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Design And Development Of A Web-Based Geographic Information System For Road Conditions In Muara Bulian

Maila Rizqi Aulia[1*], Ahmad Syukron Prasaja[2]

[1-2] Faculty of Science and Technology, Information Systems, Universitas Islam Negeri Sulthan Thaha Saifuddin Jambi, Jambi, Indonesia
Corresponding author: mailarizqiaulia@gmail.com
Email: syukronprasaja@uinjambi.ac.id

ABSTRACT

The development of information technology has significantly influenced information management and dissemination, including in road infrastructure. However, road condition data collection in Muara Bulian is still conducted manually, resulting in ineffective data management and limited public access to accurate information. This study aims to design and develop a web-based Geographic Information System (Web-GIS) for road conditions in Muara Bulian. The study employed a descriptive qualitative method using observation, interviews, documentation, and literature review for data collection. The system was developed using the Waterfall model, consisting of requirements analysis, system design, implementation, and testing. The application was developed using Python and the Flask framework, with SQLite as the database and Leaflet.js and QGIS to support interactive map visualization. The results show that the system can display road condition information through interactive digital maps, provide road location search and detailed information, support basemap switching, facilitate road data management, and generate reports. Black Box Testing confirmed that all system functions operated according to the specified requirements. The Web-GIS is expected to support the government in managing road infrastructure data and facilitate public access to road condition information effectively and efficiently.

Keyword : Web-GIS, Road Conditions, Geographic Information System, Flask, Waterfall

INTRODUCTION

Road infrastructure plays a strategic role in supporting regional development, economic activities, the transportation of goods and services, and community mobility. The availability of adequate road infrastructure can improve connectivity and facilitate access to public services, educational institutions, commercial areas, and government facilities. Conversely, inadequate road infrastructure and poor road conditions may disrupt mobility and hinder social and economic activities. Therefore, road infrastructure requires effective and sustainable management supported by accurate and accessible information. However, road data management and information dissemination in Muara Bulian have not been fully integrated into a digital information system, making the management and accessibility of road information less effective. To address this problem, this study proposes the development of a web-based Geographic Information System (Web-GIS) capable of presenting road information through interactive digital maps and supporting structured road data management.

Roads constitute an essential component of the land transportation system and contribute significantly to regional development. Effective road management involves planning, development, maintenance, monitoring, and evaluation processes. In Indonesia, road management is regulated under Law Number 38 of 2004 concerning Roads, which emphasizes the importance of planned and

sustainable road development and maintenance. The implementation of effective road management requires accurate, structured, and accessible information to support infrastructure planning and decision-making. Therefore, the availability of well-organized road data is important for government agencies responsible for managing transportation infrastructure.

Muara Bulian is the administrative center of Batanghari Regency, Jambi Province, Indonesia. The area functions as a center for government administration, trade, education, and public services. Consequently, the availability and management of road infrastructure play an important role in supporting the mobility and daily activities of the community. The road network in Muara Bulian consists of paved, gravel, and unpaved roads with different characteristics and levels of utilization. Although road infrastructure has been developed in several areas, some road sections still require proper management and monitoring to support more effective infrastructure planning.

Based on interviews conducted with the Department of Public Works and Spatial Planning of Batanghari Regency, several road sections in Muara Bulian experience different physical conditions influenced by factors such as infrastructure age, weather conditions, environmental factors, and traffic intensity. Roads that are frequently used by heavy vehicles may experience more significant deterioration. These conditions demonstrate the importance of structured road data management to support infrastructure monitoring and planning. Accurate information regarding road locations and attributes is necessary to assist government agencies in managing infrastructure data and to provide relevant information for the public.

Currently, road information management in Muara Bulian is still limited because spatial data and road attribute information have not been fully integrated into an accessible web-based system. Conventional or manual data management may create difficulties in organizing, updating, retrieving, and disseminating information. Government agencies may experience challenges in managing road data efficiently, while the public may have limited access to accurate and understandable information regarding road infrastructure. This condition indicates the need for a digital platform capable of integrating geographic locations with relevant road information.

A Geographic Information System (GIS) provides a technological approach for managing and presenting geographically referenced information. GIS integrates spatial data with descriptive attributes and presents them through digital maps, allowing geographic objects and their characteristics to be visualized more effectively. The use of GIS can facilitate the management and accessibility of geographically referenced data by connecting spatial locations with relevant attribute information [1]. With the advancement of internet technology, GIS has evolved into *Web-GIS*, which enables geographic information to be accessed and presented through web browsers and internet-connected devices.

Web-GIS offers advantages in terms of information accessibility, data visualization, and information dissemination. Geographic information can be presented through interactive maps that allow users to explore spatial objects and obtain associated attribute information. Unlike conventional information management methods, Web-GIS enables users to access geographic information online without requiring specialized desktop-based applications. These capabilities make Web-GIS suitable for supporting the management and dissemination of road infrastructure information.

Previous studies have demonstrated the application of Web-GIS technology in addressing various road and infrastructure information problems. Rifandi et al. developed a web-based Geographic Information System for mapping damaged roads in Kampar Regency. The system applied the Waterfall development method and provided facilities for mapping road damage and supporting reports submitted by the public. The study demonstrated the potential of Web-GIS to facilitate the identification of road-related problems and improve communication between communities and government institutions. However, its primary emphasis was on community participation in reporting damaged roads, whereas the present study focuses on structured road information managed directly by authorized administrators [2].

Saniasih designed a Web-GIS to support bridge condition survey activities in Jambi. The study demonstrated that web-based geographic information technology can be applied to organize and visualize transportation infrastructure information in a digital environment. The system focused specifically on bridge infrastructure and survey-related information. Although the study is relevant to the management of transportation infrastructure, the present research differs in terms of its object and information scope because it focuses on road infrastructure and integrates road locations with attributes such as road name, length, width, and surface type [3].

Indrayani et al. discussed the dissemination and implementation of a Web-GIS-based system for road damage reporting and mapping in Palembang City. The system enabled members of the public to identify and mark locations of damaged roads through a web-based map, demonstrating the usefulness of Web-GIS in supporting public participation and improving access to road damage information. However, the main contribution of the study was focused on the dissemination and use of a public reporting system, whereas the present research focuses on the design and development of a centralized information platform where road data are managed by authorized government administrators and accessed by the public [4].

Laksmana et al. developed a Web-GIS for presenting geospatial information related to district roads in Banjarharjo Village. The system provided an interactive map containing information related to administrative boundaries, road networks, water areas, facilities, and infrastructure. The study demonstrated that Web-GIS can improve the visualization and accessibility of geographic information related to road networks. Nevertheless, its primary emphasis was on the visualization of geographic features and road networks, while the present study focuses more specifically on integrating road locations with structured road attributes to provide more informative road-related information [5].

Jati et al. developed a Web-GIS for mapping road damage in Sitiung District, Dharmasraya Regency, using the Waterfall method. The system included road damage mapping, public reporting, road data management, and visual documentation features. The results of system testing showed that the developed functions operated according to the expected requirements. Although the study demonstrated the effectiveness of Web-GIS for managing road damage information, its primary orientation was the identification of damaged roads and the involvement of the public in reporting infrastructure problems. The present study differs by emphasizing the provision of structured road information through a centralized system managed by authorized administrators [6].

Based on the reviewed studies, Web-GIS has been applied to various purposes, including road damage mapping, public reporting, infrastructure surveys, and geographic visualization. These studies demonstrate the potential of web-based geographic technology to improve the accessibility and visualization of infrastructure information. However, the existing approaches have different orientations, ranging from community participation and public reporting to general geographic visualization and infrastructure survey activities.

The gap identified in this study is the need for a centralized Web-GIS specifically designed to manage and present structured road information in Muara Bulian. The proposed system does not focus on collecting public reports regarding road damage. Instead, road data are managed directly by authorized administrators from the responsible government institution. This approach is intended to ensure that the information available in the system is organized and managed according to institutional requirements.

The proposed system integrates spatial road data with descriptive attributes in a web-based environment. The information presented includes road names, lengths, widths, and surface types, while detailed physical road condition data are managed internally by authorized administrators. The integration of geographic locations and descriptive information enables users to access road-related information through an interactive digital map.

The Web-GIS is designed for two categories of users. The first category consists of administrators from the Department of Public Works and Spatial Planning of Batanghari Regency. Administrators are responsible for managing road information, including adding, editing, deleting, and updating data

in the system. The second category consists of members of the public who can access and explore the available road information through the interactive Web-GIS platform. This user-based structure is intended to maintain organized data management while improving public accessibility to relevant information.

The proposed Web-GIS provides several features to support road information management and presentation. These features include interactive digital maps, road location searches, detailed road information, basemap selection, road data management, and report generation. Spatial data are presented through geographic coordinates on digital maps, while descriptive attributes provide additional information about individual road sections. The integration of these components is expected to improve the clarity and accessibility of road infrastructure information.

From the perspective of government agencies, the proposed system is expected to support the digitalization and structured management of road infrastructure data. An integrated information system can facilitate data organization, retrieval, updating, and monitoring compared with conventional or manually managed information. The availability of structured geographic data can also support infrastructure planning and provide relevant information for future decision-making processes.

For the public, the Web-GIS is expected to provide easier access to road information through an online interactive platform. Users can access available information through internet-connected devices and explore road locations through digital maps. This accessibility can improve information dissemination and provide a more transparent mechanism for delivering relevant road infrastructure information to the community.

The system development process applies the Waterfall model, which consists of requirements analysis, system design, implementation, and testing. The system is developed using the Python programming language with the Flask framework and SQLite as the database. Leaflet.js is used to support interactive digital map visualization, while QGIS is utilized for the preparation and management of geographic data. The integration of these technologies supports the development of a web-based geographic information system capable of presenting road information in an accessible and interactive format.

The scope of this study is limited to Muara Bulian in Batanghari Regency. The system focuses on presenting road information through interactive digital maps and does not include advanced spatial analysis, automatic notifications, mobile applications, or direct public reporting features. Furthermore, the development process is limited to the testing stage, while future implementation and maintenance can be carried out by the relevant government institution.

Based on the identified problems and the research gap, this study aims to design and develop a Web-GIS for road conditions in Muara Bulian that can present road data and information effectively and informatively. The expected outcome of this research is a web-based geographic information system that integrates spatial road data with relevant road attributes and presents the information through interactive digital maps.

The developed system is expected to assist the Department of Public Works and Spatial Planning of Batanghari Regency in managing road infrastructure data in a more structured and digital manner. In addition, the system is expected to facilitate public access to road information and improve the dissemination of infrastructure-related data. Therefore, the proposed Web-GIS is expected to support more effective, efficient, transparent, and integrated road information management and contribute to the future development of web-based geographic information systems for infrastructure management.

METHODOLOGY

2.1 Research Method

This study employed a descriptive qualitative approach to identify problems and analyze the requirements for developing a Web-based Geographic Information System (Web-GIS) for road conditions in Muara Bulian. Data were collected through observation, interviews, documentation, and

literature review. The collected data were analyzed and used as the basis for designing the proposed system. The system development process applied the Waterfall model to ensure that the development stages were carried out systematically and sequentially.

2.2 Research Stages

The research stages were organized systematically to support the design and development of the Web-GIS. Each stage was interconnected and conducted sequentially, as illustrated in Figure 1.

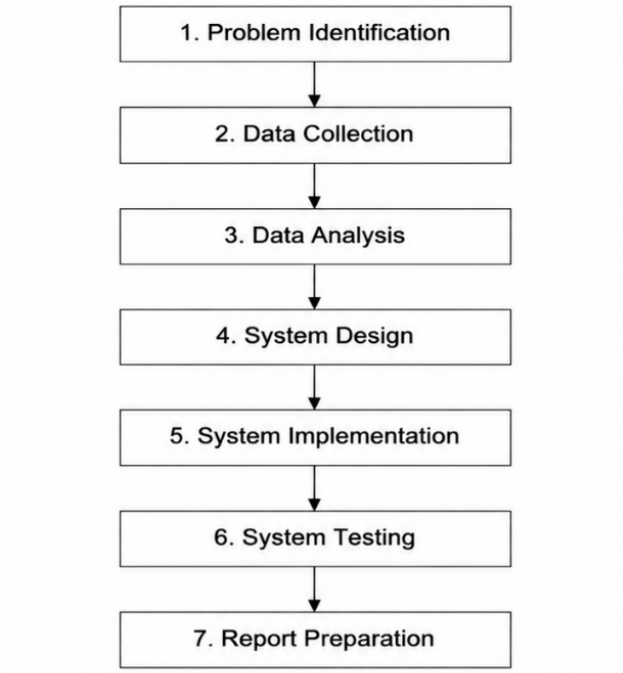

Figure 1. Research Stages

The research began with problem identification to determine the limitations of the existing road information management process. Data were then collected through observation, interviews, documentation, and literature review. The collected data were analyzed to identify user requirements and system needs. The system was subsequently designed using Unified Modeling Language (UML) and implemented as a web-based Geographic Information System. Finally, the developed system was tested to evaluate its functionality and user acceptance. The research stages shown in Figure 1 are explained as follows:

1. Problem Identification
   This stage identifies problems related to road data management and the availability of road condition information in Muara Bulian.
2. Data Collection
   Data were collected through observation, interviews, documentation, and literature review to obtain information required for the research.
3. Data Analysis
   The collected data were analyzed to identify user needs, system requirements, and problems related to road information management.
4. System Design
   The system was designed using Unified Modeling Language (UML), database design, interface design, and digital map design as the basis for Web-GIS development.
5. System Testing
   The developed system was tested using Black Box Testing to ensure that its functions operated according to the specified requirements.
6. Report Preparation

The final stage involved preparing the research report based on the results of the analysis, system design, implementation, and testing.

2.3 Data Collection

Data were collected using four techniques. Observation was conducted to examine the existing road data management process at the Department of Public Works and Spatial Planning of Batanghari Regency. Interviews were conducted with relevant employees to identify problems and system requirements. Documentation was used to obtain supporting data, including administrative maps and road spatial data. A literature review was conducted to obtain theoretical references related to Geographic Information Systems (GIS), Web-GIS, road infrastructure, and system development.

2.4 System Design and Development

The system was designed using Unified Modeling Language (UML), including Use Case Diagrams, Activity Diagrams, and Class Diagrams, to describe user interactions, system processes, and data structures [8]. The system development process applied the Waterfall model, consisting of requirements analysis, system design, implementation, and testing [7].

The Web-GIS was developed using Python and the Flask framework, with SQLite used for database management. Geographic data were prepared using QGIS and presented through an interactive digital map using the technology implemented in the system.

2.5 System Testing

System testing was conducted using the Black Box Testing method to evaluate whether each system function operated according to the specified requirements. The tested functions included displaying road information, searching for road locations, displaying detailed road information, interactive map functionality, and road data management.

In addition, a questionnaire based on a five-point Likert scale was distributed to obtain user evaluations regarding ease of use, interface appearance, information clarity, feature suitability, and the overall usefulness of the system.

RESULTS AND DISCUSSION

3.1 Overview of the Institution

The Department of Public Works and Spatial Planning of Batanghari Regency is responsible for managing regional infrastructure, including road infrastructure. The Highways Division is responsible for collecting, managing, and evaluating road data, including road names, length, width, type, status, and conditions.

However, road data management has not been fully integrated with a geographic information system. Therefore, a Web-based Geographic Information System (Web-GIS) was developed to support more effective and integrated management and presentation of road condition information.

3.2 Requirements Planning

a. Existing System

The existing road condition data management process is still conducted manually. Field officers collect road data, which are subsequently recorded using Microsoft Excel and used for reporting purposes. However, the data are not integrated with digital maps, making spatial information difficult to access and manage. The existing system is presented in Figure 2.

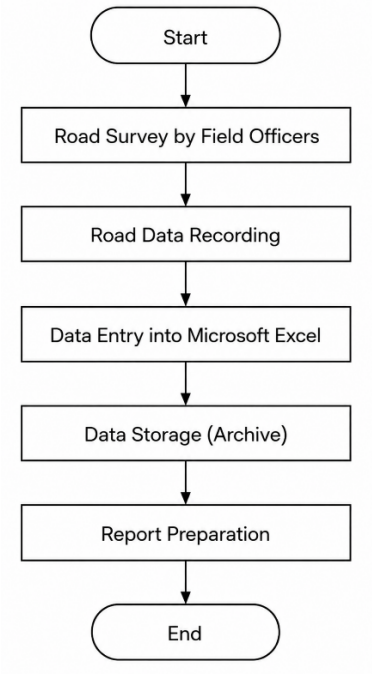

Figure 2. Existing Road Condition Data Management System

b. Proposed System

The proposed Web-GIS integrates road data with an interactive digital map. The system involves administrators and the general public. Administrators can manage road data and generate reports, while the public can access the map, search for road locations, and view road information without logging in. The proposed system is presented in Figure 3.

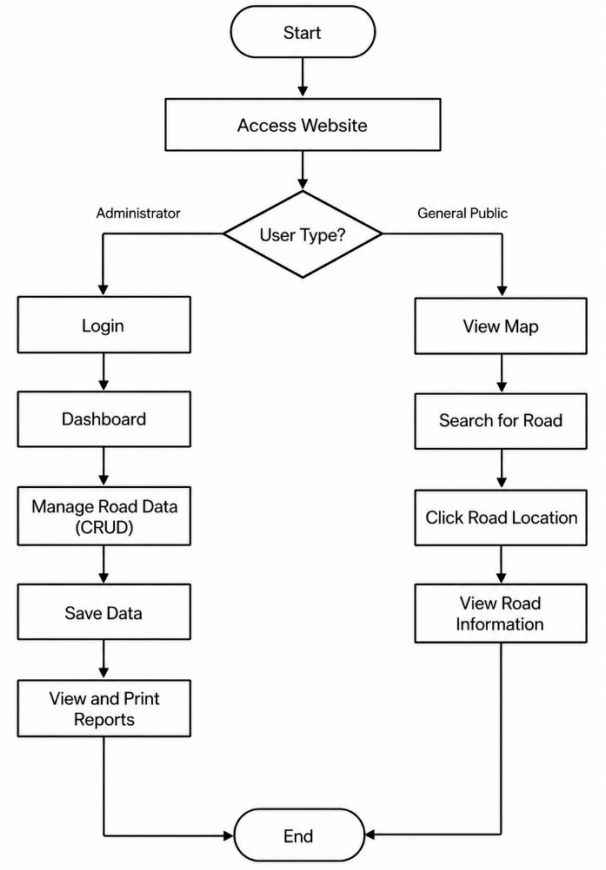

Figure 3. Proposed Web-GIS System

3.3 System Modeling

a. Use Case Diagram

The Use Case Diagram illustrates the interactions between two types of users and the Web-GIS system, namely the Administrator and the General Public. The Administrator is responsible for managing road information, including logging into the system, adding, editing, deleting, and viewing road data, as well as generating road condition reports. Meanwhile, the General Public can access the Web-GIS without logging in to view the road condition map, search for road locations, view detailed road information, and select the available basemap. The diagram shows the functional relationships between each actor and the system features.

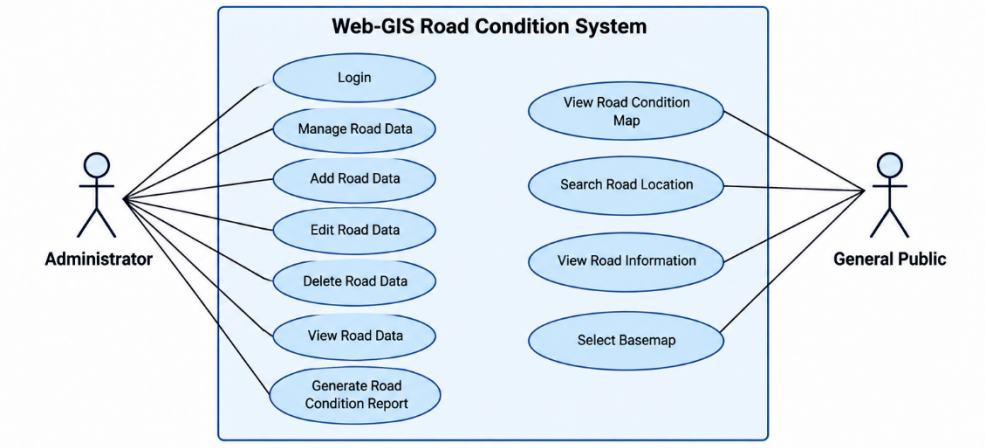

Figure 4. Use Case Diagram

b. Activity Diagram

The Activity Diagram illustrates the workflow of the Web-GIS system, including the processes performed by the administrator and the general public. The administrator workflow includes logging into the system, managing road data, managing road condition information, and generating road condition reports. Meanwhile, the general public can access the Web-GIS, view the road condition map, search for road locations, and view detailed road information. The diagram describes the sequence of activities and system responses from the beginning to the completion of each process.

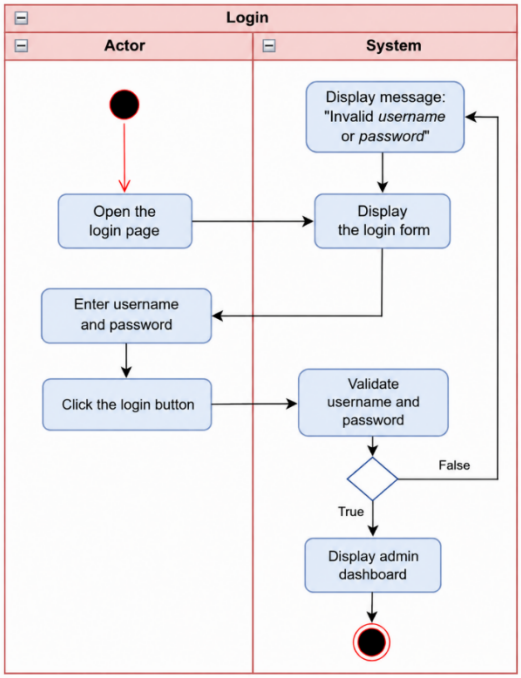

Figure 5. Activity Diagram

c. Class Diagram

The Class Diagram illustrates the structure of the Web-GIS system and the relationships between its main classes. The diagram consists of the Admin, Road, RoadConditionReport, GeneralPublic, and Basemap classes, including their attributes, methods, and associations. The Admin class is responsible for managing road data and generating road condition reports, while the General Public can view road information, search for road locations, and select the available basemap. The Road class contains the main road attributes, including road name, length, width, road type, surface, status, condition, latitude, and longitude. The data types of the attributes are defined according to their actual data characteristics, such as VARCHAR for textual data and REAL for numerical data.

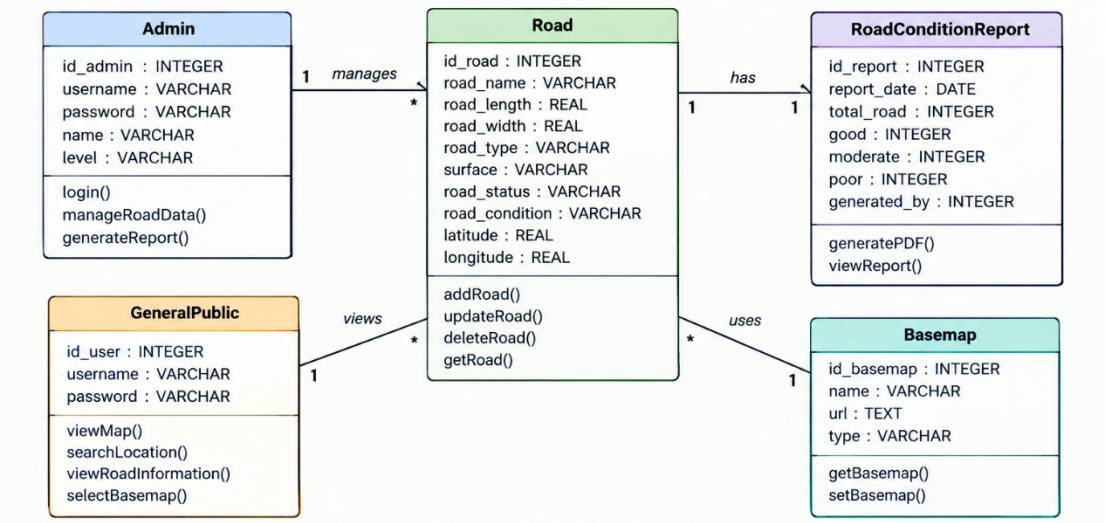

Figure 6. Class Diagram

3.4 Implementation

The implementation stage presents the main interfaces of the developed Web-GIS for Road Conditions in Muara Bulian. The system consists of two types of users, namely administrators and the general public. Administrators can manage road data and generate reports, while the public can access road condition information through an interactive digital map.

a. Home Page

The Home Page is the initial interface displayed when users access the system. This page provides options for accessing the system as an administrator or as a member of the general public.

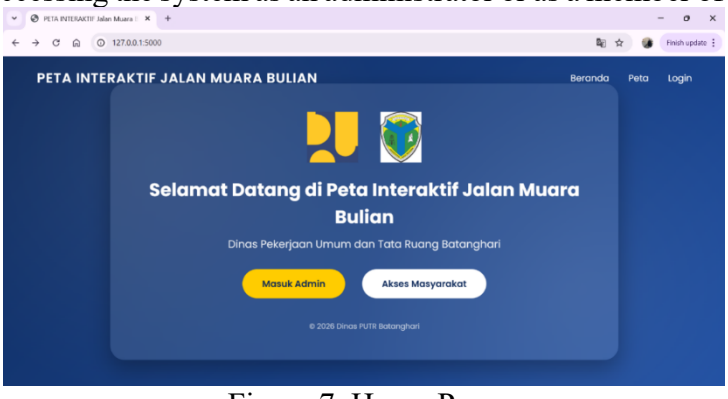

Figure 7. Home Page

b. Administrator Login Page

The Login Page is used by administrators to enter their username and password before accessing the system. The authentication process ensures that only authorized users can manage road condition data.

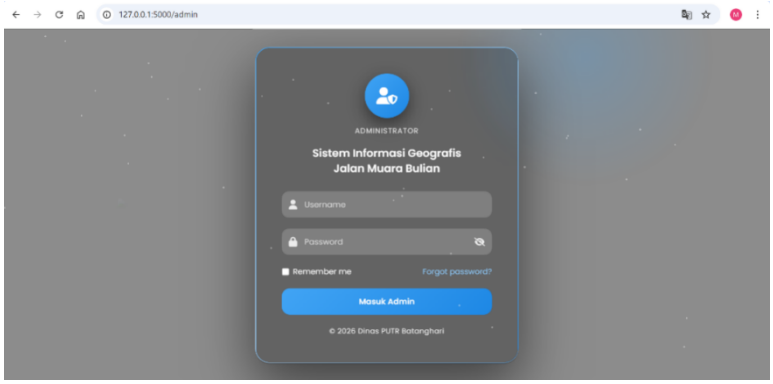

Figure 8. Administrator Login Page

c. Administrator Dashboard

The Dashboard serves as the main interface for administrators after successfully logging into the system. It provides access to the main system features and information required for managing road condition data.

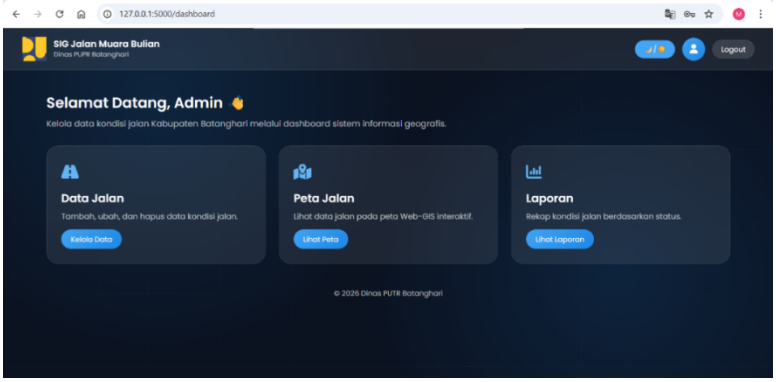

Figure 9. Administrator Dashboard

d. Road Data Management Page

The Road Data Management Page allows administrators to manage road information, including adding, editing, and deleting road data. The data are stored in the system database and can be used for further visualization and reporting.

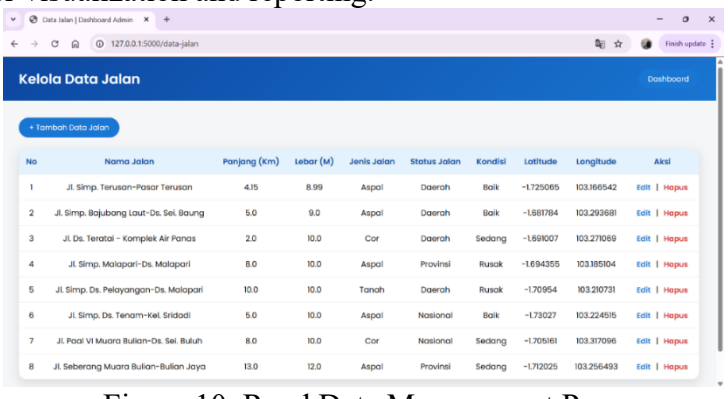

Figure 10. Road Data Management Page

e. Road Condition Map

The Road Condition Map displays road locations through an interactive digital map. Users can view the spatial distribution of roads and access road information based on their geographical locations.

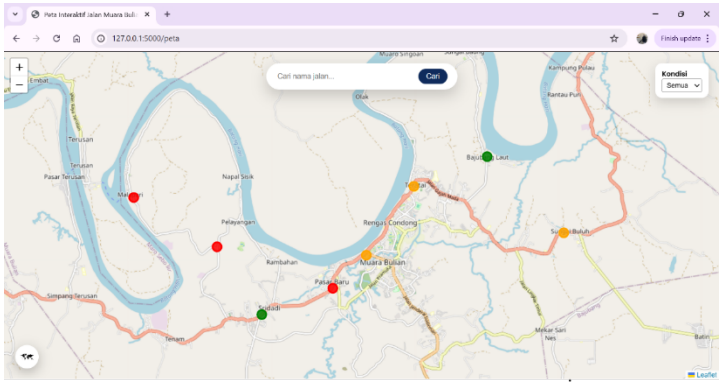

Figure 11. Road Condition Map

f. Road Information Page

Users can obtain detailed information about a road by selecting its location on the map. The information displayed includes the road name, length, width, road type, road status, and road condition.

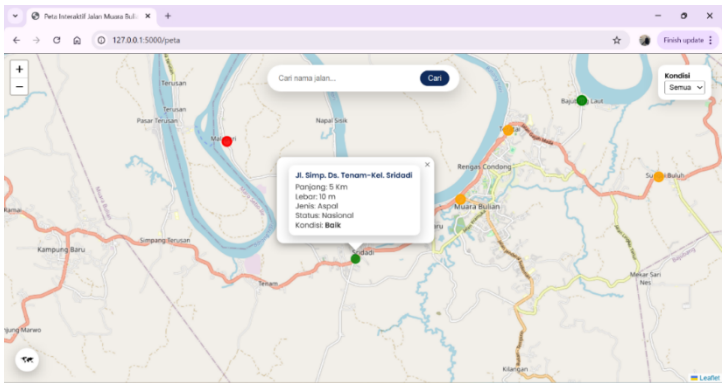

Figure 12. Road Information Page

g. Road Condition Report Page

The report page provides a summary of road condition data managed by the administrator. The system also provides a feature for generating and printing road condition reports in PDF format.

Figure 13. Road Condition Report Page

3.5 System Testing

System testing was conducted to evaluate the functionality and user acceptance of the developed Web-GIS. The testing process consisted of Black Box Testing and user evaluation using a Likert scale.

a. Black Box Testing

Black Box Testing was conducted to evaluate the functionality of the system without examining the internal program code. The testing focused on the main functions of the Web-GIS, including administrator login, road data management, road condition map visualization, road

location search, road information display, basemap selection, and report generation. The test results are presented in Table 1.

No.	Function Tested	Test Input	Expected Result	Actual Result	Status
1	Administrator Login	Valid username and password	The system authenticates the administrator and displays the administrator dashboard	The administrator dashboard was displayed successfully	Valid
2	Add Road Data	Complete road data, including road name, length, width, type, surface, status, condition, latitude, and longitude	The system saves the new road data to the database	The road data was saved successfully	Valid
3	Edit Road Data	Updated road information	The system updates the selected road data in the database	The selected road data was updated successfully	Valid
4	Delete Road Data	Selected road data	The system deletes the selected road data from the database	The selected road data was deleted successfully	Valid
5	View Road Condition Map	Access to the road condition map	The system displays road locations on an interactive map	The interactive road condition map was displayed successfully	Valid
6	Search Road Location	Road name or location keyword	The system displays the corresponding road location	The corresponding road location was displayed successfully	Valid
7	View Road Information	Select a road location on the map	The system displays detailed information about the selected road	Detailed road information was displayed successfully	Valid
8	Select Basemap	Select an available basemap option	The system changes the map background according to the selected basemap	The selected basemap was displayed successfully	Valid
9	Generate Road Condition Report	Select the report generation function	The system generates a road condition report in PDF format	The PDF report was generated successfully	Valid

Based on the results presented in Table 1, all tested functions operated according to the expected results and the specified functional requirements. The Black Box Testing results indicate that the developed Web-GIS successfully supports administrator functions and public access to road condition information.

b. User Evaluation Using a Likert Scale

In addition to functional testing, user evaluation was conducted using a questionnaire based on a five-point Likert scale. The questionnaire consisted of five statements covering ease of use, interface appearance, clarity of information, feature suitability, and overall system usefulness. The questionnaire was distributed to five respondents who were involved in evaluating the developed Web-GIS.

Each statement was assessed using a five-point Likert scale, where a score of 1 represented “Strongly Disagree” and a score of 5 represented “Strongly Agree”. The maximum possible score was calculated based on the number of respondents, the number of questionnaire statements, and the maximum Likert score, as follows:

Maximum Score = Number of Respondents × Number of Statements × Maximum Likert Score

Maximum Score = 5 × 5 × 5 = 125

The questionnaire obtained a total score of 122 out of a maximum score of 125. The percentage of the obtained score was calculated as follows:

Percentage = (122 / 125) × 100% = 97.6%

Based on the interpretation criteria used in this study, the result was categorized as “Very Good”. This result indicates that the respondents provided a positive evaluation of the developed Web-GIS in terms of ease of use, interface appearance, information clarity, feature suitability, and overall usefulness.

CONCLUSION

Based on the design, implementation, and testing results, the Web-GIS for Road Conditions in Muara Bulian was successfully developed to provide digital and integrated road condition information. The system allows administrators to manage road data and enables the public to access road information through an interactive digital map without requiring a login. The main features, including road data management, map visualization, road location search, detailed road information, and report generation, operated according to the system requirements. The Black Box Testing results showed that all system functions worked properly, while the user evaluation using a Likert scale received a "Very Good" rating. Therefore, the developed system can support road condition data management and improve public access to road information in Muara Bulian.

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