

Implementation of Web-GIS Forest Resource Potential Mapping Using Y-Model

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Abstract— Sukabumi is one of the West Java Province regions with the potential for forest resources. The lack of renewal in the way data is processed has led to the need to develop information systems for mapping potential forest resources focused on the Sukabumi region. In doing so, the development of the system will help the government manage forest resources more efficiently. In the system development process, the Y-Model Framework of Web-GIS Development is used as a development method that is a combination of waterfall and agile approaches followed by 4 phases, with a combination of geographic information system engineering with the help of ArcGIS as a tool for mapping and web-based application development contexts. At the development stage, it was also built using text-to-speech technology to provide voice capabilities for the information displayed. The development of web-based GIS applications will help facilitate access to information about potential forest resources in the Sukabumi region for the community and related parties. The results of the development of this system are visualized in the form of maps based on the Geographic Information System (GIS) and presented online through a web application. The success of using the Y-Model framework in the development of this system is demonstrated in the User Acceptance Test (UAT) test results through a questionnaire instrument distributed to respondents with an average value obtained above 82%, which shows the level of user satisfaction with the system has been well received and shows that the application has met the needs of the user.

Keywords— Web-GIS, Y-Model, Forest Resource Potential, User Acceptance Test, UAT.

I. INTRODUCTION

A forest is defined as a unit of ecosystem that forms a layer of land containing natural resources dominated by abundant trees in a natural environment, which are inseparable from one another. The functions and benefits of forests for human life can be felt either directly or indirectly, to directly be able to provide economic benefits in the form of wood forest outcomes (industrial, forests, fuels, etc.) and non-wood forests (ghetto, rotan, fruits, etc.), which are of economic value while indirect. Forests can provide both ecologically beneficial and environmental services, such as regulating water management in nature (hydrology), and carbon storage can preserve biodiversity and habitats, the largest supply of oxygen, and the most tourist attraction[1].

Sukabumi is one of the West Java province regions with quite potential forest resources. According to the Ministry of Forestry, in the year 2020, Sukabumi has a state forest area that includes conservation forests, shelter forests, and production forests of 109.871,33 Ha[2], less than 26% of the administrative territory of the district. UPT and BUMN manage the country's forest areas in Sukabumi under the Ministry of Environment and Forestry (Mountain National Park).

Gede Pangrango, Mount Halimun Salak National Park, Natural Resource Conservation Hall, and Perum Perhutani). For outside the State Area based on the Governor's Regulation. No.64 of 2017, administered by the West Java Provincial Forestry Department, the Sukabumi Proof has a sufficiently large forest resource, and the potential exists on the indicative data of the people's forest of the West Jawa Provincial Forestry

Department. By 2021, Sukabumi had a people's forest of 78,963,28 Ha, accounting for 18% of the administrative territory of Sukabumi, most of which was spread across the territory and also the city forest of 204,4 Ha, counting for 0,048% of the administrative area of Sukabumi, spread over the district and the city.

In addition to the fairly potential forest area, the Sukabumi region has the potential for diverse forest resources, both in the form of forest (wood and non-wood) tourism and environmental services. Based on the ground check data of the field in 2022, there are 128 forest farm groups spread across the territory of Sukabumi, including SDH potential such as wood forest output production of 59.110,96 m3, HHBK production such as honey of 275 stop produced 615 kg, wood fungus production of 370,000 log produced 186,615 kg.

At present, the problem found mainly regarding the collection of potential data SDH that exists in the region of Sukabumi among them is the potential SDH has not been fully inventoried, so that the mapping and presentation of the potential data of SDH become impaired. Then in terms of technology, there is an emergency fund that is needed for application for data processing about the potential of SDH that can bridge the interaction of other users internally due to the existing information system has not met the needs of the user because of the lack of space to load and data on the potential for forest resources. Some input and coding subsystems must be improved upon existing systems to produce new outputs. This research aims to develop a text-to-speech technology based interactive geographic information system (Web-GIS)[3] that is based on the web and provides information about the

potential for forest resources in the Sukabumi region. This will allow users to interact with one another through the application already in place to address any gaps or additional user needs. Web-GIS combines graphic mapping design, digital maps with geo-analysis, computer programming, and a database following its role[4], as for some related studies such as Cholid Fauzi[5], Endo Kristyono [6], Abdullah Ali [7], Ai Rosita [8] who, have used the Y-Model framework as a method to develop systems with this method. Therefore, this is the basis for researching the application of the Y-Model framework in the development of Forest Resource Information Systems in the Sukabumi Region-based GIS Web.

II. RESEARCH METHODOLOGY

The research methodology is depicted in Figure 1 and is explained in detail in this section, among other things:

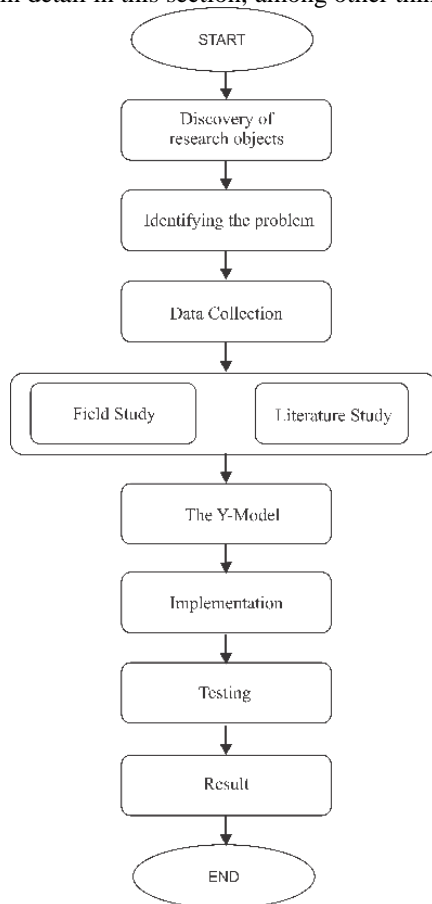


Figure 1. Phase of Methodology

- 1) *Research Objects*: Identifying the study's focus, which is the forest.
- 2) *Recognizing the issue*: a) how can the Sukabumi region's prospective forest resource information be presented in a real-time, interactive manner that enables staff to manage data online? b) how is the Y-Model approach applied to develop possible information systems on forest resources?

- 3) *Data Collection*: Data gathering through field research and literature analysis.
- 4) *Model Proposed*: As an approach to system development, the Y-Model Framework.
- 5) *Implementation*: A phase of system development.
- 6) *Testing*: UAT and Blackbox testing.

A. The Information System

Information systems are defined as data processing activities that can be started by collecting, processing, analyzing, and storing information to disseminate further information filtered from previous processes for an individual's or organization's progress and interests [9]. Usually, in an information system, something is usually processed, produced as data into information, and intended for a goal or purpose [10] [11].

B. Geographic Information System (GIS)

In computer science, one of the applications that can read a map today is GIS in Indonesia called Geographic Information System, a computer-based system. It is used to store data and manipulate geographical information [12]. SIGs are also designed to collect, store, and analyze geographical location objects and phenomena [13]. Thus, GIS as a computer system has the following four capabilities in handling geographically-referenced data: (a) input, (b) data management (storage and calling of data), (c) analysis and manipulation of data, and (d) output.

C. Web-GIS

Web-GIS is a part of the development of GIS applications that are digital maps usually used as one of the communication media that utilizes the Internet function as a tool to publish, integrate communication and provide information as well as maps digitally function to analyze and ask for information related to GIS through the Internet network [14]. The Website-GIS (Web-GIS) can perform the search, collection, storage, retrieval, analysis, and display of geospatial information in the Internet environment so that it will be obtained management of information that is actual, factual, accurate, and optimal to get a picture of the spatial relationship with the actual conditions in a region [15].

D. Spatial data and data attributes

Spatial data is data that refers to a location that has geographical reference coordinates [16]. The attribute data details the information of each area or coordinate available, for example, the number of people in a province, the open green space in a region, and others [17].

E. The Forest Resource (SDH)

The authors conclude that forest resources are natural resources derived from forests that can be useful to meet human life needs.

F. Text to Speech (TTS)

TTS (Text to Speech) is a speech technology that transforms written text into speech based on the content's original language[18].

G. The Y-Model

The Web-GIS development in this research uses the Y-Model Web GIS Development Methodology framework (YMWD). This is the theoretical methodology for developing systems proposed by Ananda, Curia, and Ngigi[19]. This method combines web development and software development on GIS applications, both complex. Adopting a separate and more comprehensive methodology rather than using software development methodology, in general, is considered necessary. With this model, system development can be used to make software needs with spatial specifications easier to meet and well-defined.

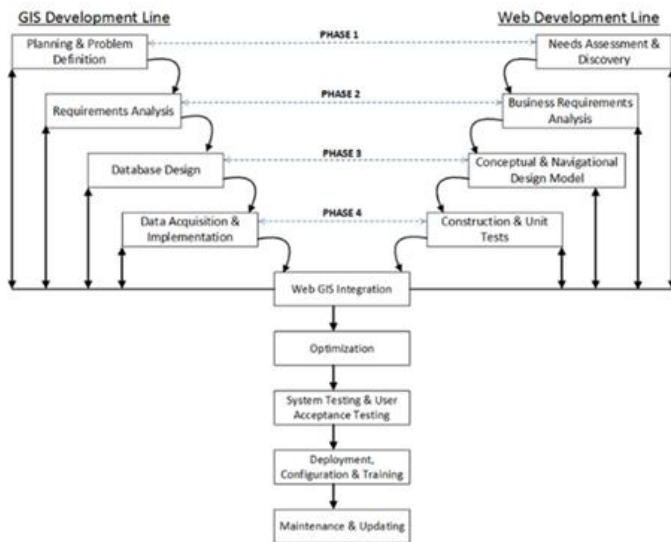


Figure 2. Y-Model Web-GIS Development Methodology

This Y-Model framework ensures that the Web-GIS application development process is structured and integrated so that the application meets the goals and expectations of the user. This methodology, called Y, is taken from the representation of the methodological diagram in the form of the letter Y, as shown in Figure 2. YWDM is a framework for developing Web-GIS forestry for potential mapping resources of forests.

The web-GIS development process using YWDM follows several phases. In the early stages of determining the planning analysis and formulation of the problem in the GIS application development section and the need assessment in the web development section. The second phase identifies and analyzes functional and non-functional needs in systems in both web and GIS elements. The third phase enters the stage of designing the GIS database and defining the design concepts and models of interactive web navigation. Enter the fourth phase, the most important phase for the GIS development section, namely the data acquisition and implementation process that can be constructed and tested on the web deployment section. The next stage for the integration and management process is divided

into several stages, including optimization, testing, configuration, training, and maintenance. Information Systems are defined as data processing activities that can be started by collecting, processing, analyzing, and storing information to disseminate further information filtered from previous processes for an individual's or organization's progress and interests. Usually, in an information system, something is generally processed, produced as data into information, and intended for a goal or purpose.

III. RESULT AND DISCUSSION

A. Phase 1

1) *GIS Development Line*: Planning and problem definition to prepare spatial data that contains layers of maps such as the boundaries of the territory, the scope of the forest space that is outside the area as well as in the area, and the spread of potential information of forest resources in the region of Sukabumi which is then visualized in the Web-GIS application.

2) *Web Development Line*: Need assessment and discovery. There is a need from the Department of Forestry for the inventory of potential forest resources that exist in the Sukabumi web-based area as a way to accelerate input data in real-time and accelerate field data renewal, evaluation of activities already carried out, and ease of accessibility for internal employees.

B. Phase 2

1) *GIS Development Line*: Requirement analysis: Analyze the functional needs of the development side of GIS, among others:

- The system can receive input as a digital map (GeoJSON).
- The system can display coordinate data in the map layer.
- The system can add data, update data, and delete potential data SDH within the scope of the boundaries of the administrative territory of Sukabumi interactively on the database.

2) *Web Development Line*: Business requirement analysis: Determining needs on the web development side such as identifying input and output from related business processes, designing use case diagrams and use case scenarios to clarify the features required by the Web-GIS application, and visualizing the business process of the Web GIS application. Based on Table I, it is said that the functional requirements for developing this system are four as a guide for the system's creation.

TABLE I
 FUNCTIONAL REQUIREMENT

Functional Requirement	
Code	Details
FR 01	User Management Manage user access rights in the application.
FR 02	Data Management of SDH CRUD maps the layer of SDH
FR 03	Export data Exporting data in Excel format

Functional Requirement	
Code	Details
FR 04 Maps	View maps with layering text to speech.

C. Phase 3

1) *GIS Development Line*: Database design in the development of this application The database used is Maria DB which is illustrated using class diagrams to describe the objects present in the application, including the required spatial data associations in Figure 3.

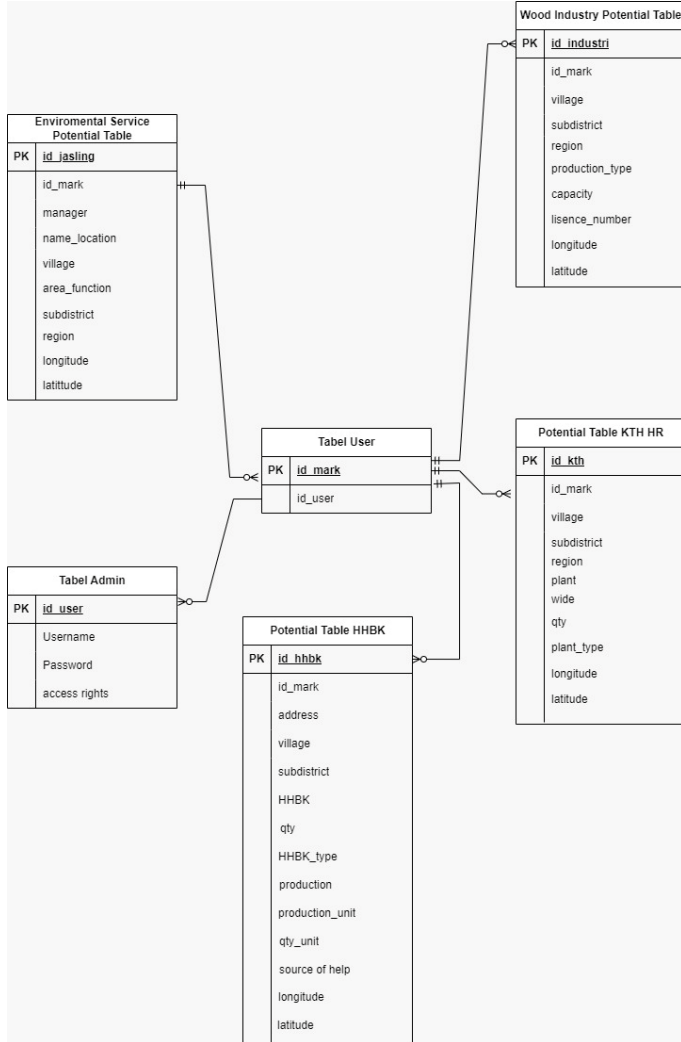


Figure 3. Database design

2) *Web Development Line*: Conceptual and Navigational Design Model. A conceptual model is a model that depicts a system as a whole using a modeling diagram, namely Unified Modeling Language (UML) is the modeling language used as a standard used in object-oriented modeling. UML is used to model specifications and document Web-GIS development designs. The UML models used in this study are a use case diagram in Figure 4 that describes the relationships and interactions of actors involved with components within a system. This study has three types of actors: general user,

admin, and super admin. Based on the needs of access to the UML, it is possible to design a menu structure that is a picture of the menu in the application that will be created and drawn in the form of the following diagram.

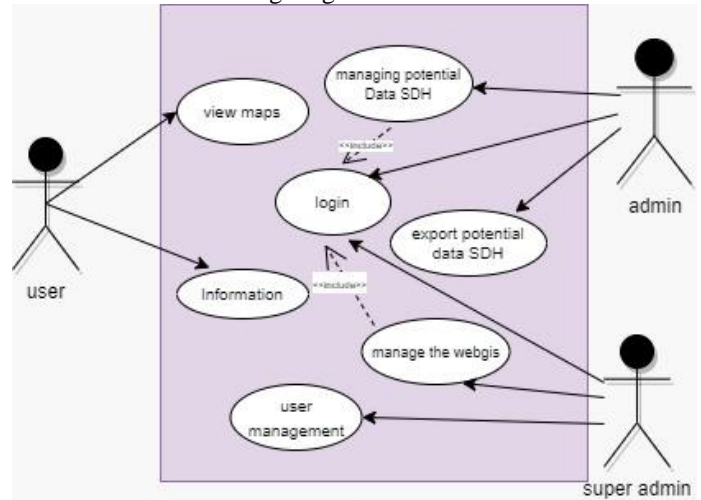


Figure 4. Use Case diagram

D. Phase 4

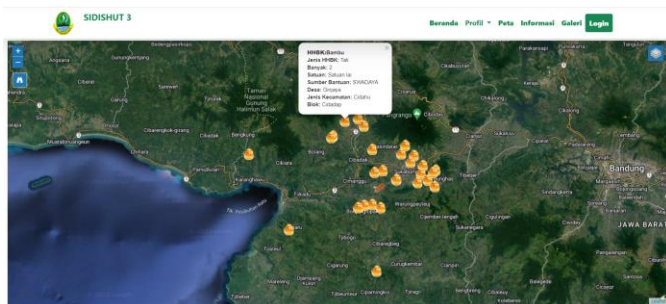
1) *GIS Development Line*: Data Acquisition and Implementation. In this stage, data is collected systematically and structured from various sources using various approaches, including field surveys and satellite images represented in previously designed database schemes. Data acquisition aims to obtain accurate, relevant, high-quality data to support decision-making or research. This process involves the identification of data sources, data acquisition, data validation, and data integration into appropriate systems or environments. Identify the data sources necessary for mapping potential forest resources in the area, such as spatial data, satellite image data, and other relevant data through field mappings, acquiring satellite image data, or exploiting existing data from related institutions. This phase also carried out the encoding process for implementation into the web form using PHP and JavaScript programming tools and the representation of coordinate data into a map using GeoJSON to shape files. Data layers in the form of points and polygons are provided in Table II to help with the implementation process.

Layer Map	Data Layers	
	Topology	Feature Attribute Table
Subdistrict boundary	Line	arc attribute Table
Administration of Sukabumi	Polygon	polygon attribute Table
The forest cage	Polygon	polygon attribute Table
Critical land	Polygon	polygon attribute Table
Non-timber forest products	Point	point attribute Table
Industri area	Point	point attribute Table
Environmental services	Point	point attribute Table

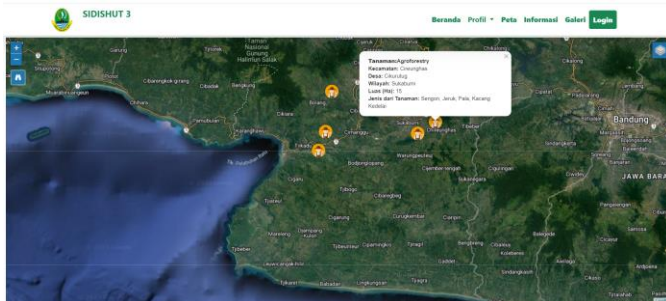
2) *Web Development Line*: Construction Unit and Test. In this phase, encoding begins to be carried out according to the requirements of the previous phase. This Web-GIS uses black box testing and User Acceptance Testing (UAT), useful for

mastering the system according to its planning and specifications.

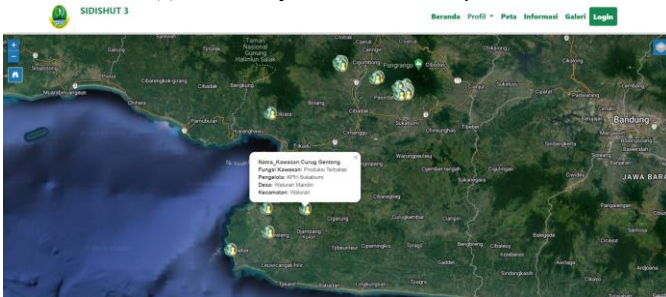
3) *Marker*: A marker is a map that displays the point of a location. The markers available on this map page are categories included in the potential of forest resources, such as markers for non-timber forest products, the timber industry, environmental services, and community forest farmer groups where there is information about the data when clicked on the map at each point. Figure 5 (a) the marker process for marking Non-Timber Forest Products and marked with a picture of a barrel. Figure 5 (b) the marker for marking community forest farmer groups in the Sukabumi area with a Google hybrid background marked with a farmer's symbol. Figure 5 (c) is the marker process for marking environmental services in the Sukabumi area with a Google Hybrid background marked with a picture of the symbol of people and the world.



(a). Marker of Forest Area in Sukabumi



(b). Community Forest Farmer Group Markers

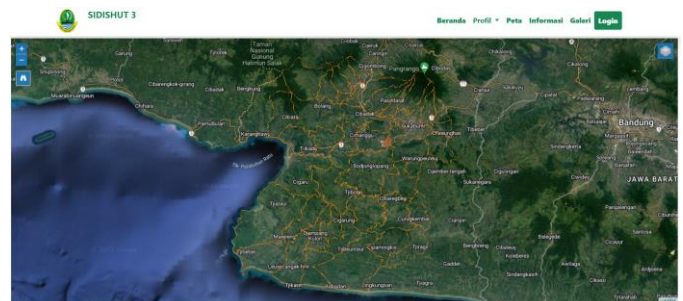


(c). Environmental Service Markers

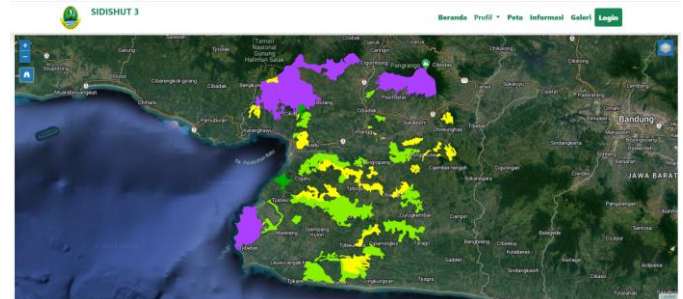
Figure 5. Mapping Marker of The Forest Resources Potential

4) *Polygon*: Polygon is data that contains information about the area and usually has an area. The available polygons in this information system are in the form of the administration of the Sukabumi sub-district, critical land, and forest areas where each polygon has a different color based on the criteria and color scheme regulated in the regulations of the minister of

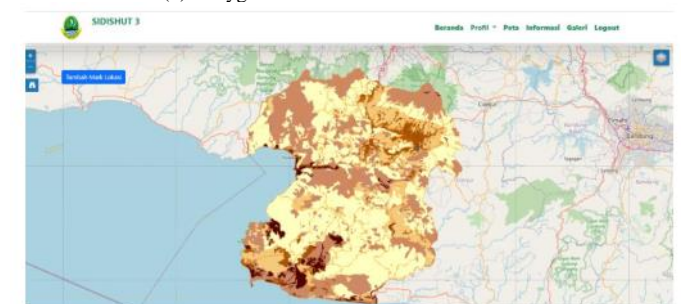
environment and forestry. Figure 6 (a) the process of making polygons is carried out to limit the area of each sub-district in the Sukabumi area. In making these polygons, it is marked with an orange dividing line. Figure 6 (b) the polygon results for the Sukabumi forest area category. The conservation forest is purple, the protected forest is dark green, the limited production forest is light green, and the permanent production forest is yellow. Figure 6 (c) the polygon results for the critical land category in Sukabumi, slightly critical land areas colored in light brown, critical land areas colored in pale brown, critical potential areas colored in brown, very critical areas colored in light yellow, and non-critical land areas colored in dark brown.



(a). Sukabumi Administrative Polygon



(b). Polygons of the Sukabumi Forest Area



(c). Polygons of Sukabumi Critical Land

Figure 6. Information Mapping Polygon Areas of The Forest Resources

E. Phase 5

1) *Web-GIS integration*: This stage is part of implementing the Web-GIS component using the selected Y-Model framework and ensuring good integration between the front-end and back-end components in the Web-GIS system. This stage also identifies and fixes integration problems or errors that may arise during testing. The integration process involves the interface resulting from the implementation, i.e., the main page interface image, the login interface admin image, the data input

interface image, and the interface page map image. Data points to the potential for forest resources in Sukabumi in Figure 11. These data points include the potential spread of non-wood forest output, industrial wood spread, the potential spread of environmental services, and the potential spread of natural tourism in the Sukabumi area. The testing carried out on this system, as mentioned in phase 5, is the Unit testing using the Blackbox method[20]. Table III will display the test results on some features the admin will run to access the information system.

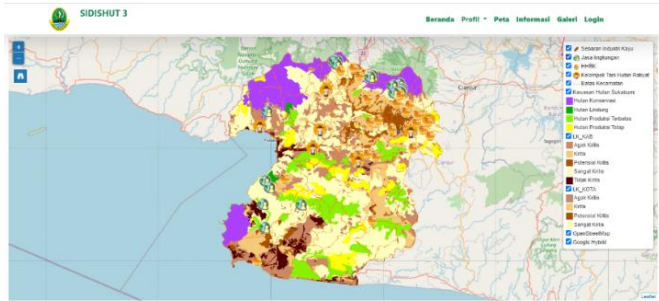


Figure 11. Interface Map with Layering

TABLE III
 UNIT TESTING

Name Process	Blackbox Testing	
	Plan test	Result
Showing data maps	The system can display map data from GeoJSON to *.shp files	OK
Input data	Implementation of SDH data.	OK
Save the data	The system will store data and display data on the map layer.	OK
Delete the data	The system will delete the data in the database, and the point will not appear on the map layer.	OK
Export data	Draw data into Excel format.	OK

Table III from Blackbox testing displays several examples of successful test cases, including:

- View map data from GeoJSON to *.shp format demonstrating the implementation of SHP successfully.
- Determine the potential SDH data.
- Databases can be used to store data.
- The map layer data must be deleted.
- Data export to Excel format.

TABLE IV
 USER TESTING

Questions	Table Result of Question					
	SSx5	Sx4	BSx3	TSx2	STx1	Total
Is this web-based system for analyzing potential resources of forests useful, in your opinion?	75	25				95
Do you think this system of informational monitoring of potential online day laborers is necessary?	65	28				93

Questions	Table Result of Question					
	SSx5	Sx4	BSx3	TSx2	STx1	Total
Can you imagine how much easier it would be for you to collect data about potential resources of forest occupants if there were a system like this?	60	32				92
Does this informational system have the potential to be used for forest resources? In your opinion, monitoring based on the internet is simple to utilize and make sense of.	40	48				88
Does this informational system have the potential to be used for forest resources? Monitoring that is accessible on the internet and simple to comprehend, in your opinion, could be a valuable resource for forests.	85	12				97

The application was tested using the user acceptance testing (UAT) method to guarantee user delight and maintain system functionality. UAT stands for User Acceptance Testing. The interaction between the system and the end user functions to support it. Functions operate following the user's requirements [21]. During the testing procedure, when the system's development phase is over. The first UAT test was conducted by submitting five questions to 20 respondents who acted as an administrator, where the administrator is an internal government official.

2) *Results of First Question:* From Table IV, the total score of 20 respondents as admin for the first question is 96, and the average score is $96/20=4.8$. Presentation value is $4.8/5 = 0.96 \times 100 = 96\%$.

3) *Results of Second Question:* From Table IV, the total score of 20 respondents as admin for the second question is 93, and the average score is $93/20=4,65$. Presentation value is $4.65/5 = 0.93 \times 100 = 93\%$.

4) *The Third Question:* From Table IV, the total score of 20 respondents as an admin for the third question is 92. The average score is $92/20 = 4.6$. Presentation value is $4.6/5 = 0.92 \times 100 = 92\%$.

5) *The Fourth Question:* From Table IV, the total score of 20 respondents as an admin for the fourth question is 88, and the average is $88/20 = 4.4$. Presentation value is $4.4/5 = 80,88 \times 100 = 88\%$.

6) *The fifth question:* From Table IV, the total value of 20 respondents as admin for the fifth question is 97 average value is $97/20 = 4.85$ Presentation value is $4.85/5 = 0.97 \times 100 = 97\%$.

According to the data above, 85% or more of the tests were completed satisfactorily, which is a respectable score. This shows the importance of this web-based forest resource

potential monitoring information system, particularly in SDH potential data management, as a new data collection method related to spatial data.

IV. CONCLUSION

Implementing the Y-Model Framework in the development of information systems for mapping potential for forest resources in the Sukabumi region is an effective approach to new innovations in mapping. To date, Web-GIS is the most appropriate application for the speed of obtaining data and aggregate information, spatial and non-spatial, as well as accuracy in the data input process. The YDWM methodology is implemented in five stages, i.e., phase 1 includes planning and formulation of materials, phase 2 analysis of functional and non-functional needs, Phase 3 makes geospatial database design and web navigation, phase 4 performs acquisition of geospatial data of web construction, the final stage is integration and management. The results of implementing the YDWM methodology in this study are characterized by developing the new interface pages, mainly in the map menu. From the data that has been obtained and processed into a GIS, it can be seen that the data on potential forest resources in Sukabumi includes the distribution of potential non-timber forest products, the distribution of industrial timber, the distribution of potential environmental services, and the distribution of natural tourism potential in the Sukabumi region. And from the results of testing applications made through questionnaire instruments distributed to respondents, an average value of above 82% is obtained. This indicates that user satisfaction with the system has been well received and the application has met user needs. The development of this system is expected to be a new innovation in the management of geospatial data and information on related agencies.

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