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Seedling and Seed Ordering System: A PWA Prototype Implementation

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Abstract

Air pollution in urban areas is a significant global challenge, and Jakarta is one of Southeast Asia's most polluted major cities. Efforts to address this problem are through the greening of urban areas. The Jakarta Special Region Seed and Plant Protection Development Center (PPBPT) is vital in providing and distributing plant seeds to the community. However, ordering manual seeds is still a significant obstacle to effective and efficient distribution. This research aims to develop a prototype application of Progressive Web Applications (PWA) based seed and seed ordering information system. Using the Extreme Programming (XP) method in this research, the PWA application provides a new perspective to accelerate the handling of urban environmental problems while providing reliable public digital services. The application development cycle with the XP method produces good software with faster turnaround time, lower costs, and responsiveness to user needs. The research results in an information system prototype application with various functions, such as user registration, identity verification, seedling ordering, stock management, and order history. The system proved to automate the seedling ordering process significantly, thus improving stock management efficiency and seedling distribution in 18 gardens under PPBPT. Indirectly, the results of this research support urban greening and contribute to improving air quality in Jakarta. Furthermore, the application can be developed by adding various forms of digital technology to help urban greening in different forms of support or other public service applications.

Keywords: Progressive Web Application (PWA), Extreme Programming (XP), Seedling Ordering System, Greening

1. INTRODUCTION

Air pollution has become a significant issue in the context of environmental health globally, especially in densely populated urban areas. Poor air quality worldwide causes more than six million deaths annually, at an economic cost of more than $8 trillion, exceeding 6.1% of global GDP [1]. According to IQAir's 2022 world air quality report, Indonesia ranks as the country with the worst air quality in Southeast Asia, with an air pollution level of 30.4 µg/m3; Jakarta is the city with the worst air pollution in Indonesia, at 36.2 µg/m3 [2]. One of the efforts to reduce high air pollution is through greening programs in urban areas; trees in more polluted areas

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are more effective in removing air pollution than trees in environments with better air quality [3].

The Jakarta Special Region Provincial Seed Development and Plant Protection Center (PPBPT), as a UPT of the Ministry of Forestry and Agriculture of the Republic of Indonesia, is an institution that has a strategic role in ensuring the availability and distribution of superior seeds for the agricultural, horticultural and forestry sectors in urban areas. Through the existence of 13 nurseries spread throughout the Jakarta area and various programs, PPBPT has significantly contributed to maintaining the balance of the ecosystem and reducing air pollution in the city of Jakarta. One of the services PPBPT provides is accepting applications for free seeds and seedlings for all residents and institutions in the Jakarta area. The service program will increase the green area in the Jakarta area and increase community involvement, and educational approaches to sustainable agriculture and forestry are becoming increasingly important. Even though it has used Google Forms, the community's service of ordering seeds and seedlings still needs to be managed manually, not using an information system with an integrated database. PPBPT operators who handle seedling and seed orders have to manually check the stock of seeds from 18 nurseries, process data, recapitulate orders from Google form entries, and confirm to orderers manually. From the community's perspective, the current ordering system needs more information about the seedlings ordered. This condition provides challenges and obstacles for PPBPT in delivering faster and more efficient seedling ordering services for Jakarta residents. Another obstacle is that the availability of order information and seedling data on the 18 gardens below is not updated, so it cannot be used as a basis for making decisions and policies in developing PBPPT.

Based on Indonesia's Population projections from 2020-2035 from the 2020 Population Census, the Population of Jakarta in 2024 reached around 10.68 million people [6]. This large Population provides a challenge for PPBPT in delivering fast, efficient, and reliable seed ordering services, so a digital information system is needed to increase the efficiency and effectiveness of the seed and seed ordering process for the people of Jakarta. In addition, this research has urgency in efforts to expand digital transformation at PPBPT through automation of seed and seed ordering services as a progressive step to answer the challenges of the times and meet the increasingly high expectations of the community towards the ease of accessibility of seed and seed ordering services which will ultimately increase the contribution of the agriculture and forestry sector to a healthy ecosystem in the city of Jakarta as part of sustainable development in Indonesia.

This research aims to produce an initial version of a seedling and ordering information system equipped with database management. This will improve operational efficiency, data accuracy, and transparency, accelerating business

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processes and improving seedling ordering performance at PPBPT. Implementing modern information systems can reduce data processing time by 60% and reduce data error rates by 40% [4]. The next objective of this research is that the output data from the information system benefits PPBPT in collecting, organizing, and analysing seedling and seed order data, which can generate insights that support innovation and continuous improvement. Recent research shows that the integration of technologies such as the Internet of Things (IoT) and data analytics into information systems can help improve operational efficiency and drive decisions based on real-time data analysis [8],[9]. In addition, implementing data-driven systems allows companies to optimize their business strategies, such as defining customer segments and improving value propositions through more scalable and responsive decision-making [5],[6].

The use of PWA technology in this research for the seedling and seed ordering system at PPBPT provides convenience for the community in accessing plant ordering and distribution services quickly and efficiently without the need for special applications. PWA technology improves accessibility as it can be accessed through various devices, including low-specification mobile phones, and works offline once installed. This is important to ensure that people from all economic backgrounds can actively participate in urban greening programs. Urban greening has been proven effective in absorbing pollutants such as PM2.5 and carbon dioxide (CO^2), improving air quality in urban areas. Research shows that urban green spaces can reduce pollutant concentrations by up to 65% in some places and have a significant impact on lowering ambient temperature [7]. In contrast to some previous research on the design or development of PWA systems, this research has used agile development methods that use extreme programming to speed up the process and results without reducing the quality of the application itself. This differs from previous studies that used traditional development approaches such as UML [8], Water Fall [9], [10], or the final output is only limited to application design [11]This research also uses a prototype model with the advantage of fast implementation time. Still, it can produce all the primary interfaces and features needed, as well as less user involvement and more concise system development procedures than other development models [12]. The design of PWA-based application prototypes for Government agencies' public services, especially in the environmental field, is a novel aspect of this research, complementing several PWA studies in the health sector [13], Chemistry [14], health management [15], education [11] and finance [8].

2. METHODS

This study's research and prototype development method uses the extreme programming (XP) approach, which is part of the agile development method. Agile development methods ensure that customer needs are always heard at all points in

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the development process and maintain the integrity of that information for system sustainability and adaptation to changes in the system and its environment [16]. The XP method allows for a quick reaction to changes before the application is completed, which is essential for developing software. [17]. XP is one of the most popular Agile methodologies, emphasizing intensive communication, rapid feedback, and simplicity in design. [18]. The extreme programming method has four stages that must be passed [19], namely:

a. Planning: At this stage, a needs analysis is carried out, and user stories are created that describe the output, features, and functions of the software to be developed. In this study, user stories focused on seedling data and catalog, ordering process, and seedling stock management. The research and development team worked closely with users to determine the prioritization of user stories, which were then grouped for incremental delivery iterations.
b. Design: The design stage in XP follows the Keep It Simple (KIS) principle. Extreme Programming will use Spike Solution for complicated designs directly related to the goal. For example, the user interface design in user seedling ordering is created with a simple design that can be tested and evaluated by users, thus allowing for quick improvements based on user feedback. Extreme Programming also supports refactoring, where the software system is changed to change the structure of the code and simplify it, but the code's results do not change.
c. Coding: At this stage, the coding process begins with building a series of unit tests. After that, the developer will focus on implementation. Extreme Programming is known as Pair Programming, where the process of writing programs is done in pairs. Two programmers work together on one computer to write the program. This allows for real-time problem-solving and real-time quality assurance. In this study, application development used four programmers, each working on 13 program code modules in pairs.
d. Testing: This stage tests the code in unit tests. In Extreme Programming, this is known as the XP acceptance test, commonly called the customer test. The customer performs these tests, focusing on the features and functions of the system as a whole. These acceptance tests are derived from implemented user stories [20]. In this phase, testing uses the black-box method, where testing is done without knowing the internal structure of the code but focuses on the functionality generated according to the user's story. The PPBPT seedling ordering operator conducts the acceptance test, ensuring the system meets the requested needs. Then, the system is evaluated and improved periodically, allowing for system enhancements according to user feedback during the development process.

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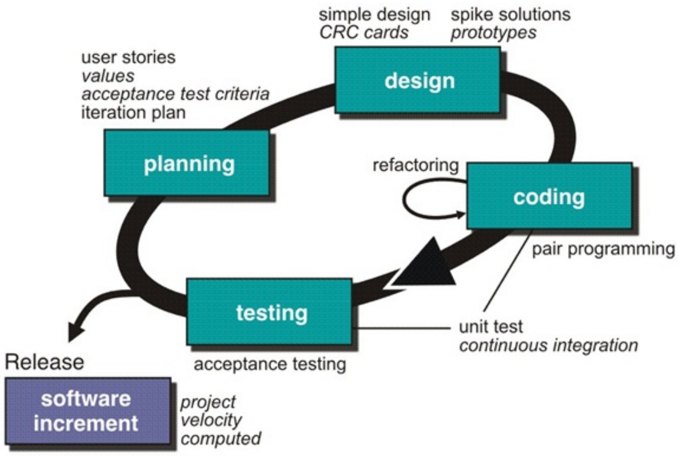

Figure 1. Extreme Programming Process [19]

Communication is vital in XP. The development team and the client must constantly dialog to ensure that the developed product meets the user's needs. Therefore, during the research and development process, the PPBPT seed and seed ordering information system application utilizes cloud server technology so that communication, testing, and feedback related to the application being worked on can run quickly and effectively. Rapid feedback is obtained through short development iterations, lasting one to two weeks. At the end of each iteration, a working prototype module is immediately piloted and evaluated by PPBPT operators. This allows the team to adjust based on feedback before investing too much time and resources. The XP development method can produce good software with faster turnaround times and lower costs than traditional methods. The XP development method can produce good software with a quicker turnaround time and lower cost than conventional methods. The XP research method emphasizes a development process more responsive to user needs than traditional methods while building better-quality software. [21]The final product of this research is a prototype of a seedling ordering system using the Progressive Web Application (PWA). The prototype is an intermediary for developers and users to interact in information system development activities. [22].

3. RESULTS AND DISCUSSION

3.1. Planning

Several functional and non-functional requirements were identified in the planning stage of developing a PWA prototype for the seedling ordering system at PPBPT Jakarta. Individual and institutional users must undergo a registration and

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verification process using ID cards, with a maximum order limit of 2 seedlings per individual and ten seedlings per institution per year. The Head of the Garden does stock management, while PPBPT centrally monitors the stock of the 18 nurseries under its responsibility. The community orders seedlings through a Google form link, and the PPBPT operator must contact the garden manager by phone or physical visit. This often causes delays in ordering due to limited information on seedling stocks in all existing gardens. With the new system, users can access real-time stock information across 18 nurseries in Jakarta, facilitating the distribution and tracking of seedlings from users and managers. The system should record order history, send notifications via WhatsApp, and be available 24/7 with data encryption. The application should also be responsive and easy to use on various devices. Prioritization in prototype development:

1) User Registration and Verification - Implementation of registration with ID card upload and validation by operator.
2) Seedling Ordering - Setting order limits (2 seedlings per individual, ten seedlings per institution) and integrating institution application letters.
3) Stock Management - The Farm Head does input, stock updates, and centralized reporting.
4) Notifications - Integration with WhatsApp API for seedling-picking notifications.
5) Data Security - Implementation of encryption to protect ID card data.
6) Booking History - Users store and access the booking history.
7) Scalability and Performance - Optimize the app to accommodate thousands of users and respond to high traffic.

3.2. Design

At this stage, the author begins to design the system according to previously summarized user needs. The author uses system tools such as Use Case Diagrams, Activity Diagrams, and ERD, as well as application interface design.

1) Use Case Diagram

The use case diagram presented in Figure 2 above illustrates the interaction in the system, which has three main actors: UPT Admin, Garden Admin, and Community. The UPT Admin is responsible for management functions such as logging in, maintaining user data, verifying documents, managing articles and news, viewing reports, and maintaining seedling stocks. The Garden Admin monitors and updates seedling stocks and views reports on the gardens they manage. As the application user, the community can register, update their profile, order seedlings, and monitor their order status. The interaction between these actors is centered on the flow of seedling request management, stock management, and document verification, which ensures a well-coordinated system.

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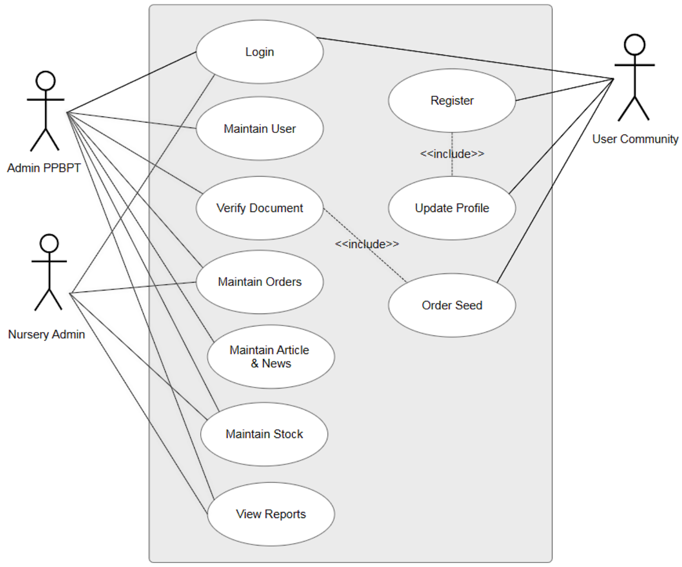

Figure 2. Use Case Diagram

2) Activity Diagram

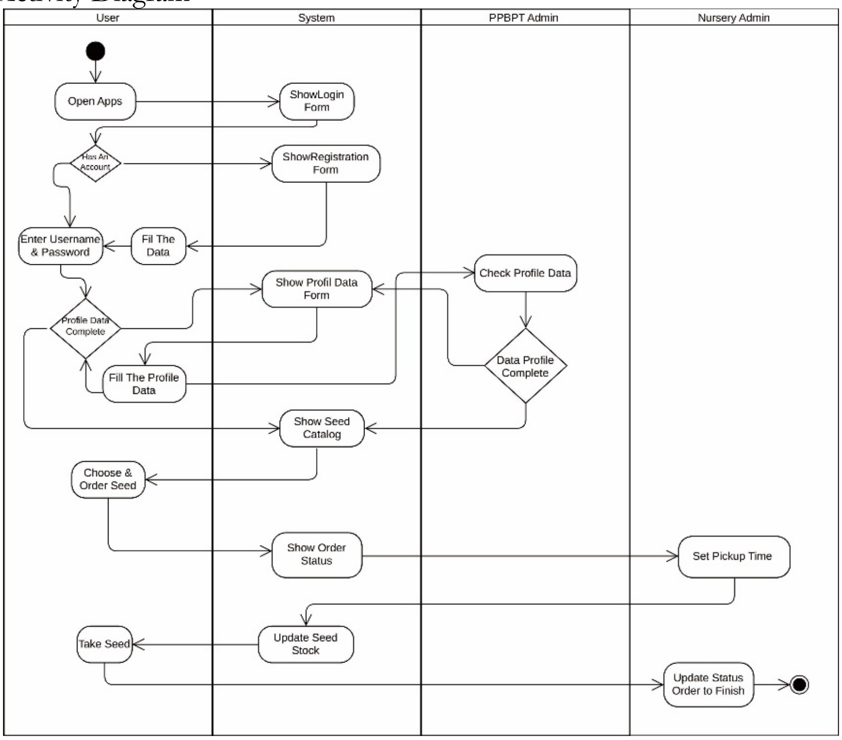

Figure 3. Activity Diagram

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Figure 3 activity diagram illustrates the workflow of the seed and seed ordering system at the Center for Seed Development and Plant Protection (PPBPT) involving four actors: User, System, Operator, and Garden Admin. The process starts with the user accessing the application and logging in. After successfully logging in, the user selects the desired seeds, and then the system will display a list of seeds and proceed to the order page. After that, the user completes the order data and sends a seedling request. The Operator then verifies the request and validates the user data. If the data is valid, the Garden Admin approves the request to process the seedling preparation. Once the seedlings are ready for pickup, the system will notify the user to pick them up. This flow is designed to ensure that the ordering process is structured and coordinated and can be monitored by the parties involved, from users and operators to garden managers, to optimize seedling distribution.

3) Entity Relationship Diagram (ERD)

The ERD, as shown in Figure 4, illustrates the database structure of the seedling and seed ordering system, which consists of several main tables, such as seedling category, seedling stock, user, seedling order, and garden. Each table is connected to a relation that describes the interaction between entities. For example, the seedling order table is connected to the user and farm tables, which allows the system to record who placed the order, the type of seedlings ordered, and from which farm the seedlings will be taken. The seedling stock table contains information about the amount of seedlings available in each garden, while the seedling category and seedling type tables organize the types of seedlings available. This ERD helps visualize how different data in the system relate to each other and efficiently supports the application's stock management, ordering, and reporting functions.

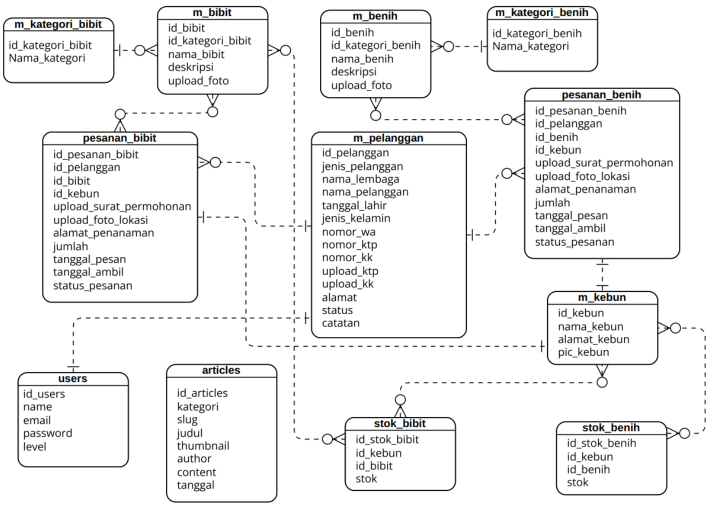

Figure 4. Entity Relationship Diagram

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4) System Interface Design

Figure 5 shows three Seedling and Seed Request Information System application interface designs. After logging in, the application will display a seed catalog, where users can view a wide selection of available seed products, with a "Select" button below each product to start the ordering process. Once the user has selected a product, the application will display more information about the product, including a description and other information. This page also has an "Order Seedlings" button to continue the ordering process. Users can view their order progress after ordering seeds or seedlings, with order statuses including "Awaiting Confirmation," "Processing," "Ready to Pick Up," and "Received," which makes it easy for users to monitor the status of the seeds they have ordered.

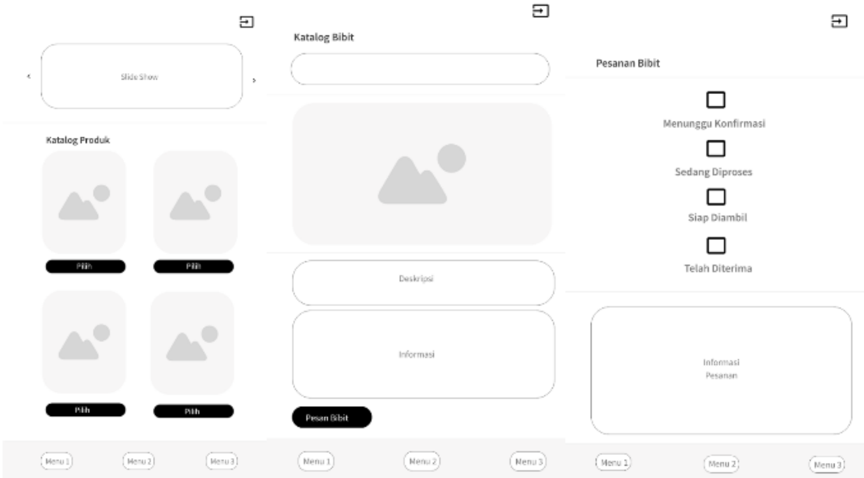

Figure 5. Interface Design

5) Coding

In the coding stage, the Seedling and Seed Application Information System application was developed using the Laravel framework, and the coding approach followed the Extreme Programming (XP) method. The coding process begins with building a series of unit tests for each main feature, such as user registration, seed ordering, stock management, and notifications. These unit tests ensure that each part of the code works according to the needs and specifications set during the planning stage. After the unit tests are created, the focus shifts to implementing the code that runs the application's business logic.

Also, in XP, pair programming is the process in which two programmers work in pairs on one computer to write code collaboratively. In developing this application, Pair Programming was applied to improve code quality and speed up problem-solving. One programmer writes the code, while the other monitors, provides feedback, and identifies potential problems. This enables real-time problem-solving and quality assurance so that errors in the code can be immediately

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identified and corrected. This approach allows applications to be developed iteratively and efficiently while minimizing bugs during further testing.

6) Testing
The testing phase in developing the Seed and Seed Application Information System application follows the XP method, where testing is carried out iteratively along with the development of application features. The test used is the Blackbox Testing method, where testing focuses on system functionality without knowing the internal details of the code. This test ensures that each feature runs according to the requirements determined during the planning stage. Each feature is tested to ensure the input produces the expected output. In the XP method, pre-prepared unit tests are run after the code is implemented to verify each application part. Testing is done iteratively until each feature functions properly. The following table describes the testing for each feature in the application using the Blackbox Testing method:

Table 1. Black Box Testing Result

Features	Test Case	Input	Expected Output	Status
Front End	The user opens the app and navigates the menu	Access to the main page	The main page opens, and navigation works	Pass
Dashboard Backend	Admin opens dashboard	Login as admin	Open the admin dashboard with full access	Pass
User Login and Profile	The user logs in and changes the profile	Username, password, profile data	The user successfully logged in, and the profile was updated	Pass
Customer Master Data	Admin manages customer data	Add/edit/delete customers	Customer data successfully added/edited	Pass
Farm Master Data	Admin manages garden data	Add/edit/delete garden data	Garden data managed successfully	Pass
Seeds and Seeds Master Data	Admin adds and updates seed data	Add/edit seedlings/seeds	Seed data is successfully saved	Pass
Stock Management	Head of Garden updates seedling stock	Stock quantity input	Seedling stock successfully updated	Pass

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Features	Test Case	Input	Expected Output	Status
Order Management	The operator processes the user's order	User order input	Order processed successfully	Pass
Order Transaction	User orders seedlings	Seedling selection, order confirmation	Order successfully placed and recorded	Pass
Stock Report	Admin displays the seedling stock report	Report access	Stock report successfully displayed	Pass
Order Report	Admin displays the order report	Report access	Order report successfully displayed	Pass
Article Management News	Admin adds and manages articles/news	Add/edit articles	Article successfully added or updated	Pass

Table 1 tests each feature with a series of test cases to ensure its functionality. The tests are performed by providing inputs according to user scenarios, and the expected outputs are checked to ensure conformity with the system specifications. Iterative testing is performed until all features pass testing and are ready for use. This method allows for quick and efficient error detection and correction using XP's principles of maintaining application quality and reliability.

7) Release and Implementation

The seedling and ordering system application prototype has been successfully implemented using the Laravel framework. The application results show that this system successfully automates the entire flow of seedling ordering that was previously done manually. The user registration and verification feature through ID card upload works well, allowing operators to validate data quickly. In addition, an ordering system equipped with order quantity limits was successfully implemented, and users can easily monitor their order status through a responsive interface. Centralized stock management by farm heads in 18 nurseries was also successfully implemented, allowing real-time seedling stock information to be updated. Seedling pickup notification through WhatsApp API integration runs smoothly, making it easy for users to know when their seedlings are ready for pickup.

Overall, the prototype system succeeded in improving the efficiency of the seedling ordering process at PPBPT, both from the user and manager sides. The system

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offers an effective digital solution, allowing seedling stock management and distribution to be more organized and monitored. The practical output of this research is that a PWA-based system can provide a user experience similar to a native application but with lower development and maintenance costs. Figures 6 and 7 are screenshots of the application from the user side of the operator or admin and the community as users or seedling orderers. PWA technology enables a faster, smoother ordering experience; some features can even be used offline.

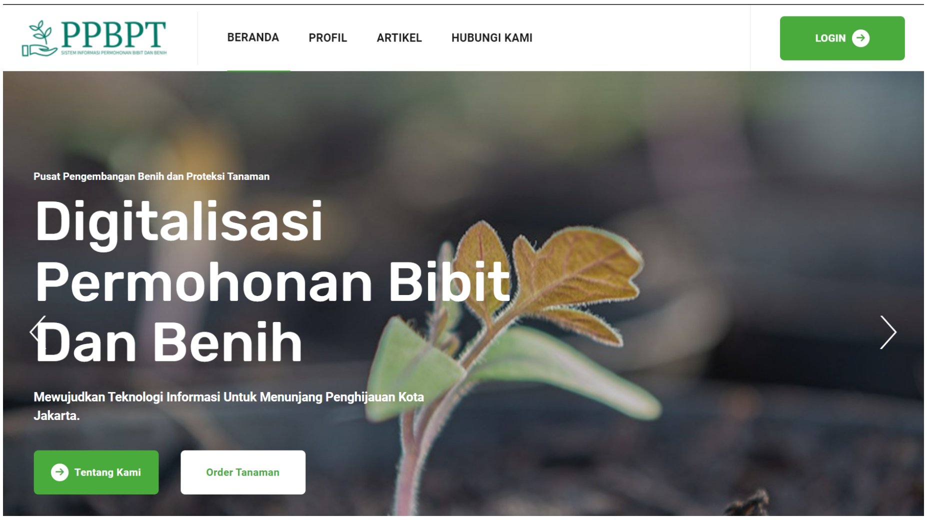

Figure 6. Front End Display

Figure 7. Admin Dashboard Page

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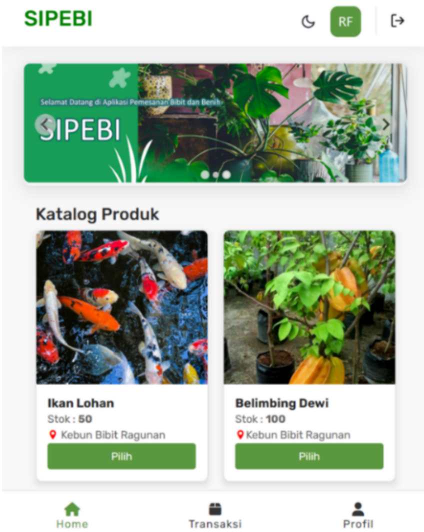

Figure 8. User Mobile Interface

3.3. Discussion

The results of this study confirm previous research on the advantages of using PWAs in various sectors, such as the financial industry [8] and the healthcare industry [13], in improving operational efficiency and user experience. For developers, PWAs make it easier to implement modern and user-centered designs. Therefore, PWAs provide a transformative and compelling alternative to traditional apps, combining the best features of web and native apps with the convenience of mobile apps [23]. During the development and testing period, PPBPT, as the manager of seedlings and seed orders, has felt the real benefits of developing this information system in the form of efficiency and effectiveness of manual processes.

The existence of 18 nurseries spread throughout the Special Region of Jakarta is a beneficial factor in seedling distribution to the community. On the other hand, the uneven coordination and mastery of digital technology in human resources in each nursery manager is a challenge for PPBPT when implementing this information system. Intensive training is needed to ensure that this technology can be used optimally. The large Population of the Special Region of Jakarta as the user community of the seedling ordering information system challenges the application's ability to handle users on a large user scale. To overcome this problem, PPBPT is required to be able to provide an application server and database that can handle this.

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Another thing that must be done is to regularly evaluate and develop this application prototype into a reliable information system application for handling the seedling ordering process of the Jakarta community. The successful implementation of this application opens up opportunities for further development, including integration with sensor technology and the Internet of Things (IoT) [24] to monitor the condition of Jakarta's environment after seedling distribution, thus providing accurate information about the benefits of seedling distribution in supporting urban greening which ultimately helps reduce pollution in the Big City of Jakarta.

4. CONCLUSION

The prototype of the Progressive Web Application (PWA)--based seedling and seedling ordering system developed in this research has successfully automated the entire seedling ordering process at the Jakarta Seed Development and Plant Protection Center (PPBPT), replacing the manual process previously used. The system allows users, both individuals and institutions, to quickly register, verify their identity using ID cards, and order seedlings online. Stock management by the Head of Gardens in 18 nurseries spread across Jakarta is also centralized and real-time, facilitating efficient seedling tracking and distribution. Automatic notifications sent via WhatsApp help users know the status of their orders, from ordering to picking up the seedlings. User data security is also maintained by implementing encryption to protect sensitive information. Implementing this research improves PPBPT's operational efficiency and supports the greening program in Jakarta, which is expected to help reduce air pollution and enhance air quality. With a more organized and easily accessible seedling distribution, the city's greening program can run more smoothly and measurably, positively impacting environmental and public health.

The implications of this research also include the potential to extend its application to other environmental programs. Extreme Programming (XP) methods in development enable rapid iteration and responsiveness to user needs, guaranteeing that the resulting application is functional and meets high-quality standards. The pair programming concept applied in XP also speeds up problem-solving and ensures bug-free code. In addition, adding a seedling requirement prediction feature based on historical data can help PPBPT manage stocks more effectively. This success opens up opportunities for further development by integrating environmental monitoring technologies such as the Internet of Things (IoT) and air quality sensors. The use of these technologies in the future is expected to provide more holistic insights into green field management and improve the efficiency of seedling distribution by predicting needs based on historical data. The potential development of this system can extend to other public service areas, such as tree planting programs in residential areas and public spaces, or even support

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other environmental initiatives, such as critical land rehabilitation. The system can also be customized to meet the specific needs of different sectors requiring structured and real-time distribution management. Thus, this research not only supports digital transformation in the forestry sector but also has the potential to strengthen environmental sustainability initiatives in urban areas more comprehensively and measurably.

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