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Implementation of the Waterfall Method in Development of Geographic Information Systems Primary School (Case Study: Kambera District)

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Abstract

Geographic information systems (GIS) are very important, especially for elementary schools in Kacamatan Kambera, East Sumba Regency. Based on data from the East Sumba Regency Youth and Sports Education Office, Kambera District has 20 elementary schools. The Youth and Sports Education Office in East Sumba Regency is the lack of integrated data on the location and data of schools spread across the region, one of which is data on schools in Kambera District. This causes difficulties in planning and equitable distribution of educational infrastructure development. In addition, limited access to information about school facilities and infrastructure hinders efforts to improve the quality of education. Not only that, the uneven distribution of schools is also an obstacle, where some regions experience a shortage of schools and a lack of educational facilities. This condition is exacerbated by limited accessibility, especially for schools in remote areas. The lack of a digital-based mapping system makes it difficult for the Office of Education, Youth and Sports to accurately monitor and evaluate school conditions. As a result, budget allocation and education policies are often not on target. The method used in this study is the Waterfall method. The purpose of this study is to determine the limitations of educational facilities in an area based on location mapping in Kambera District. The resulting system shows that it functions as expected to determine the limitations of educational facilities in an area based on location mapping in Kambera District. Based on the results of testing using the Black Box Testing method, all features in the system built were successfully tested with a 100% success percentage result.

Keywords: *Geographic Information System, Waterfall Method, Mapping, Elementary School, Kambera District, Waterfall*

1. Introduction

The development of information technology has recently experienced rapid growth, having a significant impact on system design and development patterns. Information systems have become an integral part of daily life, especially in the context of business services. This modern era demands efficiency and accuracy in task completion, and geographic information systems (GIS) are very important, especially for elementary schools in Kambera District, East Sumba Regency. Based on data from the East Sumba Regency Youth and Sports Education Office, Kambera District has 20 Elementary Schools.

The problems experienced by the Youth and Sports Education Office in East Sumba Regency are the lack of integrated data regarding the location and data of schools spread across the region, one of which is school data in Kambera District. This causes difficulties in planning and equitable distribution of educational infrastructure development. In addition, limited access to information about school facilities and infrastructure hinders efforts to improve the quality of education. Not only that, the uneven distribution of schools is also an obstacle, where some regions experience a shortage of schools and a lack of educational facilities. This condition is exacerbated by limited accessibility, especially for schools in remote areas. The lack of a digital-based mapping system makes it difficult for the Office of Education, Youth and Sports to accurately monitor and evaluate school conditions. As a result, budget allocation and education policies are often not on target. Therefore, the researcher created a geographic information system containing the mapping of elementary schools that is the solution to the problem. This geographic information system can provide convenience for the East Sumba Regency Youth and Sports Education Office and the general public in finding the location of elementary schools based on the village or village, information about the school, teachers, travel routes to the school location, and school photos that can be accessed through the website. The website that is created contains information about the school such as the name of the school, the name of the principal, the school address, the school accreditation, the status of the school (public or private), the number of teachers or employees in the school, the number of students, facilities and photos of the school. In addition to information about the school, on the website created there are travel routes to certain school locations that can be accessed in one website only. Geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, organize and display all types of geographic data [1]. A school is a building or institution for learning as well as a place to receive and give lessons [2]. So schools are educational units that provide insight and a place to develop quality character to prepare a good future for the nation.
From the description of the above problem, the researcher proposes the Implementation of *the Waterfall* Method in the Development of Geographic Information Systems for Elementary Schools in Kambera District, East Sumba Regency. Using a geographic information

system is expected to help increase efficiency in the management of elementary school data and provide easier access to information for the public to access relevant elementary school data information, including the location of elementary schools based on sub-districts to sub-districts or villages, information about schools and school photos that can be accessed through the website to improve education services in East Sumba Regency. Thus, this system also allows the Youth and Sports Education Office as a supporting tool in planning and decision-making related to the effective management of elementary schools and identifying educational needs in remote areas, so that the Youth and Sports Education Office can develop more targeted programs.
The purpose of this study is to determine the limitations of educational facilities in an area based on location mapping in Kambera District. The benefits that can be taken from this research are that it makes it easier to find out the limitations of educational facilities in an area based on location mapping in Kambera District.

2. Literature Review

2.1. Geographic Information Systems

Geographic Information System (GIS) is a computer-based information system used to process and store data or geographic information. GIS is a useful tool for collecting, hoarding, retrieving desired data and displaying data into rooms derived from real-world [2].

2.2. Leafletis

Leafletjs is an *open source JavaScript* library that can be used to create maps on the web. The technology is *open source*, which means that the code can be accessed and modified by anyone. Leafletjs provides a wide range of functions that allow users to add, manipulate, and beautify maps. This technology can be used in both desktop and mobile browsers, so users can share their maps with anyone [3].

2.3. Map

A map is a collection of areas associated with various geographical places, such as plateaus, lowlands, mountains, resources, and population potential, that have an impact on sociocultural properties and have unique characteristics in the use of appropriate scales [4].

2.4. Cartography

Cartography is the art, science, and technology of mapmaking that includes the study of its learning as a scientific document and art, and is a discipline that connects maps and mapping. Cartography not only involves map-making techniques, but also presents representations of two geographical phenomena, namely real and virtual geographical phenomena [5].

2.5. Facilities

Facilities are a means that play a role in facilitating and facilitating the implementation of various functions, both in daily life and in the work or educational environment. Its existence helps to increase efficiency and effectiveness in carrying out tasks and activities. With adequate facilities, various processes can run more smoothly, comfortably, and according to the expected goals [6].

2.6. Waterfall Method

The Waterfall *method* is a type of development model that can be analogous to waterfalls, where each stage is worked on sequentially from top to bottom. The method used in the development of web-based exam information system design software uses *the waterfall* model [7].

2.7. UML (*Unified Modeling Language*)

UML (*Unified Modeling Language*) is one of the most powerful tools in the world of object-oriented system development. This is because UML provides modeling that allows developers to create systems that are effective in communicating designs to each other. In the tests carried out with the application of UML modeling, there are several steps. UML modeling is carried out by creating *a Use Case Diagram, Activity Diagram*, and *Sequence Diagram*[8].

2.8. Black Box Testing

Black Box Testing is a testing technique used to find errors in an application system by testing its functionality without paying attention to the internal structure or details of the code used. In other words, 33333Black Box Testing is a way to test the functionality of an application system. When performing tests, the use of random data input is used to obtain definitive results. This means that if there is an error in the data entered, the information system will reject it or the data cannot be stored in the *database*. However, if the data entered is correct, then the system will receive and store the data in the *database* [9].

3. Research Methodology

3.1. Research Profile

East Sumba Regency has a total of 263 elementary schools (SD) spread across 22 sub-districts. Of these, Kambera District has a total of 20 elementary schools (SD), consisting of 9 public schools and 11 private schools. These schools serve 3,970 students spread across 192 study groups (rombel). In terms of educators, there are 261 teachers and 76 employees who play a role in carrying out educational activities in these schools. The following data on the number of elementary schools in Kambera District can be seen in Figure 1

Data Sekolah Kec. Kambera - Dapodikdasmen

No	Nama Sekolah	NPSN	Status	PD	Rombel	Guru	Pegawai	R. Kelas	R. Lab	R. Perpus
1	SD INPRES KALU	50303875	Negeri	205	11	17	8	11	0	1
2	SD INPRES KALUMBANG	50303874	Negeri	251	12	14	7	12	0	1
3	SD INPRES MALUMBI	50303845	Negeri	199	10	14	3	13	0	0
4	SD INPRES PADADITA	50303913	Negeri	283	14	17	3	16	0	1
5	SD INPRES PALINDI MBURUNG	50303925	Negeri	125	6	8	5	8	0	1
6	SD INPRES PAPINDUNG	50303923	Negeri	230	11	18	4	12	0	1
7	SD NEGERI BIDIPRAING	50303709	Negeri	128	6	7	3	5	0	1
8	SD NEGERI MAUHAU	69727872	Negeri	110	6	9	4	6	0	1
9	SD NEGERI TANAU	69855653	Negeri	61	6	9	3	5	0	0
10	SD CHARIS NATIONAL ACADEMY SUMBA	70030015	Swasta	130	6	6	2	6	0	1
11	SD KATOLIK KAHAUNGU ETI	50303857	Swasta	149	7	11	4	9	0	1
12	SD KATOLIK PRAIKUNDU	50303855	Swasta	228	12	15	3	12	0	1
13	SD MASEHI KAMBANIRU 1	50303905	Swasta	253	12	16	4	13	0	1
14	SD MASEHI KAMBANIRU 2	50303904	Swasta	179	9	10	2	11	0	1
15	SD MASEHI LAMBANAPU	50303742	Swasta	152	8	11	4	10	1	2
16	SD MASEHI LUMBUMENGGIT	50303739	Swasta	251	12	16	2	13	1	1
17	SD MASEHI PAYETI 1	50303758	Swasta	547	19	25	4	20	0	1
18	SD MASEHI PAYETI 2	50303757	Swasta	301	13	16	5	13	0	1
19	SD MASEHI PAYETI 3	50303756	Swasta	55	6	7	2	8	0	1
20	SD MASEHI PRAIWORA	69863296	Swasta	133	6	15	4	7	0	1
Total	**Total**	**Total**	**Total**	**3.97**	**192**	**261**	**76**	**210**	**2**	**19**

Figure 1: Kambera District School Data

3.2. Research Flow

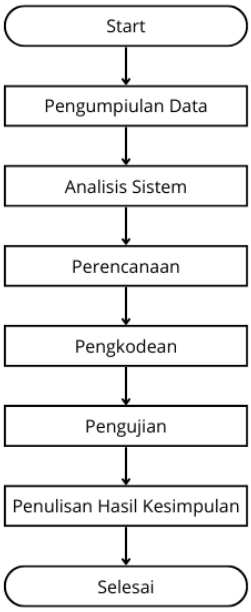

Figure 1: Research Flow

In Figure 2 the Research Flow will be explained in the following points:

3.2.1. Data Collection

The data collection method is a method that is carried out to obtain information or data needed in the design of the Implementation of the Waterfall Method in the Development of Elementary School Geographic Information Systems in Kambera District which requires accurate and up-to-date data. For this reason, data collection is carried out through several methods, including:

1. Observation
   The first method of collecting data and information is observation, which is by conducting direct observations in the field to identify the location of the elementary school as well as the physical conditions and surrounding environment. Observations were carried out by recording geographical coordinates and collecting visual data through photographs to provide a clearer picture of the situation in the field.
2. Interview
   Interviews to obtain the data needed to make a formulation and meet the research objectives, interviews are needed as one of the data collection methods. Interviews are conducted by asking and answering questions directly with the resource person to collect data and obtain the necessary research materials. So in this study, interviews were conducted, namely direct questions and answers to the Youth Education and Sports Office. The following is the interview guide in table 1

Table 1: Interview Guide

No.	Interview Questions
1.	Does the Office have problems in collecting data on elementary schools in Kambera District?
2.	Can the Office see areas where there are many and few elementary schools?
3.	Does the Agency have data on Elementary Schools in Kambera District?
4.	Does the Agency need GIS-based data collection on the location of elementary schools?
5.	Can GIS help the Service?

3. Documentation
   Documentation is a method for the process of data collection with the medium of written data images and document archives allowed by the research place. Therefore, this study uses documentation data collection techniques for research at the Youth and Sports Education Office in the form of school names, school principals, school addresses, school accreditation, school status (public or private), the number of teachers or employees in the school, the number of students, facilities and school photos.

3.2.2. System Analysis

At this stage of System Analysis, an in-depth study was carried out on various aspects related to the design of the system to be built. This process includes an analysis of existing problems and system needs to ensure that the designed solution can meet the main objectives of the development of a system designed to meet expectations and provide maximum benefits. The identification of this need includes aspects of software, hardware, human resources, and other supporting infrastructure. Furthermore, this analysis process is used to compile system specifications, design workflows, and identify potential risks or obstacles that may arise. This stage is crucial because the results of the analysis will be the basis for the next steps in the system development cycle, such as design, testing, and implementation.

3.2.3. Planning

Use Case Diagram

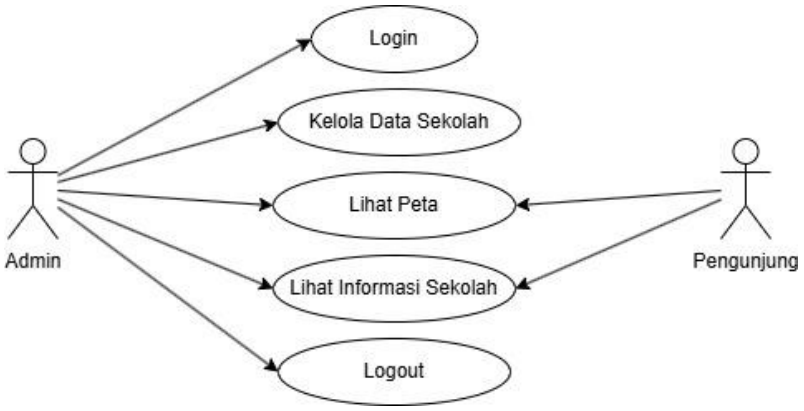

Figure 3: Use Case Diagram

In figure 3, there are 2 actors in the system that will be built, namely: admin and Visitor. Admins can log in, manage school data, view maps, view school information and log out. Meanwhile, visitors can only see the map and school information.

3.2.4. Implementation

The implementation stage is the coding stage that aims to build a system and implement a program by writing code based on the design that has been made. At this stage, all the functions and features that have been designed will be converted into executable program code, so that the system can operate according to the expected needs

3.2.5. Testing

At the testing stage, the aim is to ensure that the software features or functions operate as desired without any errors, system testing uses *black box testing* which is used for the functions of the software operation.

3.2.6. Writing Results

This stage is the final stage in the research by writing down the results of the research.

4. Results

This chapter discusses the Implementation of the Waterfall Method in the Development of Elementary School Geographic Information Systems in Kambera District which has been designed before, which includes data collection, system analysis, planning and coding.

4.1. Implementation

Research results are results obtained by researchers from research conducted in accordance with the steps and stages of research that have been made so that they can produce outputs or outputs in the form of systems and test results from the system. The Elementary School Geographic Information System is designed to provide solutions to the problems faced to determine the limitations of educational facilities in an area based on location mapping in Kambera District. After the system is completed, tests are carried out using the blackbox method to ensure that each function runs as expected.

4.1.1. Home View

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Figure 4: Home View

Figure 4 is the initial view when the user first opens the system. This page displays the system name and slider image. On this page there is also a home menu, school data and a login button to log in to the system.

4.1.2. School Data Display

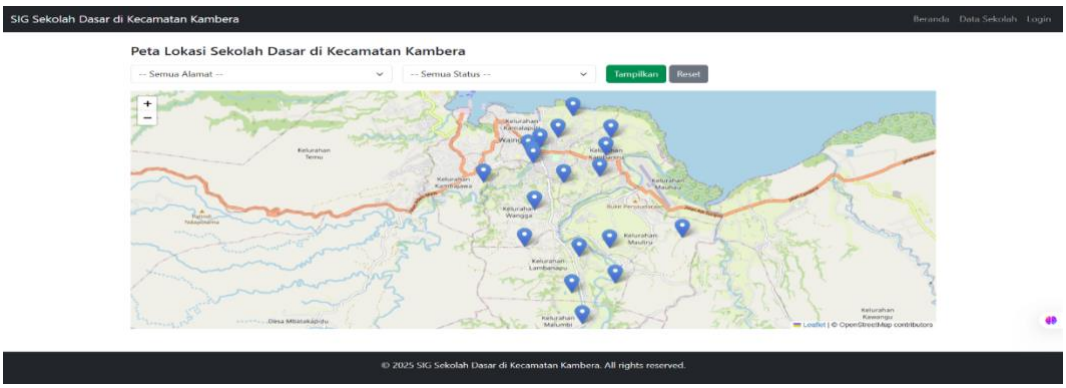

Figure 5: School Data Display

Figure 5 is a display of school data showing a map of the location of elementary schools in Kambera District. When the location is clicked, it will display the school name, address and details button. Locations can also display school data based on specific addresses and statuses using the filter function, making it easier to find and analyze the distribution of schools according to the selected criteria.

4.1.3. School Details View

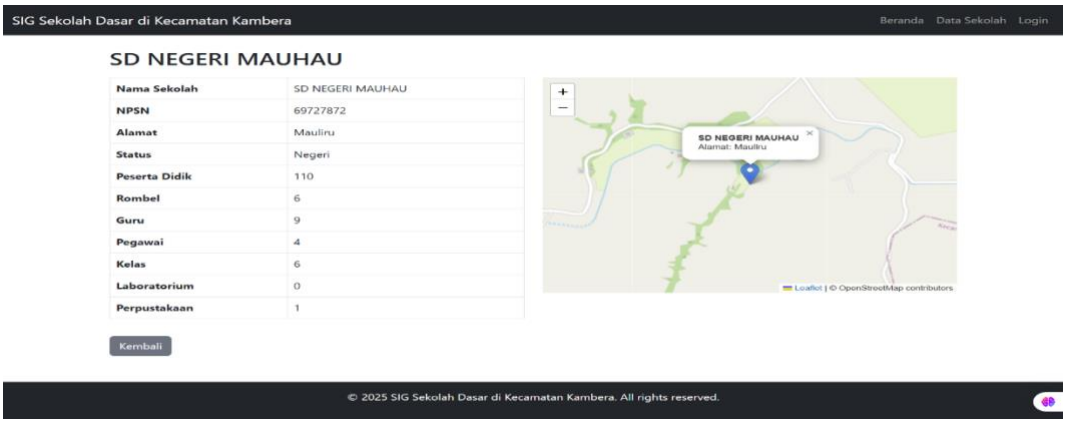

Figure 6: Detailed View of School Data

Figure 6 is a detailed display of school data that displays school data details such as school name, NPSN, address, status, students, group (Learning Group), teachers, employees, classrooms, laboratories, libraries and location maps from the selected location

4.1.4. Login View

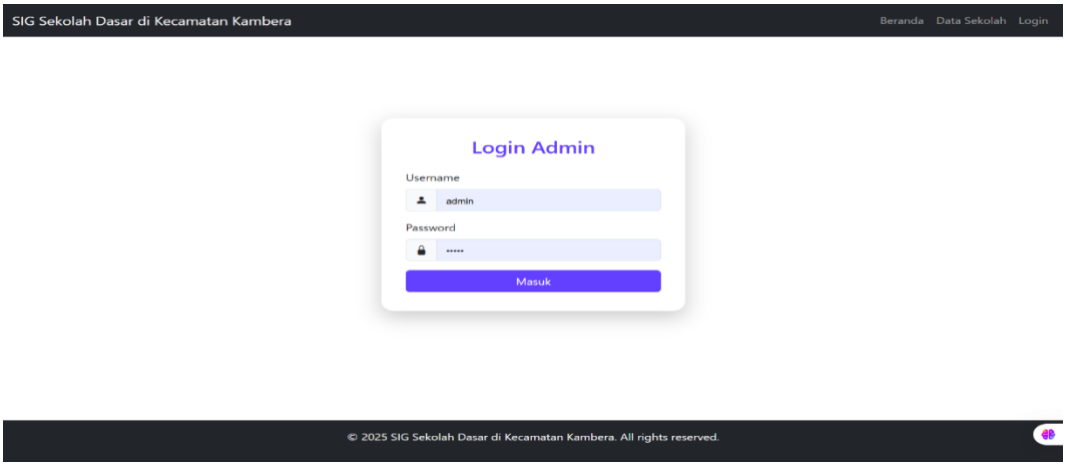

Figure 7: Login View

Figure 7 shows the admin login page. This page displays a login form consisting of username, password input, and a login button. To log in to the system, the admin can enter the email and password on the form that has been provided and then click login which will direct you to the admin dashboard page.

4.1.5. Dashboard View

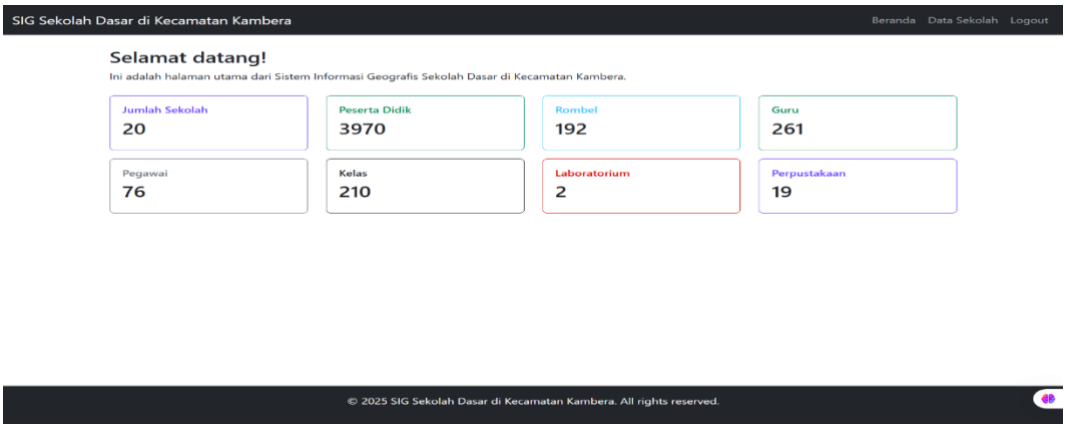

Figure 8: Dashboard Display

Figure 8 is the initial view of the admin dashboard after the admin successfully logs in. On the dashboard page there is a home menu, school data and logout. On the admin dashboard page, there are also the number of schools, the number of students, the number of groups

(Study Groups), the number of teachers, the number of employees, the number of classes, the number of laboratories and the number of libraries.

4.1.6. School Data Admin View

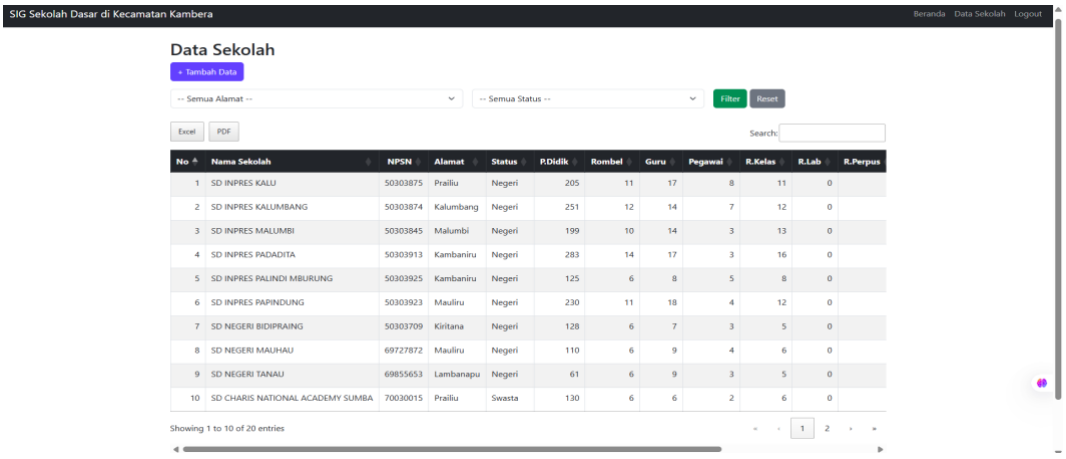

Figure 9: School Data Admin View

Figure 9 shows the school data page in admin access. On the school data page, you can see a table of all school data and can filter data by address and status. On this page there are also buttons to add data, edit, delete, download Excel and download PDF.

4.1.7. Logout View

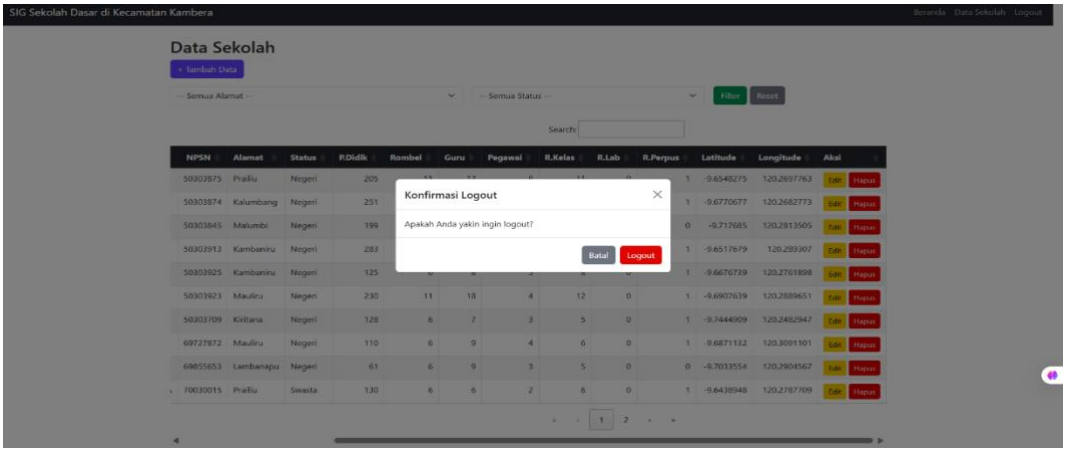

Figure 10: Logout View

Figure 10 is the Logout menu used to exit the system. After the user clicks on the Logout menu located in the upper right corner, a confirmation window will appear containing the question "Are you sure you want to log out?" accompanied by two optional buttons, namely Cancel to cancel the logout process and Log out to continue the process of logging out of the account. This feature aims to keep user data safe and prevent accidental logouts.

4.2. Testing

Testing of Elementary School Geographic Information Systems in Kambera District using the black box testing method. The results of the black box testing of the Elementary School Geographic Information System in Kambera District can be seen in Table 2.

Table 2: Black Box Testing

Functions tested	How to Test	Expected results	Test results
Login	Enter *a valid* username *and* password	The system successfully logged in and displayed *the admin* dashboard	[✓] Successful [ ] Didn't work
Login	Entering *the wrong* username *or* password	The system displays the error message "*Username* or *password* incorrect"	[✓] Successful [ ] Didn't work

Displaying School Data	*Admin* opens the school list page	The system displays a list of school data	[✓] Successful [ ] Didn't work
Add School Data	*Admin* fills in the entire field and clicks save	Data added successfully	[✓] Successful [ ] Didn't work
Add School Data	*Admin* blanks the *school data add* form	The system displays the error message "This field is required"	[✓] Successful [ ] Didn't work
Edit School Data	*Admin* changes existing school data information	School data information is successfully updated	[✓] Successful [ ] Didn't work
Clear School Data	*Admin* deletes existing school data	The system successfully deletes the selected data	[✓] Successful [ ] Didn't work
Logout	*Admin* presses the *logout button*	System log out of the *admin* account and return to the *login page*	[✓] Successful [ ] Didn't work
Displaying Map	*Admin* or visitor opens the map page	The system displays maps, coordinate points and school information.	[✓] Successful [ ] Didn't work

In Table 2, it can be seen the results of the testing of the Elementary School Geographic Information System in Kambera District using the black box method that shows successful results or successfully carried out in accordance with the expected function with a percentage of 100%. Based on the results of the test, it can be said that the application built has run well according to its respective functions.

5. Conclusions and Suggestions

Based on the results of analysis and testing from the Implementation of the Waterfall Method in the Development of Elementary School Geographic Information System (Case Study: Kambera District) shows that the developed system is able to provide information about the location of elementary schools in Kambera District. In addition, this system also helps in determining the limitations of educational facilities in an area based on location mapping, and can be used as a basis for supporting efforts to equitably distribute development and educational facilities in Kambera District. Based on the results of the test using the Black Box Testing method, all features in the Elementary School Geographic Information System in Kambera District were successfully tested with a 100% success percentage. This shows that all the main functions of the system, including displaying a map of the location of school data, adding data, editing, deleting, searching, and login and login features, have run as expected. Thus, the system is declared to have met the functionality aspect and is ready to use.

In this study on the Implementation of the Waterfall Method in the Development of Elementary School Geographic Information Systems (Case Study: Kambera District), there are still several shortcomings that need to be corrected. The current system focuses solely on displaying the location and information of the school on a web-based basis. To get the best results from the information system, you can add an android-based proximity search feature for the nearest school.

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