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Development of Geographic Information Systems in Mapping Village-Owned Enterprises in Sleman Regency

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***Abstract*— The population increase in the Special Region of Yogyakarta poses challenges, including developing Village-owned Enterprises or BUM Desa in Sleman Regency to enhance rural community welfare. BUM Desa data management currently relies on manual spreadsheets and lacks a dynamic data storage system, hindering access to accurate information. This study employed the Scrum methodology, gathering data through literature reviews, interviews, and observations to assess the current state of BUM Desa. A product backlog guided the development of a web-based GIS application through sprint planning, resulting in an application that maps BUM Desa locations in the Sleman Regency based on coordinates and provides detailed development classifications. This application enhances data management and decision-making for BUM Desa development, simplifies government data management, and improves public access to BUM Desa locations. Black box testing confirmed its functionality, with 100% validity. End-user computing Satisfaction (EUCS) surveys indicated high user satisfaction, emphasizing the application's usability and alignment with user expectations in providing accurate and accessible BUM Desa information.**

Keywords*— *BUM Desa; Geographic Information System; rural community welfare; SCRUM; village enterprise

1 INTRODUCTION

The Special Region of Yogyakarta (D.I. Yogyakarta) is one of the regions in Indonesia with a high population density [1]. The dense population presents impacts and challenges across various aspects of life. According to data from the Central Statistics Agency of the Province of D.I. Yogyakarta, the population in this region has reached 4 million in the past three years. This population is distributed across five regencies: Bantul, Kulon Progo, Gunungkidul, Sleman, and the City of Yogyakarta [2]. Based on Table 1, the population growth in Sleman Regency has reached 1.37 per cent annually, indicating an increasing economic demand in the area.

Table 1. Estimated Population Data in D.I. Yogyakarta (people)

District	2020	2021	2022
D.I. Yogyakarta	3.919.197	3.970.220	4.021.816
Kulonprogo	437.373	442.724	448.131
Bantul	1.036.489	1.050.308	1.064.286
Gunung Kidul	758.316	767464	776.705
Sleman	1.248.258	1.265.429	1.282.804
Kota Yogyakarta	438.761	444.295	449.890

The significant population growth affects the need for employment opportunities, income, and access to products and services [3]. Therefore, the Village Community Empowerment Agency (Dinas Pemberdayaan Masyarakat Desa - PMD) in Sleman Regency aims to harness the potential of Village-Owned Enterprises (BUM Desa) to advance economic growth and meet community needs.

BUM Desa aims to enhance the welfare of rural communities by developing economic programs and services such as agriculture, fisheries, crafts, tourism, and other sectors [4]. They have strategic plans to empower communities, create job opportunities, increase village income, and stimulate the local economy [5], [6]. BUM Desa is collectively established in a democratic and participatory manner by rural communities, with decisions made through cooperation with residents.

The Regulation of the Ministry of Villages, Development of Disadvantaged Regions, and Transmigration of the Republic of Indonesia Number 3 of 2021 concerning the Registration, Data Collection, Ranking, Supervision, Development, and Procurement of Goods and/or Services for BUM Desa and Joint Village-Owned Enterprises indicates that BUM Desa can be established to accommodate village activities based on the agreement of the residents [7]. According to this regulation and the data from the Community Empowerment Expert (TAPM) of Sleman Regency, there are currently 65 identified enterprises in the Sleman region. These enterprises are categorized into four groups: 38 pioneer companies in the initial development stage, 13 startups showing continuous growth, 9 companies in the advanced development stage, and 5 companies that have reached the further development stage. Table 2 shows the groups.

Table 2. Classification of Village-Owned Enterprise Progress

No	Category	Score
1	Pioneering	< 55
2	Startup	55 – 70
3	Developing	71 – 85
4	Advanced	86 – 100

The Village-Owned Enterprise Information System (SI BUMDesa) is a modern tool for managing BUM Desa information in specific regions. However, currently, BUM Desa data management is still conducted manually or using spreadsheets, which can reduce efficiency, accuracy, and ease of access to information. SI BUMDesa provides basic information about BUM Desa. Additionally, it includes features that utilize Geographic Information Systems (GIS), thereby supporting decision-making and the optimal growth of BUM Desa.

Recent studies [8], [9], [10], have been conducted to provide a solid foundation for the implementation of GIS in rural areas capable of managing village resources and potentials [8], efficiently managing village assets [9], and ensuring targeted distribution of social assistance [10]. However, a major limitation identified is the lack of navigation features capable of determining the nearest route to desired locations. The proposed research aims to address existing gaps by adding navigation features and more in-depth spatial analysis to enhance information accessibility and support better infrastructure development and public services at the village level.

Geographic Information Systems (GIS) is a technology that utilizes spatial and geographic data to map, analyze, and visually display information [11], [12]. With the feature of finding the nearest route, GIS enables users to easily locate the position of each village-owned enterprise (BUM Desa) and access relevant information more effectively. The integration of GIS mapping in SI BUMDesa will enhance the efficiency of BUM Desa data collection in Sleman [13]. Through mapping, each business can be identified and positioned according to its location in Sleman. Each BUM Desa is classified based on its growth stage, aiding in the identification and understanding of its potential. The use of different colors for each level of BUM Desa classification facilitates their identification and visualization of their development.

The development of BUM Desa with the Pioneering category is indicated by the color red, the Startup category is marked with the color orange, the Developing category is represented by green, and the Advanced category is depicted in dark blue. Each category includes parameters used to classify each enterprise, including the number of employees, business turnover, sustainability level, and the total score from each parameter owned.

The Scrum method, which adopts an Agile approach, is utilized to develop the web-based GIS application [14]. This method assists in ensuring that the geographic information system development aligns with user needs and is completed within the specified time frame. With Scrum, projects can be managed flexibly and adaptively, allowing for quick adjustments to changing requirements or conditions [15], [16].

A geospatial information system focusing on BUM Desa can be beneficial for the general public and the government. With this system, BUM Desa information becomes more accessible, facilitating government evaluation of BUM Desa and aiding in the formulation of policies that support economic growth in Sleman Regency [17]. This research is expected to make a positive contribution to the development of BUM Desa and economic growth in the region [18]. The tangible contribution of this research addresses the shortcomings of previous studies by integrating more advanced navigation and spatial analysis features. As a result, the developed system not only serves static mapping purposes but also supports more efficient navigation and decision-making processes. This research provides a comprehensive solution that can enhance the management efficiency of BUM Desa in Sleman and can be adopted by other regions with similar needs.

2 METHODOLOGY

2.1 Collection Data

The dataset required for this research consists of Village-Owned Enterprises (BUM Desa) data, including the business name, business description, score, business photos, owner's name, telephone number, and geographic coordinates. However, for personal privacy reasons, the manuscript does not include owner names and telephone numbers. The dataset was collected using three methods:

2.1.1 *Literature Review:* Reading scientific articles and various books related to the research to explore concepts, theories, and research gaps regarding the use of GIS for BUM Desa. This also involved understanding the principles, methodology, and web-based GIS implementation for BUM Desa.

2.1.2 *Interviews:* Conduct interviews with Community Empowerment Experts (TAPM) based on questions outlined in Table 3 to obtain detailed information about the background, management, classification of BUM Desa, and challenges hindering development monitoring.

2.1.3 *Observation:* Visiting the Office of Community and Village Empowerment of Sleman Regency and conducting direct observations related to the BUM Desa data collection process from villages to the stage of grouping BUM Desa data. This ensured the accuracy of location points and the precision of geographic data for BUM Desa.

Table 3. List of Interview Questions

No	List of Questions
Background of Village-Owned Enterprises (BUM Desa)	
1	Can you describe your background and how you are involved in community empowerment and BUM Desa management in Sleman Regency?
2	What are your main roles and responsibilities as a Community Empowerment Expert in Sleman Regency?
3	How do your experiences and education support your current role?
Management of Village-Owned Enterprises (BUM Desa)	
4	How is the establishment and management process of BUM Desa carried out in Sleman Regency?
5	What steps are taken to ensure the effective management of BUM Desa in compliance with regulations?
6	What are the mechanisms for reporting and evaluating the performance of BUM Desa?
7	Are there any current technologies or systems used to manage BUM Desa data and information?
8	What roles do the local government and community play in managing BUM Desa?
Classification of Village-Owned Enterprises (BUM Desa)	
9	How do you classify BUM Desa in Sleman Regency?
10	What criteria are used to classify BUM Desa (e.g., based on business type, scale, or income level)?
11	Are there different strategies or approaches applied based on these classifications of BUM Desa?
12	Can you provide examples of each classification of BUM Desa in your area?
Application of GIS in Mapping Village-Owned Enterprises (BUM Desa)	
13	What is your opinion on the implementation of Geographic Information Systems (GIS) in mapping BUM Desa in Sleman Regency?
14	How can GIS help in monitoring and managing BUM Desa?
15	Are there any initiatives or plans to integrate GIS in managing BUM Desa in your region?
16	What benefits do you expect from the implementation of GIS in this context?
17	What challenges might be faced in implementing GIS for mapping BUM Desa?

2.2 Research Data Requirements

This research utilizes data from 65 BUM Desa in Sleman Regency, obtained through a literature study, interviews, and observations. As shown in Table 4, the data is divided into four groups based on the level of development. The pioneering group consists of 38 BUM Desa with assessment scores of less than 55, the startup group comprises 13 BUM Desa with scores ranging from 55 to 70, the developing group consists of 9 BUM Desa and the advanced group comprises 5 BUM Desa [7]. The BUM Desa data includes the name of the BUM Desa, business description, score, address, photo, and the geographic coordinates of the BUM Desa [19].

Table 4. Some of the BUM Desa data in Sleman Regency

No	BUM Desa	Business Categories	Description	Score	Position
1	BUM Desa Agung Sejahtera Sumberagung	Agricultural Cultivation Business Category	Red Tilapia Cultivation and Breeding	MAJU (88,00)	- 7.761209403415981, 110.25893251742923
2	BUM Desa Sindu Mandiri Sinduadi	Trade and General Services Business Category	Village Market Management	MAJU (86,00)	-7.7669136662152125, 110.36482843596568
3	BUM Desa Amanah Berdikari Sumbersari	Trade and General Services Business Category	Pertashop	BERKEMBANG (81,00)	-7.714121401620307, 110.41454073650509
4	BUM Desa Tirtjaya Nogotirto	Trade and General Services Business Category	Village Market	PEMULA (67,00)	-7.77469631823968, 110.33468411187478
5	BUM Desa Banyu Gotro Rumpoko Banyuraden	Trade and General Services Business Category	Building and Field Management	PERINTIS (43,00)	-7.787521458132814, 110.33399702756162

2.3 Software Requirements Analysis

2.3.1 *Functional Requirements Analysis:* The process involves identifying, documenting, and understanding essential software system features, detailing its functionalities such as automating business processes, processing information, or executing specific actions [20]. In developing the Village-Owned Enterprise Information System (SI BUMDesa), functional requirements analysis focuses on addressing BUM Desa's challenges in efficient data management, comprehensive information provision, and integration with geographic mapping for effective monitoring and management. Refer to Table 5 for the current functional requirements.

Table 5. Functional Requirements

# Req	Functional Requirement	Description
RF-01	Main Page	The system can display a main page which presents information about BUM Desa in Sleman Regency and comparison graphs of BUM Desa in each district based on their classification.
RF-02	Classification Page	The system can display a classification page that allows users to select and view details of BUM Desa based on the categories of pioneering, startup, developing, and advanced.
RF-03	Map Page	The system can display a map page showing the location of each BUM Desa in Sleman Regency, complete with their coordinates.
RF-04	BUM Desa Detail Page	The system can display a BUM Desa detail page containing complete information such as BUM Desa name, business description, score, address, responsible person, phone number, and photo.
RF-05	Admin Login Page	The system should be able to display an admin login page that allows admins to log in to the system by entering a valid email and password.
RF-06	Admin Page	The system provides an admin page displaying options for managing BUM Desa data, including managing region, category, users, and districts.
RF-07	BUM Desa Data Management	The system should allow admins and super admins to add, update, and delete BUM Desa data.
RF-08	Category Data Management	The system allows super admins to manage category data, including adding, updating, and deleting category data.
RF-09	User Data Management	The system allows super admins to manage user data, including adding, updating, and deleting user accounts.
RF-10	Districts Data Management	The system allows super admins to manage district data, including adding, updating, and deleting district data.

2.3.2 *Non-Functional Requirements Analysis:* These requirements determine how a software system operates beyond its functional capabilities [20]. They specify attributes like performance, security, availability, and portability. These requirements ensure the system functions efficiently, securely, and reliably. Refer to Table 6 for detailed non-functional requirements.

Table 6. Non-Functional Requirements

# Req	Non-Functional Requirement	Description
RNF-01	Performance	The system is capable of handling concurrent usage efficiently. System response time should be fast, and page loading should be efficient.
RNF-02	Security	The security of BUM Desa data must be tightly maintained through data encryption, secure user authentication, and proper access control.
RNF-03	Availability	The system should be continuously available with minimal downtime. System recovery should be quick to

		ensure service continuity to the community.
RNF-04	Usability	The user interface should be user-friendly and intuitive, with clear instructions and easy-to-understand navigation to support smooth usability.
RNF-05	Scalability	The system should be able to scale according to the increasing needs of BUM Desa, which may grow in number and complexity over time.

2.4 Use Case Diagram

A diagram that visualizes the interaction between users (actors) and the system in a specific context [21]. Actors, as entities outside the system, are connected to one or more use cases representing actions that users can perform within the system. Use cases depict system functionality that provides value to users. The relationship between actors and use cases indicates the involvement of actors in performing specific actions. By using this diagram, it can be understood how the system interacts with users and how users use the system to achieve their goals. Figure 1 illustrates the access structure of SI BUMDesa, which has three main roles: general users, admins, and super admins.

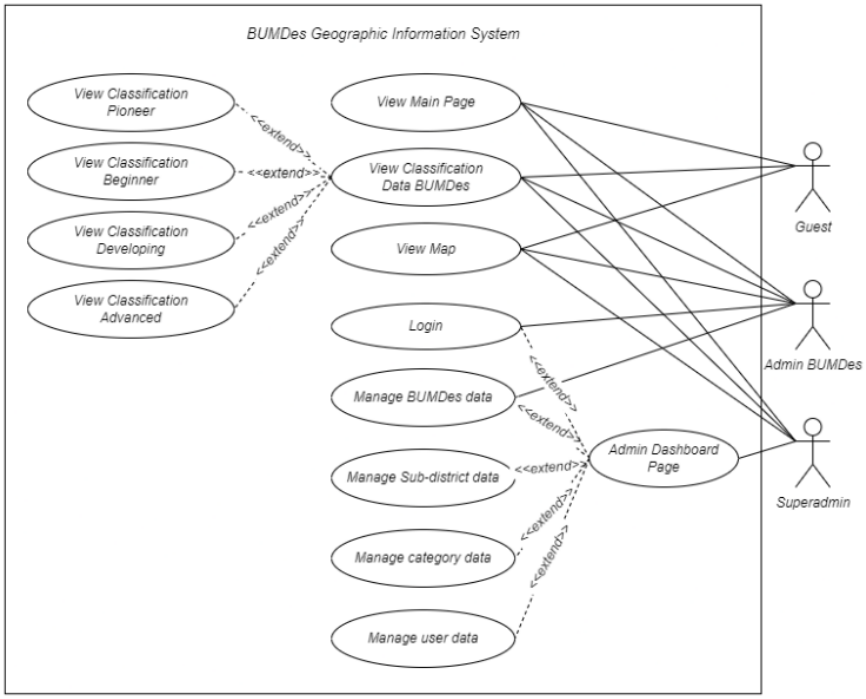

Figure 1. Use case Diagram SI BUMDesa

Users can view the main page, classifications, and BUM Desa map without logging in. Admins have the same access as general users but can also manage BUM Desa data after logging in. Super admins have full access to all system features, including BUM Desa data management, category management, user management, and district management. This clear access structure ensures users can perform actions according to their roles and responsibilities in BUM Desa management.

2.5 System Development Methodology

The development of the GIS application for mapping Village-Owned Enterprises (BUM Desa) in Sleman Regency is conducted using the Scrum methodology as depicted in Figure 2, which is an iterative Agile software development approach [22]. This methodology involves a series of steps repeated periodically to ensure transparency, adaptation, and the delivery of high value in each development iteration [23], [24].

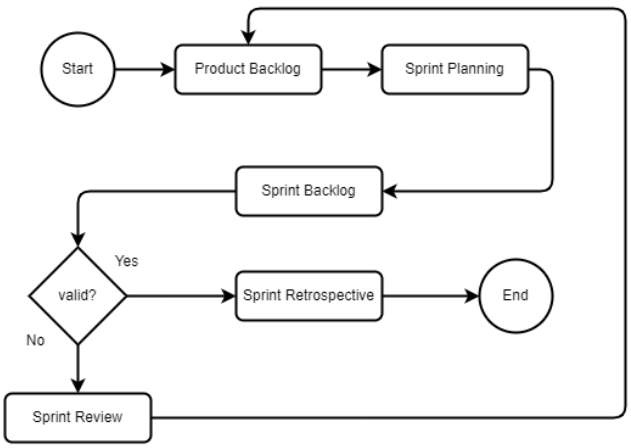

Figure 2. Flowchart Metode Scrum

2.5.1 *Product backlog:* The list of features and requirements for the SI BUMDesa application is developed based on comprehensive literature studies, stakeholder interviews, and field observations conducted in Sleman. Items in the backlog, such as BUM Desa profiles, geographic mapping, and classification features, may change or expand.

2.5.2 *Sprint Planning:* In this phase, the author selects specific items from the product backlog to include in the sprint backlog. For the SI BUMDesa project, this involves planning the development of modules such as BUM Desa data entry, Geographic Information System (GIS) integration, and classification visualization. The author estimates the time and resources needed to complete these tasks within a sprint.

2.5.3 *Sprint Backlog:* During this phase, the author executes the plan developed during Sprint Planning. Tasks from the product backlog are worked on, focusing on features prioritizing BUM Desa data management and analysis, such as developing a user interface for data input, integrating GIS mapping capabilities, and creating tools for classification.

2.5.4 *Sprint Review:* This phase involves evaluating the completed items from the product backlog. For SI BUMDesa, the author conducts testing to validate the implementation of features such as BUM Desa profile management and GIS mapping, ensuring they align with the project's objectives. Stakeholder feedback is used to make necessary adjustments in the next sprint, improving the application's ability to meet user needs.

2.5.5 *Sprint Retrospective:* In this phase, the author reviews the completed sprint and takes corrective actions to enhance the next sprint. For the SI BUMDesa project, regular sprint retrospectives help improve efficiency, quality, and software coherence with the goal of accurately mapping and analyzing BUM Desa data, ensuring effective system development.

3 RESULT AND DISCUSSION

The SI BUMDesa is a system designed to manage village-owned enterprise (BUM Desa) data in Sleman Regency. By leveraging geospatial data, this application aids in mapping, analyzing, and visually displaying BUM Desa data. Its main features include comprehensive profiles of each BUM Desa, such as business descriptions, scores, addresses, and geographic coordinates. This facilitates data management and decision-making. The application also classifies BUM Desa into four growth levels: Pioneer, Beginner, Developing, and Advanced. The use of different color codes, as seen in Figure 3, makes identification and visualization easier. This helps stakeholders understand the potential and development of each enterprise.

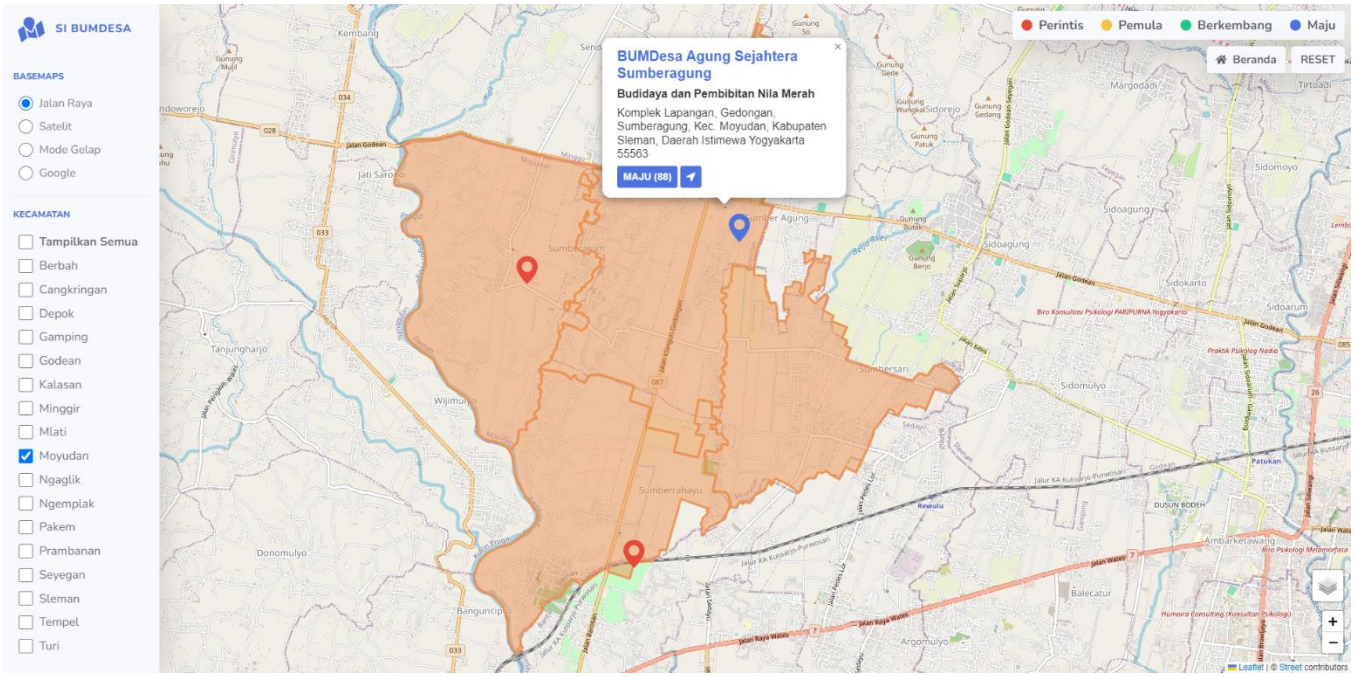

Figure 3. Maps SI BUMDesa

3.1 Implementation of Scrum

The implementation of the Scrum method in the development of the Geographic Information System for BUM Desa is a crucial step to ensure the project runs smoothly and yields excellent results. Scrum provides a structured framework using sprints to organize work, expedite decision-making, and enhance team collaboration [14]. By adopting Scrum, developers can be more flexible in adjusting project plans according to possible changes [22], [25]. This aids in

creating solutions that are responsive to the rapidly changing needs of users and the environment.

3.1.1 *Identifying the Product Backlog:* The Product Backlog becomes a key stage in implementing the Scrum methodology. The BUM Desa Product Backlog is a list of all the features and tasks needed to enhance the management and services of BUM Desa [26]. This process involves collaboration between BUM Desa managers, software development team members, and other stakeholders such as local governments and the local community. Desired features to improve the efficiency, transparency, and services of BUM Desa are identified and elaborated into items in the Product Backlog as shown in Table 7.

Table 7. Product Backlog SI BUMDesa

No	Feature Description	Priority
1	System analysis, database design, and multi-user access login system.	High
2	Admin management feature enables the management of users, districts, categories, and BUM Desa.	High
3	Map feature to display BUM Desa location points, and groups based on classification and district.	Medium
4	General user feature for accessing home page, map, and BUM Desa classification.	Low

Table 6 shows two high-priority features: system analysis, database design, and multi-user access login, along with admin management for users, districts, categories, and BUM Desa. These foundational features require special attention. The map feature for displaying BUM Desa locations and grouping by classification and district is the medium priority. The general user features for accessing the home page, map, and BUM Desa classification have the lowest priority.

3.1.2 *Sprint Planning:* After determining the main features in the product backlog, the next step is sprint planning to estimate the time required for each item. Table 8 outlines the sprint planning for these features. The system analysis, database design, and multiuser access login system require 16 hours of work as they form the system's foundation, including secure authentication. Managing admin features, including users, districts, categories, and BUM Desa, requires 66 hours due to the complexity and access rights differences between super admin and admin. The map feature, which displays BUM Desa locations and groups them by classification and district, requires 72 hours due to the need for accurate geographic data mapping and interactive feature development. The general user features for accessing the home page, map, and BUM Desa classification require 24 hours, covering basic display and navigation for information access.

Table 8. Sprint Planning SI BUMDesa

No	Feature Description	Estimated Time (Hr)
1	System analysis, database design, and multi-user access login system.	12
2	Admin management feature enables the management of users, districts, categories, and BUM Desa.	66
3	Map feature to display BUM Desa location points, as well as groups based on classification and district.	72
4	General user feature for accessing home page, map, and BUM Desa classification.	24

3.1.3 *Sprint Backlog:* The Sprint Backlog is established based on the previously created Product Backlog. It serves as a list of tasks that the development team must complete within one sprint to achieve the sprint's goals [27], [28]. This list is derived from the ranked and time-estimated Product Backlog. The Sprint Backlog contains more specific and concrete details of work compared to the Product Backlog.

3.1.3.1 *Sprint 1:* At this stage, several main tasks will be completed with a total estimated working time of 12 hours as shown in Table 9. The first task is to create a database model, which requires 2 hours. Next, creating a use case diagram will take 2 hours. Following that, the development of the system database will take 2 hours. Developing the login interface is scheduled for 4 hours, and finally, creating the login feature for superadmins and admins will take 2 hours. Through the completion of these tasks, the initial foundation of the system will be established, ensuring the existence of a solid database structure as well as a secure and functional login system.

Table 9. Sprint 1: Analysis of the system, database design, and implementation of a multiuser access login system.

Feature Description	Task	Estimated Time (Hr)
Analysis of the system, database design, and implementation of a multiuser access login system.	Creating Database Model	2
	Creating a Use Case Diagram	2
	Developing System Database	2
	Designing Login Interface	4
	Implementing Login Feature for Super Admin and Admin	2

3.1.3.2 *Sprint 2:* The main focus of Sprint 2 is the development of the admin management feature, which includes managing users, districts, categories, and BUM Desa as seen in Table 10. Firstly, an intuitive and informative dashboard interface will be created to facilitate data management. Next, access controls will be

implemented so that superadmins have full access to manage all types of data, while admins can only access and manage BUM Desa data. The features for managing user data, districts, categories, and BUM Desa will be developed separately, with time estimates adjusted according to the complexity and needs of each feature. Additional features, such as the ability to export and import data in Excel file format, and the ability to download data in PDF format, will also be added. Lastly, a feature for editing profile data will be added to allow users to manage their profile information flexibly.

Table 10. Sprint 2: Management of the admin feature, which can manage users, districts, categories, and BUM Desa.

Feature Description	Task	Estimated Time (Hr)
Management of the admin feature, which can manage users, districts, categories, and BUM Desa.	Creating a dashboard interface for data management.	10
	Setting up super admin access to manage user, district, category, and BUM Desa data, while admins can only access BUM Desa data.	4
	User data management feature	6
	District data management feature	8
	Category data management feature	4
	BUM Desa data management feature	16
	Export and Import Data feature to Excel file	8
	Download feature to PDF file	4
	Profile data editing feature	6

3.1.3.3 *Sprint 3:* In this sprint, the development focuses on implementing map features that allow users to display the locations of BUM Desa and group them by classification and district, as shown in Table 11. Initially, the implementation will utilize Leaflet Javascript to display an interactive map. Subsequently, the location points of each BUM Desa will be displayed on the map with relevant information details through a popup feature. A base map feature will be provided to allow users to choose a map model according to their preferences. Then, features will be added to display BUM Desa based on classification and districts in the Sleman Regency. Users will also be given the option to view routes to BUM Desa locations using Google Maps through a routing feature.

Table 11. Sprint 3: The features on the map include displaying the locations of BUM Desa and grouping them based on classification and districts.

Feature Description	Task	Estimated Time (Hr)
The features on the map include displaying the locations of BUM Desa as well as grouping them based on classification and districts.	Displaying the map using Leaflet JavaScript.	8
	Showing the location points of each BUM Desa on the map.	8
	The base map feature allows users to choose the map model according to their preferences.	6
	Feature to display BUM Desa based on classifications: Pioneer, Beginner, Developing, or Advanced.	16
	Feature to display BUM Desa based on districts in Sleman Regency.	16
	Popup feature displaying information such as BUM Desa Name, business description, and address.	6
	Route feature allowing users to view routes to BUM Desa locations using Google Maps.	8
	Reset the feature to clear all selected options.	4

3.1.3.4 *Sprint 4:* In Sprint 4, the main focus is on developing features that allow general users to access the home page of the BUM Desa application, as shown in Table 12. These features include several important aspects, such as general explanations about BUM Desa, as well as detailed information about each classification of BUM Desa. Additionally, users can view comparison charts of the number of BUM Desa in each district, providing a clear overview of the distribution of BUM Desa in the Sleman Regency area. Furthermore, the feature will enable users to display BUM Desa data based on their classification, making it easier for users to find specific information according to their needs.

Table 12. Sprint 4: The features used for general users to access the home page, map, and classification of BUM Desa.

Feature Description	Task	Estimated Time (Hr)
The features for general users to access the home page, map, and classification of BUM Desa.	Displaying an explanation of BUM Desa.	4
	Displaying explanations for each classification of BUM Desa.	4
	Showing a graph, which compares the number of BUM Desa in each district.	8
	Displaying BUM Desa data based on their classification.	8

3.1.4 *Sprint Review:* This phase involves evaluating the work done in each sprint, including reviewing data security and the progress of implemented features to ensure alignment between the user interface and its functions. Data security levels in this application not only review accessibility based on roles (access management) but also include measures like encrypting data in the SQL Server database, configuring the web server with an SSL certificate for HTTPS connections, using VPN protocols for secure network connections, and ensuring data backup with automated scheduling to the cloud. Additionally, cybersecurity involves configuring network and application firewalls to block malicious traffic and monitoring IDS logs to detect and respond to potential threats. Feature evaluation is

conducted through black box testing of admin and general user features, as illustrated in Figure 4's architecture.

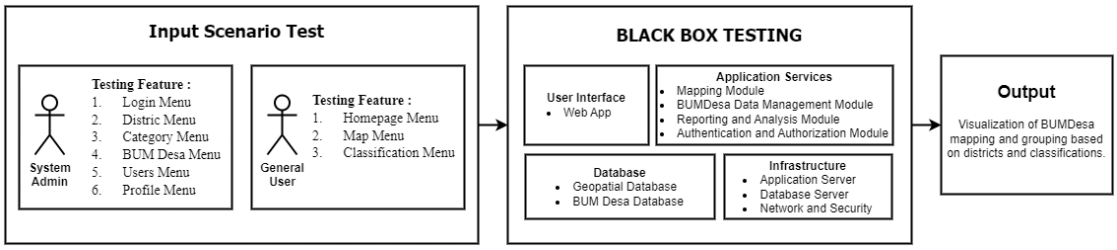

Figure 4. Blackbox testing architecture of SI BUMDesa

Black Box Testing is conducted to test the application's functionality without inspecting its internal code, focusing on the input and output of the application [29]. This testing involves various usage scenarios to ensure that all features work according to specifications and that there are no disruptive bugs [30]. Testing was carried out by creating scenarios based on the cases within the application, which were then provided to the TAPM admin to execute the application according to the created scenarios. The test results were then analyzed; if any cases produced invalid or failed results, the application would be corrected. If all scenarios were successfully executed, the application was considered successful. Table 13 provides an example of the black box testing scenario results conducted on the TAPM admin side.

Table 13. Admin black box test results

No	Testing	Scenario	Expected Outcome	Test Result
Testing Feature: Login Menu				
1	Correct email and password	Redirect to the admin dashboard	The admin dashboard page is displayed	Valid
2	Incorrect email or password	Stay on the login page	Display error message indicating incorrect credentials	Valid
3	Super admin email and password	Redirect to admin dashboard with access to CRUD operations	Admin dashboard page is displayed with CRUD access	Valid
4	Admin email and password	Redirect to admin dashboard with access to BUM Desa and profile	Admin dashboard page is displayed with BUM Desa CRUD access and profile edit	Valid
Testing Feature: District Menu				
1	Button "District"	Clicking on "District" button	Opens district page and displays all district data	Valid
2	Button "Add"	Clicking on "Add" button	Redirects to add district page to input district data	Valid
3	Button "Save"	Clicking on "Save" button	Redirects to district page with the new district listed	Valid
4	Button "Edit"	Clicking on "Edit" button	Redirects to edit district page with district data displayed	Valid
5	Button "Update"	Clicking on "Update" button	Redirects to district page with updated district data	Valid
6	Button "Delete"	Clicking on "Delete" button	Deletes data from the district page and remains on the district page	Valid
Testing Feature: Category Menu				
1	Button "Category"	Clicking on "Category" button	Opens category page and displays all category data	Valid
2	Button "Add"	Clicking on "Add" button	Redirects to add category page to input category data	Valid
3	Button "Save"	Clicking on "Save" button	Redirects to the category page with the new category listed	Valid
4	Button "Edit"	Clicking on "Edit" button	Redirects to edit category page with category data displayed	Valid
5	Button "Update"	Clicking on "Update" button	Redirects to a category page with updated category data	Valid
6	Button "Delete"	Clicking on "Delete" button	Deletes data from the category page and remains on the category page	Valid
Testing Feature: BUM Desa Menu				
1	Button"BUM Desa"	Clicking on "BUM Desa" button	Opens BUM Desa page and displays all BUM Desa data	Valid
2	Button "Add"	Clicking on "Add" button	Redirects to add BUM Desa page to input all BUM Desa data	Valid
3	Button "Save"	Clicking on "Save" button	Redirects to the BUM Desa page with the new BUM Desa listed	Valid
4	Button "Edit"	Clicking on "Edit" button	Redirects to edit BUM Desa page with BUM Desa data displayed	Valid
5	Button "Update"	Clicking on "Update" button	Redirects to BUM Desa page with updated BUM Desa data	Valid
6	Button "Delete"	Clicking on "Delete" button	Deletes data from the BUM Desa page and remains on the BUM Desa page	Valid
Testing Feature: Users Menu				
1	Button "Users"	Clicking on "Users" button	Opens Users page and displays all user data	Valid
2	Button "Add"	Clicking on "Add" button	Redirects to add user page to input all user data	Valid
3	Button "Save"	Clicking on "Save" button	Redirects to the Users page with the new user listed	Valid
4	Button "Edit"	Clicking on "Edit" button	Redirects to edit user page with user data displayed	Valid
5	Button "Update"	Clicking on "Update" button	Redirects to the Users page with updated user data	Valid
6	Button "Delete"	Clicking on "Delete" button	Deletes data from the Users page and remains on the Users page	Valid
Testing Feature: Profile Menu				

1	Button "Profile"	Clicking on "Profile" button	Opens profile page and displays all profile data	Valid
2	Button "Edit Data"	Clicking on "Edit Data" button	Redirects to edit profile page to modify personal data	Valid
3	Button "Update"	Clicking on "Update" button	Redirects to profile page with updated personal data	Valid

Table 14 presents the test results focusing on features accessible to general users, such as accessing the home page, map, and BUM Desa classification. The results indicate that these features also function well, providing users with the expected experience, and allowing them to easily and efficiently access the information they need.

Table 14. General user black box test results

No	Testing	Scenario	Expected Outcome	Test Result
Testing Feature: Homepage Menu				
1	Homepage	Opening the SI BUMDesa website in a browser	Displaying the homepage, website name, and explanation of BUM Desa	Valid
2	"Get Started" Button	Clicking on the "Get Started" button	Scrolling down the Homepage, displaying information on the BUM Desa classification	Valid
			Displaying a graph comparing the number of BUM Desa in each district based on classification/group	Valid
3	"View Data" Button for pioneer group	Clicking on the "View Data" button for the pioneer group	Displaying all BUM Desa data for the pioneer group	Valid
4	"View Data" Button for beginner group	Clicking on the "View Data" button for beginner group	Displaying all BUM Desa data for the beginner group	Valid
5	"View Data" Button for developing group	Clicking on the "View Data" button to develop group	Displaying all BUM Desa data for the developing group	Valid
6	"View Data" Button for advanced group	Clicking on the "View Data" button for advanced group	Displaying all BUM Desa data for the advanced group	Valid
7	Pioneer Classification Button	Clicking on the Pioneer Classification button	Displaying all BUM Desa data for the pioneer group	Valid
8	Beginner Classification Button	Clicking on the Beginner Classification button	Displaying all BUM Desa data for the beginner group	Valid
9	Developing Classification Button	Clicking on the Developing Classification button	Displaying all BUM Desa data for the developing group	Valid
10	Advanced Classification Button	Clicking on the Advanced Classification button	Displaying all BUM Desa data for the advanced group	Valid
11	Explore Button	Clicking on the Explore button	Redirecting to the map page and showing the distribution of BUM Desa in Sleman Regency	Valid
12	Map Button	Clicking on the Map button	Redirecting to the map page and showing the distribution of BUM Desa in Sleman Regency	Valid
Testing Feature: Map Menu				
1	Checkbox Show All	Check the "Show All" checkbox	The map will display all polygons of each district area with different colors	Valid
2	Specific District Checkbox	Check the checkbox of a specific district, e.g., "Berbah"	The map will display the selected district polygon with its respective color	Valid
3	Pioneer Button	Click the Pioneer button	The map will display the distribution points of pioneer BUM Desa based on the selected districts	Valid
4	Beginner Button	Click the Beginner button	The map will display the distribution points of beginner BUM Desa based on the selected districts	Valid
5	Developing Button	Click the Developing button	The map will display the distribution points of developing BUM Desa based on the selected districts	Valid
6	Advanced Button	Click the Advanced button	The map will display the distribution points of advanced BUM Desa based on the selected districts	Valid
7	BUM Desa Marker	Click on a BUM Desa marker or point	A popup appears displaying the BUM Desa name, business description, and address	Valid
8	Specific Group Button	Click on a group button, e.g., "PIONEER(20)" in red color	The map will navigate to the detail page and display information about the selected BUM Desa	Valid
9	Route Button	Click on the route button	The map will navigate to Google Maps and display the route to the selected BUM Desa from the user's location	Valid
10	Reset Button	Click the Reset button	The map will clear all selections made	Valid
11	Home Button	Click the Home button	The map will navigate back to the home page	Valid
Testing Feature: Classification Menu				
1	Pioneer BUM Desa Button	Press the Pioneer BUM Desa button	Display all pioneer BUM Desa data in a table	Valid
2	Beginner BUM Desa Button	Press the Beginner BUM Desa button	Display all beginner BUM Desa data in a table	Valid
3	Developing BUM Desa Button	Press the Developing BUM Desa button	Display all developing BUM Desa data in a table	Valid
4	Advanced BUM Desa Button	Press the Advanced BUM Desa button	Display all advanced BUM Desa data in a table	Valid
5	BUM Desa Name	Click on a specific BUM Desa name	Navigate to the detail page and display the information	Valid

3.1.5 *Sprint Retrospective:* The final stage in Scrum is Sprint Retrospective, where reflection on the development process takes place after all Sprints are completed. Evaluation of the successful progress achieved and identification of areas for improvement in the next Sprint occur. Developers review their experiences during the development process, collaboration, or challenges faced. Through this reflection, actions can be found to enhance productivity, efficiency, and the quality of work in the future.

3.2 Development Results

The development from these Sprints includes essential features for the BUM Desa information system: data management, location mapping, and classification. Each feature went through needs analysis, design planning, code implementation, and testing. The result is a more structured system aligned with user needs, expected to positively impact BUM Desa progress in Sleman Regency. Figure 5 shows the main page of the BUM Desa Information System, including a brief explanation of BUM Desa, classification, and a graph comparing the number of BUM Desa in each district.

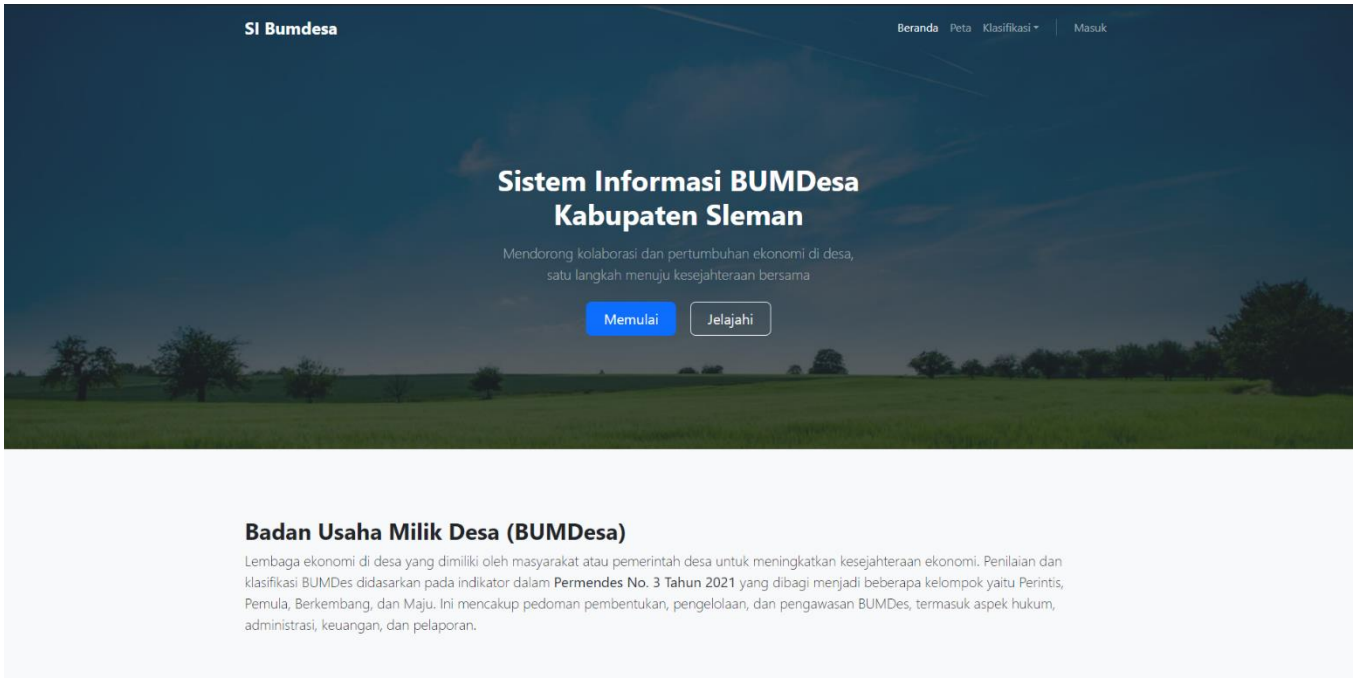

Figure 5. SI BUMDesa Home Page

Figure 6 displays the map page view within the BUM Desa Information System (IS). This page showcases an interactive map allowing users to view the distribution of BUM Desa locations and display BUM Desa based on classification and region in Sleman Regency.

Figure 7 is an example visualization of all the locations of BUM Desa situated in Sleman Regency, particularly in Moyudan District. It displays all BUM Desa according to their classifications in that area.

Figure 8 displays the classification page within the SI BUMDesa, particularly focusing on the "Developing" category. This page may contain information about BUM Desa classified as "Developing" among all available classifications, such as Pioneer, Startup, Developing, and Advanced.

Figure 9 showcases the main dashboard of SI BUMDesa, summarizing vital data and statistics about BUM Desa in Sleman Regency. It provides quick access to key features, allowing administrators to monitor progress, manage data, access reports, and address critical activities efficiently. This centralized presentation ensures effective monitoring and management of BUM Desa.

This application contributes by facilitating the grouping of Village-Owned Enterprises (BUM Desa) according to existing classifications, simplifying government data management. Additionally, users can easily locate or be directed to BUM Desa locations through the app's routing feature, thereby enhancing information accessibility for the public.

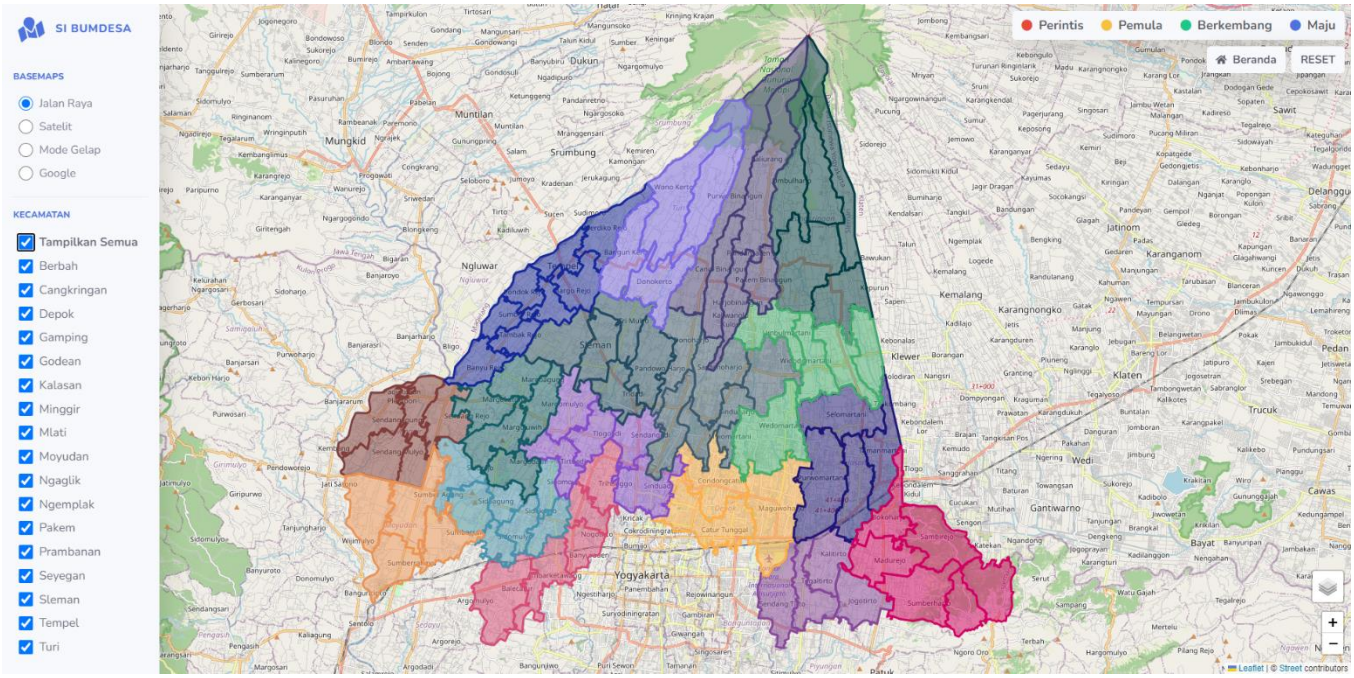

Figure 6. SI BUMDesa Map Page

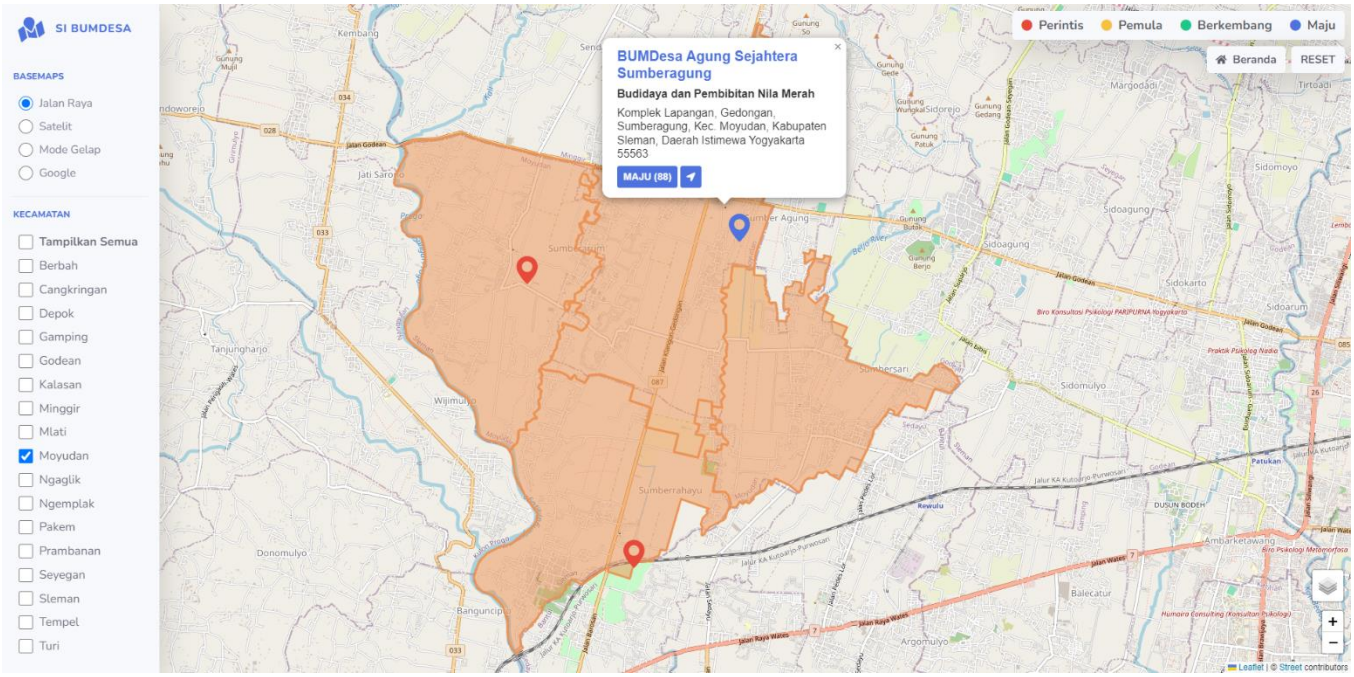

Figure 7. BUM Desa in Moyudan Sub-district

3.3 End User Computing Satisfaction

System testing is conducted to ensure that the developed Geographic Information System (GIS) application for BUM Desa functions properly and meets user needs. This testing evaluates the usability of the application from the user's perspective [31]. Through the End-User Computing Satisfaction (EUCS) survey, users provide feedback on the content, format, accuracy, timeliness, and ease of use of the application, which is then analyzed to identify areas needing improvement [32]. This testing employs positively framed statements to measure user satisfaction and elicits responses on a Likert scale ranging from 1 to 5, as shown in Table 15.

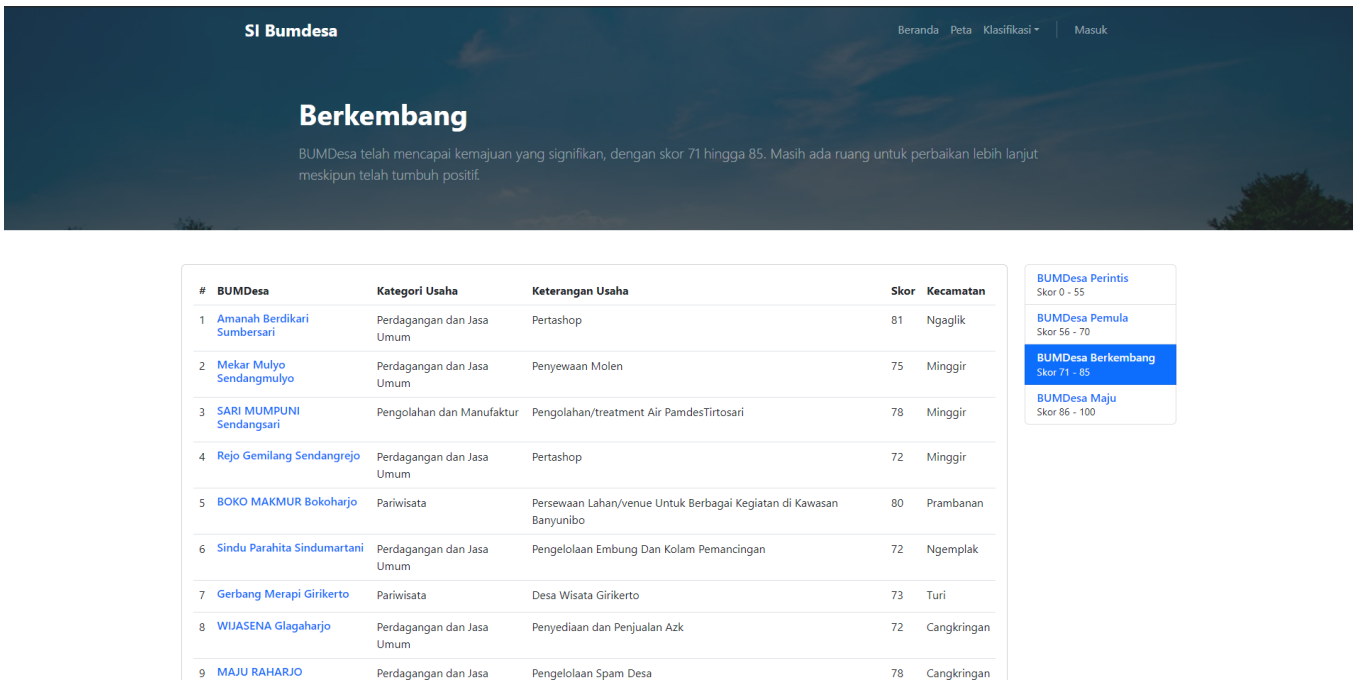

Figure 8. SI BUMDesa Classification Page

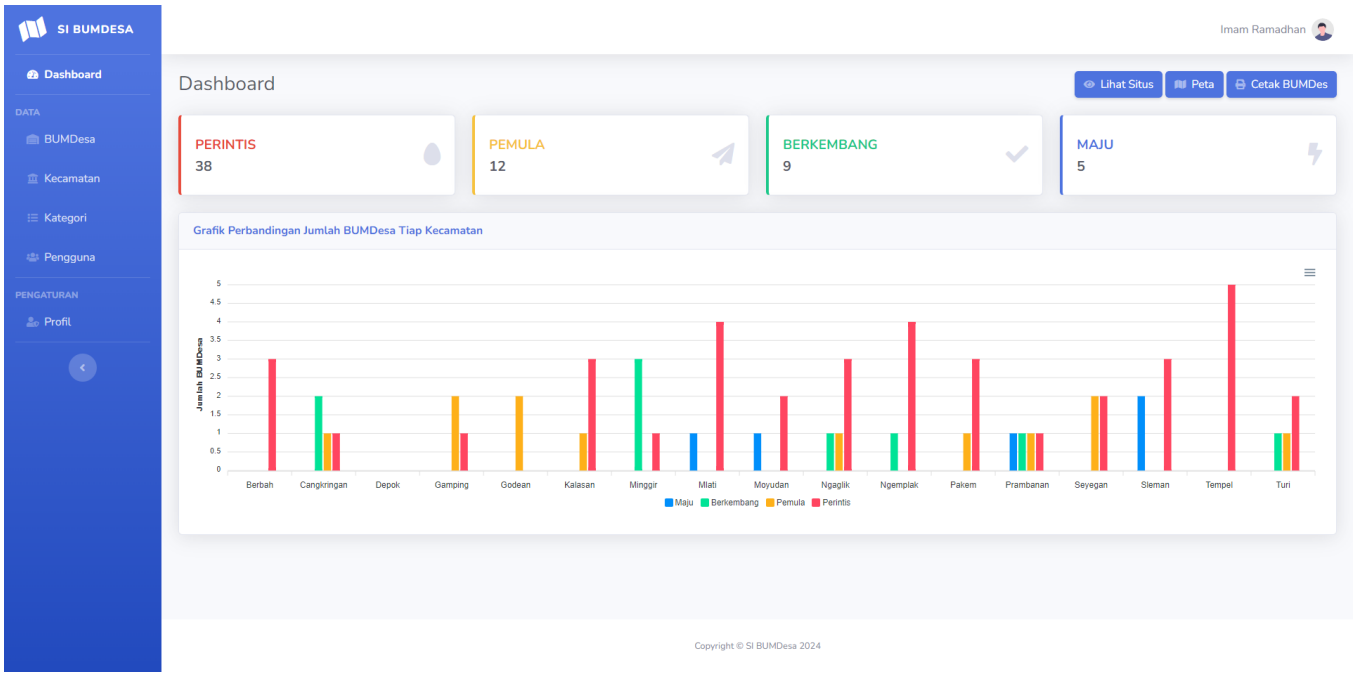

Figure 9. SI BUMDesa Dashboard Page

Table 15. EUCS Testing Value Scale

Scale Value	Description
1	Strongly Disagree
2	Disagree
3	Uncertain
4	Agree
5	Strongly Agree

The EUCS testing was conducted on 10 respondents, consisting of general users. Table 16 evaluates the content of the GIS application, focusing on its completeness and relevance to users' needs. Survey results show strong satisfaction: 80% strongly agreed and 20% agreed that the content met their expectations. There were no responses indicating disagreement or neutrality, highlighting the application's effectiveness in delivering relevant and comprehensive information.

Table 16. Content of EUCS

Measurement Scale	Value	Frequency	Total Value	%
Strongly Disagree	1	0	0	0
Disagree	2	0	0	0
Neutral	3	0	0	0
Agree	4	7	28	20
Strongly Agree	5	23	115	80
Total		30	143	100

In Table 17, users rated both the accuracy of the GIS data and the reliability of the system. The survey results revealed a high level of satisfaction, with 74% of respondents strongly agreeing and 26% agreeing that the information was accurate and reliable. This feedback underscores the crucial role of accurate data representation in GIS applications.

Table 17. Accuracy of EUCS

Measurement Scale	Value	Frequency	Total Value	%
Strongly Disagree	1	0	0	0
Disagree	2	0	0	0
Neutral	3	0	0	0
Agree	4	9	36	26
Strongly Agree	5	21	105	74
Total		30	141	100

In Table 18, the evaluation focused on how well the information was organized and presented to users. Results showed high satisfaction: 69% strongly agreed and 29% agreed that the format was user-friendly and well-organized. Only 2% of respondents were neutral. This feedback highlights the GIS application's effectiveness in presenting information clearly and in an organized manner.

Table 18. Format of EUCS

Measurement Scale	Value	Frequency	Total Value	%
Strongly Disagree	1	0	0	0
Disagree	2	0	0	0
Neutral	3	1	3	2
Agree	4	10	40	29
Strongly Agree	5	19	95	69
Total		30	138	100

Table 19 evaluates the timeliness of information delivery which is crucial for decision-making. Results indicate high satisfaction: 69% strongly agreed and 26% agreed that information was delivered promptly. A small percentage (4%) were neutral. This highlights the application's effectiveness in timely information delivery, supporting efficient decision-making processes.

Table 19. Timeliness of EUCS

Measurement Scale	Value	Frequency	Total Value	%
Strongly Disagree	1	0	0	0
Disagree	2	0	0	0
Neutral	3	2	6	4
Agree	4	9	36	26
Strongly Agree	5	19	95	69
Total		30	137	100

Finally, in Table 20, Ease of Use assesses how user-friendly and intuitive the application is. The survey results were highly positive, with 76% of respondents strongly agreeing and 20% agreeing that the application was easy to use. A small percentage (4%) of respondents remained neutral, and there were no negative responses.

Table 20. Content of EUCS

Measurement Scale	Value	Frequency	Total Value	%
Strongly Disagree	1	0	0	0
Disagree	2	0	0	0
Neutral	3	2	6	4
Agree	4	7	28	20
Strongly Agree	5	21	105	76
Total		30	139	100

The EUCS survey results show that users are highly satisfied with the SI BUMDesa GIS application across all aspects. Positive feedback underscores its effectiveness in delivering accurate, timely, well-organized, and user-friendly information. These insights are vital for future improvements to ensure the application consistently meets user expectations. By addressing areas for enhancement, we can improve the overall user experience and utility of the application in managing BUM Desa data and supporting decision-making processes effectively.

4 CONCLUSION

The web-based GIS application for mapping Village-Owned Enterprises (BUM Desa) in Sleman Regency provides easy access for data management and information retrieval based on the location and classification of BUM Desa. Trial runs have shown the application to function well, achieving a 100% success rate using black box testing methods. The EUCS survey also indicates high user satisfaction levels, confirming the application's effectiveness, user-friendliness, and alignment with expectations.

In addition to efficient mapping and classification of BUM Desa, the application allows each BUM Desa manager to submit separate progress reports. Moreover, it can be integrated with other systems, such as broader village information systems or regional development platforms within the Sleman Regency. Future development plans for the application include adding new features, addressing scalability issues, and conducting long-term impact studies for sustainable BUM Desa development. Thus, this research provides a robust foundation for further GIS application development to support the management and development of BUM Desa in Sleman Regency.

AUTHOR'S CONTRIBUTION

Imam Ramadhan is the lead author responsible for the research, paper writing, and technical management. Meanwhile, the second author, Ika Arfiani, supervised the research and guided how to analyze the data and writing methods.

COMPETING INTERESTS

By the publication ethics of this journal, Imam Ramadhan and Ika Arfiani, the authors of this article, confirm that there are no conflicts of interest (COI) or competing interests (CI) associated with this work.

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