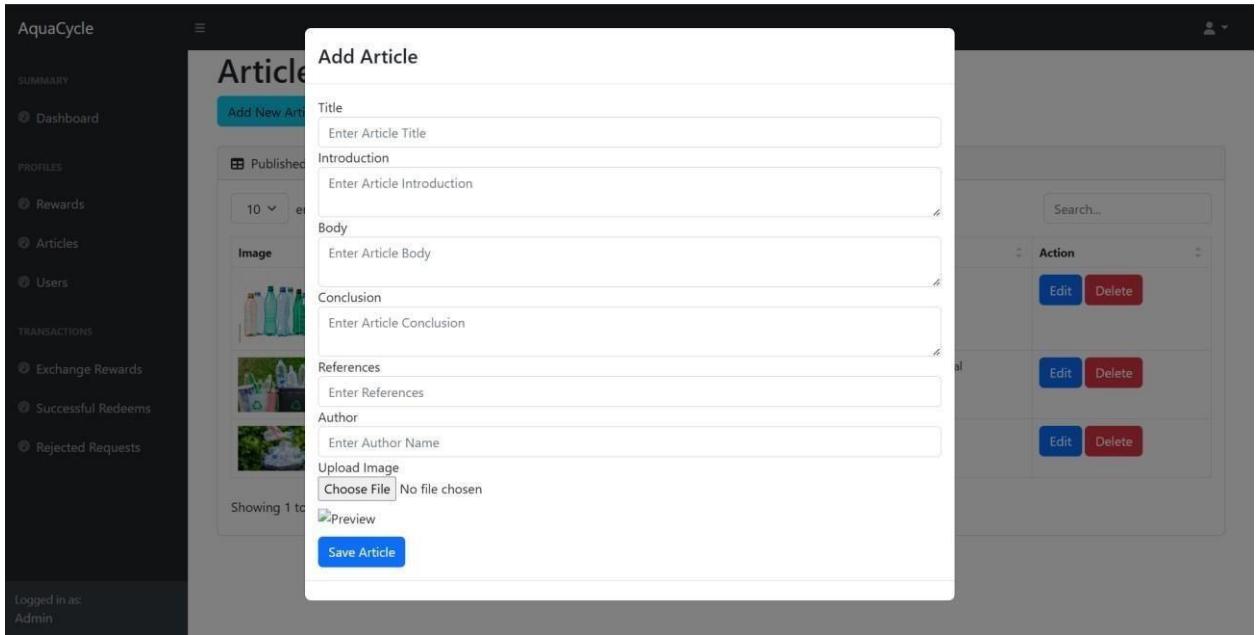
Click Add Article.

Fill in the article details, including Title, Introduction, Body, Conclusion, Reference and

Author.

Upload an image of the Article if applicable.

Click Save Article.



Step 6.3: Edit Article:

Click Edit.

Change article details that you want to change, including Title, Introduction, Body, Conclusion, Reference and Author.

Click Update Article to save.

Step 6.3: Click the Delete button to delete any article you want.

Successful and rejected:

Step 7.1: in the Sidebar menu you can view your successful exchange by Clicking “Successful Redemeems”

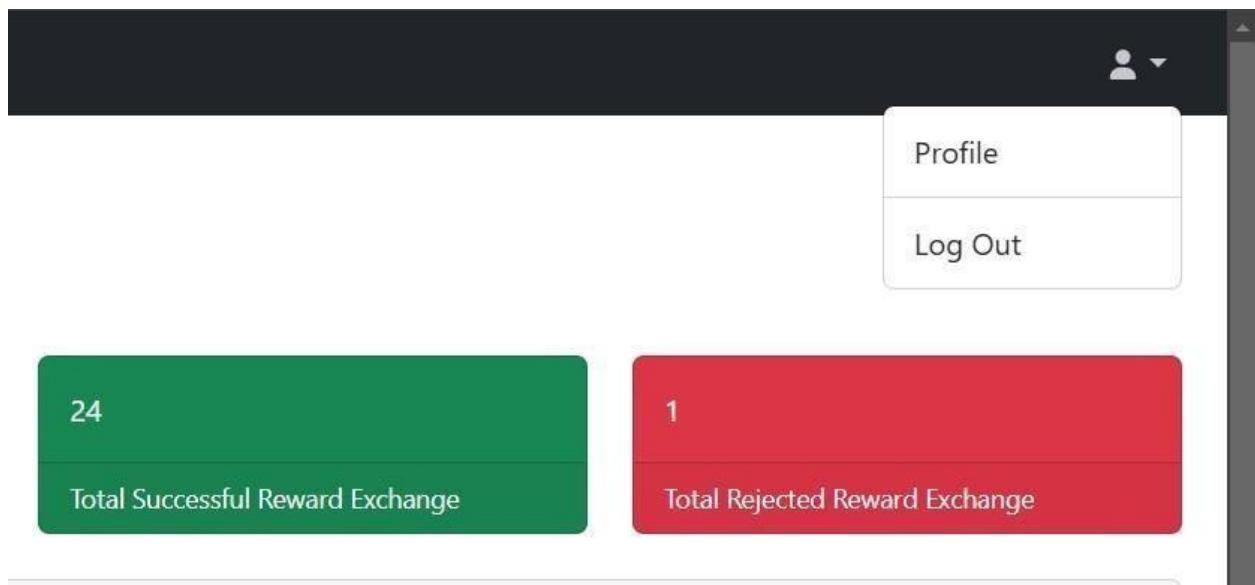
Redemeems”

Step 7.2: in the menu bar you can view your Rejected exchange by Clicking “Rejected Requests”

Logging Out:

Step 8.1: Click on your profile icon in the top-right corner.

Step 8.2: Select **Log Out** to securely end your session.



Appendix I

Curriculum vitae

