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Design and Development of the Mobile-Based Hydroponic Planting Machine Application MyHydro

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Abstract

In the contemporary era, technological advancements have significantly impacted various aspects of human life, offering increased efficiency and convenience. Indonesia, aiming to enhance international competitiveness, recognizes the importance of integrating technological innovation across economic sectors. Despite its abundant natural resources, Indonesia's vital agricultural sector faces challenges, including the limited adoption of modern technology, resulting in suboptimal productivity. This study focuses on addressing these challenges by developing the MyHydro mobile application, utilizing IoT and Progressive Web App (PWA) technology to enable remote monitoring and control of hydroponic systems. The research methodology includes literature review, user requirement analysis, system design, and black-box testing. Results show that MyHydro successfully bridges the gap between traditional farming practices and modern technology. Users can efficiently monitor and control hydroponic systems, enhancing crop yields and promoting sustainability in Indonesian agriculture. In conclusion, MyHydro offers a valuable solution to modernize Indonesian farming, aligning with global trends in smart agriculture. It empowers farmers and contributes to the nation's agricultural growth.

Keywords: Hydroponic Technology, Agriculture Innovation, Sustainable Farming, Remote Monitoring, Progressive Web App

1. INTRODUCTION

The advancement of technology in this contemporary era has had a significant impact on various aspects of human life. The rapid development of technology has brought us into an era where everything can be accessed and managed more conveniently and efficiently [1]. This has also resulted in tremendous benefits for society in carrying out various daily activities [2]. In Indonesia, in line with global changes and the drive to enhance international competitiveness, it is important to

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make technological innovation an integral part of various economic and industrial sectors [3].

Although the potential of technology to enrich and optimize specific sectors in Indonesia is immense, the agricultural sector, which historically plays a crucial role in the country's economy, still faces several serious challenges. Despite Indonesia's abundant natural resources and fertile agricultural land, productivity and efficiency in this sector often fall short of their full potential [4]. The lack of adoption of modern technology in traditional farming practices is one of the primary obstacles faced [5, 6].

The challenges related to the agricultural sector encompass various aspects, including efficient water resource management, weather control, accurate crop monitoring, and sustainable farming approaches that focus on resource conservation. In this context, an innovative solution that can integrate modern technology with farming practices becomes highly relevant [7, 8].

One promising solution is the use of technology-based hydroponic systems. This system enables more efficient, water-saving, and environmentally-friendly farming. However, for hydroponic systems to become more effective, better monitoring and control of various parameters such as temperature, humidity, light intensity, and plant nutrition are required.

The use of Internet of Things (IoT) and mobile applications is key to bringing this innovative solution to the Indonesian agricultural sector [9, 10]. With the development of remote-operated hydroponic planting machines through the internet and the related MyHydro mobile application, we can introduce a level of monitoring and control previously unattainable in hydroponic farming. This will not only enhance farming productivity and efficiency but also support the vision of sustainable agriculture.

Previous research conducted by Rismayani with the title "Design of Web-Based Hydroponic Plant's Room Temperature and Water Nutrition Monitoring System" aimed to implement a technology system for monitoring room temperature and water nutrition of hydroponic plants based on a web application. Using a web-based system design method, the results showed that the use of this system could help control the room temperature and water nutrition of hydroponic plants. In the implementation test of the system, feedback was obtained from 35 respondents, with 87.5% rating it as good, 9% as satisfactory, and 3.5% as not good [11]. This research supports the current study in the application of technology in the form of an application to assist hydroponic plant growth. The similarity lies in the monitoring of room temperature and water nutrition. However, this current research differs in the development of an application that

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can monitor and control these aspects through the app, including temperature, humidity, light intensity, and nutrition on each hydroponic shelf.

Another research study conducted by Rahib, titled "Sistem Pengendali pH Air dan Pemantauan Lingkungan Tanaman Hidroponik menggunakan Fuzzy Logic Controller berbasis IoT," discusses the creation of software and hardware systems to control water pH and monitor the environment of hydroponic plants based on the Internet of Things (IoT). The system was built using fuzzy logic control and utilized cloud server development to simplify farmers' control over the growing medium and hydroponic plant environment. The research resulted in pH meter sensor accuracy of 98.38%, DHT22 sensor accuracy of 97.91%, humidity accuracy of 95.89%, and accuracy of other sensors. Additionally, the use of the Blynk application worked well with an average server ping time of 18ms and an average device response time of 83s [12]. This research shares similarities in the application of IoT in system development. However, in that study, the focus was not on creating an application but rather on utilizing the existing Blynk application. This is a difference seen in the current research, which places more emphasis on system design and application development.

The MyHydro mobile application is a key element in this solution. This application is specifically designed to facilitate farmers or agricultural managers in monitoring and controlling hydroponic planting machines from their mobile devices, both Android and iOS. This application can easily monitor data such as temperature, humidity, light intensity, and nutrition on each hydroponic shelf. Additionally, the application help users to take direct actions, such as watering vegetables, adjusting humidity, controlling light intensity, and providing the necessary nutrients for plants.

Therefore, in the context of ongoing economic and technological development, the development of the MyHydro mobile application is a crucial step in supporting the growth of the agricultural sector in Indonesia. With this application, it is expected that farmers can optimize their hydroponic practices more effectively, improve crop yields, and achieve more sustainable farming. This application will provide significant benefits to the Indonesian society and strengthen the role of technology in driving innovation in the agricultural sector.

2. METHODS

This research aims to develop and test the MyHydro mobile application related to Internet of Things (IoT)-based hydroponic planting machines. The research method employed will encompass several crucial stages to ensure the development and testing of this application meet the requirements. The stages in this research method include literature review, user needs analysis, system design, and system testing.

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The first stage of this research involves conducting a literature review to gain a deep understanding of the concepts of hydroponics, IoT technology, Progressive Web Apps (PWAs), and existing mobile applications. A review of the technology and equipment available to support the development of this application will also be conducted.

Hidroponics is a method of cultivation that does not use soil as the growing medium. Instead, hydroponic systems utilize a special nutrient solution that is directly supplied to the plant roots, providing them with the necessary food and water, including nitrogen, phosphorus, potassium, micronutrients, and water [13].

IoT stands for the Internet of Things, a concept where various physical devices or objects around us (such as electronic devices, sensors, vehicles, household appliances, and many more) are connected to the internet and communicate, share data, and interact with the environment and users [14]. The primary goal of IoT is to provide greater intelligence and connectivity to these objects [15, 16].

PWA stands for Progressive Web App, which is a type of web application developed using modern web technologies with the aim of providing a user experience similar to native mobile apps but accessed through a web browser [17]. PWAs have become a popular solution in web development because they combine the advantages of native apps with the ease of web app development and distribution. The benefits of PWAs include reduced development costs, the ability to reach a broader user through the web, and improved user engagement [18, 19].

Mobile applications are software programs specifically designed to run on mobile devices, such as smartphones and tablets. Mobile apps can have various purposes and functions, and users can download and install them through official app stores on their devices, such as the App Store for iOS (Apple) or Google Play Store for Android devices. Mobile apps have become an integral part of many people's daily lives, helping them communicate, work, play, shop, and engage in various other activities. Over time, mobile apps continue to evolve with new features and advanced functionalities to meet the diverse needs of users [20, 21].

This second phase, which is the user needs analysis, particularly for hydroponic farmers or agricultural managers, is a crucial step in the development of the MyHydro application. This phase involves interviews and surveys to identify the most important features and functions in the MyHydro application. Interviews were conducted with several hydroponic farmers or managers in various locations in South Tangerang. From the interviews, it can be concluded that most farmers have not widely adopted technology, thus requiring significant labor and time to ensure their hydroponic plants receive the necessary nutrients. Therefore, the use of technology in the form of the MyHydro application can be a useful solution for farmers to monitor and control the nutrient needs of their hydroponic plants.

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The third stage involves designing the system using BPMN (Business Process Model and Notation) and UML (Unified Modeling Language) diagrams so that the application can be built to meet the identified requirements. Additionally, the design of the MyHydro mobile application is developed based on the analyzed needs and specifications. The development will encompass creating a responsive user interface, integrating with IoT sensors on the hydroponic planting machines, and setting up remote monitoring and control capabilities.

The next stage involves testing the initial prototype of the MyHydro application using existing hydroponic planting machines. The testing process is conducted with the aim of ensuring that the application can effectively monitor and control the machines. Testing in this research is performed using black-box testing. Black-box testing is a software testing method where the application developer tests the functions and features of an application without detailed knowledge of the internal code structure or how the application is implemented. In black-box testing, the primary focus is on the external behavior of the application and whether it meets the specified functional requirements [22].

The research method employed in this study enables the development of a targeted application, optimization of features and functions based on user needs, and ensures that the application can make a positive contribution to the hydroponic agricultural sector in Indonesia.

3. RESULTS AND DISCUSSION

3.1 BPMN

BPMN stands for Business Process Model and Notation. BPMN is a standard graphical notation used to document, design, and depict business processes in easily understandable diagram forms [23]. This notation was developed by the Object Management Group (OMG) and has become a widely adopted industry standard in the realms of business and information technology [24].

The application of BPMN involves using different symbols to represent elements within a business process, such as tasks, gateways, events, message flows, sequence flows, and more. BPMN diagrams can become quite complex with numerous elements interacting to depict a business process in detail [25].

In the case of the MyHydro application, BPMN was used to model and design the application's workflows and processes. This ensured that the application's features aligned with the needs of hydroponic farmers and agricultural managers. The resulting BPMN model for MyHydro is presented in Figure 1, offering a visual representation of the application's structured processes and interactions.

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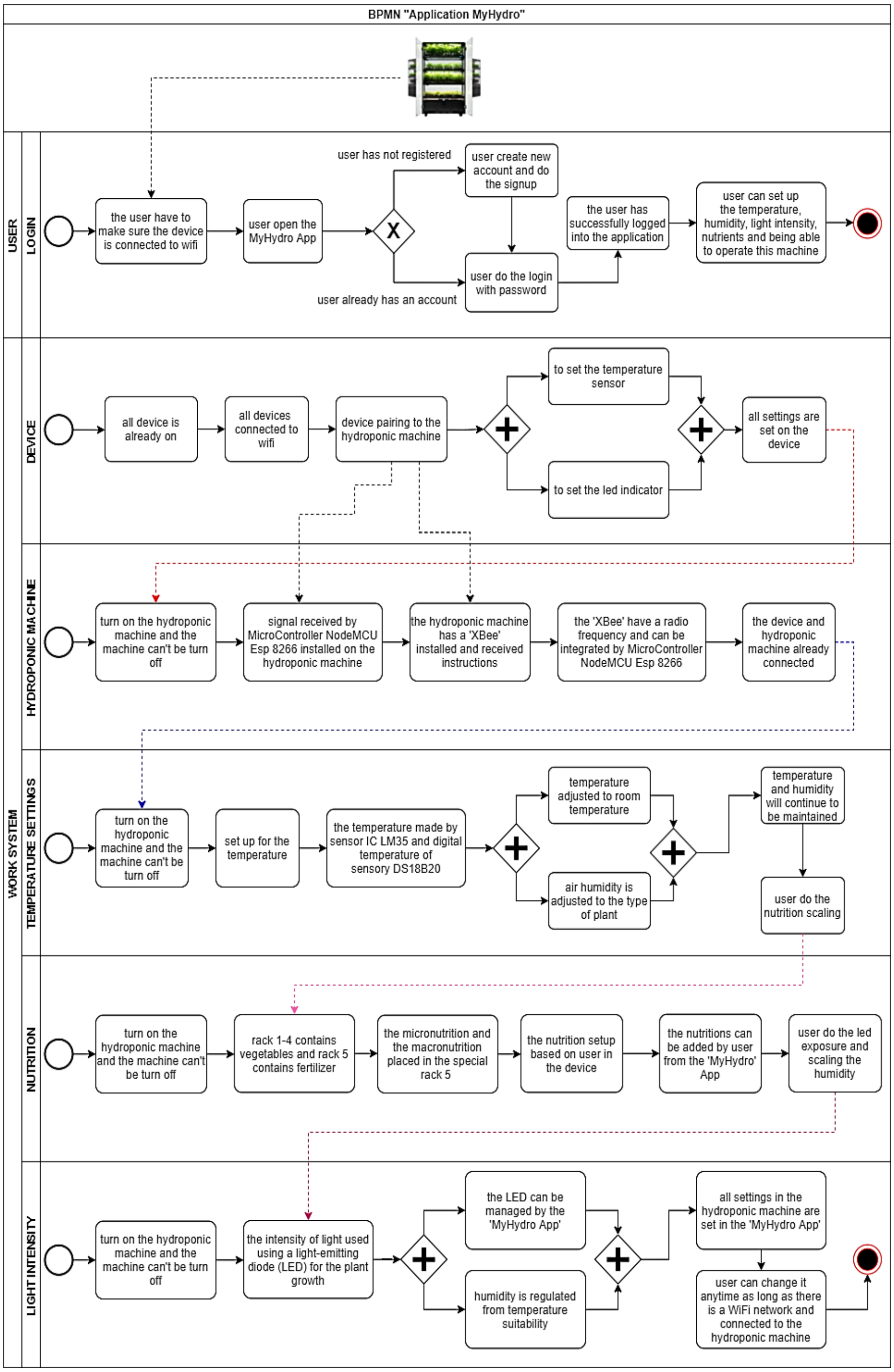

Figure 1. BPMN MyHydro Application

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At a high level, the MyHydro application process, as illustrated in Figure 1, starts with the user ensuring that all devices are powered on and connected to a pre-configured Wi-Fi network. It's also important to confirm that these devices have been successfully paired with the hydroponic machine.

Once these prerequisites are met, users can proceed to utilize the MyHydro application. Within the application, they gain access to a range of menus, including options for configuring settings such as temperature, humidity, light intensity, and nutrient levels. Moreover, the application allows users to operate the hydroponic machine seamlessly, enabling them to manage their hydroponic setup effectively.

3.2 Use Case Diagram

A Use Case Diagram is a component of the Unified Modeling Language (UML) frequently utilized in software development to illustrate a system's functionality from a user perspective. It's a type of diagram in system modeling that's employed to depict the interactions between external actors and the system being studied or developed [26]. For the design of a Use Case Diagram in the system being constructed, please refer to Figure 2.

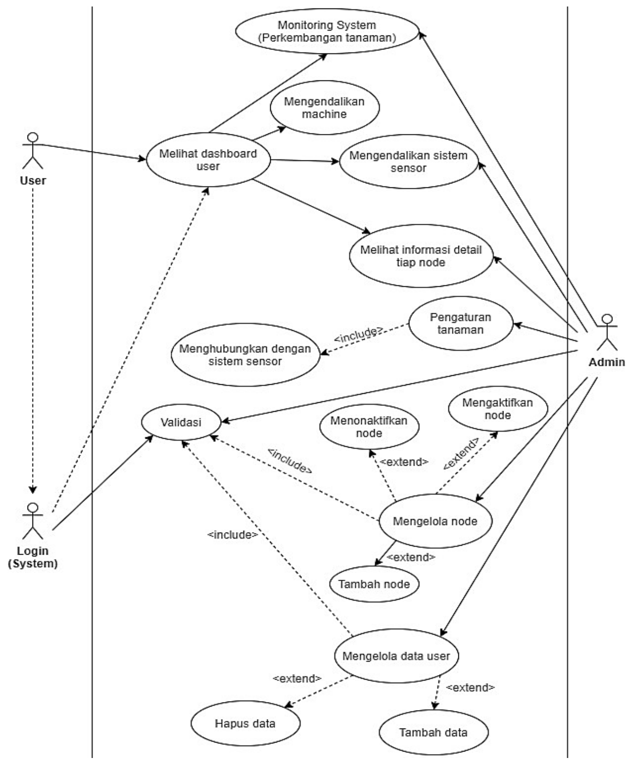

Figure 2. Use Case Diagram MyHydro Application

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As shown in Figure 2, the system exhibits two user roles within the application: "User" and "Admin." The "User" role serves the purpose of monitoring plant development, issuing commands, and controlling the hydroponic machine for tasks like watering the plants on each shelf, adjusting nutrient levels, temperature, light intensity, and humidity. Users can also manage the sensor system, which provides information about each plant's condition, allowing for remote monitoring and easy tracking of plant progress.

On the other hand, the "Admin" role possesses the same capabilities as a "User" but with additional administrative functions. Admins have the authority to oversee all the data within the MyHydro Application through an admin dashboard. This dashboard encompasses the management of sensor data, nodes, plants, and user data, giving administrators comprehensive control over the system's operation and data management.

3.3 Class Diagram

A Class Diagram is a visual representation used to illustrate the structure and relationships between classes (objects) within a software system. This diagram provides a visual depiction of the entities in the system and how they interact with each other [26]. The design of the Class Diagram for the system can be observed in Figure 3.

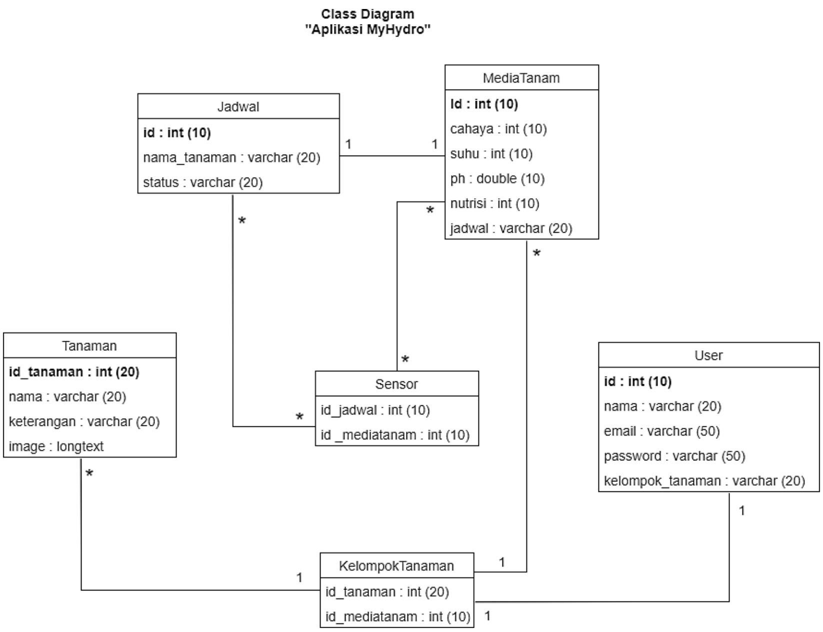

Figure 3. Class Diagram MyHydro Application

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The system incorporates several pivotal classes that collectively define its structure and operations. The "User" class serves as a repository for user data, encompassing individuals with access to the application. In contrast, the "Tanaman" class (Plant) holds comprehensive information about individual plants within the system, including their names, images, and specific requirements such as light, temperature, pH, and nutrient needs. "KelompokTanaman" (Plant Group) is responsible for organizing plants into logical groups, streamlining management. The "MediaTanam" class (Growing Media) focuses on the growing medium used for the plants, detailing its composition and properties. "Jadwal" (Schedule) plays a vital role in task scheduling and monitoring for the hydroponic machine, ensuring timely care for the plants. Finally, the "Sensor" class captures data from various sensors and provides essential feedback, contributing to effective monitoring and control processes for the hydroponic machine. Together, these classes establish the system's foundation, enabling seamless data organization, management, and critical interactions for successful hydroponic plant cultivation and system operation.

3.4 Application Design

The MyHydro application is developed as a multi-platform solution accessible through both mobile and desktop platforms using Progressive Web App (PWA) technology. In the concept of PWA, the primary role is played by the service worker. The service worker is responsible for handling fetch events from the browser, then deciding whether the request will be forwarded to the server or retrieved from the cache, depending on the online or offline network status.

The implementation of PWAs in applications relies heavily on JavaScript code. JavaScript is the programming language of choice for building the logic that drives service workers, caching strategies, and other core functionalities of PWAs. It enables developers to create and customize service workers, allowing them to tailor the behavior of these service workers to suit the specific requirements of their applications. By leveraging JavaScript, developers can optimize the caching strategy and ensure that it aligns with the nature of the application and the preferences of its users. The caching strategy typically used by the service worker is the network-first method and cache fallback. By using this strategy, the service worker can check for responses when the network provides new data, and if successful, it will present the latest data to the browser. In case of failure, the service worker will retrieve data from the cache. The implementation of PWA in applications is done using JavaScript code, which can be seen in Sourcecode 1 and Sourcecode 2.

Sourcecode 1. Registers a Service Worker

```
if ('serviceWorker' in navigator) {
    navigator.serviceWorker.register('sw-myhydro.js')
        .then(registration => {
            //service worker berhasil dijalankan
            })
        .catch(error => {
            alert('Service Worker registration failed:', error);
        });
}
```

Sourcecode 2. File sw-myhydro.js for caching assets and handling offline access

```
self.addEventListener('install', event => {
    event.waitUntil(
        caches.open('myhydro-v1')
          .then(cache => {
            return cache.addAll([
                '/',
                'index.php',
                'styles.css',
                'app-myhydro.js'
            ]);
        })
    );
});


self.addEventListener('fetch', event => {
    event.respondWith(
        caches.match(event.request).then(response => {
            return response || fetch(event.request);
        })
    );
});
```

Source code 1 is a portion of the content in the app.js file that is used to activate the service worker. In this code, the service worker for the MyHydro application, previously created, is checked to examine whether it contains memory cache data related to the application's installation on the device. Source code 2 is part of the content in the sw-myhydro.js file, which includes the reading of the device's cache. The program will inspect the device's cache and determine application can be accessed offline or online. The outcome of the application development in this research includes several pages with various features. The initial page of the MyHydro application can be seen in Figure 4.

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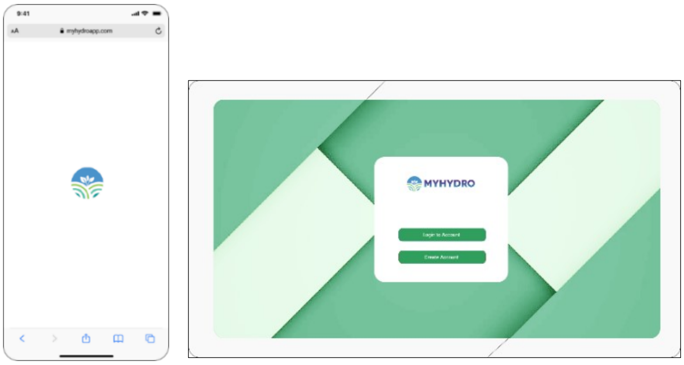
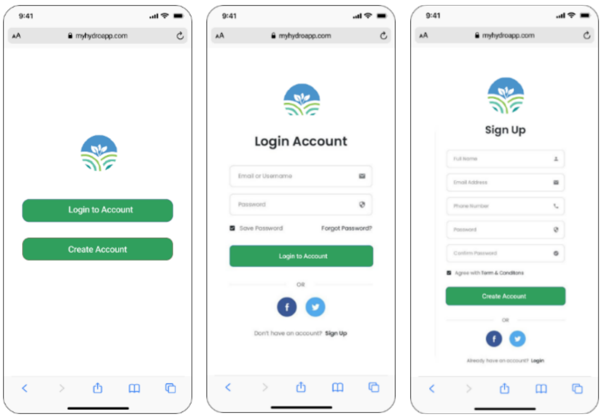


(a) (b)

Figure 4. MyHydro Application Main Page (a) Mobile (b) Web

As seen in Figure 4, there is the main page of the MyHydro application when accessed for the first time on both mobile and web platforms. The primary page for the mobile platform is a splash screen displaying the MyHydro Application logo, while the main page for the web platform is the login page. On the mobile platform, after passing through the splash screen, the application will display the login menu selection page, as depicted in Figure 5.



(a) (b) (c)

Figure 5. Login Menu Options Page (a) Login or Create (b) Login Account (c) Sign Up

As depicted in Figure 5, if a user already has an account, they simply need to press the "Login to Account" button. However, if a user does not have an account, they can press the "Create Account" button. To create an account, users are required to complete all the fields, including full name, email, phone number, and password. Additionally, users must agree to the terms and conditions outlined in the application by checking the corresponding checkbox. In this application, users also

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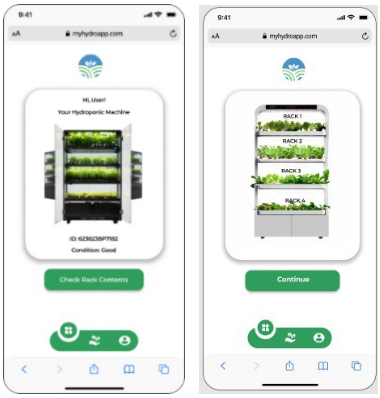
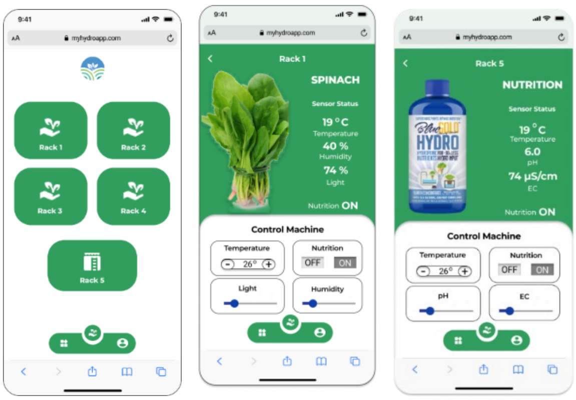
have the option to register using their social media accounts, such as Facebook or Twitter. After completing the registration, users can log in to the application and access the application's home page, as shown in Figure 6.



(a) (b)

Figure 6. Home Menu Page (a) Machine (b) Check Rack Contents

In Figure 6, we have the home menu page within the MyHydro application. The application features three main menus at the bottom that users can access: the home menu, the rack control menu, and the profile menu. On the home page, the connected hydroponic machine is displayed, including its machine ID and current status. If not yet connected to a machine, the application will prompt users to connect to an available hydroponic machine. Users can also view the racks of the machine by pressing the "Check Rack Contents" button, which displays the contents of all the racks, indicating whether they are filled or not. The next menu is the rack control menu, shown in Figure 7.



(a) (b) (c)

Figure 7. Rack Control Menu Page (a) Rack List (b) Rack 1 Detail (c) Rack 5 Detail

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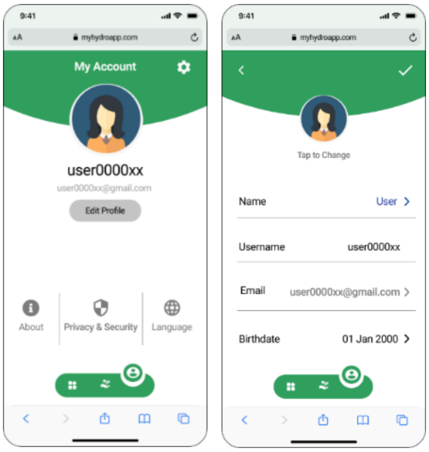
Figure 7 represents the rack control menu page, which features the plant-related functionalities of the MyHydro application. When a user selects one of the racks from the list, they are directed to a detailed page displaying information about sensor status and control access to the machine on each rack. The machine access control can be utilized anytime and anywhere, allowing users not only to monitor plant growth but also to nurture and manage their development.

The contents of each rack follow the model of the rack in use. For example, in Figure 7, racks 1 through 4 contain plants, while rack 5 contains nutrients. For racks containing plants, users can adjust temperature, humidity, light, and nutrition sensors. As for rack 5, which serves as a nutrient reservoir (containing several types of fertilizers or liquid nutrients), users can configure temperature, pH, EC, and nutrition sensors to ensure the stability of nutrients in the reservoir, providing essential nutrition for the vegetables in each rack. The next menu within the application is the profile menu, as seen in Figure 8.



(a) (b)

Figure 8. Profile Page (a) View Profile (b) Edit Profile

In Figure 8, the profile page is displayed, containing user-related information and several other submenus such as "About," "Privacy & Security," and "Language." When users press the "Edit Profile" button, they are directed to the edit page. On the edit page, users can change their profile picture, name, email, and date of birth. The username field is readonly and cannot be altered. For a clearer understanding of each submenu within the profile menu, please refer to Figure 9.

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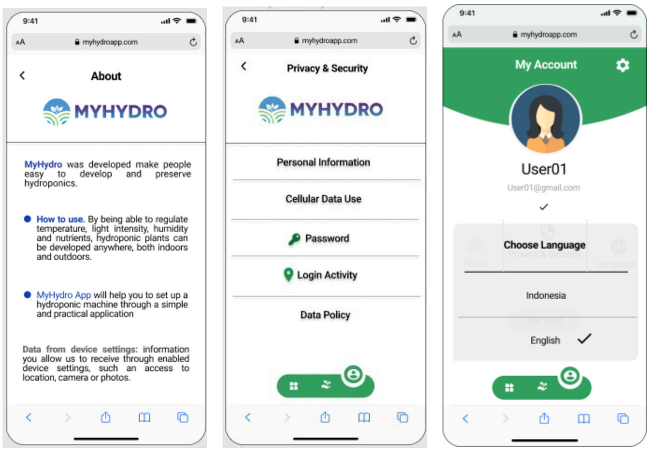

(a) (b) (c)

Figure 9. Profile Sub Menu Page (a) About (b) Privacy & Security (c) Choose Language

In Figure 8, there are submenu pages within the profile menu. The first one is the "About" page, which provides detailed information about the application, how to use it, and what features are available in the MyHydro application. The second submenu is the "Privacy & Security" page, which explains the terms and rules within the application, as well as an explanation of the data that the application will collect and require, such as personal information, cellular data use, password, login activity, data policy, and more. The third submenu is the "Language" page, which allows users to change the language for ease of use. There are currently two language options available, which are Indonesian and English. The testing process conducted in this research involves black-box testing, as outlined in Table 1.

Table 1. Black-box Testing Result

No	Testing Scenario	Expected Outcome	Test Result	Status
1	Empty one or all fields during the Create Account	The system displays an error message	An error dialog appears saying "Please fill out all fields"	Valid
2	Enter an email that is already registered in the application during the Create Account process	The system displays an error message	An error dialog appears saying "Email is already registered"	Valid
3	Fill out all fields during the Create Account process	Fill out all fields during the Create Account process	A message dialog appears saying "Account registered successfully." Then,	Valid

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No	Testing Scenario	Expected Outcome	Test Result	Status
			it redirects to the Login page	
4	Enter an incorrect username and password during the Login to Account process	The system displays an error message	An error dialog appears saying "Account information is incorrect"	Valid
5	Enter a registered username and password during the Login to Account process	The system redirects to the Home page	The Home page is displayed	Valid
6	Click the Check Rack Contents button on the Machine page in the Home	The system displays the rack list	A list of all racks, whether filled or empty, is displayed	Valid
7	Click on one of the Racks in the Rack Control menu	The system displays the rack details	Rack details such as plant/nutrient details, sensors, and rack control are displayed	Valid
8	Change the machine control settings on one of the racks	The system saves the changes in control settings, and the machine adjusts to the latest control settings	The machine operates the control settings according to the user's input	Valid
9	Change the language to another language	The system changes all language elements to the selected language	The system changes all elements to the selected language	Valid

The testing results as seen in Table 1 show that all 9 testing scenarios have a "Valid" status, meaning they are in line with the expected outcomes. This indicates that the MyHydro application has been thoroughly tested and meets the standards set by the application developers, making it suitable for general use. Consequently, the MyHydro application is now capable of aiding farmers in managing hydroponic systems and simplifying their tasks.

4. CONCLUSION

The MyHydro application represents a significant step forward in the realm of modern agriculture, particularly in the context of hydroponic farming. Developed

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as a multiplatform solution accessible through both mobile and desktop platforms using Progressive Web App (PWA) technology, this application offers a range of features designed to empower farmers and agricultural enthusiasts.

One of the standout features of MyHydro is its user-friendly interface, which has been designed with the user's convenience in mind. Users can easily create accounts, manage their profiles, and switch between languages, ensuring accessibility for a diverse user base. This approach to inclusivity is particularly important in promoting the adoption of innovative technologies within the agricultural sector.

The application's core functionality is centered around monitoring and controlling hydroponic systems. MyHydro provides detailed information on plant conditions, nutrient levels, and various environmental parameters for each rack. This level of granularity allows users to make informed decisions about their farming practices, leading to improved crop yields and resource efficiency.

The rigorous testing process, as evidenced by the 9 testing scenarios with "Valid" status, demonstrates the application's robustness and reliability. It complies with the high standards set by the developers, making it not only a practical tool for hydroponic farmers but also a reliable one.

MyHydro has the potential to revolutionize hydroponic farming in Indonesia. By bridging the gap between traditional agricultural practices and modern technology, it provides a pathway to sustainable and efficient farming. This integration of technology into agriculture aligns with the broader global trend of smart farming, where data-driven decision-making and automation contribute to enhanced productivity and environmental stewardship.

The MyHydro application offers a promising solution for hydroponic farming in Indonesia. Its comprehensive feature set, user-friendly interface, and rigorous testing make it a valuable tool for those looking to optimize their farming practices, increase crop yields, and contribute to the development of a more sustainable agricultural sector. This application will provide significant benefits to the Indonesian society and strengthen the role of technology in driving innovation in the agricultural sector.

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