Utilizing OpenStreetMap for Collaborative Mobile Reporting System in Irrigation Infrastructure Management

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ABSTRACT

Keywords
Irrigation
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Irrigation involves the artificial application of water to the soil, crucial to promoting crop growth where rainfall is insufficient, thus supporting healthy plant development and increasing yields. In Indonesia, a large part of the irrigation infrastructure is in disrepair, affecting agricultural productivity and causing food shortages and economic instability, especially among low-income populations. Meanwhile, mobile phones have become an essential part of everyday life in Indonesia due to their affordability and utility, which facilitate access to digital resources. Anticipated to reach 97% smartphone penetration by 2029, particularly with Android devices, this technology supports an innovative mobile application strategy for irrigation maintenance. This app enables farmers and community members to report issues collaboratively, accelerating the identification and repair process to improve agricultural management. Complementing this approach, OpenStreetMap (OSM) provides an editable global map resource, continuously updated by users and leveraging tools such as Leaflet JS to offer developers the ability to create interactive and customizable maps, enhancing infrastructure management through community participation. This study introduces a mobile reporting system for managing irrigation infrastructure, integrating several technical components to effectively address maintenance needs. The technical setup involves Windows 11, Visual Studio Code, PHP with Laravel for backend operations, and React JS with Leaflet JS for front-end design, running on hardware featuring an Intel Core i5 CPU and NVIDIA GTX 1650 GPU. Key APIs like Get Close Segments, Post Report, and Get The system facilitates data submission with locations and photos, provides report history viewing and filtering, and enhances user engagement through transparency in infrastructure management. The test with local farmers demonstrated the responsiveness and compatibility of the system across various platforms, ensuring that user reports are processed efficiently with reliable admin access for monitoring and tracking.

1. Introduction

Irrigation is the artificial application of water to the soil to promote crop growth, particularly in places with insufficient rainfall, ensuring that plants receive the essential hydration for healthy development and increased yields [1], [2], [3]. In Indonesia, a substantial part of the irrigation infrastructure is in disrepair, reducing agricultural production and resulting in food shortages with economic instability, particularly among low-income groups. The primary, secondary and tertiary canals that make up the irrigation system are under the control of local organizations that are responsible for monitoring and maintaining the systems [4]. Field personnel examine irrigation channel damage and categorize repairs depending on severity; small damages may be repaired using readily accessible supplies, while more serious concerns escalate for budget considerations. Proper

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irrigation management is critical to maintaining food production and farmers' livelihoods in the region [5], [6].

Mobile phones have become vital in Indonesian daily life due to their affordability and utility, allowing people of all economic levels to access the digital world, interact with loved ones, and acquire information [7], [8]. The prevalence of smartphones, particularly among those using the Android operating system, is expected to reach about 97% by 2029. Smartphones have several advantages, such as high-quality cameras and Internet access, which help them integrate into daily activities [9], [10]. An innovative open participation strategy based on a mobile application improves irrigation infrastructure maintenance by allowing users, including farmers and community members, to report problems immediately and collectively. This technique streamlines the process of recognizing and treating irrigation concerns, resulting in faster fixes and enhanced agricultural management.

Digital maps are virtual representations of geographic locations that include raster and vector data to depict elements such as roads and landmarks, with coordinate systems used for precise position tracking via map projections. OpenStreetMap (OSM) is a collaborative effort that builds a free, editable global map, allowing anyone to view, update, and use geographic data provided by community members via GPS and aerial images. OSM was founded in 2004 to oppose proprietary mapping limitations and is constantly updated by users, making it a reliable resource for a variety of applications such as navigation and disaster response. The platform uses vector data formats for several forms of geographical data, such as *MultiLineString* data for irrigation information, and accompanying technologies like Leaflet JS, a lightweight mapping toolkit, enabling developers to create interactive and customizable maps efficiently across various platforms.

This study presents an innovative approach of mobile reporting system for irrigation infrastructure that integrates multiple technical components to efficiently address maintenance needs. The system requires compatible browsers such as Chrome, Safari, and others, each with specific minimum versions along with an Android version of at least 4.0, ensuring wide accessibility. The architecture includes a mobile website for public use that employs OpenStreetMap technology, a back-end server for both mobile and monitoring applications, and Firebase for storing images related to irrigation damages, while database storage compiles all application data. The technical specifications encompass software such as Windows 11 OS, Visual Studio Code for development, and PostgreSQL for robust data management, using PHP with the Laravel framework for back-end functionalities, and React JS paired with Leaflet JS for the front-end. The hardware requirements specify an Intel Core i5 CPU, NVIDIA GTX 1650 GPU, 16GB RAM, and significant storage capacity, ensuring optimal performance. The backend leverages Laravel for secure data exchanges and PostgreSQL for database operations, with key APIs such as Get Close Segments, Post Report, and Get Report By ID supporting core functionalities. These enable users to report irrigation system failure through an intuitive mobile interface, facilitating real-time problem tracking and community collaboration. Features include submitting reports with location and image data, viewing history, filtering previous entries, and accessing detailed reports, enhancing user engagement and transparency in infrastructure management. The system thus provides a comprehensive tool for participatory management of irrigation infrastructure, fostering efficient maintenance and community involvement.

During the two-day testing period for an irrigation reporting mobile application, I used the QGIS application to analyze an irrigation distribution map from the Batu City Public Works and Spatial Planning Office, with a focus on the irrigation channels near Purnama Hotel in Punten village, where many farmers live. On the first day, I presented the program to three farmers, sending them a link on WhatsApp so they could test its capabilities while I monitored their interactions. On the second day, I increased my testing to 17 users, including seven farmers. The program allows users to enter data and submit photographs for irrigation reporting, and these submissions are processed rapidly. Performance data displaying execution durations for various tasks demonstrated the system's responsiveness, while compatibility testing proved appropriate functioning across multiple browsers and screen sizes (minimum Android version 4.0). The reporting function guarantees that user input creates success messages, and administrators may access these reports via a dedicated admin page, where they can monitor and track user reports. In addition, the application's history area allows the user to monitor their submissions.

The rest of this article is organized as follows. Section 3 discusses several related theories to provide a more comprehensive and in-depth understanding of the topic. Section 4 discusses how mobile reporting systems are used, the features of smartphones, and their application in irrigation. Section 5 discusses the general overview of the system, the *OpenStreetMap* platform, the spatial data formats, the irrigation data formats, and the supporting technologies. Section 7 including the design of the reporting system, the requirements of the system, the architecture of the system, and the technical specifications. Section 8 discusses the analysis of the system performance evaluation and the result of the report. Lastly, this article concludes with some future works in Section 9.

2. Related Works

In 2014, Ernawati et al. presented research on the geographic information system related to irrigation in Bengkulu province [11]. However, the geographic information system created uses the Google Maps API. Google Maps API service is paid. Unlike the Google Maps API, the OpenStreetMap service is free. In their research, they displayed a map in their application and then gave markers to the map. The markers on the map consisted of red and green markers. Green markers indicate that activities of the irrigation project have been completed. Red markers indicate that irrigation project activities are still in progress.

In 2022, Matilla et al. conducted a study discussing low-cost solutions that utilize novel interfaces and wireless communications, but underlined the importance of further testing in different situations to determine their wider application and efficacy. Precision agriculture and ICT provide new monitoring solutions, but they must also address the digital divide to ensure that all potential users can use them. Furthermore, these technologies must be affordable to attract and benefit end users, especially smallholder farmers with limited resources.

In 2022, Obaiden et al. conducted a study on sustainability, agriculture must use sophisticated technology while maintaining a balanced grasp of its benefits and drawbacks [12]. Although IoT and sensory systems improve water management efficiency, water restrictions, security issues, and communication challenges frequently hinder their adoption. Research and development are essential to address these challenges and increase long-term efficacy. Although technology may save costs and improve accuracy, it also requires strong security measures to protect data and maintain reliable operations.

In 2023, Zapata et al. conducted a simulation method intended to optimize the management of improved infrastructure in irrigation systems, addressing the new challenges posed by increasing costs and environmental concerns [13]. The method integrates different irrigation technologies on farmland, including pivot center and drip irrigation, and simulates crop responses to different management tactics to help farmers make better decisions. Although the program accurately replicates irrigation techniques and has been validated through theoretical case studies, it shows certain limitations, such as the need for further studies to refine the double cropping arrangement for different climatic conditions. Furthermore, the study emphasizes the lack of a universal irrigation approach, which implies that specific studies are needed depending on local environmental characteristics. These findings highlight the need to carefully estimate the energy costs and pumping requirements when constructing irrigation systems.

In 2024, Lunstad et al. conducted a study on water distribution systems that focused on the establishment of an integrated water distribution system that coordinates smart irrigation devices with existing infrastructure, similar to the successful model of the electricity grid, to improve demand-side water management tactics [14].

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3. Irrigation Infrastructure in Indonesia

This section presents functions, general conditions, types of irrigation infrastructure, and infrastructure management.

3.1. Functionalities

Irrigation is the artificial application of water to the soil, usually to assist in the cultivation of crops [15], [16]. 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 [17], [18]. By providing a consistent and controlled water supply, irrigation helps maintain soil moisture, prevent drought stress, and promote healthy plant growth [19]. In addition, irrigation can aid in soil fertility management, as it facilitates fertilizer application and helps control weed growth and mitigate frost damage [20]. Ultimately, irrigation is crucial for food production, landscape maintenance and the support of ecosystems in arid and semi-arid regions [21].

3.2. General Condition

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 as shown in Figure 1. 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 sustainability of farmers' livelihoods, who depend on crop yields for their livelihoods. Long-term impacts include soil degradation, increased food insecurity, and economic instability in affected areas.

Fig. 1. Damaged Irrigations in Indonesia

3.3. Types of Irrigation Infrastructure

Irrigation Infrastructure has three types, namely primary, secondary, and tertiary [22], [23]. Primary irrigation canals are canals that come directly from the river [24]. 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 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 into a new branch, the new branch is a tertiary canal.

3.4. Infrastructure Management

The management of the 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, the data on the length of irrigation, the number of primary irrigations, the number of secondary irrigations, and the number of tertiary irrigation. There is also data on 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 [25]. 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 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.

4. Mobile Reporting System

This section explains the use of mobile device features, the implementation of open participatory systems through smartphones, and the maintenance of irrigation infrastructure.

4.1. The Use of Mobile Devices

For Indonesians, mobile phones have become an indispensable part of their daily existence [26]. Two factors driving this widespread acceptance are usefulness and price. Many more people can now afford competitive cell phones and data plans, making mobile technology more accessible to everyone [27]. This enables people of all income levels to engage with the digital world, stay in touch with loved ones, and obtain information. Social networks, messaging applications, and mobile banking have integrated themselves into daily life, promoting community, financial inclusion, and communication. In particular, because of its low cost and ease of use, the Android operating system is the market leader in Indonesia.

The statistics further support the importance of mobile phones in Indonesia. 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 access to information. The overwhelming number of users and their dependence on mobile devices underscore their pivotal role in shaping Indonesia's social and economic terrain.

4.2. Features of Smartphone

Smartphone usage is characterized by actively using the numerous functionalities of the smartphone device, including its built-in features, for example, using its camera [28] wifi or mobile data, browser, and location feature. Early smartphones provided only single-frequency and mostly GPS-only observations [29]. In 2017, Samsung S8 and Huawei P10 smartphones were released as the first multi-GNSS devices capable of tracking carrier phase measurements [29]. In addition to that, there are Wi-Fi or mobile data features. Wi-Fi is an unlicensed technology that focuses on the Physical (PHY) and Medium Access Control (MAC) layers [30]. It is suitable for mobile and high-speed Internet access and is deployed mainly for enterprise and home networks [30].

4.3. 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 [31]. In the mobile application, the public can directly participate in reporting irrigation damage in Batu City. In reporting it as shown in Figure 2 the user first goes to the location where the irrigation is damaged. After that, the user takes a photo of the irrigation. The user then uploads the photo to the application. In addition, users are also required to fill in the damage level and optional information. After filling in all data accordingly, the user can press the 'Submit Report' button.

Fig. 2. Flow of open participatory reporting

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. Damage can be handled because the material stock and labor capacity are met. If the damage is moderate or severe. Then the section will propose the Regional Budget planning for next year.

4.4. Adoption in Irrigation Infrastructure Maintenance

In Indonesia, the demand for efficient irrigation infrastructure management has grown substantially due to the country's reliance on agriculture as the backbone of its economy [32]. With vast agricultural land that requires systematic water management, traditional methods of maintaining irrigation channels often result in delays and inefficiencies. To address these challenges, a mobile application based on an open participatory model presents a promising solution. This model invites farmers, community members, and agricultural officers to participate directly in the maintenance and monitoring of irrigation systems, ensuring timely and relevant responses to maintenance needs. Using technology, this approach can seamlessly integrate local knowledge with modern management practices, making the system more adaptive to the realities of the field.

The advantages of implementing a mobile application with an open participatory model are multiple. Facilitates mass participatory reporting, whereby users can instantly report issues such as blockages or leaks through the app, leading to faster resolutions. The app's interface is designed to be intuitive, allowing even those with limited technical skills to contribute effectively. Once an issue is reported, it is visible to all users, prompting swift collaborative action. Feedback loops enable continuous improvement of system processes as collected data inform maintenance priorities and resource allocation. This decentralized, real-time method of managing irrigation infrastructure not only improves transparency and accountability, but also reduces the costs associated with neglect and large-scale repairs. In the end, the encouragement of group participation in this model ensures that the infrastructure is robust and sustainable, which is crucial for Indonesian agriculture's future.

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5. Digital Map Technology

This section provides an overview of the system, the *OpenStreetMap* platform, spatial data formats, irrigation data formats, and supporting technologies.

5.1. 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 such as roads, rivers, and landmarks [33]. 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 by zooming in, panning, and overlays, and they often include real-time data, such as traffic updates or weather conditions. These maps are frequently accessed through APIs, allowing integration into web and mobile applications for customized mapping solutions.

5.2. Openstreetmap Platform

OpenStreetMap is a project to build a free geographic database of the world [34]. A community of mapmakers collaborates to create and maintain OpenStreetMap (OSM), which is a free, editable map of the entire world. These contributors use GPS devices, aerial imagery, and other free sources to gather data and then upload this information to the OSM database. In order to create an open and freely accessible geographic dataset, Steve Coast founded the project in 2004 as a response to the restrictive licensing of proprietary maps.

The OSM platform allows users to view, edit, and use geographic data in a collaborative way. The map data includes roads, trails, cafes, railway stations, and much more, capturing both large-scale features such as roads and small details such as benches and trees. Due to OSM's open nature, users are constantly updating and improving the data, which can produce maps that are extremely accurate and up to date.

OSM data are used in various applications, from navigation and route planning to research and disaster response. Many companies and organizations use OSM data as the basis 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.

5.3. Spatial Data Format

GIS can handle points, lines, and polygons, or raster data [35]. Point patterns arise when the important variable to be analyzed is the location of "events." [36]. The location is represented as the latitude and longitude of the location coordinate. The example of *MultiLinesString* data is shown in Figure 3.

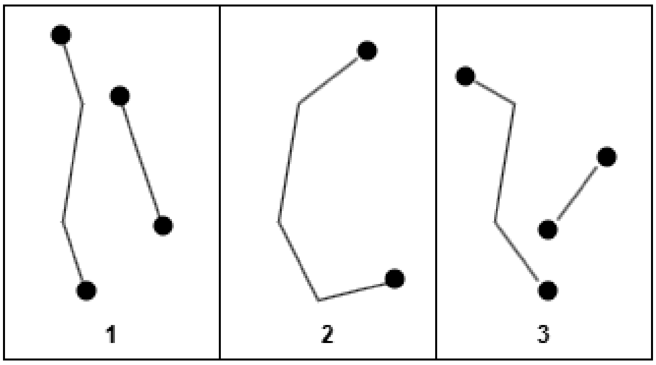

Fig. 3. MultiLineString Data Example

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5.4. 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 are geometry-type data that, if converted to text using *Postgis*, produce *MultiLineString*-type data. *MultilineString* data are a collection of *LineString* data. *LineString* data are lines that form from multiple points.

5.5. Supporting Technologies

The technology that can show and customize OpenStreetMap on the website is Leaflet JS. Leaflet.js is a super lightweight mapping library [37]. Leaflet is a leading open-source JavaScript library for creating mobile-friendly interactive maps. At around 42 KB, it offers all the essential mapping features that most developers require.

The leaflet is built for simplicity, performance, and user-friendliness. It works 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.

6. Design of Reporting System for Irrigation Infrastructure

This section presents the design of a mobile reporting system for irrigation infrastructure consisting of system requirements, system architecture, and technical specifications.

6.1. System Requirements

In mobile website application, a browser that should be installed on a device to run the app without problem is one of these browsers, 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.

6.2. System Architecture

Figure 4 is a picture of the general design of the system, for the system information of the mobile website and the admin website. Public users use the mobile website. OpenStreetMap technology is displayed in the irrigation infrastructure reporting mobile web application. Then, there is a back-end 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 the admin website application.

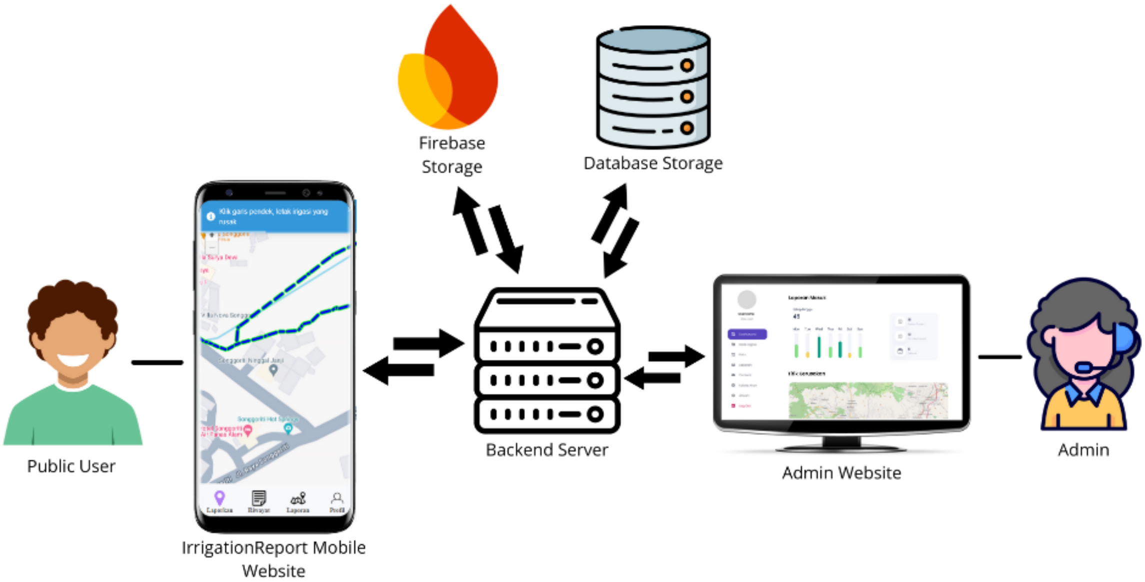

Fig. 4. General System Design

6.3. Technical Specifications

Technical specifications of these systems consist of software requirements and hardware requirements. The software requirements of these systems are:

Table 1. Software Requrement

Softaware 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.
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 front-end to production.

The hardware requirements of these systems are:

Table 2. Hardware Requrement

Hardware name	Description
Central Processing Unit	Intel Core i5-10300H

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Graphics Processing Unit	Intel(R) UHD Graphics and NVIDIA GeForce GTX 1650
Memory	16GB DDR4
Hard drive	476,92 GB

7. System Implementation

This section describes the implementation of a mobile reporting system for irrigation infrastructure consisting of back-end implementation and mobile applications. In the back-end implementation there are features, API get close segments, API post report, and API get report by ID. In the mobile application, there are report It features, search features on the history page, filter features on the history page, history detail features, and report features.

7.1. Backend Implementation

The backend for a mobile application using React.js, Laravel, and PostgreSQL involves using Laravel to manage server-side logic and create a secure and efficient API for data interactions, while PostgreSQL handles robust database management. Leaflet.js is integrated for interactive mapping capabilities, and the Vite library is used to optimize the development and build processes, ensuring fast and dynamic user experiences.

1) *Get Close Segments API*

This API is used in the report it features of the mobile website application. Two query parameters are needed to use this API. The parameters are the latitude and longitude of the current user location. Then, there is a code to run a query that selects id, name, and *GeoJSON* of geometry of the segment from the irrigation segments table. After that, there is where the query is 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 as shown in Figure 5. 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 maintenanced_by. Next, a report_segment1 variable is created which contains the code to create a row in the report_segment table by utilizing 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.

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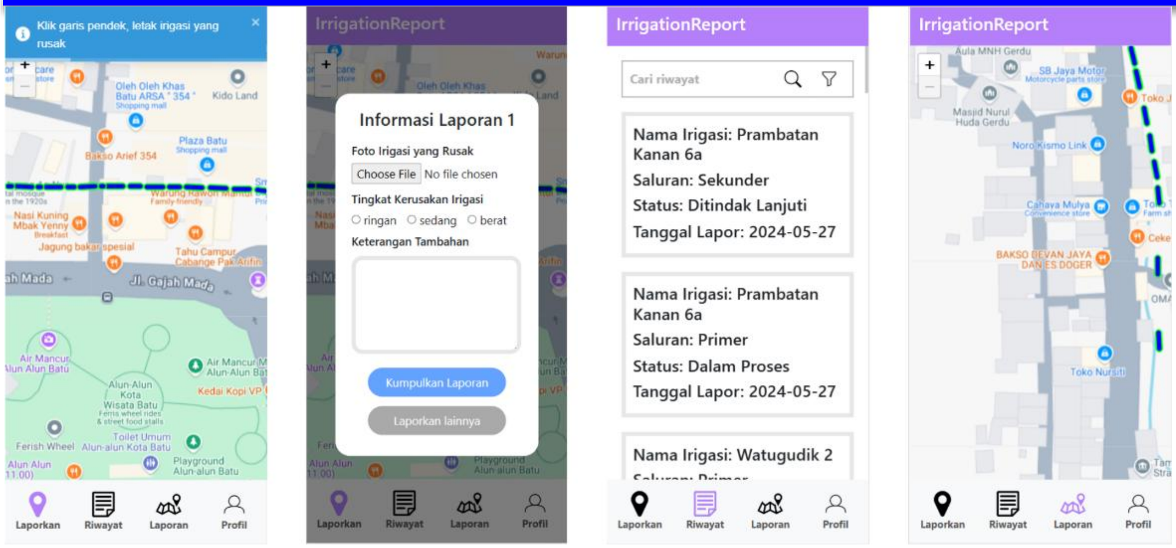

Fig. 5. Screenshots of Report It, History, and Reports Features

3) Get Report By Id API

This API performs a function whose parameter is the id entered in the route. Inside the 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, a location is given 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.

7.2. Mobile Application

A mobile application that uses React.js for an open participatory reporting system enables users to easily report and track issues in real time, fostering community-driven participation, and collaboration. Using React.js, the app offers a responsive and intuitive interface that allows users to contribute data seamlessly, enhancing transparency and accelerating response times for reported issues as shown in Figure 6.

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 shown in Figure 7. For the first time on this page, blue toast info is displayed with the message "*Click on the short line, the location of the damaged irrigation*". If the user clicks on one of the short lines, the system will display a pop-up. The pop-up can be seen in Figure 5.6. The pop-up contains a report form. In the report form, it contains input from damaged irrigation photos, levels of irrigation damage, and additional information. Then below it, there are 2 buttons. The top button is used to send the report data that has been inputted to the back-end server. After sending, the back-end server will validate the data. If the data is correct, the back end 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 back-end server.

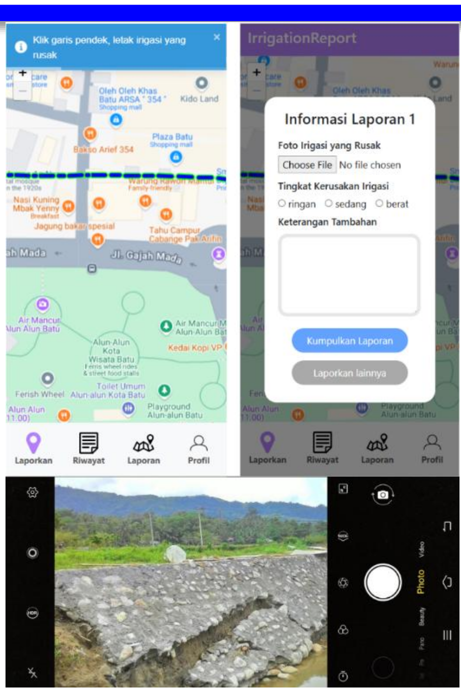

Fig. 6. Screenshot of Report It Feature

2) Search Feature in History Page

If the user presses the "History" button on the bottom bar, the system will display the history page of the report. This page contains reports that have been previously reported. Users can search for reports by irrigation name in the search box above the reports. All you have to do is type the name of the irrigation you want to search for and then press the button with the magnifying glass icon. Once pressed, the system will display the report with the irrigation name that the user entered.

3) Filter Feature in History Page

In addition to searching, users can also filter the 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.

4) History Detail Feature

If the user presses one of the report history buttons 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 reported location so that the “Location 1” button is active. By pressing the "Location 2" button, the user can choose the third location as well as the second location reported. 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 report page. On that page, there are irrigation segments that the user has previously reported. If one of the segments is pressed, a pop-up containing the report data will be displayed. The data in the report include the name of the irrigation, the type of canal, the status, and the level of damage.

8. Evaluation

This section evaluates system performance, system compatibility, and reporting results.

8.1. 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 looking, 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 in 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.

8.2. 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 [38]. 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 required to execute this function was 403.13 ms. If there are many irrigation segments, such as in the apple-picking area of agrotourism, it takes 543.2 ms. Then, for the reporting function, 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 the 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 on 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.

8.3. Reporting Results

When a user reports damage to 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 back-end will send a response with the message 'Report data successfully sent.' Then, the front-end 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 administrator of 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. In addition, the administrator can also view reports submitted by users on the report page. On that page, there are features for exporting data, searching, and filtering data. The page displays the reports in rows, and each row contains 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 administrator clicks on 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 upper right corner, there are two buttons: one to follow up on the report and the other 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 the report data by going to the report page. On the report page, the irrigation segments that have previously been reported will be displayed. If one of the segments is clicked, the system will display the report data for the selected segment.

9. Conclusion

This paper presents a mobile application for irrigation reporting that leverages a robust back-end structure using React.js, Laravel, and PostgreSQL, ensuring a secure and efficient data exchange process. The integration of interactive mapping through Leaflet.js and enhanced development speed via the Vite library contributes to a dynamic user experience. This system allows users to report and monitor irrigation issues in real-time through an intuitive interface, featuring capabilities for reporting, historical data search, and detailed filtration of past contributions. Performance evaluations conducted over two days demonstrated the application's reliability across various browsers and devices, underscoring its adaptability and user-friendliness. In addition, the system evaluation highlights its efficient handling of performance metrics, with key functionalities executed within acceptable time frames across different scenarios. Compatibility testing confirmed that the application supports a variety of browsers and Android versions, ensuring accessibility for various user groups. The backend's ability to manage databases effectively, coupled with a user-friendly mobile front-end, facilitates a seamless reporting and management process for irrigation maintenance.

For future developments, integrating predictive analytics could significantly enhance the application's value by forecasting maintenance needs and optimizing resource allocation. Enhanced user engagement through tailored notifications could improve user interaction and reporting efficiency. In addition, advanced data visualization tools could be developed to assist administrators in making more informed decisions, ultimately refining irrigation management strategies.

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