

An Implementation of Mobile-based Reporting System for Irrigation Infrastructure Maintenance Using Openstreetmap

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Abstract—In this digital era, the use of maps has shifted to digital maps that can be accessed through map applications. Map applications can be used to map irrigation channels in a city. Currently, the Public Works and Spatial Planning Agency of Batu City already has an irrigation reporting application in the form of an Android app. However, many people are reluctant to install the app because it can take up storage space on their smartphones. To address this issue, a web-mobile irrigation reporting application using OpenStreetMap with customizations via Leaflet JS needs to be developed. OpenStreetMap was chosen as the map to chart the irrigation channels in Batu City because it is free to use. The Leaflet JS library is required to display and customize this map within a website. The frontend of this application uses the React JS library, while the backend uses the Laravel framework. The Database Management System (DBMS) used for the application's database is PostgreSQL. The database utilizes the PostGIS extension to process and store geographic data for the Geographic Information System (GIS) being developed. The application has three main features. During Black Box Testing, these features were subjected to eight different test cases. The results of the testing showed that all expected outputs of the system matched the actual outputs produced by the system.

Index Terms—irrigation canal; Public Works and Spatial Planning(PUPR) Agency; OpenStreetMap; React Javascript; Laravel.

I. INTRODUCTION

Maps are used when you want to travel to a place where you don't know the location, distance, and route. In addition, maps are also used to determine the condition of an area. In this digital era, the use of maps has shifted to digital maps that can be accessed through map applications. According to sixt.com, the best map application is Google Maps. However, mapping areas with Google Maps services is not free.

Related to the mapping of the area, the Batu City Government wants to map the irrigation area in its area. In the mapping, the Batu City Government wanted to use a free and open source map service. Therefore, the service from OpenStreetMap was chosen in the mapping. However, OpenStreetMap still needs to be customized before use.

Currently, the PUPR Agency of Batu City already has an irrigation reporting application in the form of an android application. However, reporting using the android application has several problems. One of the problems is that users must install the application first. The application will fulfill the user's smartphone storage. In addition, the application can only be installed on certain versions of android. So, users need a website application that can be comfortably used on mobile devices.

From these problems, irrigation reporting applications in the form of web-mobile using OpenStreetMap services with customization using Leaflet JS need to be developed. The application is expected to facilitate the people of Batu City in reporting irrigation damage in Batu City. Thus, the application can help in maintaining the quality of irrigation systems in Batu City.

This study presents the implementation of

The following sections are organized as follows: Section ?? drawbacks some related studies on blockchain implementations and crowdfunding systems. Section ?? describes the business model for a crowdfunding system with blockchain technology. Section ?? explains the technical aspects of token-based crowdfunding model for Indonesian cooperatives. Section VII presents the discussion on system's requirements acceptance through evaluation. Lastly, this paper is concluded in Section VIII with future studies presentations.

II. IRRIGATION INFRASTRUCTURE IN INDONESIA

A. Functionalities

Irrigation is the artificial application of water to the soil usually for assisting in growing crops [1], [2]. The primary function of irrigation is to ensure that plants receive the necessary amount of water to grow and produce yields, especially in regions where natural rainfall is insufficient. By providing a consistent and controlled water supply, irrigation helps to maintain soil moisture, prevent drought stress, and promote healthy plant growth. Additionally, irrigation can aid in the management of soil fertility, as it facilitates the application of fertilizers, and helps in controlling weed growth and mitigating frost damage. Ultimately, irrigation is crucial for food production, landscape maintenance, and supporting ecosystems in arid and semi-arid regions.

B. General Condition



Fig. 1. Damaged Irrigations in Indonesia

Indonesia's Deputy Minister of Home Affairs explained that based on the results of the 2014 irrigation technical audit by the Ministry of Public Works and Public Housing showed that of the surface irrigation area of around 7.145 million hectares, around 46% of them were in a damaged condition. The bad state of Indonesia's irrigation has a substantial influence on many elements of life and the economy. Without a good irrigation system, the water supply to farmland is reduced, which can result in a decrease in crop yields. When crops do not get enough water, their growth is stunted, and the production of foods such as rice, vegetables and fruits is reduced. This can lead to food shortages and increased food prices, making it difficult for people, especially those on low incomes, to meet their nutritional needs. In addition, damaged irrigation can also affect the livelihood sustainability of farmers, who depend on crop yields for their livelihoods. Long-term impacts include soil degradation, increased food insecurity, and economic instability in affected areas.

C. Types of Irrigation Infrastructure

Irrigation Infrastructure has three types, namely primary, secondary, and tertiary. Primary irrigation canals are canals that come directly from the river. To make irrigation canals, the river is given a cement wall that dams the flow of the river. When the river water rises, the river can be made to branch off on the side. When the primary channel is split into new canals, the new canals are called secondary canals. When there are rice fields that need to be irrigated, beside the secondary canals, the secondary canal will be made a new branch, the new branch is a tertiary canal.

D. Infrastructure Management

The management of irrigation infrastructure is under the authority of the Batu City PUPR Office in the water resources and irrigation network section, the irrigation operations and maintenance section. The section has field people. The section processes data on irrigation channels throughout Batu city. The data, namely data on the length of irrigation, the number of primary irrigation, the number of secondary irrigation, and the number of tertiary irrigation. There is also data on the condition, what percentage is good, what percentage is lightly damaged, what percentage is moderately damaged, and what percentage is severely damaged. In each irrigation there is a sluice gate to regulate how much discharge in an irrigation, and how high the water level is. This is done so that water can meet all existing needs.

When an irrigation canal is damaged, the section records the level of damage, whether it is light, medium or heavy. If the level of damage is light, for example, the irrigation is handled, there will be field people, called workmen. Those in charge of opening and closing the irrigation gates are called sluice officers. The section already has stocks of cement, sand and other materials to repair damage that is classified as minor. However, when there is moderate or severe damage they cannot handle it and it is reported to the leadership to be included in the planning database to be proposed for Regional Budget activities.

III. MOBILE REPORTING SYSTEM

A. The Use of Mobile Devices

For Indonesians, mobile phones have become an indispensable part of their everyday existence. Two factors driving this widespread acceptance are usefulness and price. Many more people can now afford cellphones and data plans that are competitive, making mobile technology more accessible to all. This enables people of all income levels to engage with the digital world, stay in touch with loved ones, and obtain information. Social media, messaging apps, and mobile banking have integrated themselves into everyday life, promoting community, financial inclusion, and communication. Notably, because of its low cost and ease of use, the Android operating system is the market leader in Indonesia.

Statistics support the importance of mobile phones in Indonesia even more. By 2029, with more than 270 million people on the planet, smartphone penetration is expected to be close to 97%. This means that practically everyone depends on their mobile phone for daily tasks, communication, and information access. The overwhelming quantity of users and their reliance on mobile devices underscore their pivotal function in molding Indonesia’s social and economic terrain.

B. Features of Smartphone

The smartphone use is characterized by actively utilizing the numerous functionalities of the smartphone device, including its built-in features, for example, using its camera [3], wifi or mobile data, browser, and location feature. Early smartphones only provided single-frequency and mostly GPS-only observations [4]. In 2017, the Samsung S8 and Huawei P10 smartphones were released as the first multi-GNSS devices which are able to track carrier-phase measurements [4]. Beside of that, there is wifi or mobile data features. Wi-Fi is an unlicensed technology that focuses on the Physical (PHY) and Medium Access Control (MAC) layers [5]. It is suitable for mobile and high-speed Internet access and is mainly deployed for enterprise and home networks [5].

C. Open Participatory System

An open participatory model is an approach that invites individuals of diverse backgrounds to actively participate in decision-making processes, idea generation, and collaborative activities [6]. In the mobile application, the public can participate directly in reporting irrigation damage in Batu City. The flow in reporting it, first the user goes to the location where the irrigation is damaged. After that, the user takes a photo of the irrigation. Next, the user uploads the photo to the application. In addition, users are also required to fill in the level of damage and optional information. After all the data has been filled in accordingly, then the user can press the ‘Submit Report’ button.

After reporting, the admin will check the data. If the damage is minor, the irrigation operation and maintenance section of the Public Works and Spatial Planning Agency will send a field person. The damage can be handled, because the material stock and labour capability are fulfilled. If the damage is moderate or severe. Then the section will propose the Regional Budget planning for next year.



Fig. 2. Flow of open participatory reporting

D. Adoption in Irrigation Infrastructure Maintenance

The initial idea for implementation began when the android application made by the agency was only installed by a few people on the google play store. The problem experienced by the public users is that they do not want to install the application because the application will only fill the storage of people’s smartphones. Therefore, a website application is needed that can be comfortably used on the user’s smartphone.

IV. DIGITAL MAP TECHNOLOGY

A. Overview

Digital maps are virtual representations of geographic areas that use layers of spatial data, combining raster (pixel-based) and vector (point, line, polygon) data to depict various features like roads, rivers, and landmarks. They operate using coordinate systems, such as latitude and longitude, to precisely locate places on Earth, and employ map projections to represent the curved surface of the Earth on a flat screen. Users can interact with digital maps through zooming, panning, and overlays, and they often include real-time data, like traffic updates or weather conditions. These maps are frequently accessed through APIs, allowing integration into web and mobile applications for customized mapping solutions.

B. Openstreetmap Platform

OpenStreetMap is a project to build a free geographic database of the world [7]. OpenStreetMap (OSM) is a collaborative project that creates a free, editable map of the world, maintained by a community of mappers. These contributors use GPS devices, aerial imagery, and other free sources to gather data and then upload this information to the OSM database. The project was founded in 2004 by Steve Coast as a response to the restrictive licensing of proprietary maps, aiming to create an open and freely available geographic dataset.

The OSM platform allows users to view, edit, and use geographical data in a collaborative manner. The map data includes roads, trails, cafes, railway stations, and much more, capturing both large-scale features like roads and small details like benches and trees. The open nature of OSM means that the data is constantly being updated and refined by users, which can lead to highly accurate and up-to-date maps.

OSM data is used in various applications, from navigation and route planning to research and disaster response. Many companies and organizations use OSM data as the foundation for their products and services, benefiting from its detailed and community-driven approach. The open license of OSM allows for broad usage and adaptation, making it a vital resource for geospatial data and a powerful example of the potential of open-source projects.

C. Spatial Data Format

GIS can handle points, lines and polygons, or raster data [8]. Point patterns arise when the important variable to be analyzed is the location of "events." [9]. Location is represented as the latitude and longitude of the location coordinate. A linestring, or simply a line, represents a path connecting locations through a sequence of two or more ordered points. Features like roads and rivers are often depicted using linestrings. A polygon, on the other hand, illustrates an area. Its outer edge is formed by a ring, which is a closed and simple linestring as previously described. Any holes within the polygon are similarly outlined by rings.

D. Irrigation Data Format

The irrigation data format uses a vector data format. Based on data from the Batu City public works and spatial planning office in the natural resources section, there is geometry type data which if converted to text using postgis produces MultiLineString type data. MultiLineString data is a collection of linestrings data. Linestring data is a line that form from multiple point.

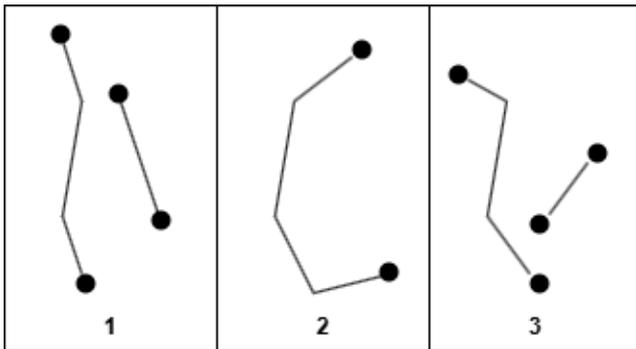


Fig. 3. MultiLineString Data Example

E. Supporting Technologies

Technology that can show and customize OpenStreetMap on the website is Leaflet JS. Leaflet.js is a super-lightweight mapping library [10]. Leaflet is a top open-source JavaScript library for creating mobile-friendly interactive maps. At around 42 KB, it offers all the essential mapping features most developers require.

Leaflet is built for simplicity, performance, and user-friendliness. It functions effectively on all major desktop and mobile platforms, supports numerous plugins, and boasts a beautiful, user-friendly, and well-documented API. Its straightforward and readable source code makes it easy and enjoyable to contribute to.

V. DESIGN OF REPORTING SYSTEM FOR IRRIGATION INFRASTRUCTURE

A. System Requirements

On mobile website application, a required browser that should be installed on a device to run the app without

problem is one of these browser, such as Chrome, Safari, Samsung Internet, Opera Mobile, UC Browser, Android Browser, Firefox, QQ, Baidu, and KaiOS Browser. For Chrome, the minimum supported browser version is version 6. For Safari, the minimum supported browser version is version 6. For Opera Mobile, the minimum supported browser version is version 12. For UC Browser, the minimum supported browser version is version 15.5. For Firefox, the minimum supported browser version is version 3.6. The minimum Android version compatible with the application is version 4.0.

B. System Architecture

Figure 4 is a picture of the general system design, for system information of mobile website and admin website. The mobile website is used by public users. OpenStreetMap technology is displayed on the irrigation infrastructure reporting mobile web application. Then, there is a backend server which is the backend of the mobile website application and the monitoring website application. There is a place to put data in the form of damaged irrigation images in Firebase Storage. Then there is also Database Storage which is a database where to put all the data related to the mobile website application and admin website application.

C. Technical Specifications

Technical specifications of these systems consist of software requirement and hardware requirement. Software requirement of these systems are:

Software name	Description
Windows 11 OS	The operating system used is Windows 11
Visual Studio Code	A text editor that is useful for typing program code for creating information systems, both frontend and backend.
PgAdmin 4	PgAdmin 4 is an application used to make it easier to organize, edit, and repair databases that use PostgreSQL.
PostgreSQL 16.1	PostgreSQL is an enterprise-class, open source database management system and is a relational database management system.
Google Chrome	Google Chrome is one of the most popular browser in the world.
PHP	PHP is a high-level programming language commonly used as a backend.
Laravel Framework	The Laravel framework is a PHP framework that makes it easy to create information systems. In this system, this framework used as backend

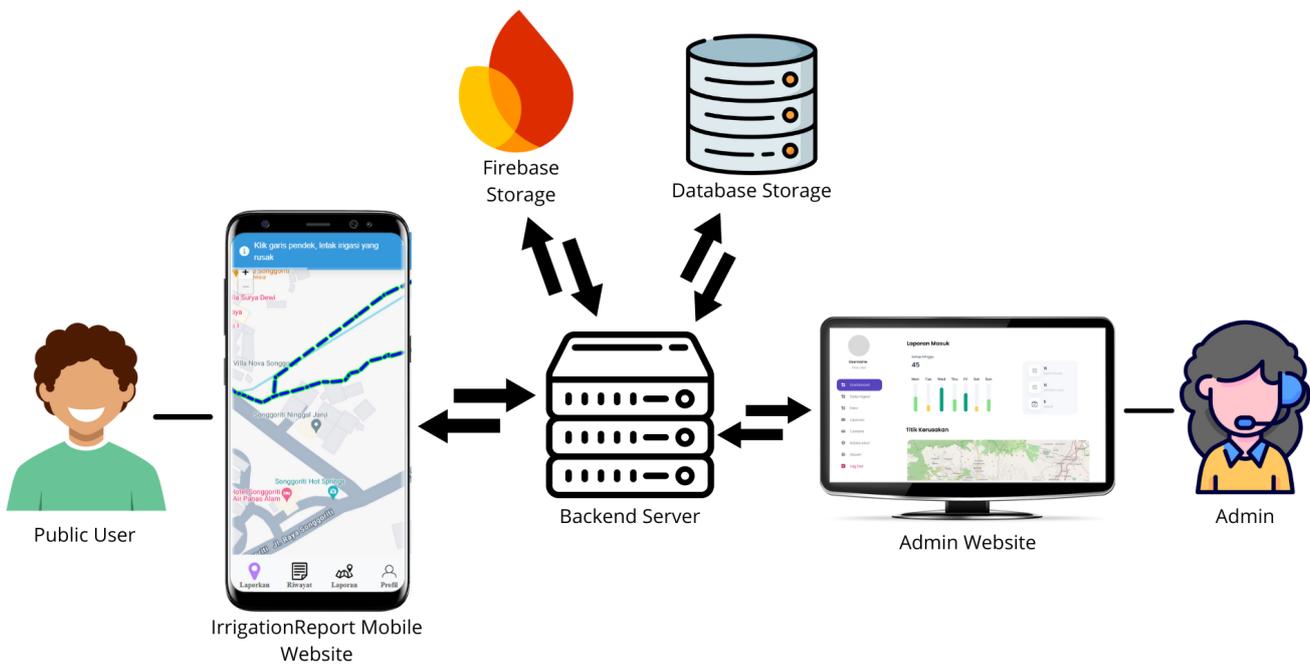


Fig. 4. General System Design

Software name	Description
React JS library	The React JS library is a library used in creating the frontend of a web-based application.
Leaflet JS library	Leaflet JS library is a library used to show OpenStreetMap and add vector data format to the website.
Vite library	Vite is a library used to create React JS projects. Vite makes it easy to deploy the frontend to production.

Hardware requirement of these systems are:

Hardware name	Description
Central Processing Unit	Intel Core i5-10300H
Graphics Processing Unit	Intel(R) UHD Graphics and NVIDIA GeForce GTX 1650
Memory	16GB DDR4
Hard drive	476,92 GB

VI. SYSTEM IMPLEMENTATION

A. Backend Implementation

1) *Get Close Segments API*: This API is used in report it feature of mobile website application. Two query parameters are needed to use this API. The parameters are

the latitude and longitude of the user's current location. Then, there is a code to run a query that select id, name, and geojson of geometry of the segment from the irrigation segments table. After that, there is where query to select only segments that are 100 meters from the user's current location.

2) *Post Report API*: This API performs a function in which there are processes. Firstly, the system checks the inputted data and its data type. Then, a report variable is created in which the create process is run using the ReportList model to create a row in the report_list table. The data filled in the process are user_id, status_id, no_ticket, and maintenance_by. Next, a report_segment1 variable is created which contains the code to create a row in the report_segment table by utilising the report variable. This can be done because the ReportList model is related to the ReportSegment model. The data included in the table are segment_id, level, and note. Then, the upload_dump_id1 variable is created which executes the function to upload the image uploaded by the user. The function also executes the process of creating one row in the upload_dump table. The data entered into the table are filename, file_type, size, folder, file_url, uploader_ip, and uploader_status. Then the function returns the id of the row. Then create one row in the report_photo table using the report_segment1 variable. This can be done because the ReportSegment model is related to the ReportPhoto model.

3) *Get Report By Id API*: This API performs a function whose parameter is the id entered in the route. Inside the

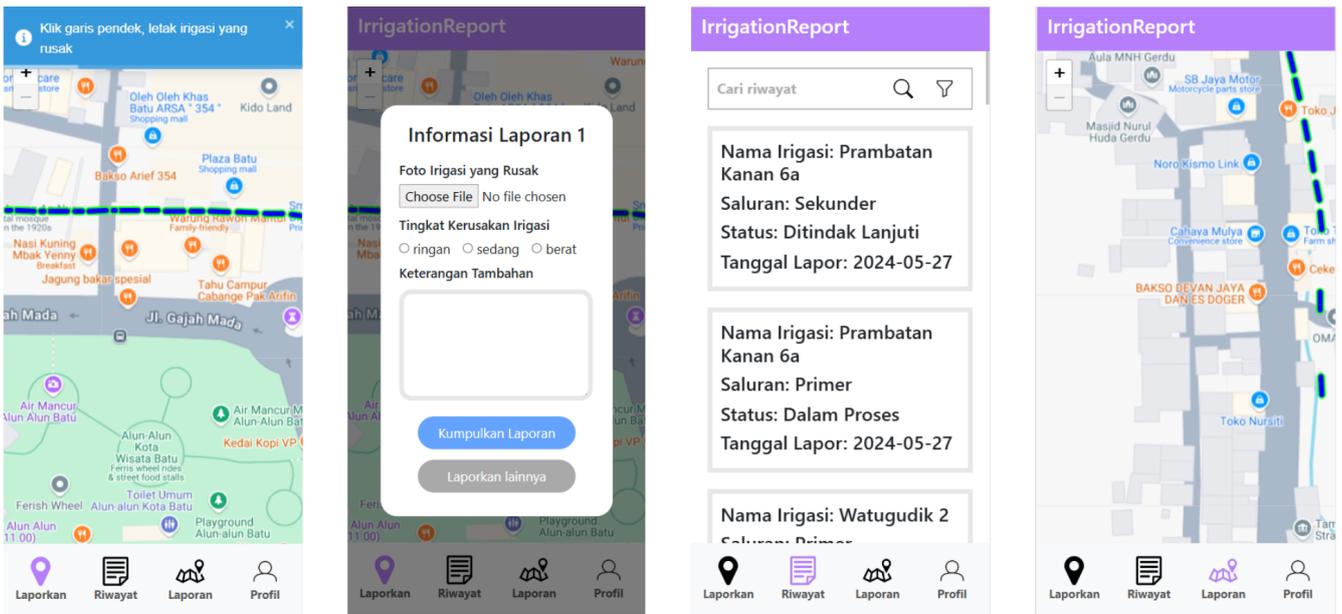


Fig. 5. Screenshots of Report It, History, and Reports Features

function is a try catch. Inside the try, a variable with the name report is created. Inside the variable, a query builder is executed on the report.report_list table. After that, it is given a where to get a report with an id according to the id in the function parameter. Next, join the tables report.status, report.report_segment, report.report_photo, file.upload_dump, map.irrigations_segment, map.irrigations. Then, the columns taken from these tables are report id, ticket number, date the report was created, date the irrigation was repaired, irrigation damage level, damage description, report status, irrigation name, irrigation canal type, URL of the reported image.

4) *Get All User Reports:* This API performs a function with a request parameter. First, I create a userId variable, which contains the user id of the user. Then I create a search variable that contains the contents of the search parameter query. Furthermore, there is also a filter variable that contains the contents of the filter parameter query. Then, a check is made, if the search and filter variables have contents, the system will perform a query by adding a check that the irrigation name must contain the contents of the search variable. In addition, in the same query, a check is made to ensure that the status name is the same as the contents of the filter variable. Next, a check is made, if the filter variable has contents, then the system will perform a query by checking the status name must be the same as the contents of the filter variable. After that, given a check, if the search variable has content, the system will run a query by adding checking the irrigation name must contain the contents of the search variable. After each query is executed, the system will display the query results as a response.

5) *Get All User Reported Segments:* This API performs a function with a request as the parameter. Two query parameters are required to run this function. The two parameters are the latitude and longitude of the user's current location. The two parameters are entered into two variables, namely the latitude and longitude variables. In addition, a userId variable is also required which contains the user id. from user login session. Then a select query is executed to get the data, namely segment id data, irrigation damage level, geojson of irrigation segment line, report status, irrigation name, irrigation canal type. The data is from the report list table, joined with the status table, report segment, irrigation segments, and irrigations. The data displayed is data with the same user id as the id from the user login session. In addition, the data displayed is data with segment lines within a 100 meter radius of the user's current location. After query is executed, the system will display the query results as a response.

B. Mobile Application

1) *Report It Feature:* After the user has successfully logged in, the user will be directed to the report page. On this page, a map and segments in the form of short lines are displayed. At the first time to this page, a blue toast info is displayed with the message "Click on the short line, the location of the damaged irrigation", as can be seen in Figure 5.5. If the user clicks on one of the short lines, the system will display a popup. The popup can be seen in Figure 5.6. The popup contains a report form. In the report form, it contains inputs of damaged irrigation photos, irrigation damage levels, and additional information. Then below it, there are 2 buttons. The top button is to send the report data that has been inputted to the backend server. After

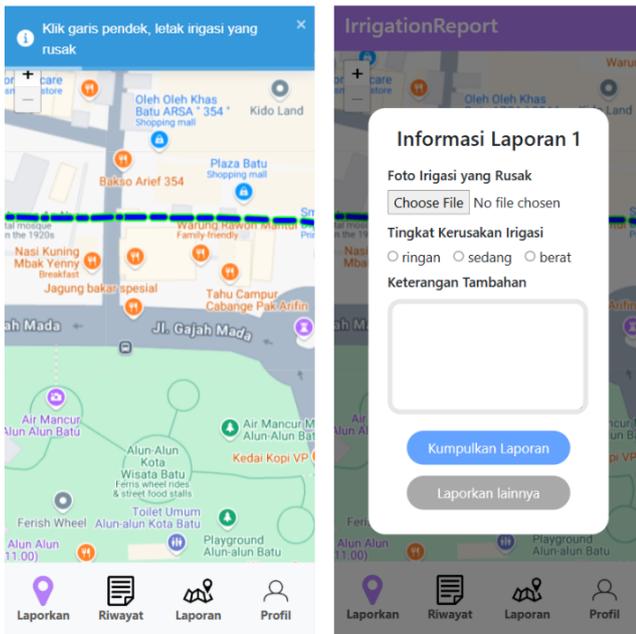


Fig. 6. Screenshot of Report It Feature

sending, the backend server will validate the data. If the data is correct, the backend will send the data to be stored in the database. In addition, there is another report button. The button functions so that users can report reports in other locations, apart from the previous location. In the end, the user can send 3 reports in different locations simultaneously to the backend server.

2) *Search Feature in History Page:* If the user presses the “History” button on the bottom bar, the system will display the report history page. This page contains reports that have been reported previously. Users can search for reports by irrigation name in the search box above the reports. All you have to do is type in the name of the irrigation you want to search for, then press the button with the magnifying glass icon. Once pressed, the system will display the report with the irrigation name as typed by the user.

3) *Filter Feature in History Page:* In addition to searching, users can also filter report history data. Do this by pressing the button with the filter icon. Then, select the status filter, for example with the status “Followed Up”. If pressed, the system will only display reports with follow-up status.

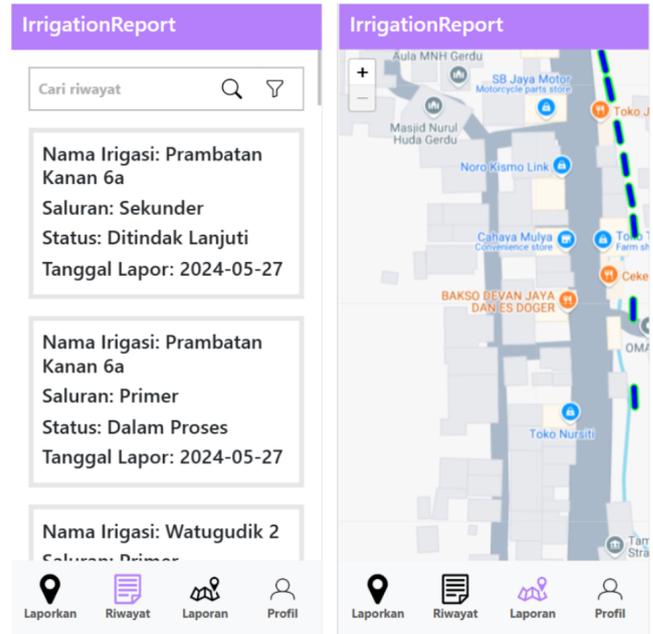


Fig. 7. Screenshot of History and Reports Feature

4) *History Detail Feature:* If the user presses one of the report history on the history page, the system will display the report details of the report history. If in one report the user reports 3 segments at once, then the report details will display the 3 buttons above. When first accessing the report detail page, the system will display the first location reported so that the “Location 1” button is active. The user can select the second location reported by pressing the “Location 2” button, as well as the third location. In addition, the report detail page displays the name of the irrigation, the type of irrigation channel, the status, the level of damage, a description, and a photo.

5) *Reports Feature:* If the user presses the “Reports” button on the bottom bar, the system will display the reports page. On that page, there are irrigation segments that have been reported previously by the user. If one of the segments is pressed, a popup containing the report data will be displayed. The report data includes the irrigation name, canal type, status, and damage level.

VII. EVALUATION

This section evaluates system performance, compatibility and reporting result.

A. Evaluation Scenario

I tested it for two days. On the first day, I opened the irrigation distribution map that I got from the Batu City Public Works and Spatial Planning Office. I opened it using the QGIS application. After I looked, it turned out that there were many irrigation channels to the left of the Purnama Hotel. The area is located in Punten village. There are many farmers in IP2TP Punten, because of that I went there. There, I asked the farmers there to try the application that I

had made. First I asked for the farmer's WhatsApp number. Then, I sent the website link of my application to the farmer via WhatsApp. After that, I asked the farmer to open the link and try all the features in the application that I made. I observed user activity on every feature of the application. I noted when users encountered difficulties or when the system did not perform as expected. On the first day, I was only able to test the application with 3 farmers. On the second day, I managed to test the application with 17 users, 7 of whom were also farmers.

B. System Performance and Compatibility

Each system is developed to meet user functional requirements, and system functional performance is its utility and the ultimate user value measure [11]. The system's performance is measured based on time, the less time required to execute a function, the higher the system's performance for that function. The first system performance I measured was the performance in displaying irrigation segments in the report feature. The time needed to execute this function was 403.13 ms. If there are many irrigation segments, such as at the agro-tourism apple-picking area, it takes 543.2 ms. Then, for the function of sending reports, it takes 8.715 seconds.

For the system's performance in displaying 24 report history lists, it takes 166.9 ms. For the function of displaying report history details, if only one segment is reported in a single report, it takes 200 ms. For the same function, but with three segments reported in a single report, it takes 190 ms. Then, for the function of displaying previously reported irrigation segments, it takes 400.86 ms.

The compatibility of a website can be determined based on its suitability after being tested across various browsers and browser versions, different screen sizes, and Android versions. After checking, it was found that the browsers compatible with the application are Chrome, Safari, Samsung Internet, Opera Mobile, UC Browser, Android Browser, Firefox, QQ, Baidu, and KaiOS Browser. For Chrome, the minimum supported browser version is version 6. For Safari, the minimum supported browser version is version 6. For Opera Mobile, the minimum supported browser version is version 12. For UC Browser, the minimum supported browser version is version 15.5. For Firefox, the minimum supported browser version is version 3.6. After testing on various smartphone screen sizes, all screen sizes were found to be compatible with the application. The minimum Android version compatible with the application is version 4.0.

C. Reporting Results

When a user reports damage on a specific irrigation segment (a short line), the system processes the reported data to be stored in the database. If the reported irrigation segment can be saved to the database, the backend will send a response with the message 'Report data successfully sent.' Then, the frontend of the website will display a message at

the top of the screen (toast) with the message "Your report has been successfully submitted".

After the report is successfully submitted, the admin from the Public Works and Spatial Planning department can view the report through the admin website. On the admin website, the admin can view the report on the dashboard page under the latest reports. Additionally, the admin can also view reports submitted by users on the reports page. On that page, there are features for exporting data, searching, and filtering data. The page displays the reports in rows, with each row containing data for one report. There are five columns: date, report number, report status, irrigation name, and actions. In the actions column, there are two buttons: one to view the report details and another to delete the report. When the admin clicks the details button, the system will display the report details page. On this page, the reporter's information is shown, including report number, name, email, phone number, and status. Below the reporter's information, there is the report location, which includes data such as irrigation name, type, channel, report location, description, village, district, and photo. In the top right corner, there are two buttons: one to follow up on the report and another to reject the report.

After that, the user can view the reported data on the history page. The user can navigate to the history page by pressing the history button on the bottom bar. On the history page, there is a list of reports that the user has previously submitted. If the user taps on one of the reports, the system will display the details of the selected report. Users can also view report data by going to the report page. On the report page, the irrigation segments that have been previously reported will be displayed. If one of the segments is clicked, the system will display the report data for the selected segment.

VIII. CONCLUSION

The Android application would only take up storage space on the user's smartphone. Therefore, the creation of a web application that can be comfortably used on smartphones is necessary. In this project, irrigation distribution data is needed and then sent to a PostgreSQL database. The data is then processed in the PostgreSQL database, which uses the PostGIS extension, so that it can be used in the backend. After testing each of the main features of the application, it was found that the application can function as expected.

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