JPPIPA 11(4) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Design and Development of Website and Android-Based Aceh Biodiversity Applications

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Received: January 30, 2025
Revised: March 04, 2025
Accepted: April 25, 2025
Published: April 30, 2025

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DOI: 10.29303/jppipa.v11i4.10535

Abstract: Aceh is an exceptional region in Indonesia characterized by significant biodiversity and abundant natural wealth. Despite these numerous benefits, there is limited information regarding the potential of biodiversity in this region. Therefore, this research aimed to design and develop Website and Android-based applications to facilitate access to information regarding biodiversity in Aceh. In the development process, the Waterfall method was used, and the applications consisted of two main components, namely the back-end and the front-end. The users were divided into three categories, including contributors, verificators, and admins. After the development was complete, functionality testing was conducted using the black box method, and usability was examined using the Post-Study System Usability Questionnaire (PSSUQ). The results of functionality testing showed that both applications operate efficiently, thereby providing users with a satisfying experience when accessing information about Aceh biodiversity. The usability score was approximately 7 for Website-based and 6 for Android-based applications, showing a high level of usability.

Keywords: Android; Biodiversity; Black box testing; Post-study system usability questionnaire (PSSUQ); Website

Introduction

Biodiversity is the collection of all forms of life, ranging from unicellular to multicellular organisms, present worldwide. It consists of three main components, namely species, genetics, and ecosystems. Currently, human existence is highly reliant on diverse forms of life, showing the crucial role of understanding and preserving biodiversity in the present context (Sarkar & Margules, 2002; Souza et al., 2015).

Aceh is one of the provinces in Indonesia, located in the northern part of Sumatra Island, with an average altitude of approximately 125 meters above sea level. The province is characterized by various regions and functions, including forests covering around 3.5 million hectares and a rich biodiversity of several species of flora and fauna. The forests and water conservation regions include Nature Reserves, Protected Forests, Limited Production Forests, Production Forests, and Conservation Forests (Gumay et al., 2019; Linkie et al., 2014; Cochard, 2017; Rangel et al., 2012; Mellin et al., 2011). Despite these numerous benefits, inefficiencies arise when accessing biodiversity information. Consequently, there is a crucial need for an information source that comprehensively covers biodiversity, particularly in Aceh.

In 2021, the Informatics Department and the Biology Department of the Faculty of Mathematics and

How to Cite:
Subianto, M., Harnelly, E., Misbullah, A., Afidh, R. P. F., Akhyar, F., Irfan, M., … Zulfan. Design and Development of Website and Android-Based Aceh Biodiversity Applications. *Jurnal Penelitian Pendidikan IPA*, *11*(4), 68-80. https://doi.org/10.29303/jppipa.v11i4.10535

Natural Sciences at Syiah Kuala University collaborated to design an Aceh Biodiversity Information System. The purpose of this system is to provide information on the collection data of various living organisms, specifically in Aceh, contributing to an enhanced understanding of biodiversity (Subianto et al., 2021; Roy & Saran, 2004; Tabrani & Pudjiarti, 2017; Jannah, 2019). However, its development remains incomplete, limiting the species data available on Website and hindering widespread usage. Consequently, this research aims to create higher quality website and Android-based Aceh Biodiversity applications, intending to become the Aceh Repository Biodiversity Collection, where different individuals can access information about the biodiversity present in the province.

Method

This research consists of several stages following the principles of the waterfall method (Heriyanti & Ishak, 2020), with the research flow presented in Figure 1.

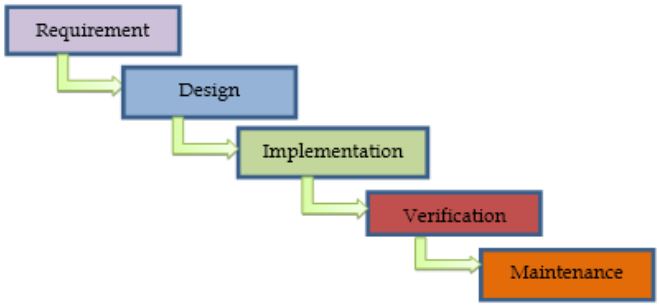


Figure 1. Research flow

Requirement

In the initial stage, observation is conducted to identify existing system problems for a comprehensive understanding of the problems and the roots. After identifying the problems, a needs analysis is conducted to ensure the system under construction fulfills its usage requirements and aids in development planning. This analysis covers functionality requirements, including functional and non-functional needs, as well as user identification. Moreover, there are user types that must be identified, including contributors, who are responsible for publishing species data in the application. Secondly, verificators are tasked with verifying each submission before storing the data in the system database. Finally, admins are responsible for managing verificators. Following the completion of the needs analysis, a literature review is carried out to understand similar research, and documentation of the essential tools in application development.

Design

The design stage entails designing the system in 4 steps, including creating a use case diagram showing the relationship between application actors and activities performed. Furthermore, it includes a deployment diagram showing the application infrastructure and component connections, an Entity Relationship Diagram (ERD) representing the relationship between entities in the database, and diagrams for Android-based applications using the primary data source from REST API, with an offline database (Doglio, 2018; Gupta & Gouttam, 2017; Ibrahim, 2020; Jadhav & Gonsalves, 2020). Components in Android-based application architecture include Activity/Fragment, ViewModel and LiveData, Repository, Model, and Room, as well as Remote Data Source.

The design stage entails designing the system in 4 steps, including creating a use case diagram showing the relationship between application actors and activities performed. Furthermore, it includes a deployment diagram showing the application infrastructure and component connections, an Entity Relationship Diagram (ERD) representing the relationship between entities in the database, and diagrams for Android-based applications using the main data source from REST API, with an offline database. Components in Android-based application architecture include Activity/Fragment, ViewModel and LiveData, Repository, Model and Room, as well as Remote Data Source.

Implementation

The implementation stage is the coding process based on the previously established system design. In the planned application development, two main components play critical roles, namely the back-end and the front-end.

Firstly, for Website-based application, the back-end uses the ExpressJS framework with JavaScript programming language executed in NodeJS (Mardan, 2018). Meanwhile, the front-end uses the NextJS framework with JavaScript programming language executed in NodeJS (Jartarghar et al., 2022; Teklemariam et al., 2016; Ardiyanto & Ardhianto, 2024; Larman & Basili, 2003; Mfenjou et al., 2018; Dong, 2023). The database used is MySQL and development tools include Visual Studio Code and Postman.

Verification

The verification stage is system testing to ensure proper functionality as specified. This application testing includes two types, namely functionality using the Black Box Testing method to identify well-functioning features and potential problems. Additionally, there is usability testing using PSSUQ method (Valadi & Broneske, 2020; Thuering & Mahlke,

2007). This entails users testing the application and filling out a questionnaire, which consists of a list of questions to be answered, including (Malik & Frimadani, 2023):

I am satisfied with the ease of using the system.
This system is easy to use.
I can complete tasks and scenarios quickly using the system.
I feel comfortable using the system.
It is easy to learn to use the system.
I can become productive quickly using the system.
This system provides error messages that tell me how to fix problems.
Recovery from mistakes made using the system is easy and quick.
The information provided with the system is clear.
It is easy to find the information I need.
This information is effective in helping me complete tasks and scenarios.
The order of information displayed is clear.
The system interface is enjoyable.
I like using the system interface.
The system has all the functions and capabilities I expected.
I am satisfied with the system.

Maintenance

The maintenance stage occurs after the testing process, where the results serve as a basis for making improvements to the application system. The results obtained are studied, analyzed, and re-implemented into the system to ensure the developed application achieves higher quality.

Result and Discussion

Development Results for Website-Based Applications Back-End

The development of a website-based application back-end results in REST API connected to the MySQL database (. REST API is used to execute commands requested from the Website front-end and provide data responses in JSON format. For secure access to public data, JSON Web Token (JWT) is used as an authentication method. REST API consists of 30 endpoints with various functions, as shown in Table 1.

Table 1. REST API for Website-Based Application

Endpoint	Function
/species	Getting all published species data
/species/total	Obtaining the number of species in each kingdom
/species/islike	Checking if the user has liked a species
/species/like	Liking a species
/species/dislike	Unliking a species
/species/comment	Commenting on a species
/species/deletecomment	Deleting a comment
/species/getcomment	Getting all comment data on species
/kingdom	Getting kingdom data along with species in each kingdom
/submission	Getting species submission data
/submission/updatestatus	Changing the status of species submission by the verificator
/submission/store	Adding species submission data
/submission/update	Updating species submission data
/register	Adding user account data
/verify	Verifying user account email
/login	Validating the account for login and obtaining a JWT token
/users	Getting user account data
/users/updateprofile	Updating user data
/users/updatephoto	Updating user photo
/users/updatepassword	Updating user password
/generate-certificate	Generating a certificate for the user
/admin/addverifier	Changing the user's level from contributor to verificator
/admin/updateverifier	Changing verificator kingdom
/admin/deleteverifier	Changing the user's level from verificator to contributor
/phylum	Obtaining phylum data
/class	Obtaining class data
/ordo	Obtaining order data
/family	Obtaining family data
/genus	Obtaining genus data
/logs	Getting user activity log data

Development Results for Website-Based Application Front-End

The development of a Website-based application front-end is conducted using the NextJS framework with the concept of a single page (Jartarghar et al., 2022; Biyyapu et al., 2023; Iskandar et al., 2022; Furqani & Muliono, 2021). The resulting front-end pages of the Website-based application are as follows:

Home Page

The home page serves as the initial page when launching the Aceh Biodiversity application. This page provides a brief explanation of the application, a message to contribute by publishing species, statistical data grouped by kingdom, and a data distribution map, as shown in Figure 2.

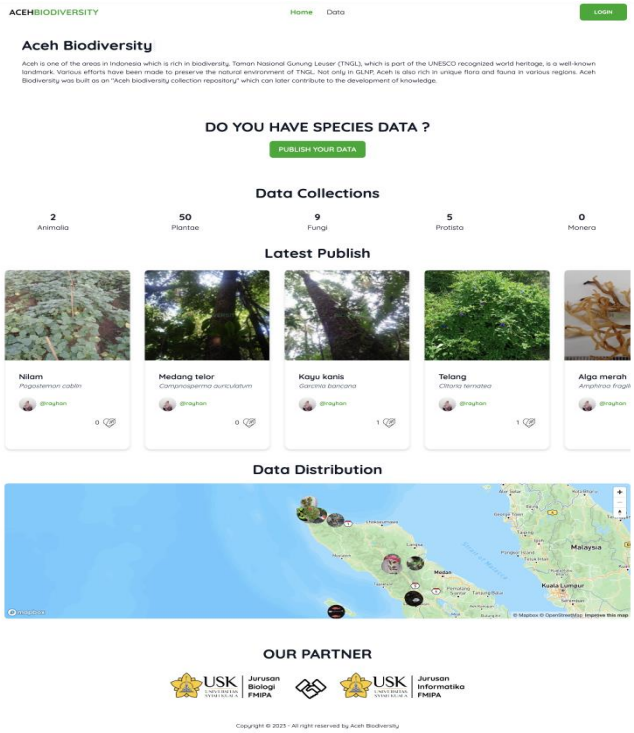


Figure 2. Home page

Sign-Up and Login Pages

The sign-up page is where users register for the application by completing a form to sign up for an account. After creating an account, users can proceed to log in on the login page.

Data Page

The data page shows the available species in the application, categorized by kingdom, as shown in Figure 3. Each species is presented with its photo, local and Latin names, the contributor of the species, and a like button.

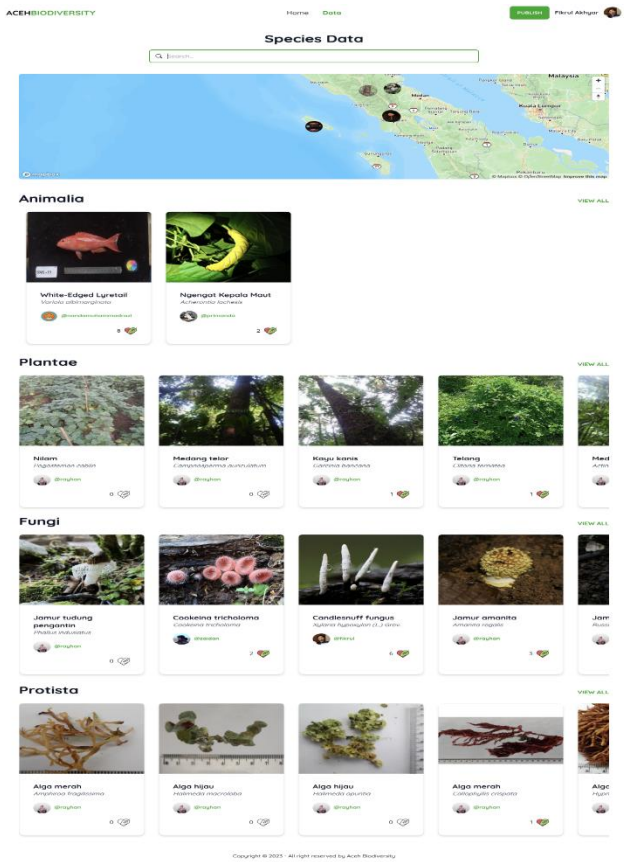


Figure 3. Data page

Species Detail Pages

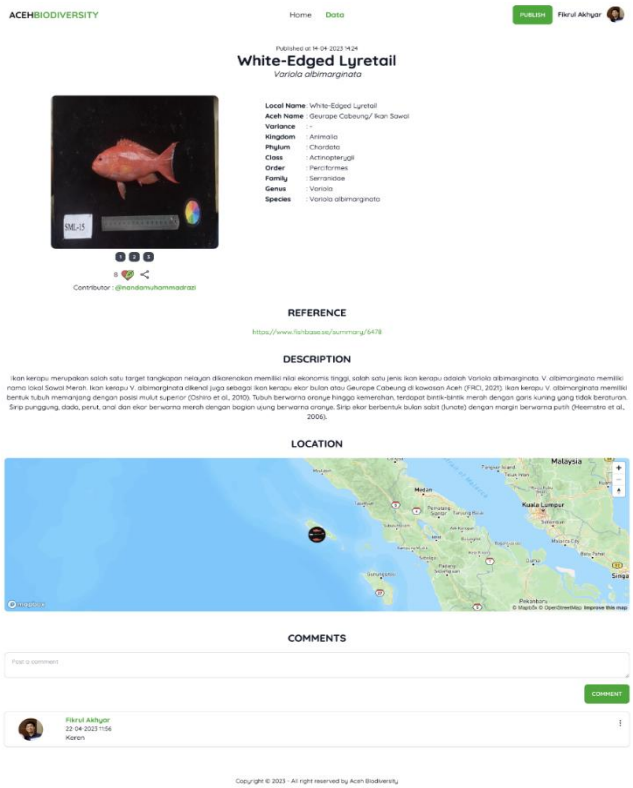
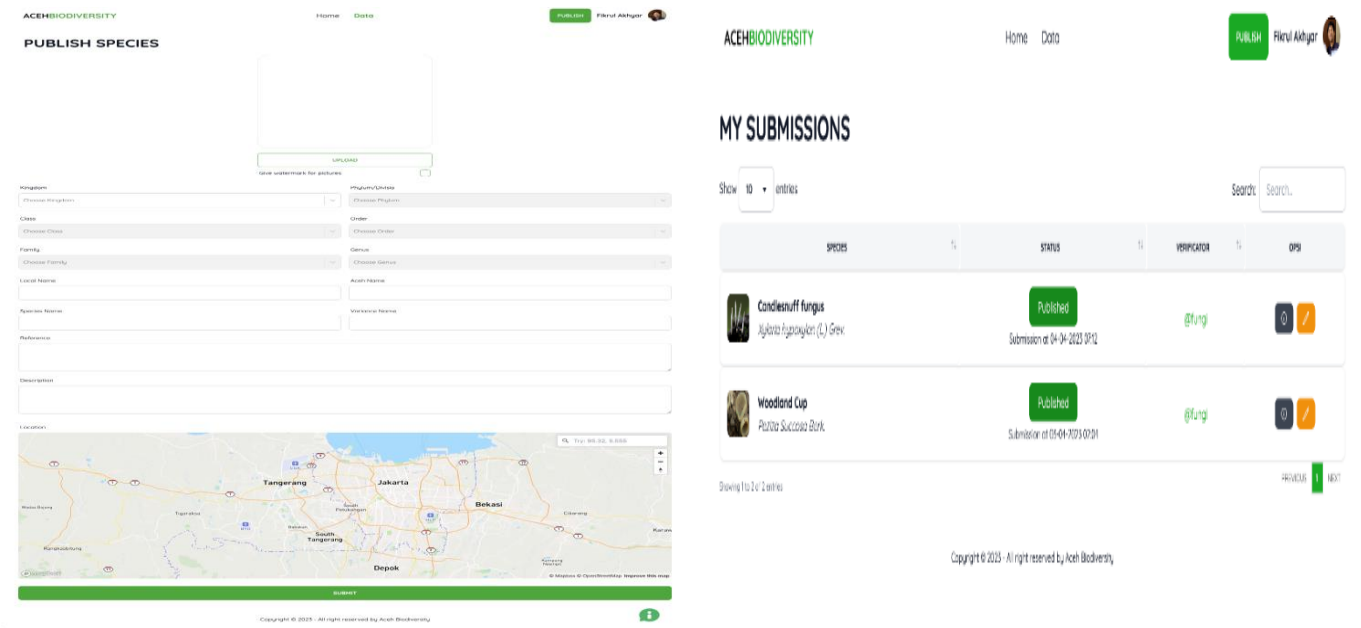


Figure 4. Species detail

The species detail page presented in Figure 4 shows detailed data on the opened species. This page shows various names including Latin, local, variant, and Aceh, as well as kingdom, phylum, class, order, family, genus, species, references, description, and the region fof the species.

Publish Species and My Submission Page

The publish species page allows users to submit species collections for display in the application. Meanwhile, My Submission Page shows species submission made by users, as presented in Figure 5.



(a) (b)

Figure 5. (a) Publish species and (b) my submission

Edit Species Page

The edit species page allows users to rectify species data already submitted, as shown in Figure 6.

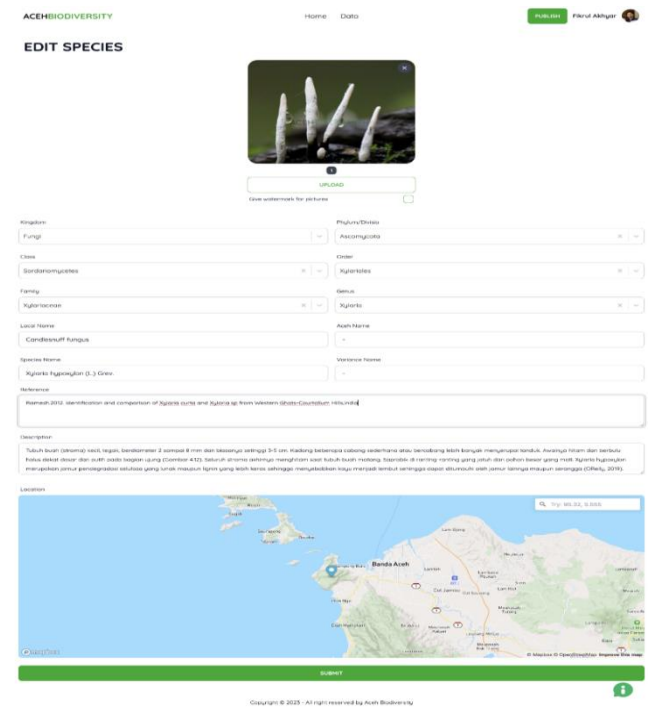


Figure 6. Species edit page

Verification Page

The verification page presented in Figure 7 is accessible only by admins and verificators.

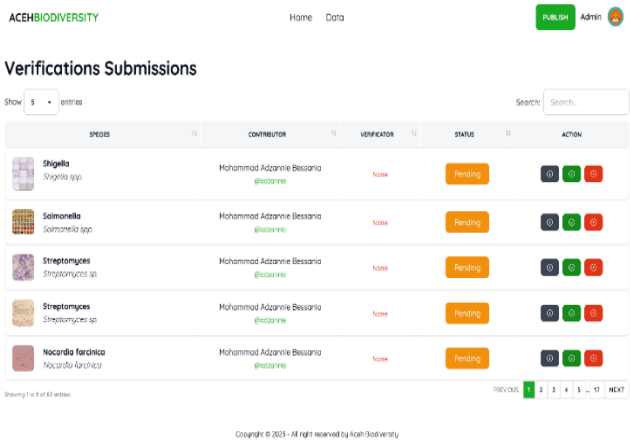


Figure 7. Verification page

Manage Verificator Page

The manage verificator page presented in Figure 8 is exclusively accessible by admins. This page facilitates the administration of users who are verificators and allows the addition, modification, or removal of the roles.

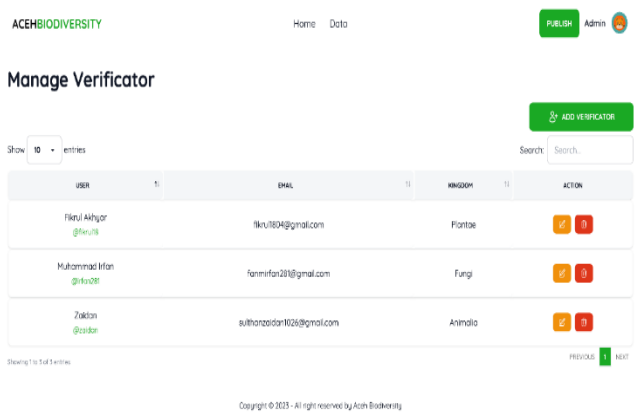


Figure 8. Manage the verification page

Development Result for Android-Application Back End

The initial phase of developing an Android-based application includes the back-end development, which functions as the connector and communicator with the data. MySQL serves as the application database based on the previously planned Entity Relationship Diagram (ERD). After the database, the development of REST API proceeds, comprising 29 API endpoints with various query options listed in Table 2.

REST API developed can be accessed through a URL and tested before being applied in Android-based applications using the Postman application.

Table 2. REST API for Android-Based Application

Endpoint	Function
	Obtaining all published species data based on the species ID
	Obtaining all published species data based on the kingdom
/species	Obtaining all published species data based on the username of the species contributor
	Obtaining all published species data along with information on whether the species has been liked by a user with the user_id as a query
/species/total	Obtaining the total number of species for each respective kingdom
/species/islike	Checking if a species publication has been liked or not
/species/like	Giving 1 like to a species publication
/species/dislike	Removing 1 like from a species publication
/species/comment	Adding a comment to a published species
/species/comment	Obtaining all comments based on the species ID
/species/deletecomment	Deleting a comment
	Obtaining all submission data based on the submission ID
/submission	Obtaining all submission data based on the kingdom ID
	Obtaining all submission data based on the user ID
/submission/updatestatus	Updating the submission status to published/pending/rejected/draft
/submission/update	Changing the data of a submission
/submission/store	Adding a new submission
/register	Registering an account
/login	Performing account authentication
/user	Obtaining all user data based on the user ID
	Obtaining all user data based on the user type ID
/users/updateprofile	Updating user profile information
/users/updatephoto	Updating user profile photo
/users/updatepassword	Updating user password
/verify/:id	Verifying a user account
/admin/addverifier	Adding a new verificator based on the kingdom
/admin/updateverifier	Updating verificator data
/admin/deleteverifier	Deleting a verificator
/generate-certificate	Generating a certificate after a user has a total of 10 publications
/kingdom	Obtaining kingdom data based on the ID
	Obtaining all species data grouped by kingdom
/phylum	Obtaining all phylum data
/class	Obtaining all class data
/ordo	Obtaining all order data
/family	Obtaining all family data
/genus	Obtaining all genus data

Development Results of Android-Based Application Front-End

The front end of the Android-based application represents the interface and workflow of the three main roles in the system, namely contributors, admins, and verificators.

Home Page

The home page presented in Figure 9 is the initial view accessible to users without authentication. After clicking on the map icon on the home page, users are directed to a page showing the distribution of species based on geographical coordinate data. Each coordinate point has a latitude and longitude, which can be visualized on the map.

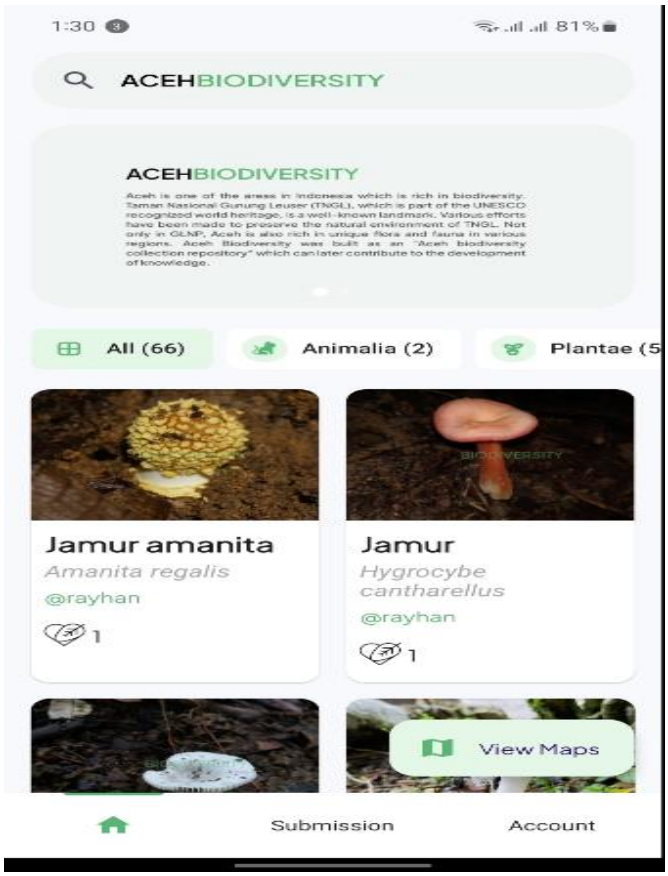


Figure 9. Home page

Register and Login

The register page allows users to create an account for the first time. After having an account, users can log in using the login feature.

Species Detail Page

The species detail page presented in Figure 10 contains various information, including species images in a carousel format, a like button, taxonomy, contributor, and verificator information, as well as a comment section.

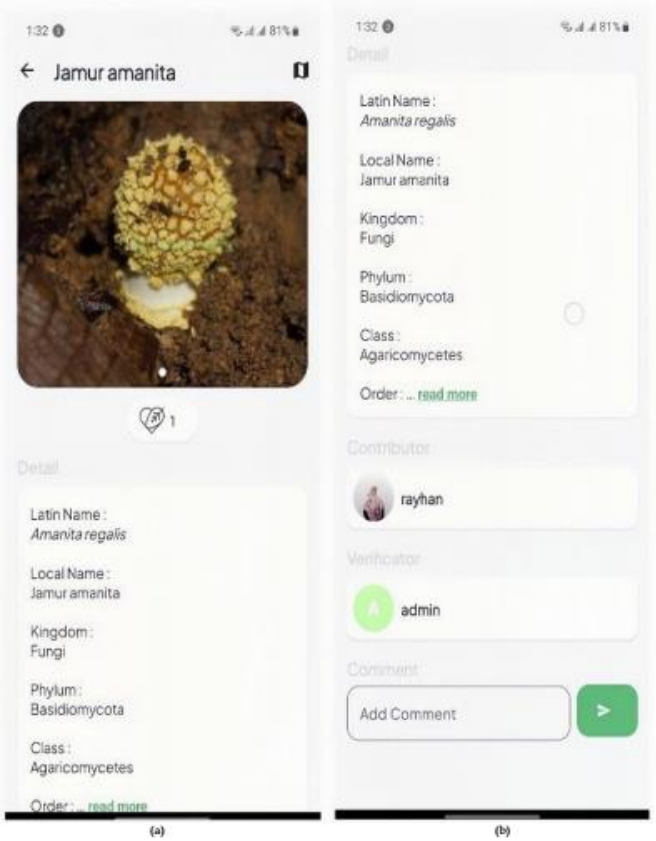


Figure 10. Page view (a) species detail and (b) comment field

My Submission Page

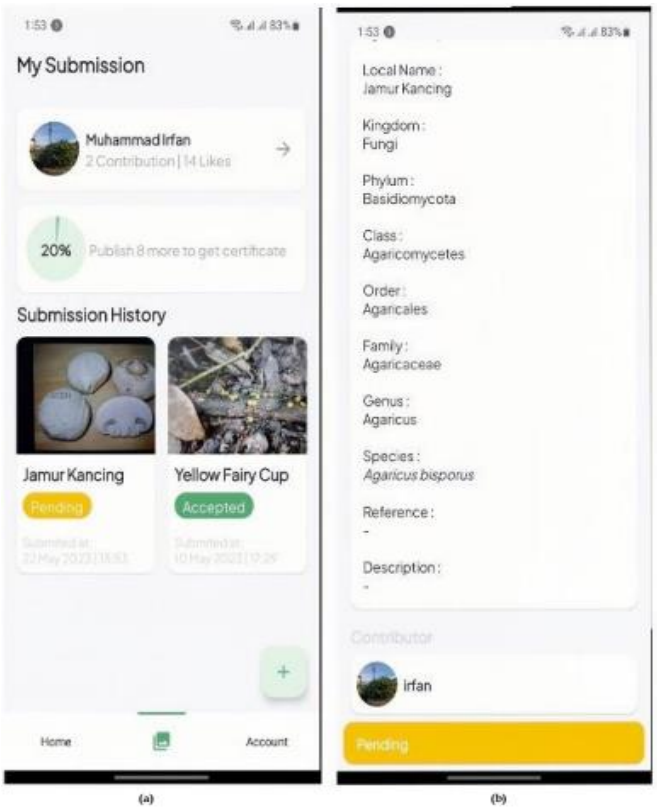
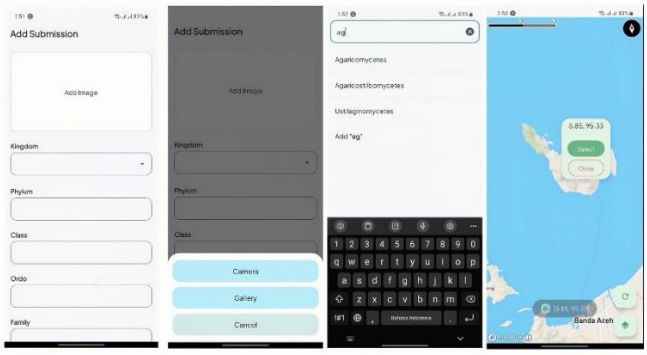


Figure 11. Page (a) my submission and (b) submission detail

My Submission Page shows a comprehensive history of all submissions made by users. After clicking on one of the submission cards, users will be directed to the submission detail page, which shows complete information submitted, including its status. Moreover, Figure 11 shows My Submission Page and submission details.

Add Submission Page

The add submission page, as presented in Figure 12, is used by contributors to create new submission by filling out the appropriate form.

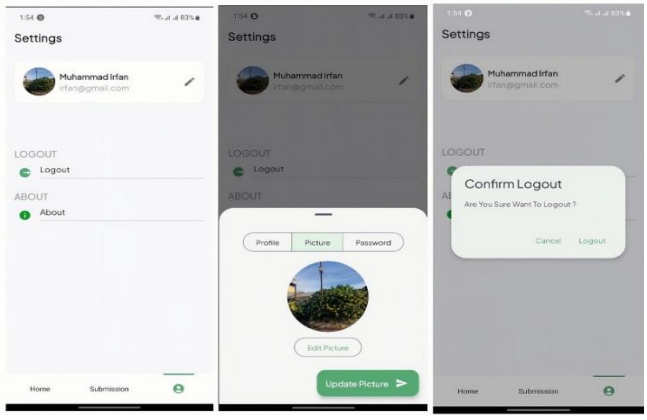


(a) (b) (c) (d)

Figure 12. Page (a) add submission, (b) image source dialog, (c) species data dropdown dialog, and (d) coordinate point selection map

Account Page

The account page presented in Figure 13 contains detailed user information, providing an option to navigate to the admin and verificator pages, including a logout button.



(a) (b) (c)

Figure 13. Page (a) account, (b) changing user data, and (c) logout

Admin Page

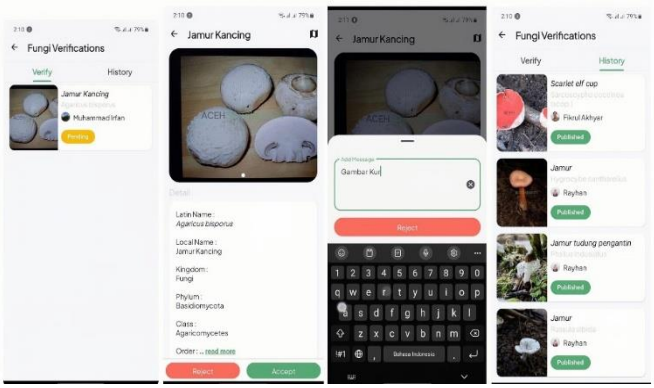
The admin page is exclusively accessible to users with admin roles, allowing the management of verificators and monitoring of user activity history. Verificators are divided by kingdom, restricting the verification of species contributions to the kingdom assigned by the admins. Figure 14 shows the admin menu page, activity logs, and the verificator list.

(a) (b) (c) (d)

Figure 14. Page (a) admin, (b) admin menu, (b) verificator list, and (c) activity logs

Verification Page

The verification page presented in Figure 15 enables verificators and admins to verify species contributions before displaying them on the main page. Admins have the authority to verify all kingdoms, while verificators can only verify contributions according to the kingdom.



(a) (b) (c) (d)

Figure 15. Page (a) verification, (b) verification details, (c) reject message dialog, (d) verification history

Android-based Application Features When No Network

When the internet connection is unavailable, the application can still be accessed on the home page, allowing users to view the list and details of each species. This functionality is enabled through data caching, where species data is temporarily stored in the local device storage of users after opening the application with the internet connection. However, other features, such as liking and commenting, cannot be performed without an internet connection. Figure 16 shows the home page when accessed in airplane mode.

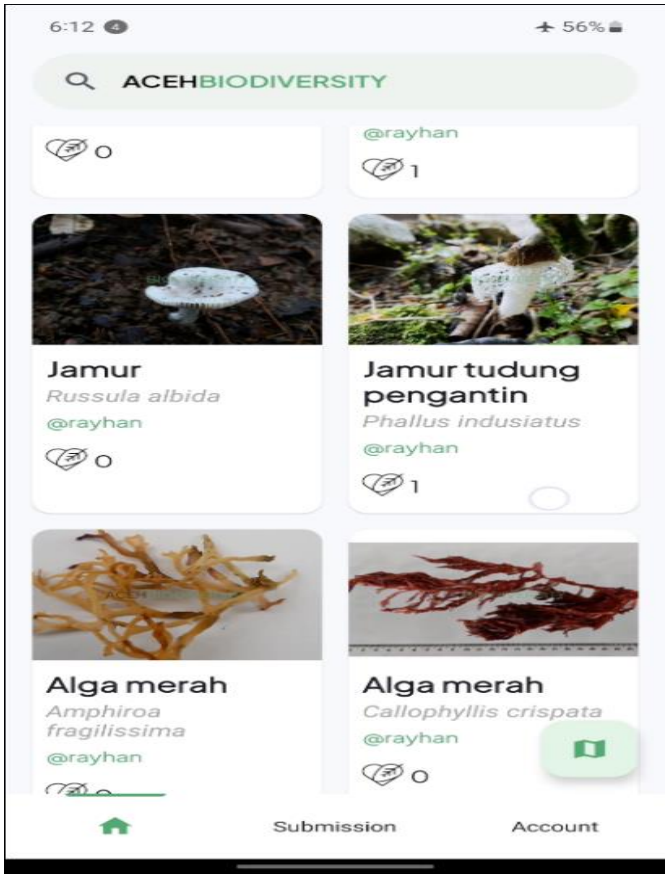


Figure 16. Home page when opened without an internet connection

Application Testing Results

Functional Testing Using Black Box Testing

Functionality testing is conducted using the black box testing method (Nidhra, 2012) to verify whether the system built is functioning as intended. The testing conducted shows that both Website-based and Android-based applications are functioning properly, as evidenced by the successful use of all features.

Usability Testing Using PSSUQ Method

Usability testing uses the PSSUQ method to assess the user-friendliness of the applications, following the test plan. After executing the test plan, users complete a questionnaire through a Google Form. The testing is conducted with 25 participants and average scores for each evaluation category in Website-based application testing are presented in Table 3.

Table 3. Average PSSUQ Testing Scores for Website-Based Application

Category	Score
Overall Satisfaction	6.19
System Usefulness	6.14
Information Quality	6.13
Interface Quality	6.36

Based on PSSUQ usability testing results presented in Table 3, Website-based application is positively received by users, as shown in scores for each category that are close to 7. The average scores of each evaluation category in Android-based application testing are shown in Table 4 below.

Table 4. Average Usability Testing Scores for Android-Based Application

Category	Score.
Overall Satisfaction	5.85.
System Usefulness	5.9.
Information Quality	5.75.
Interface Quality	5.94.

In PSSUQ method, a score of 4 shows a neutral result, while a value closer to 7, shows improvement in usability, and vice versa. Based on Table 4, it can be concluded that Android-based application developed is considered good and positively received by users as the scores surpass the neutral result and tend to approach 6.

Application Improvement

After conducting the testing, several issues encountered by users when using the application were identified. These issues have been addressed in this improvement phase to enhance quality. Table 5 shows the issues and the necessary application improvements.

Table 5. Application Issues and Improvements

Application Type	Problems	Improvements
Website	Latin species names do not follow writing rules.	Adjusting the writing of Latin species names by the system to use sentence case, which includes only capitalizing and italicizing the first letter.
	Incorrect number of likes on the user profile page.	Fixing the function used to calculate the number of likes obtained by users.
	Inconsistent sizes of species images on the data page, making it appear untidy.	Standardizing the size of species images on the data page to ensure uniformity.
	Display issues on the species detail page as the text is too long when viewed on a mobile phone.	Enhancing the layout of data on the species detail page when viewed on mobile devices.
Android	Some text and images are cropped on devices with lower screen resolutions and aspect ratios.	Refining text and image components to be more responsive to various screen sizes.

Application Type	Problems	Improvements
	Large image sizes on the add submission page potentially strain the server.	Implementing image compression feature and setting a maximum image size limit of under 2 MB.
	Non-functional email sending button on the profile page.	Making the messaging button functional, by redirecting to the email application when pressed, with pre-filled content based on the user profile.
	Incorrect total likes information on the profile page.	Improving the function for calculating the total likes received by a contributor.
	Wrong rules for writing Latin species names.	Writing Latin species names in accordance with biological conventions, using initial capitalization and italics.
	Some text and images are cropped on devices with lower screen resolutions and aspect ratios.	Refining text and image components to be more responsive to various screen sizes.

Discussion

Web-Based Application

This research developed Aceh Biodiversity Website-based application, providing a platform for sharing information about species, particularly those found in the province. Previous related investigations included developing Website-based application for storing data on medicinal plant species in Kalimantan (Haeruddin et al., 2017; Dengen et al., 2018; Patiola, 2023; Fabricant & Farnsworth, 2001) and tree species in the Kalimantan Rainforest (Asa et al., 2017; Siombo, 2021; Jaya et al., 2022). However, this research mainly focused on species data encompassing all living creatures, specifically those found in Aceh.

Other similar research includes the topic of developing Website-based application for storing data on living species around the IPB (Institut Pertanian Bogor) campus using the PHP programming language (Zuhud et al., 2014). The Aceh Biodiversity application was also developed as Website-based platform for storing data on living species in Aceh using WordPress with PHP programming language (Subianto et al., 2021). However, this research used the JavaScript programming language with NextJS framework.

Due to the expensive nature of data on living species, the application was built using NextJS framework, implementing the concept of a single-page application. Consequently, the design ensured efficient performance, even when handling large amounts of data. This was achieved by preloading the data on the server side to prevent slow down when accessed.

Android-Based Application

Some related research has been conducted (Zuhud et al., 2014) which resulted in the IPB Biodiversity (IPBIOTICS) website accessible at http://ipbiotics.apps.cs.ipb.ac.id/. However, this website has existed over a certain time, with the last recorded user activity documented in November 2015. Furthermore, this website is developed by combining the front-end and back-end, making it less flexible for platform changes. In this research, the application was divided into two parts, allowing for more flexible development on various platforms and enhancing data synchronization capabilities.

In 2017, research titled "Digital-Based Wood Atlas Information System" by Tupamahu et al. (2017) and Haviluddin (2009) successfully created Website that focused on various types of wood in Indonesia. Meanwhile, this research included all species data categorized based on the kingdom.

The background was previous research (Subianto et al., 2021), which focused on the development of the Aceh Biodiversity Information System Website. Website can be accessed through the link http://biodiversity.unsyiah.ac.id/ and is developed using the WordPress platform. As explained in the introduction, the development project for this website has not been continued, resulting in limited data availability. However, this research has a larger amount of data, which yielded a wider data distribution.

This research was built on Android-based mobile devices, which offered several advantages, including the ability to capture images directly through the user device camera. Additionally, the advantages included the capability to share species details directly in the application or on other social media platforms, and the use of some features without internet connection.

Conclusion

In conclusion, this research successfully developed the Aceh Biodiversity application on two platforms, namely Website-based and Android-based, following the initial design. Website version was built using NextJS with the Single Page Application concept, passing through functional and usability testing with positive results. Meanwhile, Android-based application has REST API back-end with 29 endpoints and 11 main pages as a client. It could display data on the home and species detail pages without internet connection due to internal device caching. The functionality testing results showed that both applications operate efficiently, providing a satisfying user experience when accessing

information about biodiversity in Aceh. Furthermore, the usability scores were approaching 7 for Website-based and 6 for Android-based, showing a high level of usability.

Acknowledgments
The author would like to thank to all parties who helped in this research.

Author Contributions
The authors contribute their work in research and preparing the manuscript as follows: M.S., E.H., and A.M., contributed to formal analysis, investigation, resources, data curation, writing-original draft preparation. R.P.F.A., F.A., and M.I., contributed to conceptualization and methodology, validation, writing—review and editing, and supervision. W.D., N., and Z. contributed to methodology, software, validation, formal analysis, writing—review and editing, visualization, and supervision.

Funding
This research is funded by Syiah Kuala University. Ministry of Education, Culture, Research, and Technology. In accordance with the Senior Lector Research Contract for Fiscal Year 2023. Contract number: 207/UN11.2.I/PT.01.03/PNBP/2023 dated May 3, 2023.

Conflicts of Interest
The authors declare no conflict of interest.

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