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# Web-Based Village Land Information System Development for Optimizing Regional Land Administration

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**ABSTRACT**

Access to land information in Indonesia is restricted, especially at the village and sub-district levels, where detailed data is essential for efficient land administration. This research aims to create a web-based Village Land Information System to improve regional land administration through the provision of organized, accessible, and dependable land data. The study employed a Research and Development (R&D) methodology using a prototyping approach, gathering data through observation, surveys, and literature analysis. Data were examined using both descriptive and quantitative methods, with validation and reliability assessments conducted on questionnaires administered to 100 respondents. The assessment employed the End User Computing Satisfaction (EUCS) and Importance-Performance Analysis (IPA) methodologies. The system development encompassed multiple phases: requirements analysis, prototype design, implementation, functionality testing, and evaluation. The Unified Modeling Language (UML) was utilized for system modeling, and user interfaces were crafted with a focus on usability. Functionality tests verified that all features functioned well, and user assessments revealed significant satisfaction with the system's content, correctness, format, usability, and promptness. The application markedly enhanced land administration by providing comprehensive land information, facilitating access, elucidating service procedures, and systematizing data storage. The results illustrate the capability of web-based technologies to enhance regional land administration and facilitate village government in improving service delivery and land information management.



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## 1. INTRODUCTION

Multiple stakeholders, including village governments tasked with policy formulation and the provision of data-driven public services, necessitate land information as an essential component. Biraro et al. highlighted the critical necessity of land information [1], whereas Musinguzi et al. underscored the pivotal role of village governments in land administration, which is essential for national development [2].

The comparison of land information system development in developed nations and countries with analogous conditions, such as Indonesia, highlights differing methodologies, even though both aim to improve land administration efficiency [3], [4]. Countries such as Sweden, Norway, and Australia have implemented digital land information systems by integrating spatial data comprehensively and providing extensive public access, which has improved transparency and efficiency [5]. Developing countries, including the Philippines, Vietnam, and Thailand, have adopted web-based systems to address issues related to overlapping land ownership and data quality. However, they continue to encounter infrastructure limitations and restricted access in rural regions [6]. Despite advancements, data digitization in rural areas in Kenya and Sri Lanka still lags behind, similar to the situation in Indonesia [7].

In Indonesia, despite the provision of land data by institutions such as the Geospatial Information Agency (BIG), the Ministry of Villages, and the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATR/BPN), limitations remain a significant obstacle. BIG supplies land toponymy data but lacks detailed information on land plots, whereas the Ministry of Villages offers data regarding village administrative boundaries. ATR/BPN offers more comprehensive parcel-based land data; however, this data remains incomplete due to ongoing land registration processes [8]. Additionally, insufficient regulations concerning the disclosure of land information impede the effective operation of public services [9].

Challenges at the village level have become increasingly intricate. In numerous villages, land information systems remain manual and lack integration. Inadequate access to technology, constrained financial resources, and insufficient human resource capabilities impede effective digital data management. Since 1980, Janti Village has not updated its physical land records. This condition results in data becoming outdated and inaccurate, often causing discrepancies between land ownership information and actual conditions. This inaccuracy affects the emergence of land ownership conflicts, complicates data validation in transactions, and hinders the village development planning process. Failure to manage land administration in a structured and integrated manner will hinder the enhancement of public services and prolong the resolution of land disputes at the village level [10]. The creation of a web-based land information system accessible to multiple stakeholders is a pertinent measure to tackle this issue. In alignment with the provisions of Law Number 6 of 2014 regarding villages, this system is anticipated to deliver accurate, accessible, and transparent data.

Prior studies have not explicitly addressed the design of land information systems at the village level that facilitate systematic land administration. The emphasis predominantly lies on the city or district scale, lacking the integration of spatial and textual data at the village level. This research will be the first to design a field-based system with dynamic coverage of a single village comprehensively. Certain studies employ analogous methodologies yet vary in context and scale. Research by Miao et al., emphasizes a national or regional scale employing a top-down approach, whereas this study adopts a local perspective concentrating on villages [11], [12]. This reveals a gap in the substance and focus of research regarding village land administration.

This study utilizes the System Development Life Cycle (SDLC) approach as a development model, which is rarely used in research related to village-level land information systems [13]. This study assesses system performance and user satisfaction to evaluate the effectiveness of the system in promoting organized village land administration. This study emphasizes the versatility of programming languages like PHP, HTML, JavaScript, and CSS, facilitating the creation of adaptive and responsive systems. The spatial database incorporates textual data in GeoJSON format, facilitating real-time data updates. This method differs from earlier research that utilized static databases or failed to include spatial integration [14], [15]. This research introduces features including spatial data visualization on land plots, thematic dashboards, map galleries, and data updating capabilities through the Geographic Information System (GIS) application. These features enhance the efficiency and organization of land administration. This study represents a significant advancement in the discipline, as prior research did not incorporate self-update features through GIS [16].

This study aims to develop and implement a land information system in Janti Village to address land administration challenges and improve community services by providing accurate, accessible, and stakeholder-oriented data.

## 2. RESEARCH METHOD

This study employs the research and development (R&D) methodology as delineated by [17], [18] to systematically advance a village land information system (village land application) in

Janti Village (Figure 1). The reason the author chose Janti Village is because the village government has not been able to provide land services to the community effectively and efficiently, such as requests for documents regarding changes in the status of control, ownership, use, and utilization of land. Apart from that, land services in Janti Village have an equivalent position to population registration services (public services) but are still carried out conventionally, in contrast to population registration, which is integrated in online applications.

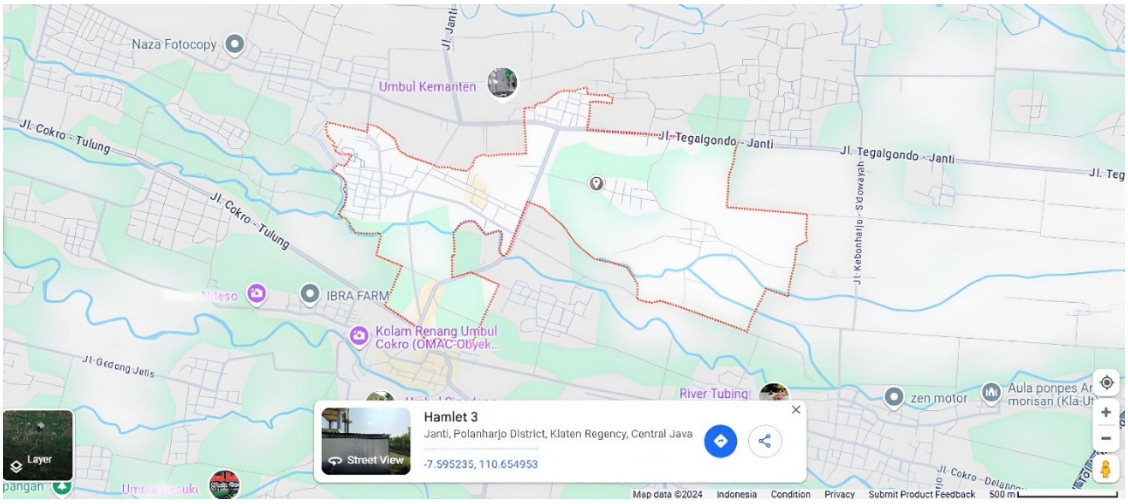

Figure 1. Research Location

This study utilizes secondary data sourced from journals, books, and articles, along with primary data gathered by the author through observations and field surveys conducted over a four-month period (10 December 2023–12 April 2024). This study engaged a community of 86 users and 14 officials from Janti Village, examining all 1,679 plots of land within the village as research subjects. Field observations provided the author with an initial understanding of the village land service mechanism, which utilized analog systems, maps, *letter C*, and land data in book format. The author then carried out a field survey, using the survey application 123, to complete and update land data, which included information on control, ownership, use, and utilization.

After the land application was realized at the Janti Village office, the author assigned 100 respondents at the beginning to test the application functionality and evaluate user satisfaction using the Lameshow formula and incidental sampling method [19]. The respondents assessed the level of application performance and application importance using a closed questionnaire with a five-level Likert scale. The average level of satisfaction was calculated using the formula recommended by [20] (Table 1).

Table 1. Range of average values for satisfaction and importance.

| Performance | Importance | Mean | Value Range |
|---|---|---|---|
| Strongly Disagree | Very Unimportant | Very Dissatisfying | 1 – 1.79 |
| Don't agree | Not important | Not satisfactory | 1.8 – 2.59 |
| Doubtful | Doubtful | Doubtful | 2.6 – 3.39 |
| Agree | Important | Satisfying | 3.4 – 4.19 |
| Strongly agree | Very important | Very satisfactory | 4.2 - 5 |

Following the collection of primary and secondary data, the author conducted an analysis utilizing the Black Box Testing (BBT) and End-User Computing Satisfaction (EUCS) methodologies. The EUCS measures significant aspects of village land applications, whereas the BBT evaluates its performance. This method aligns with the research of Wijaya et al., which indicates that the five EUCS variables—content, accuracy, format, ease of use, and timeliness—adequately assess critical dimensions of applications, and Watkins, who asserts that BBT emphasizes software functional specifications [21], [22]. Following the calculation of the average Importance-Performance value, the results are visualized through Importance-Performance Analysis (IPA).

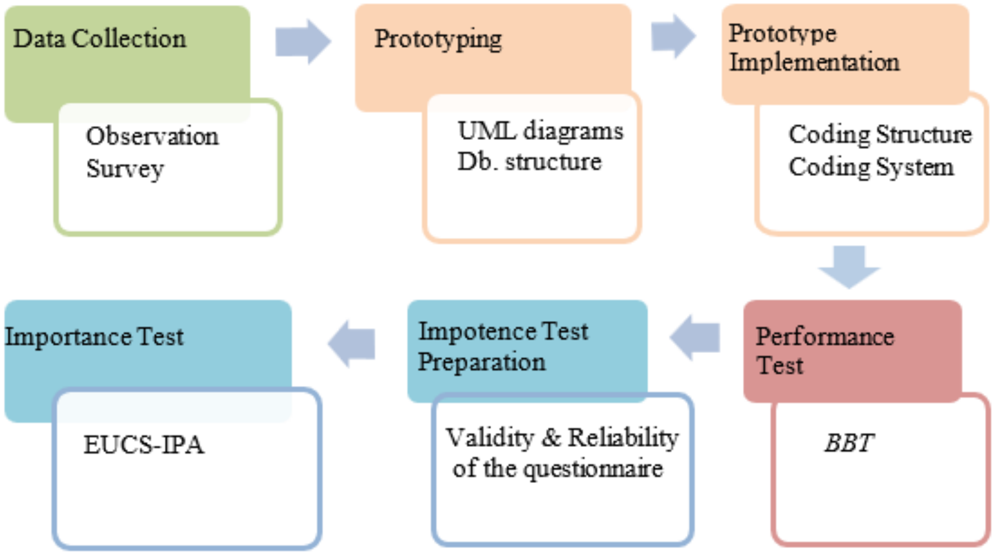


Figure 2. Research Steps

## 3. RESULTS AND DISCUSSION

The Janti Village land application development yielded findings categorized into three primary stages: needs analysis, design of the prototype, and implementation [23]. During the needs analysis phase, we delineate the distinctions between user (functional) and system (non-functional) requirements, encompassing system requirements related to operation, as well as software, hardware, and framework specifications. During the prototype design and implementation stages, we presented the coding structure of the Janti Village land application website, with particular emphasis on the home page and operator functionalities. We modeled it using UML at three levels: conceptually with use case and activity diagrams, logically with class diagrams, and physically with database structure. The implementation stage presents the coding structure of the Janti Village land application website, specifically on the home page and operator section. The subsequent subsection presents the details of these results.

### 3.1. Needs Analysis

The author learned about land services in Janti Village through interviews and observations. These include requests for copies of legal documents showing ownership and control of land, like "village C letters," "village M books," and heir and death certificates that are combined. These services are provided along with population services (Figure 2). These land services are applicable to all clients, including individuals, governmental institutions, and private legal entities. Customers are required to submit a request letter for land services to the village government, which subsequently prepares the service results in the form of printed copies of the land documents as specified. Over the past decade, the village government has infrequently conducted other land services, including the reporting of changes in land use and utilization data. The primary reason is that most customers lack the awareness to update this information and rely on third parties or legal representatives, such as the Acting Land Deed Maker (PPAT). In light of the identified weaknesses in land services, the author incorporates features into land applications to enhance and optimize these services via web-based platforms. This aligns with the findings of [24], who assert that the development of a designed application system should consider initial processes and information that reveal weaknesses. Table 2 presents a comprehensive overview of the features of the village land application.

Table 2. Needs Analysis

| No | User Requirement | Function Description, Users, the general public, and village government (1-4); Operator, land plot database manager (5-7) |
|---|---|---|
| 1 | Guide menu | Feature that directs users to the application guide page |
| 2 | Data change submission menu | Feature that directs users to the data change submission guide page |
| 3 | Dashboard menu | Feature that directs users to choose a theme/get appropriate information |
| 4 | Interactive map menu | Feature that directs the user to operable sections of spatial information: |
| 5 | Login menu | Features for entering the system (database server access and admin page) |
| 6 | Field data management menu | Features for managing field data (entry, edit, delete, and add) |
| 7 | Selection menu | Function selection menu for selecting themes and editing field information |

To implement various features in the village land application, researchers identified operational (non-functional) requirements, including hardware, software, and framework specifications. Hardware requirements consist of a laptop with 4GB to 16GB of RAM and a smartphone operating on iOS or Android with 512MB to 6GB of RAM. Software requirements specify one laptop unit equipped with at least the Windows 7 operating system and QGIS Desktop version 3.28 Firenze, utilized as a spatial database processing tool for real-time land plot updates. Visual Studio Code is utilized for script creation in application design, while phpMyAdmin serves as the database storage medium for both textual and spatial data. *StarUML* is employed for designing UML diagrams. Various web browsers, including Mozilla Firefox, Safari, Google Chrome, and Microsoft Edge, are used for accessing land applications. Microsoft Excel functions as a data processing tool for analyzing questionnaire results distributed to users, and IBM SPSS Statistics is applied for quantitative analysis of the questionnaire data for further processing. This land information system application utilizes framework specifications, specifically the Startbootstrap-SB-Admin-2 template for the operator and dashboard framework, and the *Travelista*-Master template for the user's main page framework. In conclusion, the development of this application utilizes several programming languages: Hypertext Preprocessor (PHP) for compiling primary function operations; Hypertext Markup Language (HTML) for structuring the user’s main page; JavaScript for implementing additional functional operations and static displays; and Cascading Style Sheets (CSS) for designing the interface and layout of system operations and features.

### 3.2. Design of the Prototype

Based on modeling with *StarUML* software, the author succeeded in defining a land information system model with UML diagrams, such as use case diagrams, activity diagrams, class diagrams, and land application database structure tables. The use case diagram in this research describes the application functionality in two parts, namely the user use case and the operator use case, so that it is easier to understand (Figure 3 and 4). In the activity diagram, the author groups them into three categories based on the main activities of the user account, namely: user dashboard access, user interactive map access, and operator data management (Figure 5). In the class diagram, the author groups them into five main classes and four derived classes (Figure 6). The five main classes consist of the operator class, user class, update request class, field data class, and administrative data class. Meanwhile, the four derived classes consist of the *dataobject* class; data class P4T (Control, Ownership, Use, and Utilization of Land); *taxdataclass*; and UMKM data class (Types of Micro, Small, and Medium Enterprises).

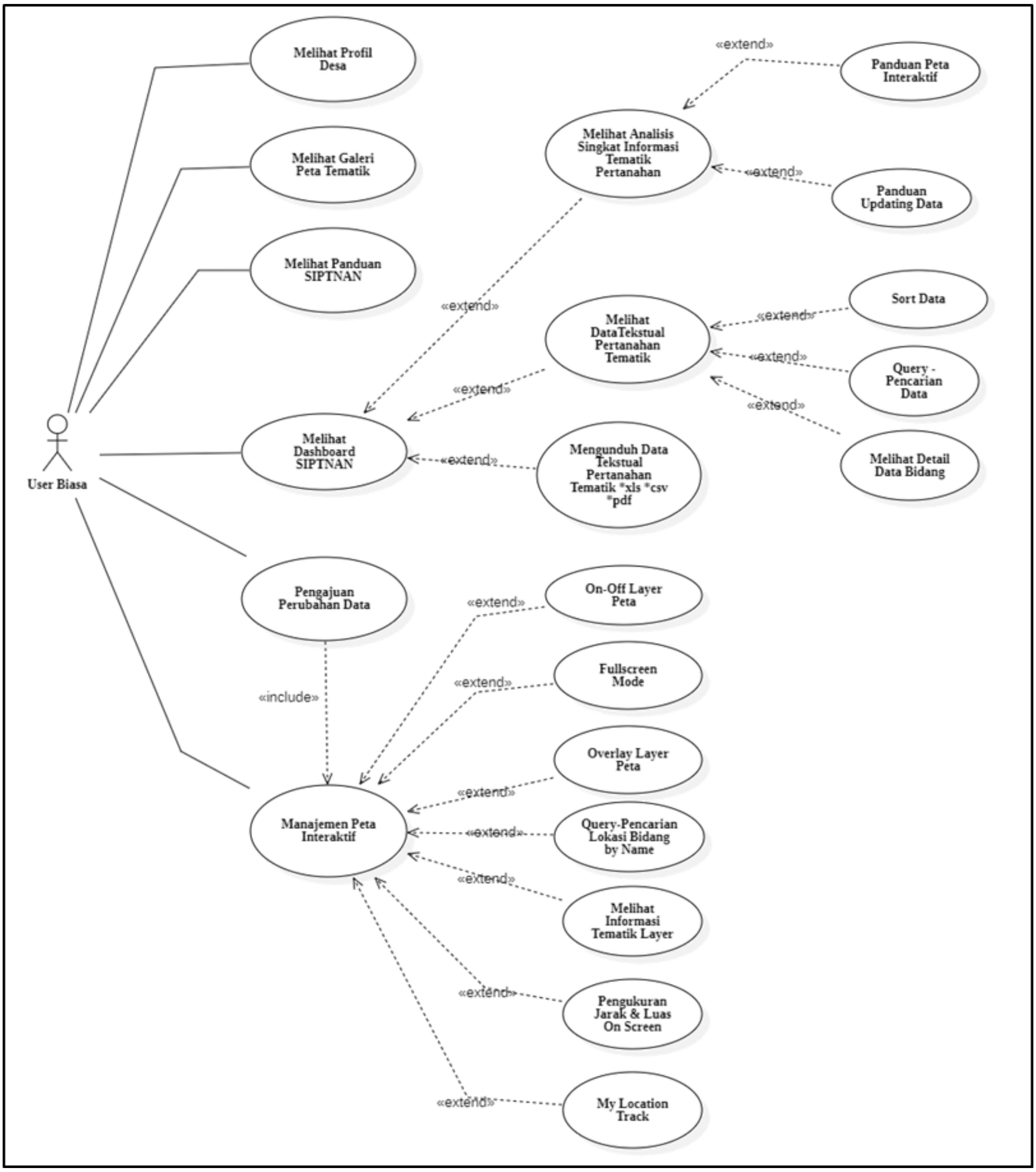


Figure 3. Use Case Diagram View on User Account

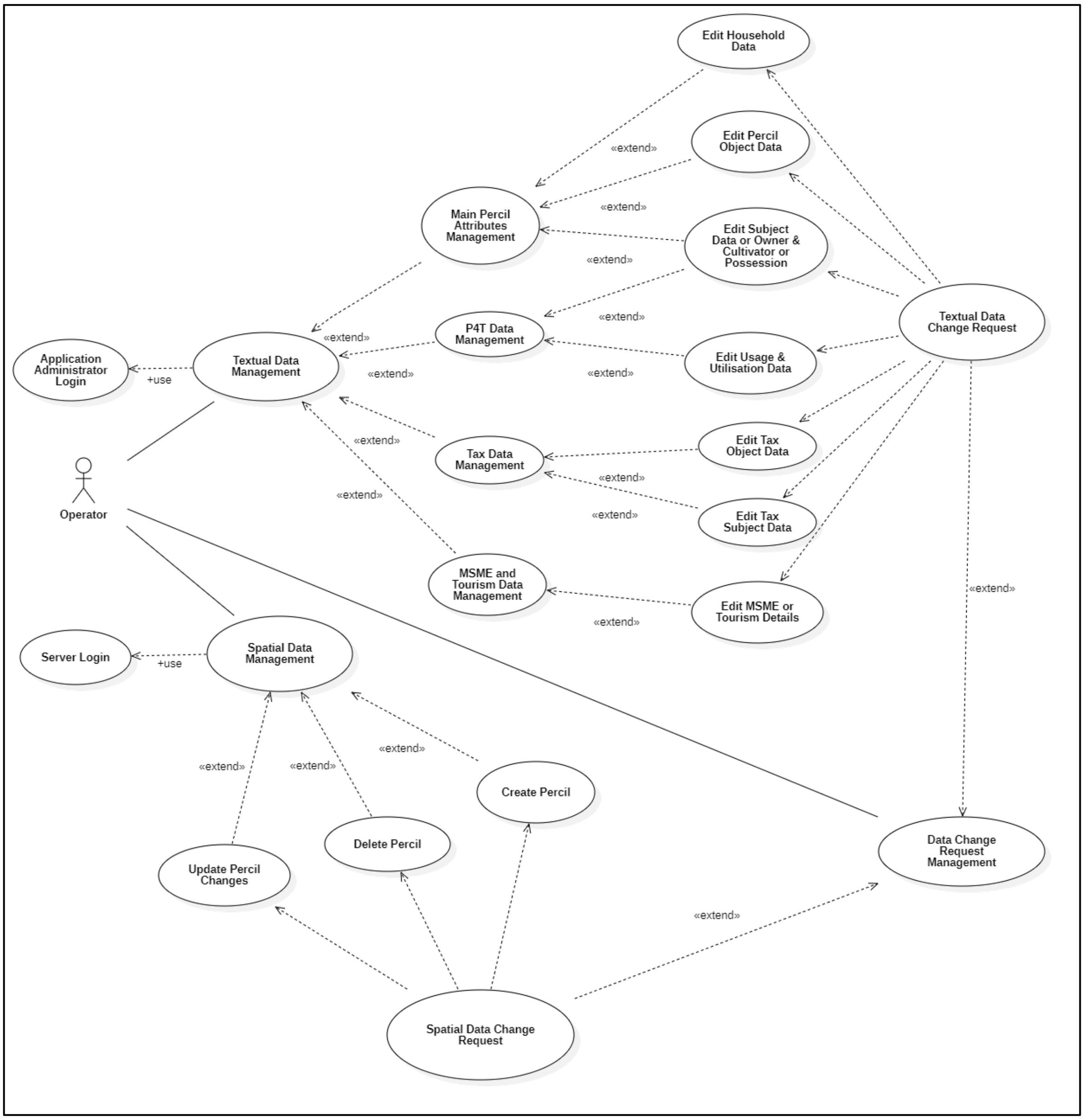


Figure 4. Use Case Diagram View on Operator Account

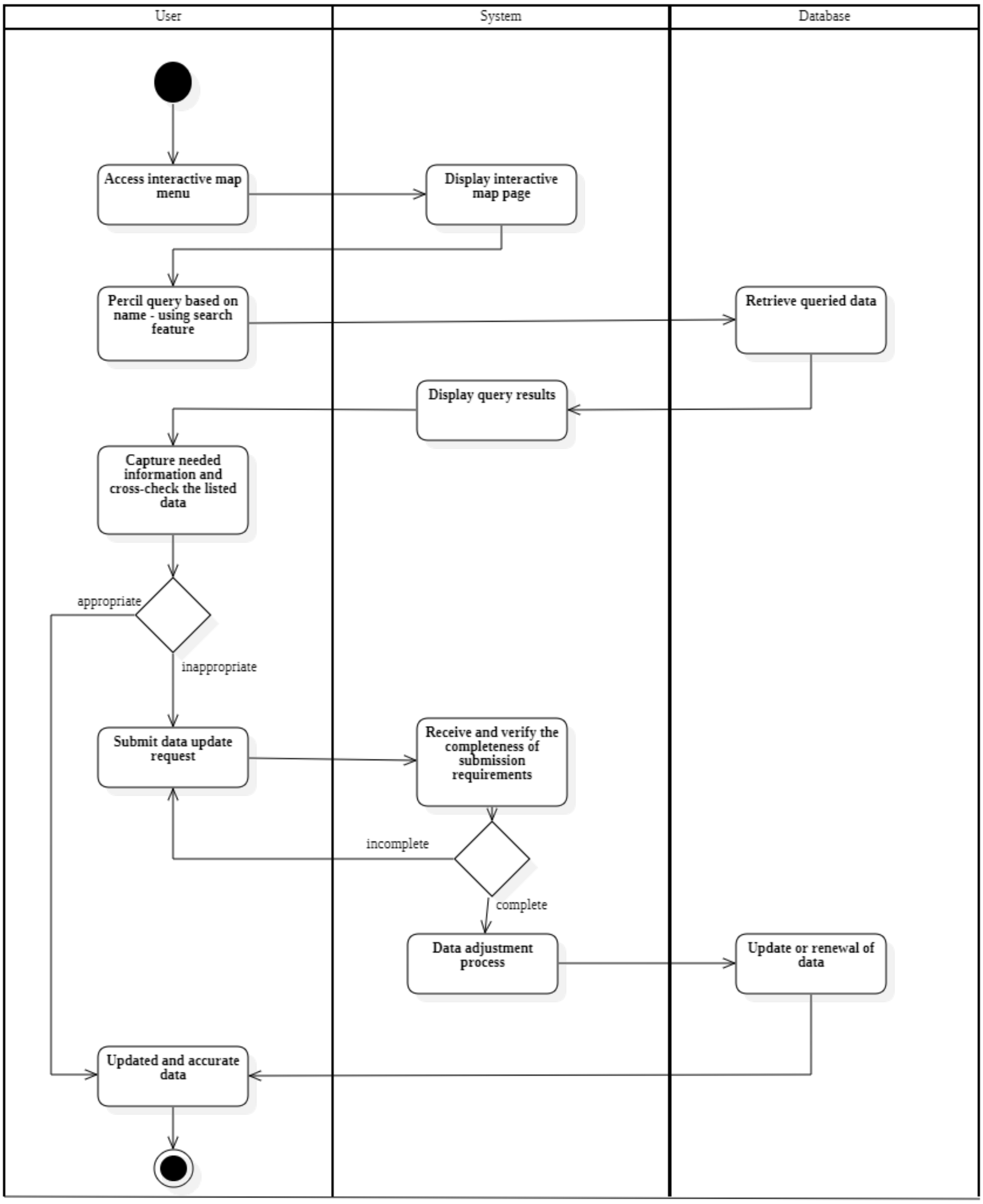


Figure 5. Activity Diagram View for Accessing Interactive Map Features

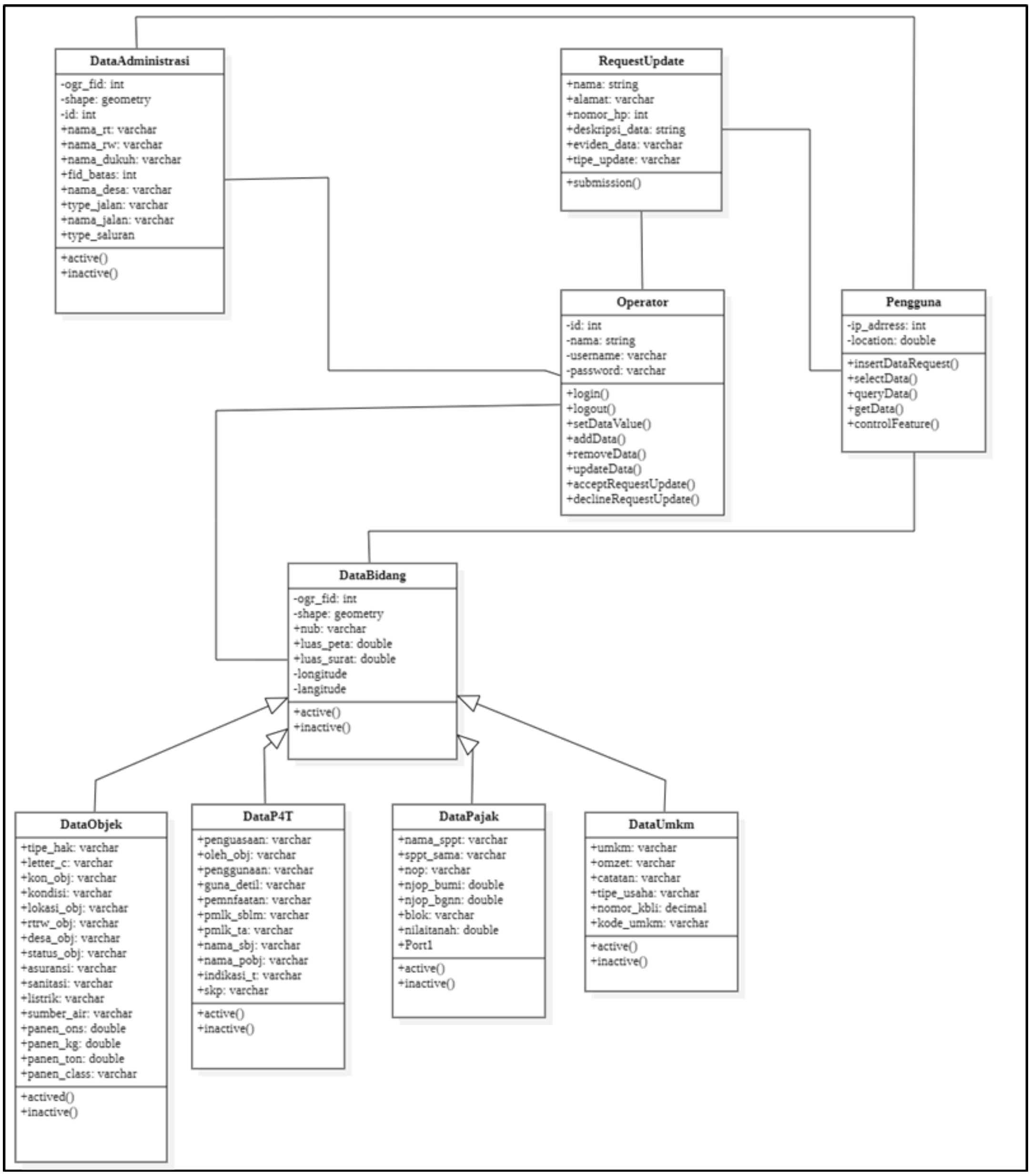

Figure 6. Class Diagram View of the Designed Application Database

Table 3, presents the database structure that contains detailed land information for villages, which is required by users and managed by operators.

Table 3. The Database Structure

| No. | Table Name | Physical Name | Primary Key | Foreign Key | Type Data |
|---|---|---|---|---|---|
| 1 | Operator Table | admin | id | - | Static |
| 2 | Village Boundary Table | batasdesa | ogr_fid, shape | - | Static |
| 3 | Hamlet Boundary Table | dukuhwgs | ogr_fid, shape | - | Static |
| 4 | RW Boundary Table | wilayah_rw | ogr_fid, shape | - | Static |
| 5 | RT Boundary Table | batas_rt | ogr_fid, shape | - | Static |

| | | | | | |
|---|---|---|---|---|---|
| 6 | Road Table | jalanwgs | ogr_fid, shape | - | Static |
| 7 | Channel Table | saluran | ogr_fid, shape | - | Static |
| 8 | Spatial Planning Table | kesesuaian | ogr_fid, shape | - | Static |
| 9 | View MSME Table | vwisata | ogr_fid, shape | - | Dynamic |
| 10 | View Agriculture Table | vpertanian | ogr_fid, shape | - | Dynamic |
| 11 | Field Table | Bidangweb | ogr_fid, shape | penggunaan, umkm | Dynamic |

According to Table 3, the primary key serves as a unique identifier for each record within the table. In spatial data, two primary keys are identified: ogr_fid and shape. Ogr_fid denotes a polygon object entity, whereas shape refers to a polygon geometric entity. A foreign key is a column that serves to identify and link records in a different table by referencing the primary key of that table. Table 2 exhibits two primary characteristics: dynamic databases and static databases. Dynamic databases consist of tables that operators can continuously manage, including editing, adding, and deleting entries. Examples of such tables are *vwisata*, *vpertanian*, *bidangweb*. static data, including administrative boundaries, typically remains unchanged.

### 3.3. Implementation

Following the design of the prototype, we outlined the coding structure of the page to obtain a comprehensive overview of the application that aligns with the specified requirements. The requirements of this application are categorized into two distinct groups: user needs and operator need, which are organized into two primary pages. The coding structure of the website page is illustrated in Figure 7.

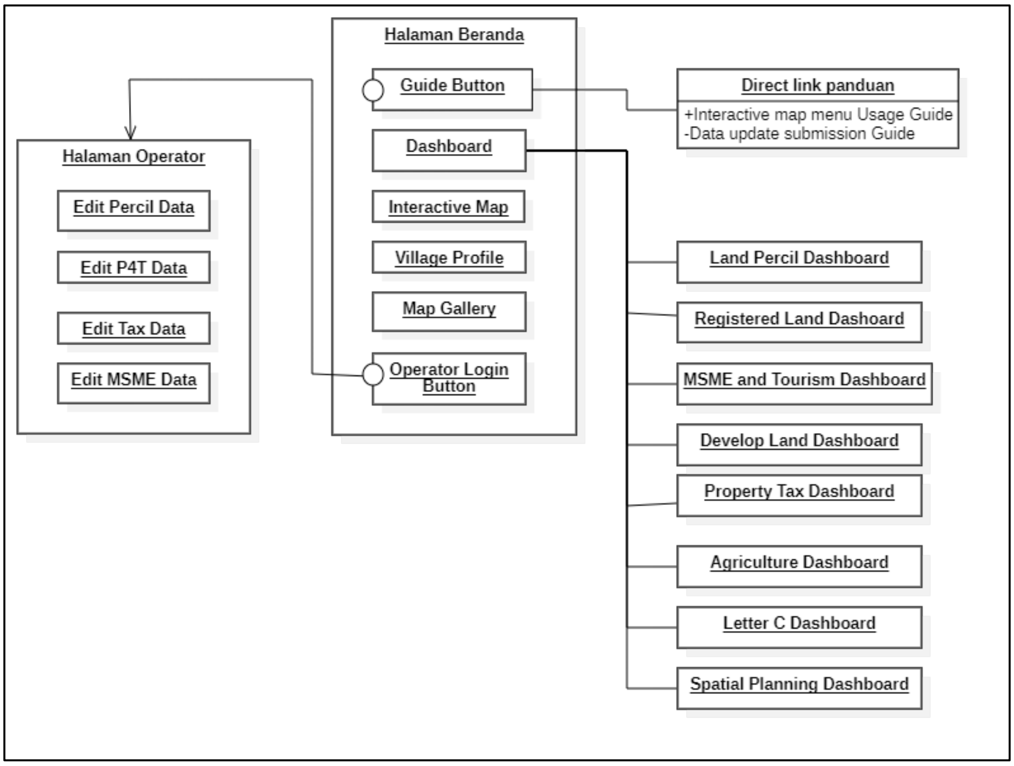

Figure 7. Website Page Coding Structure

To ensure a comprehensive discussion, it is essential to test the website-based land application [25], [26]. A team of testers, using BBT, conducts application testing for this research.

The testing team serves as a representative for the users, specifically the operators and end-users, as detailed in the methodology section. On Friday, April 12, 2024, operators and users, including employees and community representatives from Janti Village, conducted a comprehensive evaluation of each application feature, focusing on access rights, at the Janti Village Government Office. Table 4 provides a summary of the test results.

Table 4. Functional Testing Results Using Black Box Testing

| No. | Section | Action | Result |
|---|---|---|---|
| 1 | Initial Homepage | Press the HOME button on the top menu/header | Displays the initial homepage |
| 2 | | Press the DASHBOARD button on the top menu/header | Expands the sub-menu with dashboard theme options |
| 3 | | Select a theme from the expanded dashboard sub-menu | Directs to the thematic dashboard page based on the selected theme |
| 4 | | Press the ADMIN LOGIN button on the top menu/header | Displays the operator login page |
| 5 | | Press the View Detail button on the initial homepage | Directs to the interactive map section |
| 6 | | Press the Dashboard button on the initial homepage | Directs to the dashboard section |
| 7 | | Press the Guide button on the initial homepage | Directs to the application guide page |
| 8 | | Press the Detail button on a dashboard theme box on the dashboard sub-page | Directs to the thematic dashboard page based on the selected theme |
| 9 | Interactive Map Section | Press Search on the interactive map | Displays the search dialog box for parcel search |
| 10 | | Enter the owner's name in the search dialog box | Displays a list of parcel options matching the owner's name |
| 11 | | Select a parcel from the search results | Zooms in on the parcel location with a marker at the center |
| 12 | | Press the Measurement button | Displays measurement options (distance & area) |
| 13 | | Select a measurement type and perform measurement on the map | Displays the measurement results (distance or area) |
| 14 | | Press the Fullscreen button | Displays the map in full screen |
| 15 | | Press the Zoom In button | Enlarges the map display |
| 16 | | Press the Home button | Displays the entire map parcel completely |
| 17 | | Press the Zoom Out button | Reduces the map display |
| 18 | | Press the Layers button | Displays the map layer options |
| 19 | | Select and enable one or more map layer options (e.g., basemaps, boundaries) | Displays selected layers, placing the last selected layer on top |
| 20 | | Press a parcel or polygon on the map | Displays information about the selected parcel or polygon |
| 21 | Edit Percil Data | Press the View Web button on the initial homepage | Displays the initial homepage |
| 22 | | Press the Edit Data menu based on the theme of data to be changed | Displays the edit sub-menu with a table of parcels and attributes for the selected theme |
| 23 | | Search for data using the search dialog box (keywords based on table content) | Displays search results matching the entered keywords |
| 24 | | Press the Edit button next to a parcel in the table | Displays the parcel edit page for the selected attribute |
| 25 | | Fill in updated data and press the Save button | Saves changes and returns to the initial edit page |
| 26 | | Press the Cancel button | Returns to the initial edit page without saving changes |

The BBT results presented in Table 4 indicate that each feature of the land application operates effectively, with all control buttons performing their designated functions without any errors. The Janti Village Government has been utilizing this village-based land information system application since mid-March 2024 and continues to do so at present. Subsequently, a land application implementation test was conducted to evaluate the application's effectiveness in facilitating organized village land administration. The proof is conducted via gap analysis, focusing on the average importance and performance values derived from user responses regarding land applications. The results of this analysis are detailed in Table 5.

Table 5. Priority Performance Improvements for Orderly Land Administration

| No | Variable | Average Performance Score | Average Importance Score | Gap Score |
|---|---|---|---|---|
| 1 | Availability of Village Land Information | 4.560 | 4.540 | 0.020 |
| 2 | Ease of Access to Village Land Information | 4.520 | 4.455 | 0.065 |
| 3 | Clarity of Village Land Service Mechanism | 4.545 | 4.460 | 0.085 |
| 4 | Structured Storage of Land Database | 4.525 | 4.525 | 0.000 |

Table 5 indicates that the performance of the village land application aligns with user interests, as the average performance value closely matches the importance value for all variables, exhibiting a minimal gap score (0.00–0.09). The system effectively meets user expectations, particularly in delivering village land information and establishing clear service mechanisms [21], [27]. The lack of gaps in the database storage variable signifies that the system operates optimally and facilitates effective village land administration. The findings from the user response analysis are presented according to the IPA quadrant (refer to Figure 8).

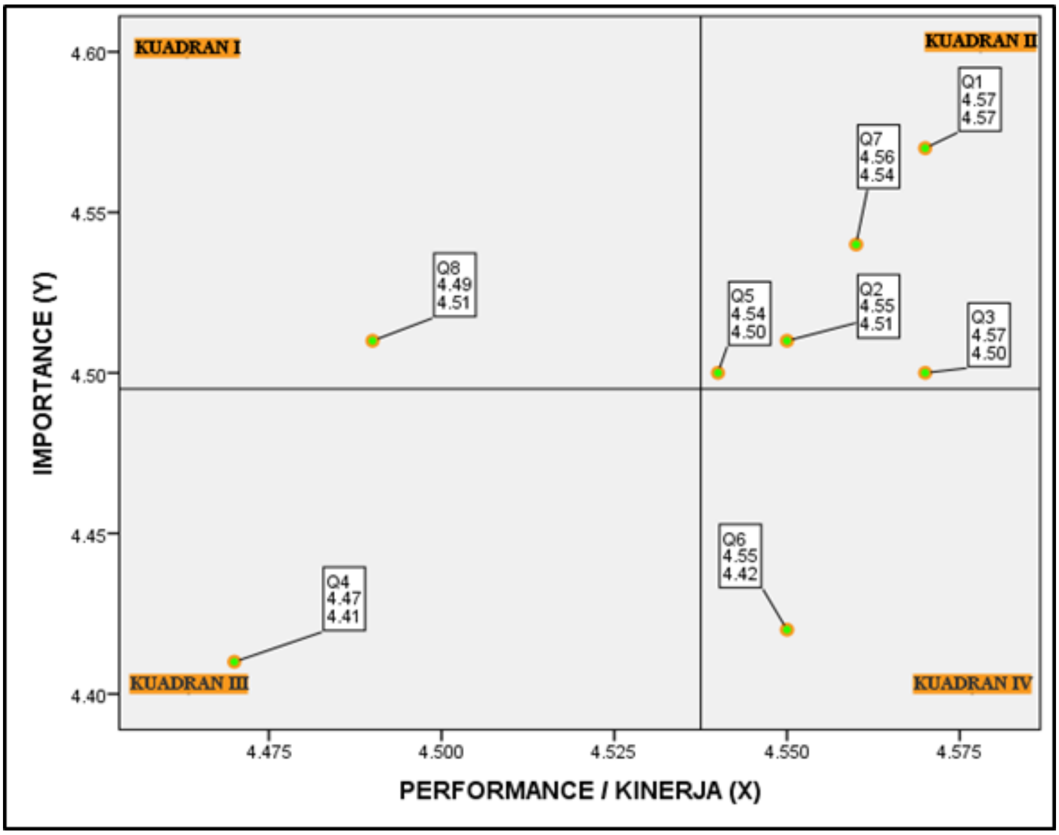


**Fig. 8.** IPA Diagram - Application Implementation Testing

### 3.4. Janti Village Land Information System: Advantages in National and Global Contexts

Although village-level land information systems have been developed by researchers in various countries, the web-based system designed for Janti Village introduces several innovations that distinguish it from similar systems at both national and international levels. At the international scale, studies such as the County Land Resources Management Information System in China [28] and the system in Oregon, USA [29] generally focus on macro-level data management or regulatory compliance, with limited access for village community participation. In Kenya, research by Lizahmy Ntonjira remains conceptual and has not yet been implemented in practice [30]. Meanwhile, the Janti Village system is designed with a bottom-up approach, prioritizing citizen accessibility through an intuitive web interface and real-time integration of spatial and administrative data—features that have not been fully realized in those international systems.

At the national level, although the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATR/BPN) has developed the National Land Information System (SIPNAS) through the portal www.bhumi.atrbpn.go.id, the fact that land registration has not yet reached 100% limits data integration at the village level. The Janti Village system addresses this challenge by adopting a community-based participatory registration method, allowing village officials and residents to update data independently. This contrasts sharply with SIPNAS, which still relies on a top-down approach and faces bureaucratic constraints. Additionally, the Janti Village system is equipped with an land conflict analysis module—an innovation not yet adopted by either the ATR/BPN system or international examples.

From a technical perspective, the strength of the Janti Village system lies in its scalability. Unlike systems in Oregon or China, which are tied to the infrastructure of developed countries, this system is designed to adapt to the limitations of digital infrastructure in rural Indonesia, such as limited internet connectivity and varying levels of technological literacy. As a result, the system not only addresses local challenges but also has the potential to serve as an integrative model for strengthening SIPNAS while providing a new reference for the development of similar systems in other developing countries.

Table 6. Comparison of the Performance of the Web-Based Application System in Janti Village with the ATR/BPN System and the International System

| No | Aspect | The Janti Village Land Application | ATR/BPN System | International Systems |
|---|---|---|---|---|
| 1 | Accessibility | Easy to access by village communities | Complex, requires special training | Requires sophisticated infrastructure |
| 2 | Data Integration | Integrated spatial and textual data | Separate data, manual process | Integrated data, based on advanced technology |
| 3 | Update Speed | Real-time | Depends on manual processes | Very fast, automation-based |
| 4 | Efficiency | High, tailored for rural needs | Less efficient in remote areas | Very high, but reliant on modern technology |
| 5 | Flexibility | Operates with limited internet access | Less flexible in system integration | Requires a stable internet connection |
| 6 | Adaptability | Designed for rural areas, highly adaptive | Less adaptive for remote areas | Less adaptive for remote areas, based on global standards |
| 7 | Transparency | High, aligned with local needs | Depends on regulations and policies | Very high, following global standards |

The integration of the system with the national land information system (ATR/BPN) is crucial for ensuring interoperability. This research identifies several integration points. The utilization of compatible data formats, such as GeoJSON, and communication protocols that facilitate data exchange between village systems and national systems is essential. We have developed an application programming interface (API) that enables our system to automatically access and update data from the ATR/BPN database. Limited or unstable internet access also presents a challenge for the utilization of web-based systems, particularly in remote rural areas. In developing this system, we considered various technical solutions, including its design for offline operation or functionality with limited internet connectivity. This enables users to implement a data synchronization feature that facilitates the downloading of necessary data when an internet connection is accessible, allowing for offline usage. This system additionally supports local area networks (LAN) to enable data exchange between devices in environments with restricted internet access. Although a series of interviews and surveys has involved with landowners, legal experts, and representatives from ATR/BPN during the needs analysis phase. However, we recognize that their involvement must be more intensive, particularly during the system testing and evaluation phase. In subsequent research, we will conduct workshops and focus group discussions (FGD) with stakeholders, including representatives of landowners, legal experts, and ATR/BPN, to gather ongoing input throughout the system development process.

## 4. CONCLUSION

This research indicates that the web-based Village Land Information System for Janti Village was successfully constructed utilizing the System Development Life Cycle (SDLC) methodology. The procedure encompassed needs assessment, prototype design, and execution. The prototype process was utilized in the planning phase, incorporating UML modeling and an enhanced database architecture. The implementation testing, conducted via the black-box method, verified that all system functions operate efficiently and satisfy the criteria of village land management. An evaluation of user satisfaction indicated a high degree of contentment, especially for system correctness, accessibility, and usefulness, albeit several aspects require improvement. The application has demonstrated its capacity to elevate service quality and optimize land administration procedures, hence enhancing information accessibility, efficiency of access, and organized data management in Janti Village. This system demonstrates the capacity of web-based platforms to enhance regional land management and facilitate improved governance at the village level.

To get the most out of the system, users should get better training so they know how to use all of its benefits. The system needs to be made more flexible so that it can be used in more places in the future. It should also have more advanced features added, like GIS maps, so that all land data can be seen at once. Evaluations must also be done on a regular basis to keep an eye on performance, encourage continuous growth, and keep users happy.

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