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Development of WebGIS Based Road Database for Support Planning Infrastructure in The City of Pematangsiantar

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Abstract: Effective road infrastructure planning requires accurate, structured, easily accessible, and up-to-date data. However, in many regions such as Pematangsiantar City, data related to the road network is still scattered, lacks standardization, and is not regularly updated. This study aims to develop a WebGIS-based road database as a tool to support road infrastructure planning and management in an efficient and transparent manner. The methods employed include the collection of primary and secondary data, digitization of road maps, and the development of a WebGIS application using web-based programming technologies and spatial database management systems. The results show that the WebGIS system developed in this study is capable of presenting road information visually and interactively, including attributes such as street names, lengths, widths, and physical conditions. This system also enables regular data updates and can be accessed by various stakeholders, including local governments and the general public. These findings are consistent with previous studies which have shown that WebGIS is effective in supporting decision-making processes and enhancing transparency in public information related to infrastructure. Therefore, the development of a WebGIS-based road database in Pematangsiantar City is expected to serve as an implementation model that can be replicated in other regions.

Say key: WebGIS; database road; GIS; infrastructure; Pematangsiantar.

I. Introduction

Effective and sustainable infrastructure planning requires accurate, integrated, and easily accessible data. Roads as one of the basic infrastructures have an important role in supporting community mobility, economic growth, and regional development. However, in practice, data related to road networks in many areas, including Pematangsiantar City, Still spread, No standardized, And not enough updated in a way periodically. Matter

This is a major challenge in the planning and decision-making process by local governments and other stakeholders.

Development technology information And communication, specifically system information Geographic Information Systems (GIS), has opened up opportunities to manage spatial data more efficiently. One of the modern implementations of GIS is WebGIS, a geographic information system that can be accessed online via a web browser. WebGIS allows users to view, manage, And analyze data spatial in a way interactive And real time. According to [Hendrayana et al. (2021)], WebGIS proven effective in serve information network road in a way digital and interactive so as to support faster and more accurate decision making in infrastructure planning.

In addition, [Wibowo and Setiawan (2020)] stated that the development of a WebGIS-based road database can improve the efficiency of road data management, especially in monitoring road conditions, identifying damage, and planning repairs. This system also supports transparency And openness information public in context development region. Ridwan, R. (2014) In his thesis on the development of a national road database based on Geographic Information Systems (GIS) in West Sulawesi Province, Ridwan emphasized the importance of spatial data integration to facilitate decision making in road management. The system developed uses Quantum GIS for spatial data creation, MapServer for WebGIS development, and PHP and MySQL for web programming and database management. Christifani, E., & Ekkyauditya, G. (2014) This study focuses on the development of a road database in Sampang District. By using the PASERManual method, they succeeded in identifying the condition of the surrounding roads and recommending the necessary handling. The application of Geographic Information Systems (GIS) helps in the management of the surrounding road network by presenting information such as the type of pavement, condition road, And type Handling Which needed. Jumaeroh, R. (2019) In his thesis, Jumaeroh developed a WebGIS-based Geographic Information System for monitoring road equipment data in Sragen Regency. This system uses PHP and MySQL, allowing input, updating, storing, and displaying data related to equipment. road. Testing system show that application can functioning with smoothly as expected. Hasan, DS (2018), This study develops a Geographic Information System for a web-based road and bridge database in Manggarai Regency. Using ArcGIS 10.1 for map processing, PostGIS for database storage, and OpenLayers for publication map in a way on line. The result is application GIS web Which give information about condition road And bridge, help in maintenance And Handling infrastructure. Mallombasi, A., Anugrah, MY, & Munir, A. (2020) their study in Enrekang District, researchers compiled a road database based on Geographic Information Systems to support development planning. They emphasized that the availability of accurate and integrated data is very important in making strategic, tactical, and operational decisions. related network road. Nugroho & Astuti (2021):

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WebGIS strengthen transparency and control public to data asset infrastructure, Maulana & Dewi (2022): GIS-based road database helps maintenance and budget efficiency. Putra & Rahmawati (2018): GIS presents road data spatially and thematically more accurately, Setiawan & Kurniawan (2019): WebGIS improves the efficiency of road mapping and repair planning.

Pematangsiantar City as one of the strategic cities in North Sumatra Province requires... system data road Which integrated And easy accessed. Development database WebGIS-based roads are a strategic solution to support infrastructure development planning, maintenance road, management Then cross, until service public. With system This way, road network data can be presented in a more comprehensive, transparent and up-to-date manner.

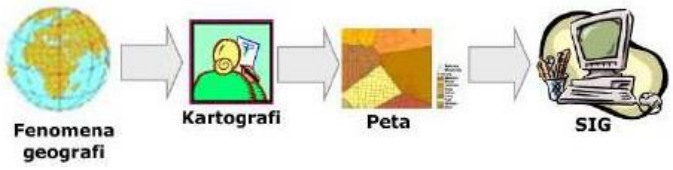
Based on background behind the, study This aiming For develop database road based WebGIS Which can used as tool help in process planning infrastructure in Pematangsiantar City. This development is expected to support the creation of a more accurate, efficient, and accessible road information system for various stakeholders.

II. Review Library

System Information Geographical (GIS)

Geographic Information System (GIS) is a computer-based system used to capture, store, check, and display data related to geographic positions on the earth's surface. GIS can present spatial data visually and analytically, making it very useful in the decision-making process, especially in the field of infrastructure planning. In the context of roads, GIS is able to map road networks, physical conditions, and other spatially relevant road attributes.

There is diverse definition from for expert about System Information Geography (GIS). According to De By (2001), GIS represents geographic phenomena in a computerized/digital manner and then visualizes the information with several techniques. Geographic phenomena are the main drivers in GIS (Figure 1).

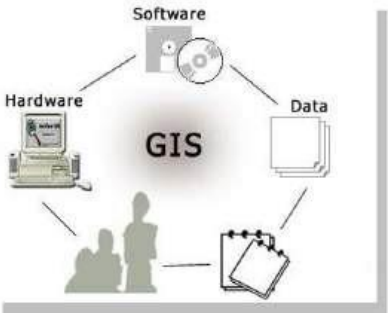


Picture 2.1. Phenomenon geography in GIS

Source: Document City Government Pematangsiantar 2024

In general GIS is A system For management, storage, processing, analysis and display of data related to the earth's surface, with

use device hard (hardware), device soft (software) as well as resource humans in spatial analysis (brainware). Components in GIS include (Figure 2)



Picture 2.2. Component GIS

Source: Document City Government Pematangsiantar 2024

System Information Geographical (GIS) consists of from five component main, that is: data, device software, hardware, applications, and humans. Data consists of spatial data that has coordinate references such as maps, satellite images, and aerial photos, as well as non-spatial attribute data such as data survey And statistics. Devices soft in the form of program computer special like *ArcGIS, QGIS* , or *GRASS* used For manage, analyze, And display data spatial. Device hard covers computer And tool Supporter like *GPS, scanner, digitizer, printers, and plotters* . *GIS* applications are procedures for processing data into information, for example through classification, *overlay, buffer,* and join table. Meanwhile, humans act as operators, developers, and analysts who run the system and utilize *GIS* to understand and manage geographic phenomena.

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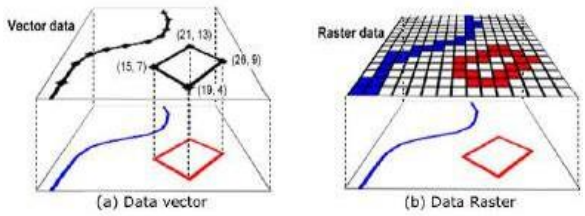
Model Data GIS

In *GIS* there are two main data types, namely geodatabase and attribute data. Geodatabase is a database that represents locations on the earth's surface and is also called a database. *GIS.* Temporary That, data attribute/tabular containing information addition (like text, images, or tables) that complement raster and vector spatial data. In its operations, *GIS* uses two data models, namely:

Data Raster – Data grid shaped or pixels, usually scan results or image digital satellites (such as *BMP, JPG, Landsat, SPOT, etc.*), with pixel positions determined by rows and columns.

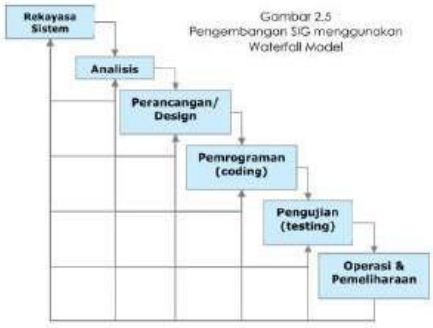
Data Vector – Represents geographic objects in the form of points, lines, and polygons. Stored as Cartesian coordinates (X, Y), where a point is represented by a single coordinate, a line by a series of connected points, and a polygon by a closed line.



Picture 2.3. Data Vector and Raster

Source: Document City Government Pematangsiantar 2024

GIS applications uses the waterfall model, which is a systematic and linear approach from analysis to system maintenance. This process includes 12 main steps, namely: assessment need, design conceptual *GIS*, survey data And device, design database, data input, pilot studies and testing, equipment acquisition, database construction, system integration, application development, and use and maintenance of *GIS systems* .

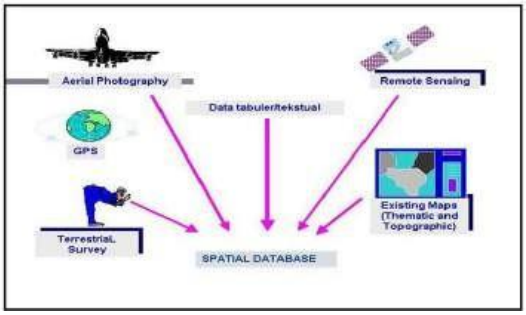


Picture 2.4. Development *GIS* use *Waterfall Model*

Source: Document City Government Pematangsiantar 2024

Technique Mapping With GIS

Data GIS consists of from data spatial And data tabular. Data Spatial can sourced from map *hardcopy*, *photogrammetry*, *remote sensing*, *GPS (Global Positioning System)* And digital terrestrial mapping. While tabular or textual data can be sourced from BPS data, survey results, studies library, etc. Data the input through various tool help, like digitizer, scanner, etc.



Picture 2.5. *GPS (Global Positioning System)*
Source: Document City Government Pematangsiantar 2024

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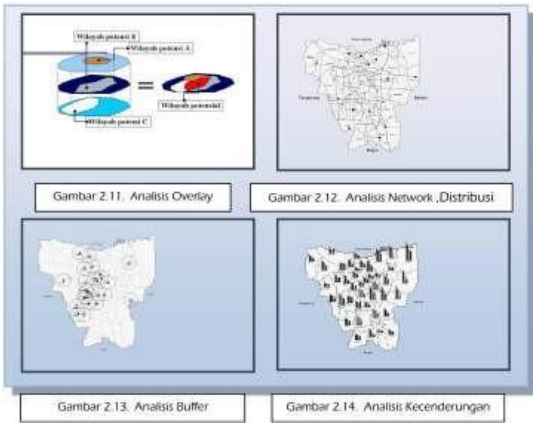
Results input data Then processed with use software *GIS* Which Finally can become a database *GIS* . Database *GIS* can have various type format And can made into analysis of various needs. Another thing that is also considered important in the *GIS database* is about the system coordinate Which used, Which objective as integration from various type data digital *GIS.* Currently, the most widely used coordinate system is the UTM *(Universal Transverse Mercator) coordinate system.*

Analysis GIS In Mapping

Software GIS provides a variety of *GIS analysis menus*, including other buffer analysis, union (overlay), *intersection* (overlay), *network* (network) simple statistics and calculations (logical Boolean) other. Will but actually in a draft spatial (spatial), known with *spatial analysis*, there are many kinds. Spatial analysis includes map *overlay* , network, nearest neighbor, diffusion, distribution, trend. In essence, this spatial analysis is the interaction in and between spaces, both concerning similarities and differences.



Picture 2.6. Analysis on GIS

Source: Document City Government Pematangsiantar 2024

WebGIS

WebGIS is a development of *GIS* that can be accessed via the internet network, allowing users to access spatial data online, interactively, and in real time. *WebGIS* provides advantages in terms of information dissemination, data integration from various source, as well as efficiency in management And Updates data. According to Ridwan (2014), use platform like *Quantum GIS, MapServer,* And base data *MySQL* can utilized effectively in the development of road *WebGIS.*

GIS is defined as a computer system used to capture, store, examine, and display data that is linked to a specific position on the earth's surface. *GIS* can display various types of data on a single map, such as roads, buildings and plants. This expertise can help users to see, analyze, and understand patterns. And connection between data. A *GIS* consists of on a bunch component Which consists of on: 1. Data, both spatial and attribute data 2. Software, software used for entry and processing data 5. GIS professional, person Which involved in software and data collection GIS

4. Hardware, devices needed to record data and process GIS data 5. Organization, manager data And all component *GIS* 6. Output : analysis, report, search, decision making, planning and workflow management. The relationship between the GIS components above can be seen in the following image.

Picture 2.7. Relatedness between component on GIS Source: Pematangsiantar City Government Document 2024

In general, application *GIS* can present in two form that is desktop *GIS* And *Web GIS.* Desktop *GIS* is an application used to manage maps locally on one computer unit, for example with use software ArcMap, QGIS And etc. Whereas Web GIS is an application

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Which allow user manage map use web browser And all The data is sent and stored to a server located in the cloud (internet), so that the map can be accessed using just a browser, without the need to prepare other software[3]. The *GIS data* is stored on server can accessed through various interface like web, mobile, on line maps and desktop.

Stage Preparation

The initial stage is to prepare all resources and funding sources and the urgency of the mapping activity. In this preparation stage, several activities are carried out to support the smooth implementation of the activity, including:

- Mobilization Personnel
- Preparation of detailed work plans and mobilization plans for experts and surveyors, complete with details of tasks and outputs produced by each personnel.
- Study to approach Which used in carry out various activity which are included in the scope of activity implementation, as well as activity plans;
- Inventory of equipment requirements for implementing activities and compiling a checklist of data and information requirements and creating a data and interview checklist form.
- Collection of secondary data in the BPKD and related OPD environments along with Tabular Data containing information on road assets in Pematangsiantar City.

Stage Area Mapping

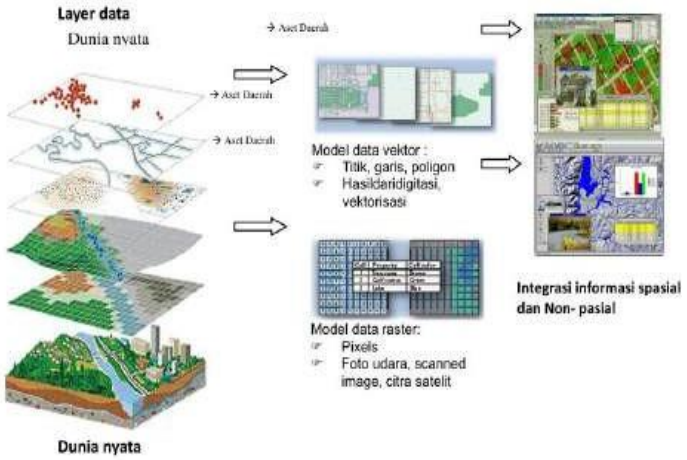
In stage mapping area done a number of activity Which support smooth implementation of activities, including: 1. Determination of Base Map Determination of base map is to agree on the type and source of base map that will be used as a reference for depicting maps in this activity in the form of Satellite Image Maps or Aerial Photos. Base maps can come from various sources, such as: *Google Satellite Maps* , Bing Map, Geospatial Information Agency (BIG), LAPAN, or from related agencies available such as Bappeda/PU. 2. Map Digitization - Base Map Digitization of Base Maps or carried out if the base map format is not yet in shp format, while other formats (such as *dwg, dxf, kml/kmz, gpx,* etc.) can be directly converted to in shp. If Maps Base the Already available in form shp format then what is done is to adjust it to the agreed Base Map to be used. 3. Desk study produces the process of overlaying base maps with regional asset maps.

Stage Survey Field

In stage survey to field done activities following: 1. Survey data secondary data to collect samples of regional asset data for Pematangsiantar City which will be loaded into *WebGIS* 2. Field survey Preparation for the field consists of preparing map field and map coverage region Which surveyed For survey regional asset samples to the field.

Stage Income and Compilation Data

In the data entry and compilation stage, the following activities are carried out: 1. Digitization Improvement (Advanced Digitization) Based on Field Survey Results Advanced digitization is carried out after obtaining field survey results to improve the location (coordinates) and geometric shape of regional assets. 2. Inputting regional asset data Inputting sample data of regional assets that have been surveyed and converting them into shp format.



Picture 2.7. Development *GIS* use *Waterfall* Model

Source: Document City Government Pematangsiantar 2024

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Stage Creation/Compilation WebGIS

GIS web development is a combination of web development and *GIS application development* , both of which have their own complexities. Therefore, in *GIS web development*, it is deemed necessary to adopt a separate methodology, which is more complete than the use of general software development methodologies such as waterfall or other approaches.

Picture 2.8. Architecture general application Web GIS

Source: Document City Government Pematangsiantar 2024

Database Road

Road database is a collection of information about road elements that are systematically arranged to support road management activities, such as planning, maintenance, and evaluation. Information in this database includes attributes such as road name, length, width, pavement condition, and type of treatment needed. Christifani and Ekkyauditya (2014) showed that road data management using *GIS* is able to provide a more accurate picture of environmental road conditions, which are then used for treatment recommendations based on the *PASER* Manual method.

Implementation WebGIS in Infrastructure Road

The implementation of *WebGIS* in road infrastructure management has proven to be effective, as shown by Jumaeroh (2019) in Sragen Regency who successfully monitored road equipment online, and Hasan (2018) in Manggarai Regency who utilized *ArcGIS* , *PostGIS* , And *Open Layers* For map interactive road And bridge. Mallombasi et al. (2020) also emphasized the importance of accurate road network data in supporting infrastructure planning. Application GIS itself process data spatial with merge data graphic and digital map-based attributes. Management can be done through various *tools* such as *ArcGIS, QGIS, MapInfo,* and others. In Pematangsiantar City, the Map application *GIS* Based Assets created use *ArcGIS* And *QuantumGIS* For manage And display data asset effectively.

The Gap Study

WebGIS implementation has been carried out in various regions in Indonesia, there are still few... study Which in a way special develop system This for City Pematangsiantar. The absence of an integrated *WebGIS- based system* for roads in this city is a research gap that needs to be filled, in order to support infrastructure planning that is based on spatial data and is dynamic.

Methodology Study

This study uses a quantitative descriptive method with a software engineering approach to develop a *WebGIS system* for road databases in Pematangsiantar City. The stages of the methodology include:

Data collection

- Primary: Survey field in the form of taking coordinate GPS, observation condition road, and visual documentation.
- Secondary: Data from agency related (Service PU and Layout Room) like map base, existing road network, and administrative data.

Digitalization and Processing Data

- Digitization And mapping network road use QGIS.
- Arrangement of road attributes (name, length, width, type, condition) into shapefile format (.shp).

Development Application *WebGIS*

- Base data spatial: *PostgreSQL + PostGIS*

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- Server map: *GeoServer/MapServer*
- Interface web: PHP and Leaflet.js
- Integration data: Shapefile from *QGIS* converted and uploaded to system *WebGIS.*

System Test

- Black Box Testing: For ensure feature walk in accordance function.
- UAT *(User Acceptance Test):* Involves technical and non-technical users to assess the usability and effectiveness of the system.

Outline Timetable Study

Month of Activities

Study literature, compilation proposals, coordination beginning with related agencies

Month 2 Primary and secondary data collection

Month 3 Digitization map, compilation attribute road

Month 4 Development database and backend *WebGIS*

Month 5 Development interface *WebGIS* and integration

Month 6 System testing and evaluation

Month 7 Finalization system, documentation, and reporting of results study

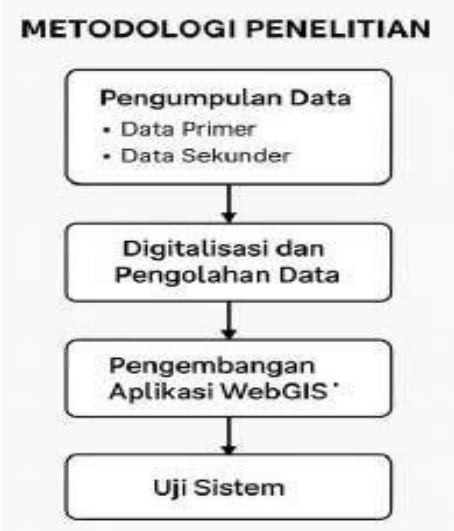

Diagram 1. Chart Flow Study

III. Results and Discussion

Visualization Data Road

Application *WebGIS* which developed for the City of Pematangsiantar able to display data network road in a way visual And interactive based on 8 subdistrict Which There is. City This located between 2°53'20"–3°01'00" N and 99°01'00"–99°06'35" E, is located in the middle of Simalungun Regency with an area of 79,971 km² at an altitude of 400–500 m above sea level. The largest sub-district is Siantar Sitalasari (23,723 km² or 28.41% of the total area). Administratively, the city borders directly on all sides with Simalungun Regency and consists of 8 sub-districts and 53 villages/sub-districts. Data the basis used in *WebGIS* development covering administrative boundary maps and road asset data.

Data Map

The Basic Data of the Regional Administrative Boundary Map from the Geospatial Information Agency (BIG) is used as the base map for the regional administrative boundaries. The data of the regional administrative boundary map is as follows. - Sub-district Administrative Boundaries

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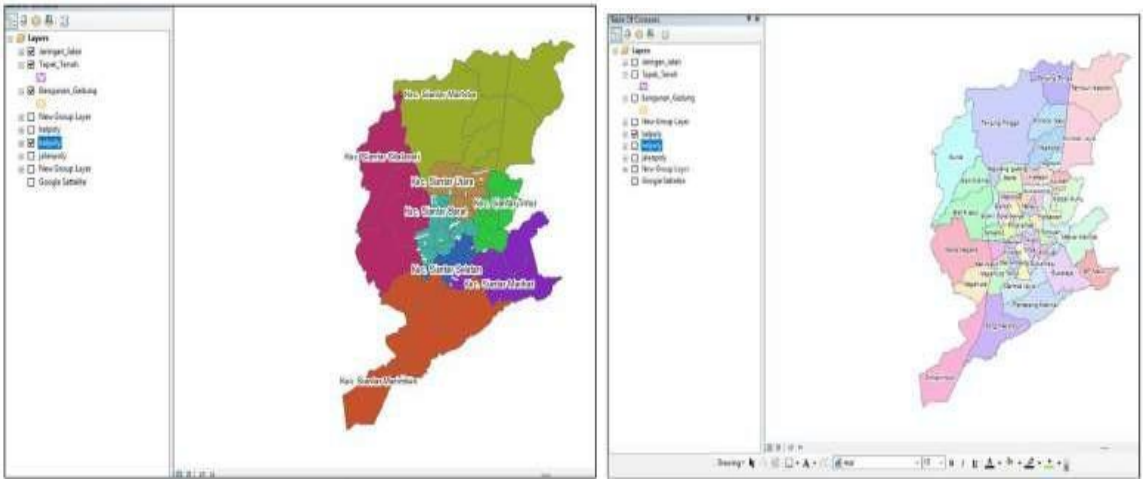
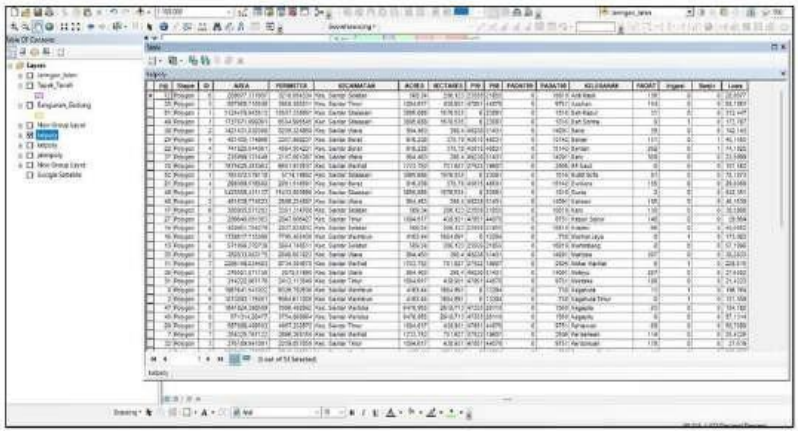


Picture 4.1. Limit Administration Subdistrict and Ward

Source: Document City Government Siantar 2024

Table 1. Data Attribute



Data Asset Road

Data Asset Which displayed on activity Compilation Database Road *WEBGIS* Based Pematangsiantar City in 2024 is a road asset. The road asset data is described in Table 4.1. and the following Maps.

Picture 4.2. Map Limit Administration City embankment Siantar

Source: Document City Government Pematangsiantar 2024

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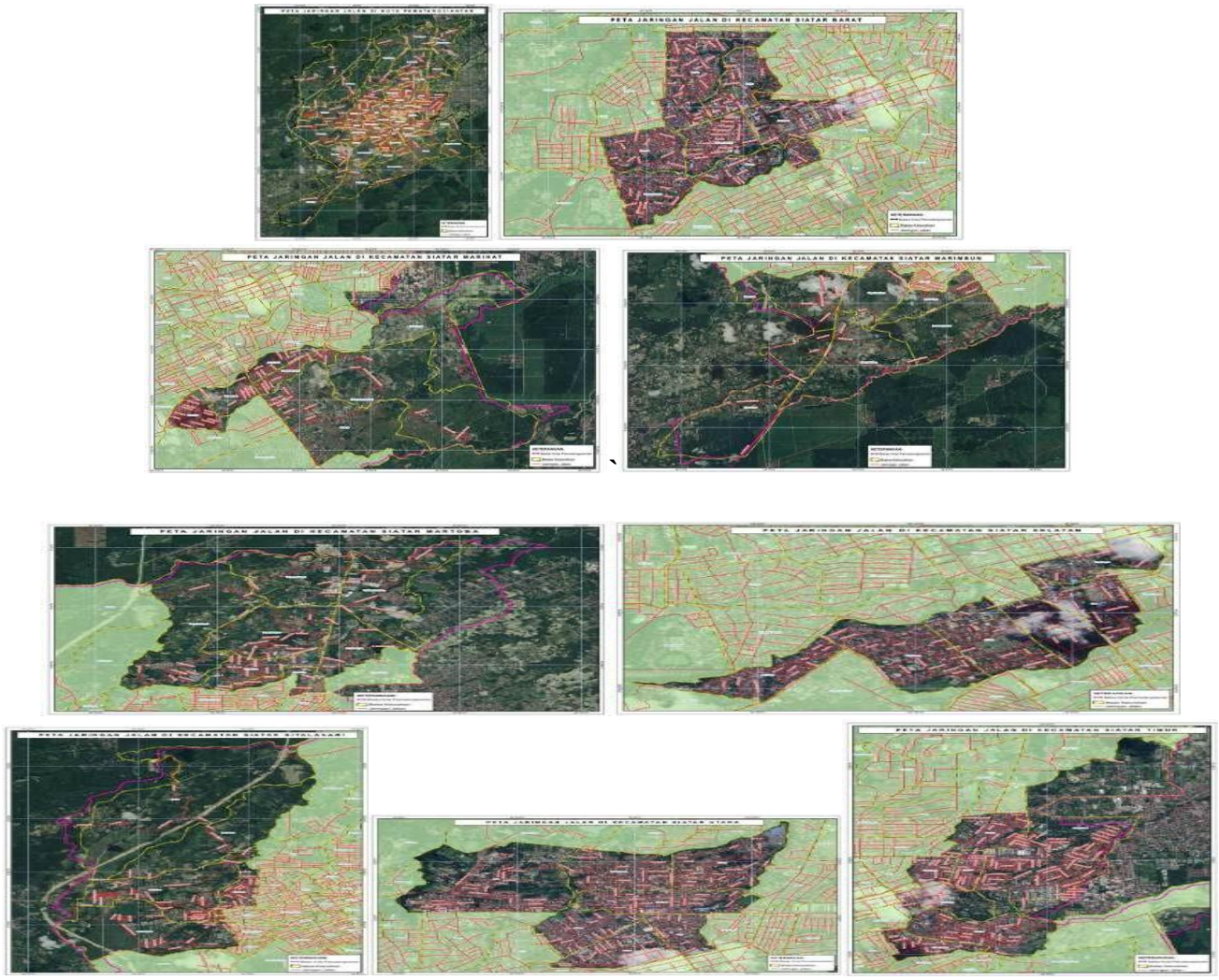
Table 2. Wide Region According to subdistrict in city Pematangsiantar

No.	Subdistrict	Wide Region (KM2)	Ratio To Total
1	Siantar Let's see	7,825	9.78
2	Siantar Marimbun	18,006	22.52
3	Siantar South	2.020	2.53
4	Siantar West	3.205	4.01
5	Siantar North	3,650	4.56
6	Siantar East	4520	5.65
7	Siantar Martoba	22723	22.54
8	Siantar Sitalasari		28.41
	Amount	**79,971**	**100.00**

Source: material Technical RTRW city Pematangsiantar

Following map network, the way on each subdistrict in Pematangsiantar



Picture 4.3. Map Network Road in City Pematangsiantar and map network West Siantar, Marihat, Marimbun, Martoba, South Siantar sub-district roads.

Source: Document City Government Pematangsiantar 2024

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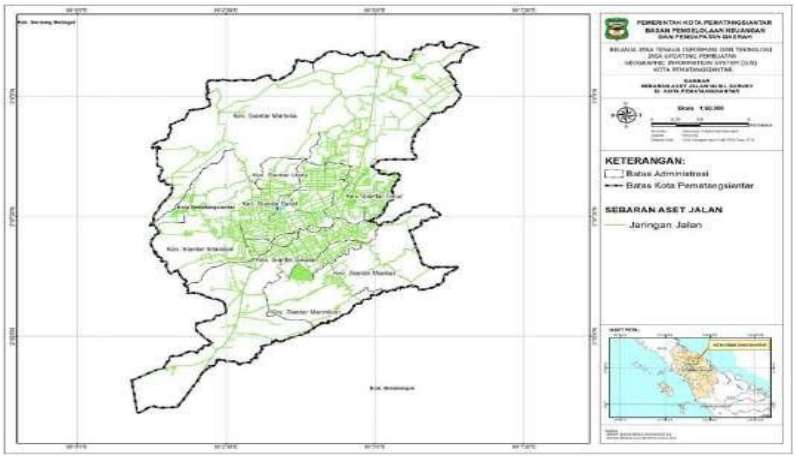
Results Mapping Road Assets

Based on the road asset data in Pematangsiatar City shown in the previous chapter, mapping was carried out by conducting a field review/survey, together with the BPKAD team, related OPDs, and the Sub-district and Village Parties, and holding a data validation meeting and location of road assets in the field and maps together with related OPDs in Pematangsiantar City. Which manage each asset road. Based on results mapping From this, a map of the distribution of road assets in Pematangsiantar City is obtained as shown in Table and Map following This.Based on results survey Also there is Lots section road Which new, Which the road section has not been included in the previous asset list table. The road assets were also mapped, so the results are described as follows.

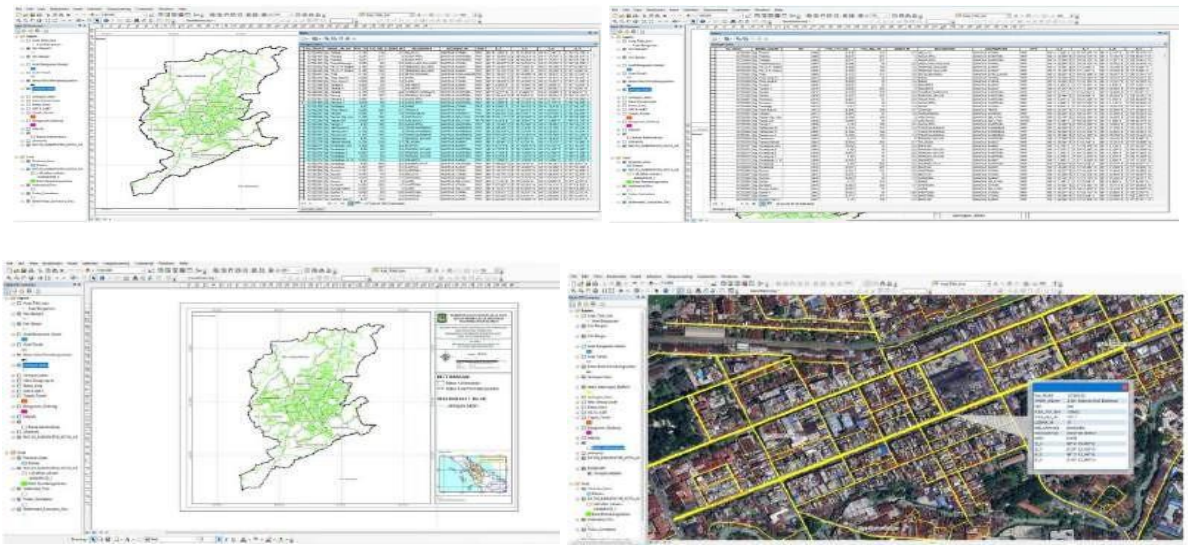


Picture 4.4. Map Distribution Road Assets

Source: Document City Government Pematangsiantar 2024

Application GIS And Design WebGIS Asset City Pematangsiantar

Application Map Asset Based on GIS City Pematangsiantar Application based on GIS (Geographic Information System) is a spatial data processing application using a computerized system by combining graphic data with object attribute data using a digital base map (basic map) of the earth's georeference. GIS data management can use various tools as programs to process GIS data such as *SAGA GIS, GRASS GIS, gvSIG, White box GAT, QGIS, Open Street Folder, OpenJUMP, ArcGIS Pro, ArcMAP, ArcGIS Desktop, QuantumGIS, Arcview, MapInfo* , And etc. Application Map Asset Based on Pematangsiantar City GIS was created using the ArcGIS/ArcMAP and QuantumGIS applications . the used as tools in process data GIS from data Asset City Pematangsiantar that has been processed. The appearance of the GIS-Based Asset Map application for Pematangsiantar City is shown in the following images.



Picture 4.5 Map Asset Based on GIS City of Pematangsiantar

Source: Document City Government Pematangsiantar 2024

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Format and Design WebGIS Asset City Pematangsiantar

Development *WebGIS* done use *GeoServer, PostgreSQL,* And library LeafletJS. This system is designed to present geospatial data interactively via the web.

LeafletJS is an open source JavaScript library used to build web-based maps. Developed by Vladimir Agafonkin since 2011, *LeafletJS* is lightweight, flexible, and supports a variety of desktop and mobile platforms. Even users without a GIS background can use LeafletJS to easily display web maps, as well as extend functionality through various plugins.

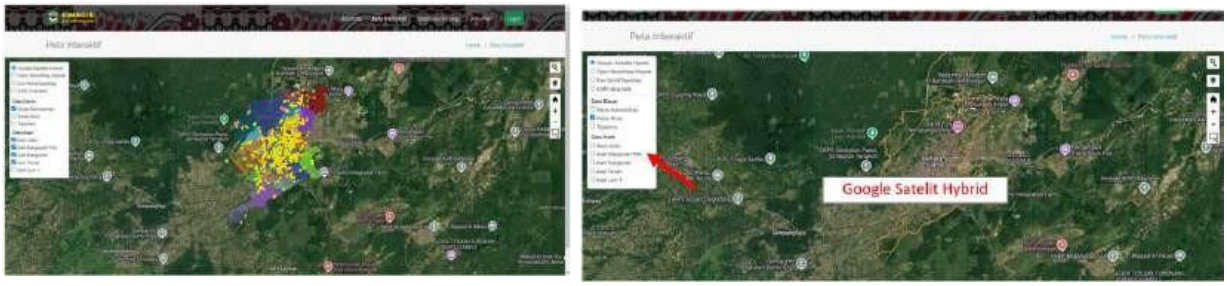
GeoServer is a Java-based *open source server* used to store, manage, And display data geospatial. GeoServer support various format and can be integrated with global mapping platforms such as *Google Earth, Bing Maps, and OpenLayers* , making it very effective in presenting spatial data online.

Design *WebGIS* Asset City Pematangsiantar

WebGIS Assets of Pematangsiantar City WebGIS assets of Pematangsiantar City that have been compiled will uploaded to website (domain) *WebGIS* City Pematangsiantar that is System Geographically Based Regional Asset Information (SIMAGIS) of Pematangsiantar City, with planned subdomain: https://simagis.pematangsiantar.go.id/ Pematangsiantar City *WebGIS* will be presented in the following description, while all coding for compiling Pematangsiantar City Asset *WebGIS will be presented in the attachment of this final report document. The appearance of the Pematangsiantar City WebGIS* homepage can be seen in Figure 4.6

Picture 4.6 Coding *WebGIS* Asset City Pematangsiantar

Source: Document City Government Pematangsiantar 2024



Picture 4.7 Page Appearance Map Interactive And appearance basemap

Source: Document City Government Pematangsiantar 2024

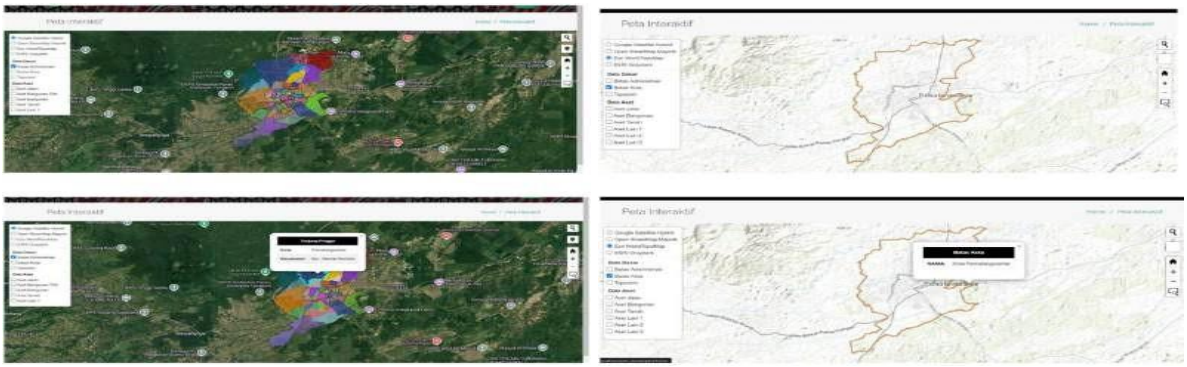


Figure 4.8 Limit Administration and city boundaries Source: Document City Government Pematangsiantar 2024

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VI. Conclusion and Suggestion

Conclusion

Development System WebGIS Based on Open Source

This research successfully developed a *WebGIS application* to map and present road asset data in Pematangsiantar City visually and interactively. The system was built using open source software such as *QGIS, PostgreSQL/PostGIS, GeoServer, and LeafletJS* which can be accessed via the web.

Utilization Data Spatial and Road Attributes

The primary and secondary data collected have been processed into a digital map that includes the network. road, attribute road (Name, long, type pavement, condition, etc.), as well as limit administrative area. This facilitates mapping and management of road assets by local governments.

Validation and Integration Data Field

Field survey activities with related OPDs showed that there were a number of new road sections that had not been recorded as assets. Mapping and validation were carried out to integrate the information into the *WebGIS system.*

Function Interactive and User Friendly *WebGIS*

WebGIS application provides interactive features such as wayfinding, spatial object identification, and layered display. System trials show that this application can be used by both technical (government agencies) and non-technical (general public) groups.

Implementation Going to SIMAGIS City of Pematangsiantar

This WebGIS is planned to be part of the Geographic-Based Regional Asset Information System (SIMAGIS) of Pematangsiantar City, thus supporting transparency and efficiency in managing regional assets.

Suggestion

Updates Data in General Periodic

Government area recommended for renew data asset road in a way routine through survey and direct integration into *WebGIS systems* to ensure the information displayed remains valid and relevant.

Training Users and Manager System

Required training for apparatus government area and operator technical so that able to manage, update, and utilize *WebGIS* systems optimally.

Development Module Addition

The WebGIS system can be further developed with additional modules, such as status information. law road, history repair, or integration with data budgeting and development planning.

Improvement Accessibility and Security System

For ensure system reliability, need to be prepared infrastructure the server that stable, and security access based on right user so that data No easy manipulated by party who are not authorized.

Collaboration Cross Agency

Required synergy cross agency and stakeholders interest so that management *WebGIS* No only become task One OPD, but become part from system information development area holistically

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