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Web-Based Geographic Information System for School Mapping in Cianjur Regency

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ABSTRACT

Education requires adequate information infrastructure to ensure equitable access to facilities. Cianjur Regency has a wide and diverse distribution of junior high, senior high, and vocational schools, yet public access to accurate location information remains limited. This study develops a web-based Geographic Information System (Web-GIS) for school mapping in Cianjur Regency using the Waterfall development method. The system integrates spatial and attribute data of 412 junior high schools, 73 senior high schools, and 186 vocational high schools, visualized through the Google Maps API. Functional testing shows that all system features operate correctly, enabling users to access school location information efficiently and accurately. The main contribution of this study lies in the integration of multi-level school distribution data into a single interactive Web-GIS platform to support public access and educational infrastructure analysis.

1. INTRODUCTION

Education is a key pillar of national development that requires adequate information infrastructure support. Accessibility to school locations is a crucial factor in determining educational equity in a region [1]. In Cianjur Regency, with an area of 361,434.98 hectares, the availability of educational facilities such as junior high schools, senior high schools, and vocational high schools is very diverse and widely spread across various sub-districts. However, the rapid growth of these educational facilities is not accompanied by easy access to location information for the public. Currently, prospective students or parents often experience difficulty in determining accurate school locations and tend to rely on verbal information or direct observation which is time-consuming and laborious [2].

Geographic Information Systems (GIS) are emerging as a technological solution capable of integrating attribute data with spatial data to effectively present location-based information [3]. Contemporary GIS has transformed into a crucial instrument in public infrastructure management due to its ability to visualize complex data into intuitive geographic information. The use of web-based GIS (Web-GIS) enables the dissemination of information in real time and is accessible to the public without limitations of space and time [4]. Through interactive map visualization, the public can see not only a list of school names but also their precise geographic positions. The development of this system is crucial in Cianjur Regency, given its vast geographic characteristics and varying accessibility challenges across regions.

The current trend in location-based information system development places a strong emphasis on data interactivity and scalability to support spatial-based public information services [5]. In addition, cloud-based mapping services have been proven to provide a stable platform for simultaneous access to large amounts of data [6]. Although information system development has been extensively undertaken, the integration of educational data covering various levels (junior high school, senior high school, vocational high school) in a single, precise coordinate platform is still rare at the local government level. This study aims to fill this gap by integrating comprehensive educational distribution data, covering 412 junior high schools, 73 senior high schools, and 186

vocational high schools across Cianjur Regency. The use of the Google Maps API in this system is designed to ensure better coordinate point accuracy in order to provide accurate navigation solutions for users.

Based on this background, this study aims to develop a Web-Based Geographic Information System for School Mapping in Cianjur Regency using the Waterfall development method. This system is expected to be an effective information medium for prospective students in determining their target schools, as well as an instrument for relevant agencies in analyzing the distribution of educational facilities in the Cianjur Regency area.

Although various Web-GIS applications have been developed to support educational information services, most existing systems focus on limited educational levels or narrow geographic scopes. Moreover, integrated platforms that simultaneously visualize junior high, senior high, and vocational school distributions with precise coordinate data at the regional level are still scarce, particularly in local government contexts. Therefore, this study addresses this gap by developing a comprehensive Web-GIS that integrates multi-level school distribution data within a single interactive platform for Cianjur Regency.

2. KAJIAN PUSTAKA

2.1. Previous Research

Several previous studies have examined the application of web-based Geographic Information Systems in education. Bernhäuserová et al. stated that GIS integration in the education sector can improve the effectiveness of spatial data management, although it still faces challenges in data integration and system implementation [7].

Li et al. developed Web-GIS as a location-based educational service platform that supports interactive spatial visualization and geographic data-based decision-making [8]. Other research explains that developing Web-GIS for public services requires attention to data scalability, ease of access, and interface interactivity so that the system can be optimally utilized by the public [9].

Several studies have also applied Web-GIS to school mapping in specific areas. However, these studies are generally limited to a single educational level or a narrow geographic scope [10][11]. Therefore, a system capable of integrating school distribution data across levels into a single, centralized and comprehensive platform is needed.

Although school mapping systems have been developed in various countries, the main challenge remains the integration of data across educational levels in areas with broad geographic coverage. This study aims to fill this gap by integrating comprehensive education distribution data, covering junior high, senior high, and vocational high schools simultaneously in Cianjur Regency. By utilizing Web-GIS technology with its broader reach, this study offers a more efficient digital solution for the public to access real-time and accurate school location information through an internet platform.

2.2. Geographic Information System

A Geographic Information System (GIS) is a computer-based system used to collect, store, manage, analyze, and display geographically referenced data. GIS is capable of integrating spatial and attribute data to produce location-based information that can be used to support decision-making [12].

Over time, GIS has been widely used in various sectors, including regional planning, public services, and education. The use of GIS in education allows for the visual and accurate presentation of information on the location of educational facilities, thus helping the public understand the distribution of educational facilities within a region [13].

2.3. WebGIS

Web-GIS is a GIS development that utilizes web technology to present geographic information online. Web-GIS allows users to access, visualize, and interact with spatial data through a web browser without the need for specialized software [14].

The use of Web-GIS offers advantages in terms of accessibility and real-time information distribution. Furthermore, Web-GIS supports user interactivity through search, navigation, and digital map visualization features, making it suitable for application in location-based public information systems [15].

2.4. Geographical Conditions of Cianjur Regency

The Geographical Location of Cianjur Regency is 106042’ East Longitude and 6021’ – 6025 South Latitude with an area of 361,434.98 Ha, an altitude of 7 – 2,962 meters above sea level. The area of agricultural land reaches 237,500 Ha (rice fields 66,180 Ha; and non-rice fields 171,470 Ha). Geographically, Cianjur Regency is divided into three Development Areas namely the Northern Region (covering 16 Districts: Cianjur, Cilaku,

Warungkondang, Gekbrong, Cibeber, Karangtengah, Sukaluyu, Ciranjang, Bojongpicung, Mande, Cikalongkulon, Cugenang, Sukaresmi, Cipanas, Pacet and Haurwangi). The Central Region (covering 9 Districts: Sukanagara, Takokak, Campaka, Campakamulya, Tanggeung, Pagelaran, Leles, Cijati and Kadupandak) and the Southern Region (covering 7 Districts: Cibinong, Agrabinta, Sindangbarang, Cidaun, Naringgul, Cikadu and Pasirkuda). The map of Cianjur Regency can be seen in the image below:

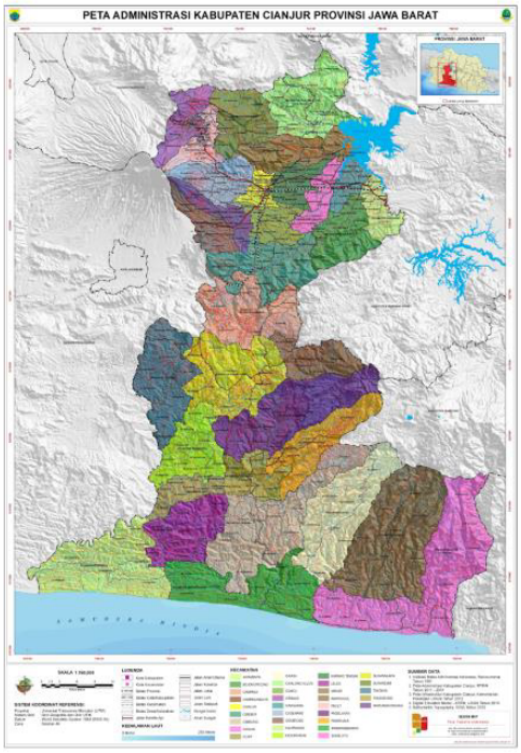

Figure 1. Map of Cianjur Regency

2.5. Manajemen Basis Data Relasional (RDBMS)

A Relational Database Management System (RDBMS) is a database management system that stores data in the form of interrelated tables. RDBMSs support data integrity, consistency, and ease of management and processing of large amounts of data [16].

In Web-GIS systems, RDBMSs play a crucial role in storing non-spatial attribute data, such as school names, educational levels, addresses, and other supporting information. Integrating RDBMSs with GIS systems enables structured and efficient management of spatial and non-spatial data [17].

2.6. Google Maps API (Application Programming Interface)

The Google Maps API is an Application Programming Interface (API) service provided by Google for integrating digital maps into web-based and mobile applications. This API provides various features such as determining coordinate points, displaying location markers, navigation routes, and interactive map visualizations [18].

The use of the Google Maps API in Web-GIS systems aims to improve the accuracy of geographic information and ease navigation for users. The integration of cloud-based map APIs also improves system performance in displaying spatial data quickly and stably [19].

3. RESEARCH METHODS

Research In designing a geographic information system, there are several design processes or stages that must be passed. In the design research of "Geographic Information System for Mapping School Locations in Cianjur Regency, Web-Based" the waterfall method was used. This model was first introduced by Winston Royce around 1970 so it is often considered a traditional systematic method, but it is the most widely used model in Software Engineering. Although this model is classical, Waterfall remains the most dominant approach in software engineering because of its systematic and sequential flow [20]. This model covers the following activities: information system engineering and modeling, needs analysis, design, coding, testing and maintenance. The stages of the waterfall method to be used are as follows.

The Waterfall method was selected because the system requirements in this study are well-defined and relatively stable, particularly regarding school data attributes, spatial coordinates, and user roles. This method allows each development stage analysis, design, implementation, and testing to be conducted sequentially and systematically, ensuring data accuracy and functional reliability. Such characteristics make the Waterfall model suitable for developing public information systems like Web-GIS that prioritize correctness and structured development.

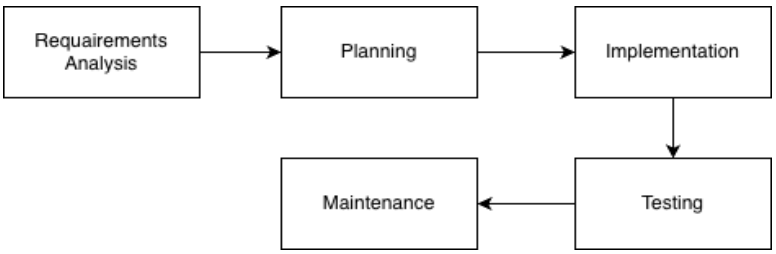

Figure 2. Waterfall Method

In accordance with the waterfall model mechanism, there are stages of software design, namely:

1. Needs Analysis

This stage focused on data collection and system specifications. The data used in this study included spatial data (latitude and longitude coordinates) and attribute data from educational facilities in Cianjur Regency, consisting of 412 junior high schools, 73 senior high schools, and 186 vocational high schools. Furthermore, the system's functional requirements were identified, such as the ability to display interactive maps, search by school name, and filter locations by educational level.

2. Planning

Based on the needs analysis, a system architecture design was conducted. This phase included the creation of an Entity Relationship Diagram (ERD) to model the structure of the school database for integration with regional data. Furthermore, a responsive web-based user interface was designed to ensure user convenience when accessing maps via computers and mobile devices.

3. Implementation

The implementation phase involves translating the design into a programming language. This system was built using PHP as the primary programming language and MySQL as the database management system. To accurately visualize spatial data, the Google Maps API service is used, allowing school coordinates to be dynamically plotted on a digital map layer.

4. Testing

After the coding phase is complete, the system is tested using the Black Box Testing method. This testing aims to validate all functional features of the system without looking at the internal code structure. The testing focuses on the accuracy of school marker placement on the map, the functionality of the navigation buttons, and the effectiveness of the school level filter feature to ensure the system runs according to user needs. The testing is intended to determine whether the software created meets the expected criteria of the software's design objectives, namely being able to map the desired schools.

5. Maintenance

Once the system is declared suitable, a maintenance phase is carried out to maintain system performance. This includes routine monitoring of server availability and updating school data if there are changes to information from relevant agencies in Cianjur Regency. This maintenance is crucial to maintaining the relevance of the information presented to the public.

4. RESULT AND DISCUSSION

Before designing a geographic information system website, an analysis must first be conducted to obtain a clear picture. System analysis is necessary to ensure the system functions as needed. This analysis is necessary to improve the system, analyze, and define problems so that it can function as needed. This system design aims to develop a new website from an existing one, where problems encountered on the old website are expected to be resolved in this new website. To determine complete requirements, system analysis is divided into two parts: functional requirements analysis and non-functional requirements analysis.

4.1. non-functional Requirements Analysis

This requirement is a type of requirement that describes the behavioral properties of the system. Some of these points, when applied to non-functional requirements for a website system, include:

- Hardware requirements analysis. The hardware required for system design includes: a laptop with an Intel Core i5 processor, a 500 GB hard drive, and a modem for internet connectivity.
- Software requirements analysis. The software used includes: Sublime Text, XAMPP 5.6.31 installer, Mozilla Firefox or Chrome.
- Human resource requirements analysis for website developers and users includes: a webmaster (admin) who can manage and design the website interface and develop the website. A user is anyone who can access the website and has the right to access it, whether by registering as a member or not. Users do not have the right to manage or control the website as a whole.

4.2. Functional Requirements Analysis

Functional requirements describe the processes the system will perform. They also describe the information the system must provide and produce. Functional requirements generally indicate the required facilities and activities within the new system. The functional requirements for the Geographic Information System (GIS) website for Mapping School Locations in Cianjur Regency are shown in the diagram below.

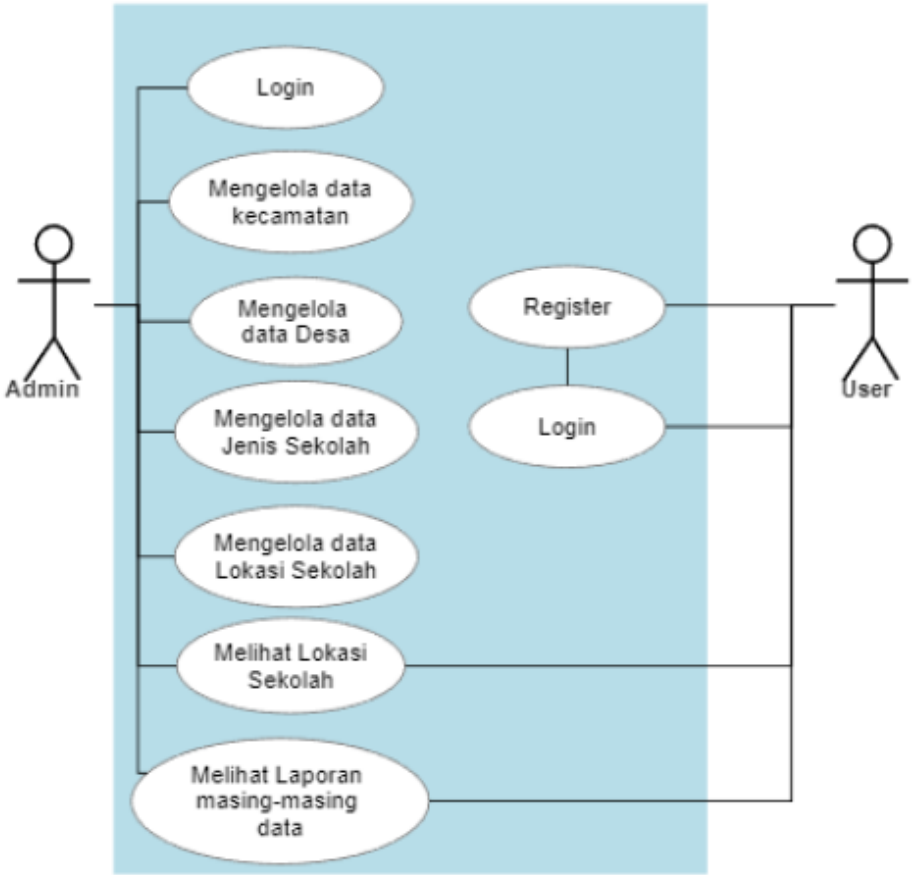

Figure 3. Use Case Diagram

4.3. Analysis of System Requirements

A system requirements analysis is conducted to understand what users need. To facilitate the analysis and comprehensively determine requirements, the system analysis is divided into two parts: user requirements analysis and admin requirements analysis.

4.3.1. Systems Analysis

Systems analysis aims to identify constraints in the existing system to provide an overview of the proposed new system. This analysis is necessary for designing the proposed new system.

4.3.2. Requirement Analysis

a. User Requirement

User requirement include everything that users need in the system, such as the initial display of the Geographic Information System website for School Locations in Cianjur Regency, which has several features, including Home, About us, Contact, and the login page.

b. Admin Requirement

An admin is a system administrator responsible for managing the system. The admin's requirements for this system include:

- Login to the system
- Manage data admin.

4.4. Design and Development

The design phase is where complete system specifications are created based on the requirements recommended in the previous phase. The conceptual design phase includes a key component, namely database design.

Database design is the initial step in creating an application to facilitate the marketing and sales programs of this geographic information system. The database design in the conceptual design phase can be seen in the following ERD (Entity Relationship Diagram):

4.5. Implementation and Design

The resulting design and planning were then integrated into the website for the Geographic Information System (GIS) for Mapping School Locations in Cianjur Regency. The following is a display of the resulting website design and planning.

4.5.1. Database Implementation

Implementation of the interface used by the user which contains information about the School Mapping Geographic Information System Web.

a. PHP MyAdmin page display

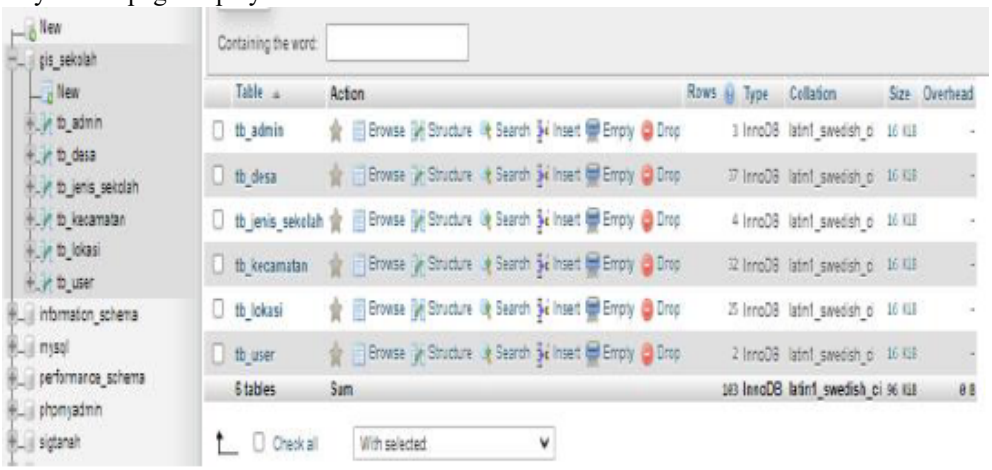

Figure 4. Table from database gis_sekolah

b. Column view of admin table

#	Name	Type	Collation	Attributes	Null	Default
1	username	varchar(20)	latin1_swedish_ci		No	*None*
2	password	varchar(20)	latin1_swedish_ci		No	*None*
3	nama	varchar(30)	latin1_swedish_ci		No	*None*

Figure 5. Column view of admin table

c. Column view of the Village table

Table structure | Relation view

#	Name	Type	Collation	Attributes	Null	Default	Cc
1	id_desa	int(3)			No	None	
2	desa	varchar(30)	latin1_swedish_ci		No	None	
3	id_kecamatan	int(2)			No	None	

Figure 6. Column view of the Village table

d. Column view of the school type table

#	Name	Type	Collation	Attributes	Null	Default	C
1	id_jenis	int(3)			No	None	
2	jenis	varchar(50)	latin1_swedish_ci		No	None	
3	deskripsi	text	latin1_swedish_ci		No	None	

Figure 7. Column view of the school type table

e. Column view of the District Table

Name	Type	Collation	Attributes	Null	Default
id_kecamatan	int(2)			No	None
kecamatan	varchar(30)	latin1_swedish_ci		No	None

Figure 8. Column view of the District Table

f. Column view of the Locations table

#	Name	Type	Collation	Attributes	Null	Default	C
1	id_lokasi	int(10)			No	None	
2	id_desa	int(3)			No	None	
3	id_kecamatan	int(4)			No	None	
4	id_jenis	int(3)			No	None	
5	nama_tempat	varchar(50)	latin1_swedish_ci		No	None	
6	jalan	varchar(150)	latin1_swedish_ci		No	None	
7	jml_siswa	varchar(4)	latin1_swedish_ci		No	None	
8	Kepala_Sekolah	varchar(40)	latin1_swedish_ci		No	None	
9	honorer	varchar(4)	latin1_swedish_ci		No	None	
10	pns	varchar(4)	latin1_swedish_ci		No	None	
11	gedung	varchar(100)	latin1_swedish_ci		No	None	
12	informasi_umum	varchar(100)	latin1_swedish_ci		No	None	
13	lat	char(30)	latin1_swedish_ci		No	None	
14	lng	char(30)	latin1_swedish_ci		No	None	

Figure 9. Column view of the Locations table

4.5.2. Interface Implementation

The following implementation represents the admin and user interface, which can be viewed and accessed by users. This website includes features that provide information about the Geographic Information System for Mapping School Locations. The following is a display of the website's design and layout.

a. Home Page Display

Figure 10. Home Page

b. About Page Display

Figure 11. About Page

c. Contact Page Display

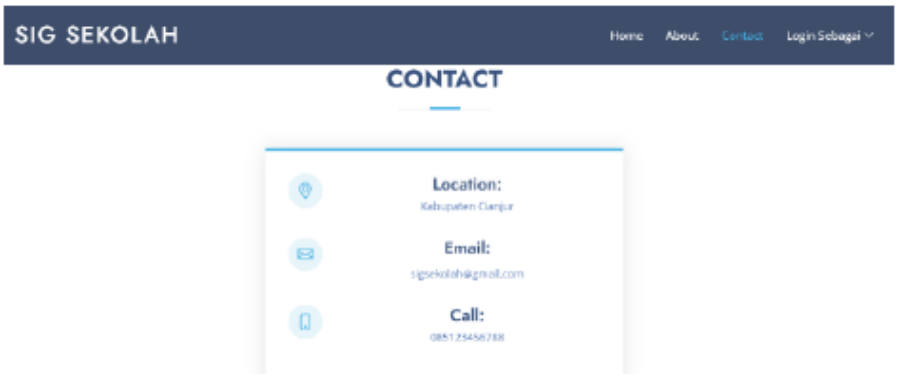

Figure 12. Contact Page

d. Admin Page Login View

Figure 13. Admin Page Login

e. Admin data management view

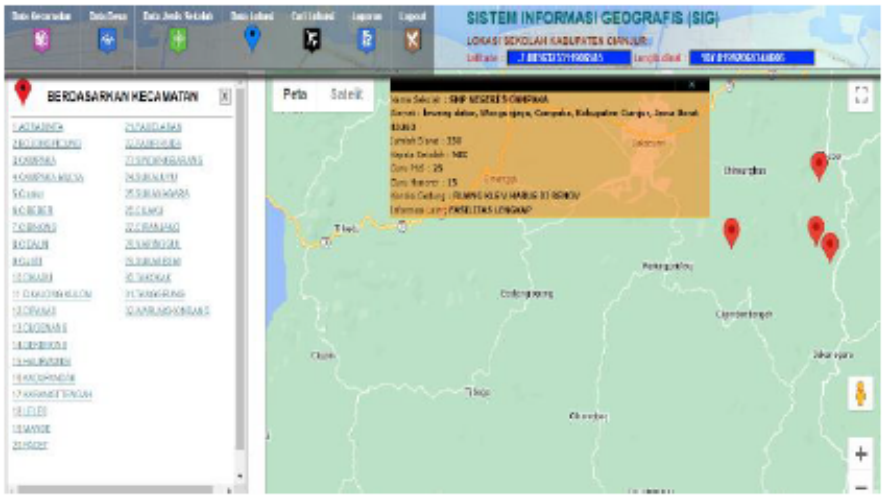

Figure 14. Admin data management view

f. Print display of data based on respective criteria

Figure 15. Print data management page

g. Display of printed data

Print Data

PEMERINTAH KABUPATEN CIANJUR
DINAS PENDIDIKAN PEMUDA DAN OLAHRAGA
LAPORAN DATA KECAMATAN

Tanggal : 12/Dec/2022

ID Kecamatan	Nama Kecamatan
1	Agrabinta
2	Bojongpicung
3	Campaka
4	Campaka Mulya
5	Arjasa
6	Cibeber
7	Cibinong
8	Cidaun
9	Cijati
10	Cikadu
11	CikalongKulon
12	Cipanas
13	Cugenang
14	Gekbrong
15	Haurwangi
16	Kadupandak
17	Karangtengah
18	Leles
19	Mande
20	Pacet
21	Pagelaran

Figure 16. Printed data page

h. User Registration View

Figure 17. Registration page

4.6. System Testing (Black Box Testing)

Testing is conducted to ensure that all features designed during the Waterfall method are functioning correctly. The following table shows the system functionality testing results:

Table 1. System Interface and Functionality Test Results

No	System Components	Testing Scenario	Expected Results	Testing Results	Status (Valid/Not)
1	Home Page	Access the main system URL	Displays an interactive map and distribution of school markers in Cianjur	The Google Maps map and school location appear correctly.	Valid
2	About Us & Contact	Click the profile and contact menu	Displays system information and contact information	The page appears with appropriate and responsive content.	Valid
3	User Registration	Fill out the new user registration form	New users are saved in the database for login access	A "Registration Successful" message appears, and the data is saved in the user table.	Valid
4	User Login	IEnter the regular user username and password	Users log in to the system as registered users	Successful login; the menu changes according to user authority.	Valid
5	Admin Login	Enter the admin username and password	Log in to the central data management dashboard	Redirected to the admin page with full access rights.	Valid
6	Data Management	Add or edit school coordinates	School data is updated in the database and changes are displayed on the map	Data updated successfully; a "Data Saved Successfully" notification appears.	Valid
7	Print Data	Click the export/print school data button	The system generates a report document (PDF, Excel)	The system automatically downloads the report file.	Valid
8	Print Results	Open the downloaded report file	Displays a list of schools that match the database	The file opens and displays the data neatly and ready to print.	Valid

4.7. Discussion

Based on implementation results, the use of the Google Maps API in this system provides advantages in terms of coordinate point accuracy. The integration of data across levels (junior high, senior high, and vocational high) in a single platform has proven to facilitate the public in conducting comparative analysis of school locations.

Distribution analysis shows that the availability of digital information is crucial for a large area like Cianjur Regency. Unlike the static tabular lists currently available, Web-GIS-based visualizations provide a spatial perspective that helps parents estimate distances and accessibility to schools.

From a technical perspective, the use of the Waterfall method ensures that every functionality, from database management to map rendering, is tested step by step. The test results in Table 1 demonstrate a 100% success rate for key features, thus declaring the system suitable for implementation as a public information medium.

Compared to previous Web-GIS studies that focus on a single educational level or limited datasets, this system integrates multiple school levels within one unified platform. Unlike systems that only provide static map visualization, the developed Web-GIS supports interactive filtering and data management features, enabling more comprehensive spatial analysis. This integration enhances the usefulness of the system as a public information tool for both users and educational authorities.

5. CONCLUSION

Based on the research and development results, it can be concluded that the web-based Geographic Information System (GIS) for Mapping School Locations in Cianjur Regency has been successfully developed and implemented. The application of the Waterfall method in the development of this system ensured that each stage, from needs analysis to testing, was structured.

This system is capable of interactively integrating and visualizing data on the distribution of educational facilities covering 412 junior high schools, 73 senior high schools, and 186 vocational high schools (SMK) in Cianjur Regency. The use of the Google Maps API has proven effective in providing precise location accuracy through latitude and longitude coordinates, making it easier for the public to access school information in real time.

Black Box Testing results indicate that all key system features, including login functions (admin and user), education level filters, location search, and data management and printing, function 100% effectively without any functional errors. Thus, Web-GIS can be an efficient digital solution for the community in estimating the distance and accessibility of educational facilities, as well as being a tool for related agencies in documenting the distribution of educational infrastructure in Cianjur Regency.

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