

Web-GIS Architecture Blueprint for Multi-Category Cultural Heritage Mapping and Classification in Bandung City Using a Waterfall Approach

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ABSTRACT

This study aims to design a blueprint for a web-based geographic information system (Web-GIS) architecture specifically designed for mapping and classifying high-intensity cultural heritage in Bandung City. Although Bandung has a very high number of heritage assets, its operational data remains fragmented, statistical, and textually protected across various scattered sources, which hinders real-time monitoring and increases structural vulnerability amidst rapid urban development. This study uses a descriptive method with a structural system design approach, requirements implementation analysis and system design phases of the Waterfall model based on the Pressman software engineering paradigm. The technical design uses Data Flow Diagrams (DFDs) and Entity Relationship Diagrams (ERDs) to organize a new multi-category data synchronization scheme in accordance with local regulations (Categories A, B, and C). The output of this study is a robust system architecture, database model, and user interface design validated through empirical alignment with the city registry and field observations. Initial testing of the interactive prototype, which included Black Box Testing across fifteen functional scenarios and a System Usability Scale (SUS) assessment involving five respondents, resulted in a 100% functional consistency rate and an average SUS score of 78.5 ("Acceptable"), indicating favorable initial usability. Rather than developing a fully operational Web-GIS platform, this study presents a validated architectural blueprint and interactive prototype that provide the technical basis for future full-scale operational implementation, deployment, and evaluation.

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1. INTRODUCTION

Bandung is widely known as the Paris of Java, reflecting its European-style architecture, particularly Art Deco, which flourished in the early 20th century [1]. These characteristics not only shape the city's identity

but also position Bandung as one of the regions with significant cultural heritage assets in Indonesia [2], [3]. In line with UNESCO's perspective, this heritage is not simply a relic of the past, but rather a sustainable asset representing historical value and community identity that must be managed in a planned manner [4], [5].

According to Bandung City Regional Regulation Number 7 of 2018, there are approximately 1,770 cultural heritage buildings classified into Category A (254 buildings), Category B (455 buildings), and Category C (1,061 buildings), in addition to 70 sites, 26 structures, and 24 cultural heritage areas [6]. Although updates have been introduced through Bandung City Regional Regulation Number 6 of 2025 concerning the Management and Preservation of Cultural Heritage [7], the regulation is essentially an administrative refinement of the previous policy. Given that the latest regulations do not provide detailed statistical data on heritage objects, the inventory data from the 2018 regulations remains the primary and valid reference to ensure consistency in the number and classification of objects in this study.

Comparatively, the number of cultural heritage objects in Bandung is quite high. Data from 2026 shows that DKI Jakarta Province only has 323 cultural heritage objects [8], while Surabaya City has 289 objects [9]. The figure of over 1,700 cultural heritage objects in Bandung indicates a much higher level of management complexity, requiring more precise monitoring instruments [10]. However, this high number is directly proportional to the increasing pressure of urban development, which threatens the existence of cultural heritage through risks such as land-use conversion and uncontrolled physical changes to buildings.

The main problem identified lies in data management, which remains conventional, static, and fragmented. Information on the distribution, type, and classification of cultural heritage remains scattered across various physical literature sources and has not been spatially integrated. The absence of coordinate-based visual representations results in weak field supervision, particularly in verifying the protection status of heritage objects in real time amidst rapid urban development. This condition creates a critical information gap that not only hinders data-driven decision-making but also increases the risk of cultural heritage loss due to misidentification of protection status by relevant stakeholders.

The implementation of Geographic Information Systems (GIS) has been widely recognized as a strategic solution for integrating attribute data with spatial data into interactive digital platforms [11]. However, existing spatial models in cultural heritage management still exhibit critical limitations. Previous GIS frameworks or bibliometric evaluations, such as those discussed by Huang [12], primarily map macro-level trends or broad spatial distributions, often failing to address micro-local data synchronization for high-density heritage sites. Similarly, while web-GIS models such as those developed by Ducatteeuw et al. [13] offer valuable place-based community mapping, they remain focused on public digital humanities representation rather than managing complex, multi-category municipal protection statuses that dynamically change with local urban regulations.

In parallel, a critical gap exists: current platforms lack a tailored architectural blueprint capable of transforming static, textual cultural heritage classifications into coordinated, interactive digital infrastructure that supports real-time municipal law enforcement and risk mitigation. It is important to note that this study fundamentally differs from the GIS study by Fatman et al. for mapping tourist attractions in Bandung City, which focused on general tourism information using Leaflet JavaScript and Agile methods, without addressing the legally mandated multi-category classification (A, B, and C) of cultural heritage assets, nor the disposition and administrative workflows required for urban heritage governance. This study directly addresses this gap by developing a comprehensive GIS blueprint specifically designed for high-density cultural heritage infrastructure in Bandung City. Going beyond generic mapping tools or purely public humanities displays, this study focuses strictly on the systems engineering and architectural design phases. It establishes a new data architecture and user role framework required for an early detection system for unauthorized urban change. By explicitly defining the system interactions, entity relationships, and data schemas necessary to overcome previous operational limitations, this blueprint provides a vital empirical and technical foundation for achieving proactive, integrated, and data-driven heritage preservation in future software development.

2. METHOD

2.1. Research Method

This study employs a descriptive method with a systems design approach. The descriptive method is used to describe the existing conditions related to the distribution and characteristics of cultural heritage in Bandung City. Meanwhile, a systems design approach is applied to generate solutions in the form of a Geographic Information System (GIS)-based design.

The resulting system design aims to integrate spatial and non-spatial data in a structured manner to support cultural heritage mapping and classification. The results of this study include a system model, database structure, and user interface design.

2.2. Research Location

This research was conducted in Bandung City, which has a large number of cultural heritage objects spread across various regions. This location was chosen based on the complexity of the data and the need for an information system capable of supporting more effective cultural heritage management and preservation.

2.3. Types and Sources of Data

The data used in this study are classified into two main categories as follows:

1. **Spatial Data:** This includes geographic location data represented by the latitude and longitude coordinates of cultural heritage objects, as well as a digital map of Bandung City.
2. **Non-Spatial Data:** This consists of supporting attribute data such as the name of the cultural heritage object, address, description, type (building, site, structure, area), and building classification based on Categories A, B, and C.

The integration of spatial and non-spatial data in this study is based on the basic principles of Geographic Information Systems (GIS), which enables more comprehensive location-based analysis [14]. All data were obtained through coordination with relevant government agencies, review of official documents, and literature studies from previous related research.

2.4. Data Collection Methods

Data collection in this study was conducted using a combination of literature-based and field-based techniques to ensure that the structural system requirements reflect real-world operational needs. The techniques used included:

1. Literature review, which involved a systematic review of reference books, scientific journals, and digital government models to establish a theoretical basis for GIS design and spatial requirements.
2. Documentation, which involved collecting and analyzing formal archives, local zoning policies, and inventory registries from relevant government agencies, including the Bandung City Culture and Tourism Office. This process involved a structured evaluation of administrative data to translate physical regulatory mandates (Categories A, B, and C) into formal database variables.
3. Direct observations were conducted at several high-density cultural heritage sites across Bandung to match physical building coordinates with official city government records. This field data collection served as a validation mechanism to verify factual spatial characteristics and align user oversight needs before formulating technical requirements.
4. Interviews were conducted in a semi-structured format with two staff members from the Bandung City Culture and Tourism Office (Disbud) who are directly responsible for heritage data administration. The interviews were used to validate the proposed functional and non-functional requirements, explain the practical workflow of legacy status disposition, and confirm that the categorization logic embedded in the system design (Categories A, B, and C) was consistent with actual field practice rather than being derived solely from regulatory text.

2.5. System Development Method

The system development method used in this study is the Waterfall model, which follows a systematic and structured process. However, this study is intentionally limited to the requirements analysis and system design phases, without covering the implementation and testing phases. This limitation is academically justified under the formal software engineering paradigm established by Pressman [15], where the system design phase serves as a basic blueprint that determines data integrity, technical feasibility, and structural scalability before any physical coding takes place. In complex urban information environments, such as the high-density cultural heritage infrastructure in Bandung, the primary failures of spatial data integration often stem from architectural and relational data fragmentation rather than implementation mechanics. Therefore, a rigorous focus on analytical modeling of system requirements and database relationships constitutes a critical and independent scholarly contribution that aims to address this structural gap, providing the verified and rigorous technical foundation necessary for the upcoming implementation phase.

The specific stages undertaken in this research include:

1. Requirements analysis, which involves identifying system requirements based on existing problems, data characteristics, and user needs for a GIS-based cultural heritage information system. This stage ensures that the proposed architecture complies with local regulatory frameworks and the complexity of data management.
2. System design, which involves developing a technical blueprint for the system, including system architecture, database design, and user interface design. This stage translates user requirements into formal logical structures, such as Data Flow Diagrams (DFDs) and Entity Relationship Diagrams (ERDs), which serve as verified specifications for future development.

Although the Waterfall model traditionally proceeds with implementation and testing, the research intentionally ends at the design stage. However, the resulting design artifacts, including the system architecture, database schema, DFDs, ERDs, and interactive interface prototypes, are then evaluated through design-based black-box scenario validation and System Usability Scale (SUS) assessments to verify functional consistency and initial usability before future physical implementation.

2.6. System Design

This system was developed by integrating spatial and non-spatial data into a GIS-based platform. It is designed to display cultural heritage locations in the form of interactive digital maps complemented by attribute information.

The design includes:

1. System architecture, which describes the process flow from data input, processing, storage in a database, and visualization in the form of a digital map.
2. Database design, which includes attributes such as identity, name, geographic coordinates, description, type of cultural heritage, and building classification.
3. User interface design, developed with usability in mind through features such as digital maps, location markers, and detailed information accessible to users.

2.7. Research Workflow

The research workflow in this study consists of the following stages:

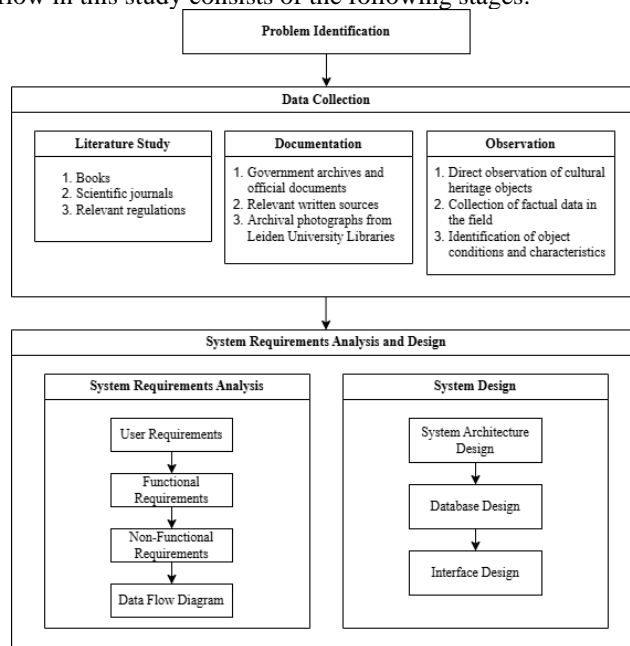


Figure 1. Research Workflow

As illustrated in Figure 1, the research began with Problem Identification, where the fragmentation and inaccessibility of cultural heritage data in Bandung City were formulated as the primary issues to be addressed. This was followed by the Data Collection phase, which was conducted through three parallel techniques: Literature Review, which referred to relevant books, scientific journals, and regulations; Documentation, which collected government archives, official documents, and archival photographs from the Leiden University Library; and Observation, which involved direct field visits to cultural heritage objects to

collect factual data and identify their condition and physical characteristics. These three techniques were further complemented by semi-structured interviews with Disbud staff, as described in Section 2.4, ensuring that the data entering the subsequent design phase reflected both documented sources and practical insights verified in the field.

The collected data was then fed into the System Requirements Analysis and Design phase, which was divided into two parallel branches. The System Requirements Analysis branch sequentially generated User Requirements, Functional Requirements, and Non-Functional Requirements, which were then translated into Data Flow Diagrams. In parallel, the Systems Design branch progresses through System Architecture Design, Database Design, and Interface Design. The outputs from these two branches collectively form a complete architectural blueprint presented in the Results and Discussion section, covering system data flow, entity relationships, and user-focused design. Finally, the resulting design artifacts and interactive prototypes were evaluated using Black-Box functional scenario validation and System Usability Scale (SUS) assessment before formulating final conclusions.

3. RESULT AND DISCUSSION

3.1. Requirements Analysis

A system requirements analysis was conducted to identify user needs and the functions that must be available in the designed Geographic Information System (GIS). This system aims to provide integrated, informative, and easily accessible cultural heritage information in the city of Bandung.

The needs analysis identified that existing cultural heritage management primarily suffers from fragmented spatial records, inconsistent classification references, and limited accessibility for public users. Consequently, the proposed requirements emphasize centralized administration, integrated spatial visualization, and standardized classification based on Categories A, B, and C.

Based on the analysis, there are two types of users in this system: administrators and general users. Administrators act as system managers responsible for processing and updating data, while general users act as those who access cultural heritage information.

The system requirements in this study consist of user requirements, functional requirements, non-functional requirements, and system modeling using Data Flow Diagrams (DFDs).

3.1.1. User Requirements

Based on the analysis results, the user requirements for this system include:

1. Administrators require a system to manage cultural heritage data in a centralized and structured manner.
2. General users require a system to access cultural heritage information easily, quickly, and informatively.

3.1.2. Functional Requirements

Functional requirements represent the main functions the system must provide, including:

1. The system must be able to display interactive Geographic Information System-based maps showing the distribution of cultural heritage.
2. The system must be able to display detailed information for each cultural heritage object, including name, address, description, type, and classification.
3. The system must provide a search feature for cultural heritage locations.
4. The system must display building classifications based on Categories A, B, and C.
5. The system must display cultural heritage types, including buildings, sites, structures, and areas.
6. The system must allow administrators to add, update, and delete cultural heritage data.

3.1.3. Non-Functional Requirements

Non-functional requirements relate to the quality attributes of the designed system, including:

1. The system must have a simple and user-friendly interface.
2. The system must present information clearly, in a structured manner, and easily understood.
3. The system must have a fast and responsive response time.
4. The system must be able to accurately integrate spatial and non-spatial data.
5. The system must be accessible anytime and anywhere via the internet.

In short, the formulation of both the functional and non-functional requirements above is not simply derived deductively from theoretical literature, but is rigorously based on empirical alignment with municipal data from the Bandung City Culture and Tourism Office, verified through factual field observations, and validated through semi-structured interviews with Culture and Tourism Office staff, as described in Section 2.4. This ensures that the structural system specifications are validated to directly address the real-world operational complexities of high-intensity heritage management.

3.1.4. Data Flow Diagram (DFD)

A Data Flow Diagram (DFD) is used to depict data flow within a system and the interactions between external entities, processes, and data stores. In this study, the DFD consists of a context diagram and a Level 1 DFD.

The context diagram is presented in Figure 2. This diagram depicts the system as a single entity interacting with two external entities: the administrator and general users.

The administrator provides input in the form of authentication data and system management data, while general users provide input in the form of search queries and information requests. The system then generates output in the form of cultural heritage information and reports for the administrator, as well as cultural heritage information for general users.

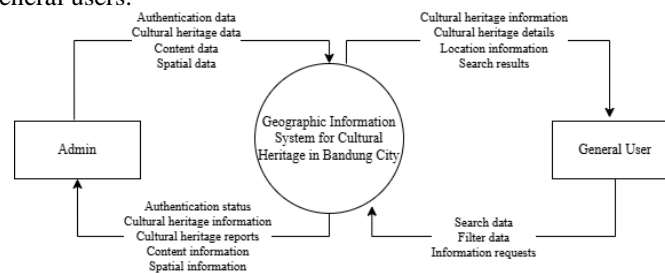


Figure 2. Context Diagram

The Level 1 Data Flow Diagram (DFD) is presented in Figure 3, representing the decomposition of the context diagram. This system consists of several main processes: authentication, cultural heritage data management, content management, spatial data management, and information retrieval and presentation.

Each process is interconnected through a database to manage and present information. The management process is carried out by administrators, while the information retrieval and presentation processes are used by general users to obtain structured cultural heritage information.

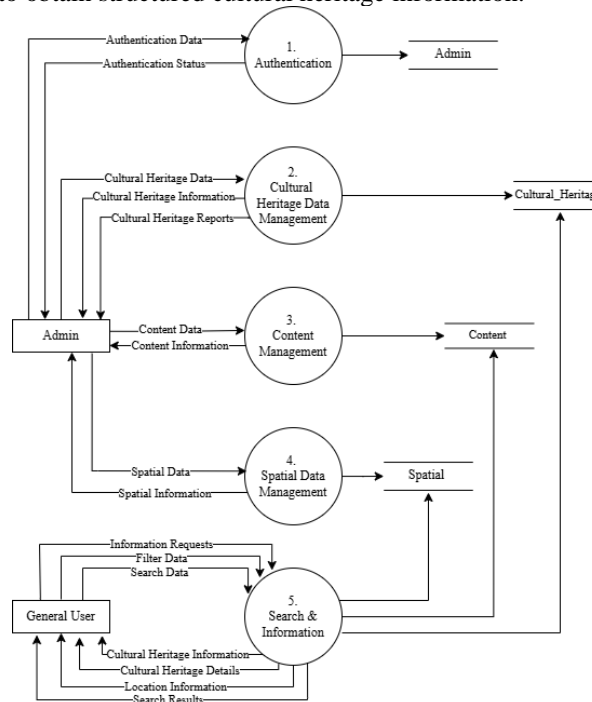


Figure 3. DFD Level 1

3.2. Architecture Design

The system architecture design is used to describe the overall structure and workflow of the system. The architecture adopted in this study is a client-server architecture, which allows users to access the system via the internet.

The system architecture in this study is illustrated in Figure 4, Architectural Design of the Cultural Heritage Geographic Information System. This system consists of three main components: client, server, and database.

The client component represents the entities that interact directly with the system, namely administrators and general users. The server component functions as a data processor and application logic manager, handling client requests and connecting them to the database. Meanwhile, the database component is used to store system data, including cultural heritage data, content, spatial data, and administrative data.

As shown in Figure 4, the system workflow begins with the client sending a request to the server. The server then processes the request by accessing the database, and the results are returned to the client in the form of displayable information.

Compared to conventional document-based legacy management, the proposed client-server architecture centralizes attribute and spatial data into a single repository, reducing data redundancy and enabling synchronized information delivery for administrative management and public access.

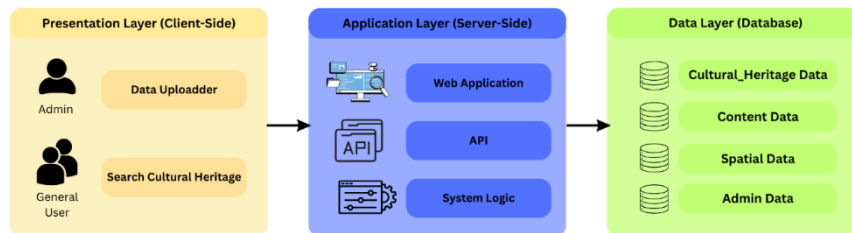


Figure 4. Design of the Cultural Heritage Geographic Information System Architecture

3.3. Database Design

Database design is performed to define the data structure used in a Geographic Information System (GIS) for cultural heritage. The model used is an Entity Relationship Diagram (ERD), which depicts the entities and relationships between data within the system.

The ERD in this study is presented in Figure 5 (Entity Relationship Diagram). The diagram illustrates the relationships between the Admin, Cultural_Heritage, Content, and Spatial entities.

The Cultural_Heritage entity serves as the primary entity, having a one-to-many (1:N) relationship with Content and a one-to-one (1:1) relationship with Spatial. Furthermore, the Admin entity has a one-to-many (1:N) relationship with Cultural_Heritage, the data manager.

These relationships demonstrate the system's ability to manage cultural heritage data in a structured and integrated manner. This relational structure eliminates the separation between descriptive heritage records and spatial information that characterizes the current manual management process, thereby supporting data consistency and future scalability.

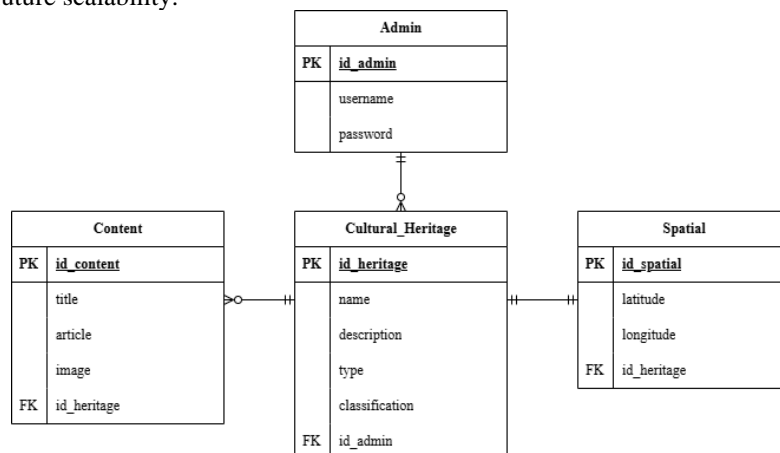


Figure 5. Entity Relationship Diagram

3.4. Interface Design

Interface design aims to describe the system interface used by users to interact with a cultural heritage GIS. The interface is designed with usability (user-friendliness), information clarity, and efficiency in data management in mind.

3.4.1. Admin Interface

The admin interface is designed to support the integrated management of cultural heritage data on a single page. This approach aims to increase efficiency in the data entry process and make it easier for users to manage various types of data simultaneously.

On the data entry page, administrators can enter key information, upload images, and specify locations using an interactive map that automatically generates coordinates. The admin interface is shown in Figure 6.

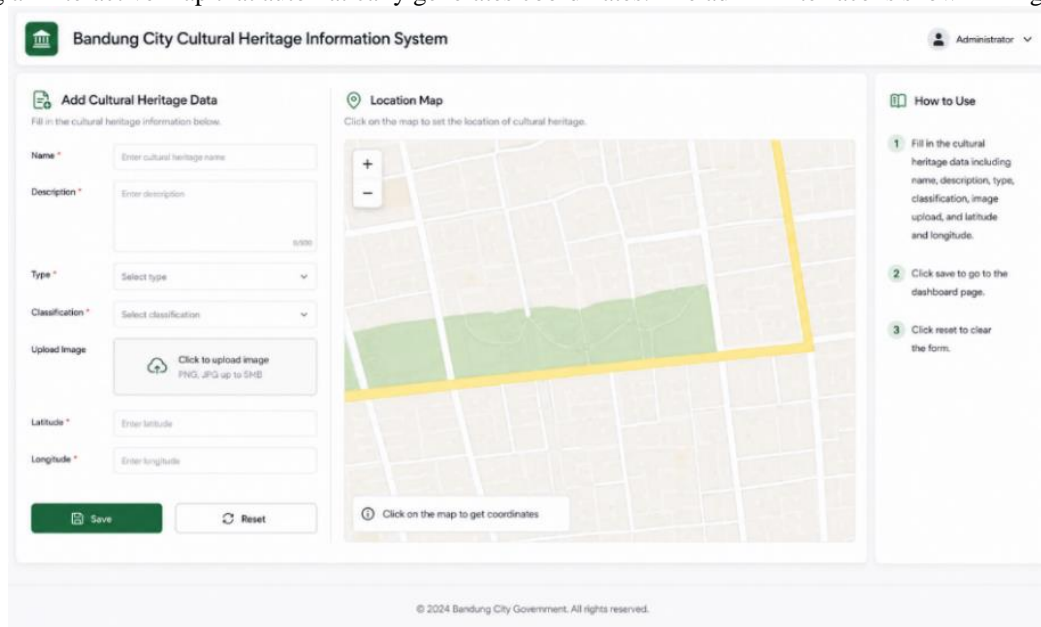


Figure 6. Admin Interface

The above interface design was developed using usability principles that emphasize layout consistency, ease of navigation, and efficiency of user interaction, in accordance with established human-computer interaction guidelines for administrative data management systems.

The interface layout is intentionally designed to minimize data entry complexity by integrating attribute input, image upload, and coordinate selection in a single workspace.

3.4.2. General User Interface

The general user interface is designed to present cultural heritage information interactively through a map-based display. The interface provides a search bar along with drop-down filters for Type and Classification, allowing general users to narrow heritage entries by category (A, B, or C) before viewing them on the map. The system displays the location distribution using colored markers labeled with their respective classifications.

Clicking on a marker opens the Cultural Heritage Details panel, which contains the asset name, description, type, classification badge, coordinates (latitude and longitude), and related photographs. This interaction model allows users to retrieve legacy information more efficiently than conventional list-based presentations by combining map visualization with attribute filtering. The general user interface is shown in Figure 7.

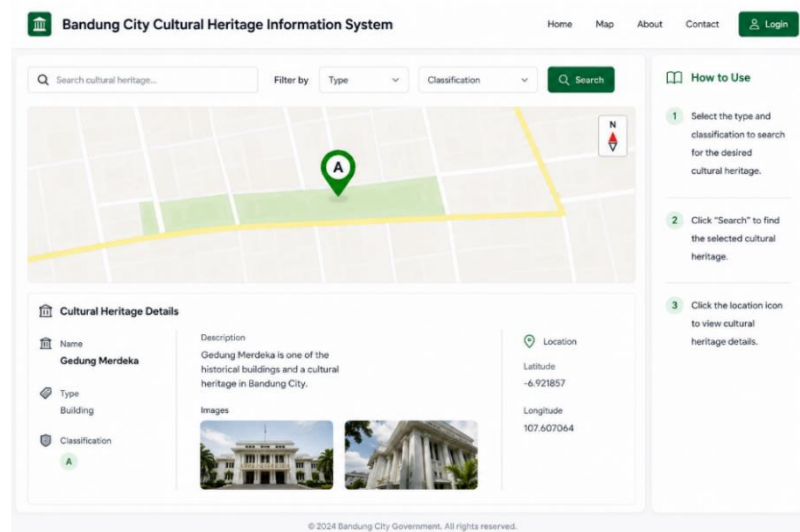


Figure 7. General User Interface

3.5. System Testing

System testing was conducted to evaluate the suitability of the proposed Geographic Information System design for cultural heritage in Bandung City to the user needs and functional requirements formulated in Section 3.1. Based on the design documentation, the system is intended to display interactive GIS-based maps, present detailed cultural heritage information, provide a search feature, display building classifications based on Categories A, B, and C, and enable administrators to manage cultural heritage data. Furthermore, the system also has non-functional requirements, including a simple, user-friendly, responsive, and structured interface capable of accurately integrating spatial and non-spatial data.

Because this research was limited to the requirements analysis and system design phases, testing was conducted on the resulting design artifacts, such as formulated requirements, data flow logic, and interactive prototypes of the admin and general user interfaces (Figures 6 and 7). Testing was conducted using two methods: Black Box Testing, to verify the consistency of the designed system's functionality based on expected inputs and outputs, and the System Usability Scale (SUS), to evaluate the perceived usability of the proposed interface design from a user perspective.

3.5.1. Black Box Testing

Black Box testing is used to check the functionality of a system without examining the underlying program code structure, focusing on the correspondence between user input and system output. Testing is performed based on the main functional scenarios formulated in the system requirements (Section 3.1) and reflected in the interface design (Figures 6 and 7).

Table 1. Black Box Testing Results

No	Feature Tested	Test Scenario	Input	Expected Result	Status
1	Admin Login	Admin enters a valid username and password	Correct username and password	System accepts authentication and displays the cultural heritage data management page	Pass
2	Admin Login	Admin enters an incorrect username or password	Incorrect username/password	System denies access and displays an authentication error message	Pass
3	Add Cultural Heritage Data	Admin fills in all cultural heritage data completely	Name, description, type, classification, image, latitude, longitude	System saves the cultural heritage data into the database	Pass
4	Add Data Form Validation	Admin leaves one required field empty	Empty name or coordinate field	System displays a validation message indicating the field is required	Pass

No	Feature Tested	Test Scenario	Input	Expected Result	Status
5	Image Upload	Admin uploads a cultural heritage image in a supported format	JPG/PNG file	System accepts and displays a preview, or stores the image	Pass
6	Location Coordinate Input	Admin enters latitude and longitude	Valid latitude and longitude	System displays the location on the map according to the coordinates	Pass
7	Interactive Map	User opens the cultural heritage map page	Access to the map page	System displays an interactive map with cultural heritage location markers	Pass
8	Cultural Heritage Detail	User selects a marker on the map	Click on a location marker	System displays the cultural heritage detail, including name, description, image, type, classification, and location	Pass
9	Data Search	User enters a search keyword	Specific cultural heritage name	System displays search results matching the keyword	Pass
10	Cultural Heritage Type Filter	User selects a type filter	Building/site/structure/area	System displays data according to the selected type	Pass
11	Classification Filter	User selects classification A, B, or C	Category A/B/C	System displays cultural heritage data according to the selected classification	Pass
12	Edit Cultural Heritage Data	Admin updates cultural heritage data	Change of name, description, type, classification, or coordinates	System saves the changes and displays the updated data	Pass
13	Delete Cultural Heritage Data	Admin deletes specific data	Delete command	System removes the data from the list and the database	Pass
14	Reset Form	Admin presses the Reset button on the add-data form	Click on the Reset button	All form inputs return to an empty state	Pass
15	General Access	User accesses the information page	Access without admin login	User can only view information and cannot manage data	Pass

Based on the results of Black Box Testing in Table 1, all fifteen functions designed for the Bandung City cultural heritage geographic information system function consistently with the predetermined functional requirements. Data management functions performed by administrators, information searches by general users, interactive map displays, data filtering, and presentation of cultural heritage details all behave according to the predetermined scenarios. Thus, the proposed design is considered to meet the functional requirements of the cultural heritage Web-GIS at the design level, with testing confirming the internal consistency of the system's input-output logic. Although all predefined scenarios were successfully completed, several interface improvements were identified during the evaluation process, including clearer coordinate validation messages, simplified navigation instructions, and increased visibility of map interaction elements. These observations do not affect functional correctness but provide useful guidance for future implementations.

3.5.2. System Usability Scale (SUS) Testing

The System Usability Scale (SUS) was used to measure the usability of the system interface based on user perceptions. This test was conducted by administering a questionnaire to respondents after they interacted with a click prototype of the proposed interface design (Figures 6 and 7). Respondents were drawn from two user groups: administrators acting as data managers, represented by staff from the Bandung City Culture and Tourism Office, and general users acting as information seekers, represented by individuals simulating the role of public users of the system.

The SUS instrument consists of ten statements rated on a five-point scale, as shown in Table 2, where a score of 1 indicates "Strongly Disagree" and a score of 5 indicates "Strongly Agree".

Table 2. SUS Statement Items

No	Statement
1	I think that I would like to use this cultural heritage information system frequently.
2	I found this system unnecessarily complex.
3	I thought this system was easy to use.
4	I think that I would need the support of a technical person to be able to use this system.
5	I found the various features in this system were well integrated.
6	I thought there was too much inconsistency in this system.
7	I would imagine that most people would learn to use this system very quickly.
8	I found this system very cumbersome (awkward) to use.
9	I felt very confident using this system.
10	I needed to learn a lot of things before I could get going with this system.

The SUS score is calculated according to the following rules. For odd-numbered statements, the contribution score is calculated as the respondent's score minus 1. For even-numbered statements, the contribution score is calculated as 5 minus the respondent's score. All contribution scores are then summed and multiplied by 2.5, expressed as $SUS = (\sum \text{contribution score}) \times 2.5$.

The questionnaire was completed by five respondents. Since this study evaluated an interactive prototype rather than an implemented information system, a small, representative sample consisting of administrative staff and potential public users was deemed appropriate for the initial usability assessment. Respondents consisted of two administrative staff from the Bandung City Culture and Tourism Office and three individuals representing general users, after interacting with clickable prototypes of the admin and general user interfaces, respectively. A summary of the responses and the resulting SUS scores are presented in Table 3.

Table 3. SUS Response Recapitulation

Respondent	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	SUS Score
R1	4	2	4	2	4	2	4	2	4	2	75
R2	5	2	4	1	4	2	5	2	4	2	82.5
R3	4	3	4	2	4	2	4	2	4	2	72.5
R4	4	2	5	2	4	2	4	1	4	2	80
R5	5	2	4	2	5	2	4	2	5	2	82.5
Average											78.5

Table 4. SUS Score Interpretation

SUS Score Range	Interpretation
< 51	Poor
51 – 68	Marginal
> 68 – 80.2	Acceptable
80.3 – 100	Excellent

Based on the calculations in Table 3, the average SUS score obtained was 78.5. According to the interpretation scale in Table 4, this score falls into the "Acceptable" category, indicating that the proposed interface design can be considered usable from a usability perspective. These results indicate that respondents found the interface quite easy to understand, that key features were easily recognized, and that the interaction flow on the admin and general user pages supported the intended use of the system.

The obtained SUS scores indicate that the proposed interface has achieved an acceptable level of usability even without a fully implemented system. However, this score still leaves room for improvement, which could be achieved through refining the interface layout, simplifying navigation instructions, improving the legibility of map elements, and clearer input validation on the cultural heritage data management form. Because this assessment involved five respondents on an interactive prototype, a larger-scale SUS evaluation is recommended after the system is physically implemented, as described in the Future Work section.

Based on the results of Black Box Testing, the proposed design meets its main functional requirements, such as cultural heritage data management, information retrieval, filtering by type and classification, interactive map display, and detailed presentation of cultural heritage objects. Meanwhile, SUS testing indicates that the proposed interface design has an Acceptable level of usability for both administrators and general users. Thus, the design of the geographic information system for cultural heritage in Bandung City

is assessed as functionally consistent with its requirements and quite beneficial in terms of ease of use at the design and prototype levels, although further testing is still needed after the system reaches the physical implementation stage.

3.6. Research Limitation

Although the proposed architecture has been evaluated through design-based functional verification and initial usability assessment, it has not undergone implementation-level validation involving operational deployment, concurrent multi-user access, performance testing, security testing, or long-term maintainability evaluation.

4. CONCLUSION

This study successfully developed a comprehensive Web-GIS architectural blueprint for managing and classifying cultural heritage in Bandung City by integrating spatial, attribute, and content data into a unified system design. The resulting blueprint includes validated system requirements, client-server architecture, database schema, Data Flow Diagram (DFD), Entity Relationship Diagram (ERD), and user interface design for administrators and general users. Initial evaluation showed that all fifteen functional scenarios passed the Black-Box Test (100% functional consistency), while the System Usability Scale (SUS) assessment achieved an average score of 78.5, indicating Acceptable usability. These results indicate that the proposed design meets the identified functional requirements and provides a practical and user-oriented basis for digital cultural heritage management. Additionally, the proposed architecture resolves the previously identified fragmentation of cultural heritage records by integrating spatial, attribute, and multimedia information into a unified Web-GIS design that supports standardized urban data management. Overall, this study provides formal technical specifications that address previous data fragmentation and build a strong foundation for the implementation and future operational deployment of a Web-GIS-based cultural heritage preservation platform.

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