

WEB GIS FOR BUILDING CALCULATION AND URBAN LAND USE ANALYSIS TOOLS IN MALANG CITY WITH 3 DIMENSIONS VISUALIZATION

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ABSTRACT

Urban land use was defined as spatial structure and spatial pattern that was implemented in urban areas. The planning of urban land use is essential for the success of the good infrastructure development, according to its function, and has no negative impact to the environment. But often there are aberration in the utilization of land use, such as the building construction that is not suit with the function of its area, or urban land use change. There needs to involve the people in evaluating the urban land use, so the possibility of that incident can be reduced. Therefore, in this study will be built a geographic information system that can help to perform urban spatial analysis as a way to evaluate the current land use condition. The data used in this study are derived from Malang urban land use plan and building data on the Soekarno Hatta Street as sample data of the building. The data will be represented in 3-dimensional map visualization, then it will be integrated with the system to perform urban spatial analysis of Malang city. The result of this study is Geographic Information System website which can be accessed directly by the public and able to help people for performing spatial analysis of Malang city. The system is also capable of performing calculation of the buildings, so that will produce spatial information which can be useful in evaluating the urban land use of Malang. Development of this system was performed in several phase, there is data gathering, requirement analysis, system design phase, implementation, and system testing. To transform spatial data into information and then visualized in 3D can be done by maps digitizing, adding the tabular data, export to database, transform data into GeoJSON format, building height calculation and use the OSM Buildings library to display buildings data as 3D view. The result of functional testing in the system show that the tested function has met its specification and in the compatibility testing shows that the system is compatible with Mozilla Firefox, Google Chrome and Opera browser.

Keywords: Land use, building calculation, 3D visualization, GIS

1. Introduction

1.1. Background

Urban land use planning is a process for determining the spatial structure and pattern. This planning includes the preparation and establishment land use planning in urban areas [9]. In Indonesia (especially in Java island), there are many violations of land use regulation such as agricultural area is used for industrial purpose, residential, shopping centre, and others, which resulted in natural disasters such as floods and landslides in various areas [6].

Considering the importance of urban land use, it is necessary to control, evaluate and disclosure the information of land use planning and development. Not only the government could be involved, but also the people who actually feel the impact of the land use problem. Therefore, every person has the right to know the land use planning, for example, every people can ask and they should be given enough of information about the RUTR or general

planning of urban land use for evaluation purpose [6].

Geographic information system that can be accessed by public for building calculation and urban land use analysis tool becomes very important because in doing land use planning there must be involvement of people participation. This information system will use spatial data which has information of land use planning, buildings, land use zoning, and other land use information. Besides that, this system also need a function that make people can perform land use analysis as an effort to evaluate the current land use planning and performing selection of the buildings, so that infrastructure development can work well and suitable for designated purpose.

In a previous study to design a spatial information system that provides information related to the planning, utilization, and control of land use planning in settlement that

populated by 698 families [10]. However, these studies only examined a small settlement in then the presented data was focused in tabular view instead focus on land use or spatial data.

Malang have been selected for the case study because currently the local government like pays little attention to land use planning, for example there are many areas of green open space is transformed into residential areas and businesses, so now Malang is a city that is getting hot in the dry season and floods in the rainy season [5].

Based on the research background, the main problem in this research is to know whether it is possible to build an WebGIS prototype for building calculation and urban land use analysis tools in Malang city with 3-dimensional visualization. The main problem formulation can be lowered to the formulation of the problem in more detail as follows:

1. How to design and build web GIS for building calculation and urban land use analysis tool in Malang city with the 3-dimensional visualization?
2. How to convert the spatial data into information and then visualized in the form of 3-dimensional (the case study are buildings in urban area)?
3. How the testing result of the web GIS for building calculation and urban land use analysis tool in Malang city with the 3-dimensional visualization?

2. Literature Review

2.1 Urban Land Use

From the previous explanations, urban land use can be interpreted as the structure and pattern of spaces that are implemented in the urban area. This land use planning is very important in order to support the successful development of qualified infrastructure, according to its function, and no negative impact to the environment (earth). If there are violations in the utilization of land use such as agricultural area is used for industrial purpose, residential, shopping centre, and others, which resulted in natural disasters such as floods and landslides in various areas [6].

2.2 Leaflet

Leaflet is an open source javascript library to create WebGIS application. This library is very light and has 100KB in size. This library quite powerful to supports all standard requirments in the WebGIS development such as markers, buffers, GeoJSON, and others [1]. This library also has an active developer community, so there were many available

plugins that support to the development of WebGIS.

2.3 OSM Buildings

OSM Buildings is an open source library developed by Jan Marsch to visualize OpenStreetMap buildings in 3D using HTML5. Using HTML5 has the benefit that the library runs on most browsers, computer and mobile devices of today [4].

2.4 Spatial Analysis in Vector Data

Spatial analysis in vector data is divided in two type, there are single and multiple layer analysis. Both of them have different operation or method in processing the vector data that can be used according to the purpose of the analysis [3].

Operations or geoprocessing data by using a single vector layer include append, select and merge/dissolve. An overview of this data processing is illustrated in Figure 1 below.

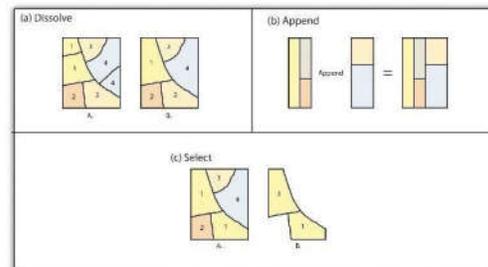


Figure 1. *Geoprocessing in Single Layer Analysis [3]*

Operations in vector data by using multiple layers, include union, intersect, simetrical difference, identify, clip, erase, and split. An overview of this data processing is illustrated in Figure 2 below.

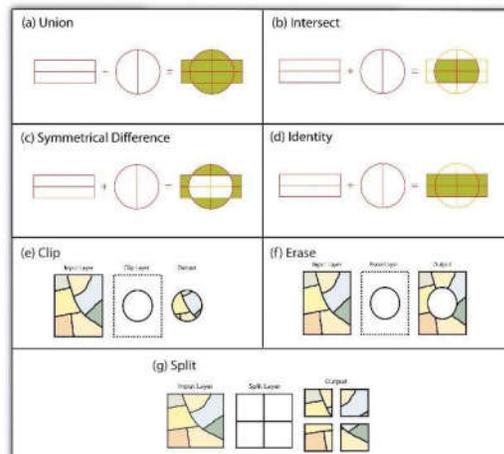


Figure 2. *Geoprocessing in Multiple Layer Analysis [3]*

This study will use one of geoprocessing method to perform analysis in multiple layers, that method is intersect. It will be used to analyze urban land use.

3. Research Metodology

3.1. Literature Study

Literature study was performed to gain knowledge about developing 3 dimensions building visualization from geospatial data. There also requires an understanding of how to perform analysis through leaflet. This study of literature is done by reading books, scientific journals and other sources.

3.2. Data collecting

Data collecting was performed in three ways, there are interview, observation and document study. Interview was performed to government official that related to existing urban land use condition. Observation was performed by taking data directly of building attributes at each sample location. Document study was performed to obtain documents that related with building attributes or land use planning. The form of data can be table or map as the spatial data. This data will take a process through Quantum GIS before can be use directly in the system.

3.3. System Development

The system development model that used in this study was waterfall model. All of step of this model is illustrated in Figure 3.

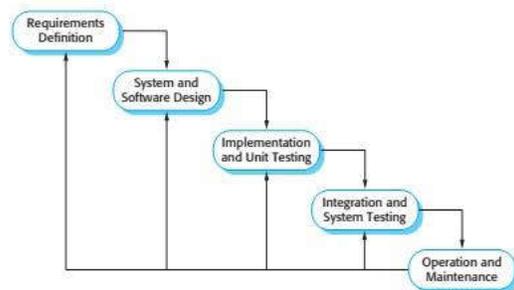


Figure 3. Waterfall Model Phases [7]

3.3.1. Requirement Definition

Requirement definition was performed by determining what requirements are needed for this system. These requirements include functional and non-functional system requirement.

3.3.2. System Design

System design is made to provide an overview of how this system will run. It will give a view of system architecture that being designed. This design includes the system usage, system process, database design, and interface design. The workflow architecture on this system can be seen in Figure 4.

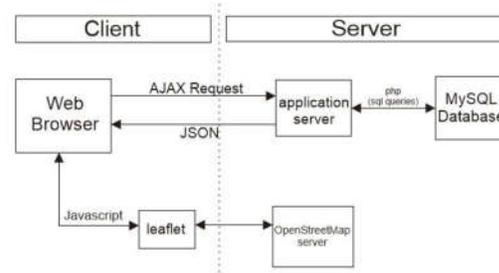


Figure 4. Workflow architecture design

3.3.3. Implementation

At this phase, the design from previous phase will be convert into the program code that can be understood by computers. Implementation of Web GIS is done by using the PHP programming language on the server side and some software/library that required in the development of this system.

3.3.4. System Testing

The system testing is done on purpose to show that the system has meet the requirement that have been defined as well as being able to run according to the required spesification. There are two test types were performed, there were functional testing using the blackbox technique and non-functional testing is done by testing the compatibility of system on some browsers.

3.4. Conclusion

Conclusion of all the phases that have been passed and suggestions with the achieved results. Conclusions drawn from the design phase until the analysis and testing of the system. Suggestions will be used to correct errors that are useful in further development.

4. Implementation

4.1. Implementation Environment

The hardware implementation environment that used is as follows:

- Intel Pentium CPU B960 @ 2.20GHz
- RAM 4.00 GB capacity
- Hardisk 500GB capacity
- Intel HD Graphic card
- Maximum resolution was 1366px x 768px

Whereas the software implementation environment are as follows:

- Windows 10 Pro 64bit.
- Xampp 1.8.3 & PHP 5.5.9
- MySQL 5.6.16
- Quantum GIS 2.12
- Mozilla Firefox 46.0
- Semantic-ui 2.1.7
- Leaflet 0.7.7
- OSMBuildings 0.2.2b

- i. Turf.js 0.15.0
- j. jQuery v1.11.1
- k. eChart v 2.1.10

In the process of implementation used Sublime Text 3 as the source code editor.

4.2. System Implementation

On the server side, the implementation begins with the digitalization process in the QGIS with a map data that has been obtained, then the result of digitization is exported to the MySQL database. Then the data will be converted into GeoJSON data through program code on the server. On the client side, the data which is received from the server in the GeoJSON or JSON form. Through the program code, data will be shown in map view with the help of leaflets. The building data will show back in 3D view with the help of OSM Buildings library. After that the function of spatial analysis and building selection can be implemented.

4.3. User Interface Implementation

User Interface Implementation that will be explained include home menu, land use analysis feature, building data editing, radius/rectangle selection tool and spatial pattern plan information.

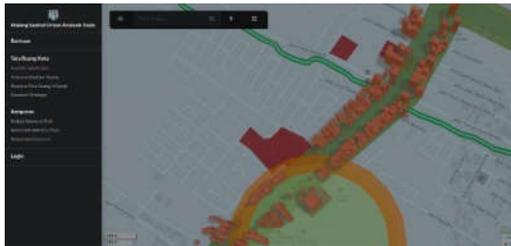


Figure 5. Home Menu

Home menu interface is an initial view from this system. This view displays all of the features that can be used by user.

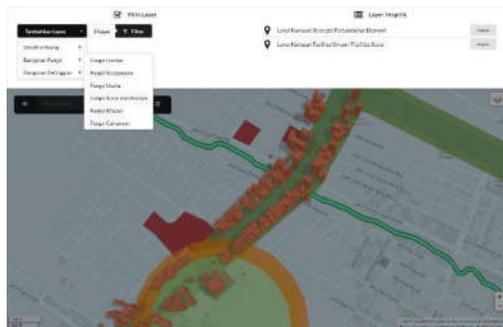


Figure 6. Land use analysis feature

Land use analysis feature is used to perform spatial analysis by utilizing one of the spatial analysis method, that is intersection. Users are asked to select some spatial layers to be analyzed and then press the filter button so the result of the intersection will be shown.



Figure 7. Building data editing

This feature is used for editing the building data in the system.



Figure 8. Radius/Rectangle Selection Tool

This tool is used for selecting buildings in radius or rectangle area that made by user. The result of this selection include numbers of selected buildings, wide of selection area, percentage of building by its function and the other spatial information.

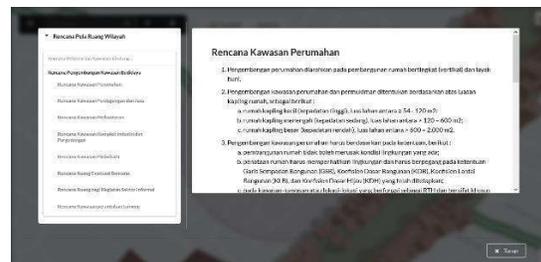


Figure 9. Spatial pattern plan information

This view will display information of spatial pattern plan in Malang city according to local regulation.

5. Testing

5.1 Functionality Testing Result

The testing was performed to 8 functional requirements with 14 test case. The result of this testing was 100% valid because the output of all test case appropriate with the expected results.

5.2 Compatibility Testing Result

This compatibility testing focuses on compatibility at the client side, such as the browser environment used. There are 4 types of browser being tested, Mozilla Firefox 46.0 version, Google Chrome 50.0 version, Opera 36.0 version, and Microsoft

Edge 25 version. Testing was performed by testing back every test case in functionality testing, and the assessment was determined by the results of the functionality and interfaces that appear on any functionality. The result of compatibility testing is shown in Table 5.1.

Table 5.1 Recapitulation of Compatibility Testing Result

Test Case	Test Result			
	Mozilla Firefox	Google Chrome	Opera	Microsoft Edge
PV-01	Valid	Valid	Valid	Not Valid
PV-02	Valid	Valid	Valid	Valid
PV-03	Valid	Valid	Valid	Not Valid
PV-04	Valid	Valid	Valid	Not Valid
PV-05	Valid	Valid	Valid	Not Valid
PV-06	Valid	Valid	Valid	Not Valid
PV-07	Valid	Valid	Valid	Not Valid
PV-08	Valid	Valid	Valid	Not Valid
PV-09	Valid	Valid	Valid	Valid
PV-10	Valid	Valid	Valid	Valid
PV-11	Valid	Valid	Valid	Valid
PV-12	Valid	Valid	Valid	Valid
PV-13	Valid	Valid	Valid	Not Valid
PV-14	Valid	Valid	Valid	Not Valid

From the test results in Table 5.1, it can be concluded that the system meets the non-functional requirements because it is compatible with the three browsers are Mozilla Firefox, Google Chrome and Opera, though the system is not compatible with Microsoft Edge.

6. Conclusion and Suggestion

6.1 Conclusion

Based on the development of the system that has been done in this study, it can be concluded as follows:

1. Designing and developing of WebGIS for building calculation and urban land use analysis tools is done through the following steps:
 - a. Collecting of data that required by the system either through interview, observation and document study. The data that required in the development of this system are spatial map of the city, a map of the building and building attributes (name, location, function and floor level)
 - b. The second phase is to determine the requirement. This phase is done by analyzing business processes, stakeholders, users,

functional and non- functional requirement, also describe the use case specifications of the system to be built.

- c. The third phase is designing the system to be built. This phase produces many system design model such as sequence diagram, class diagram, database design and user interface design.
 - d. The fourth phase is implementing the design from the previous phase by convert the design into program code. This implementation includes digitalization data, exporting data to MySQL, make geoJSON data form on the server, display the map, display the 3D building visualization, and implementing the land use analysis and building selection feature.
 - e. The last phase is system testing with *black-box* (validation testing) method and test the system compatibility to the client side environment (browser).
2. Converting the spatial data into information and then visualized in the form of three- dimensional (the case study are buildings in urban area), can be done in the following way:
 - a. Doing digitization in QGIS by drawing a vector map from the existing building map
 - b. Adding tabular data on each building feature (the results of digitization)
 - c. Export the digitization result to the MySQL database
 - d. Perform data retrieval from the database to the server and then converted into GeoJSON data form
 - e. Calculates height of the building (number of floors * 3 meters) and then inserted into the GeoJSON data form
 - f. Send the geoJSON data to the client and then displayed in 3D building vector that have a height accordance to the value of the "height" attribute in the geoJSON data form (with the help of OSM Building library)
 3. After perform the functionality testing with black-box method, this system met all of the functional requirements that have been set. The compatibility testing resulted that the system is capable of running all system functional properly on all browsers selected. However, in the Microsoft Edge browser, there's an error

on the user interface, this is because a CSS script that does not fit with the browser. It can be concluded that the system is compatible with Mozilla Firefox, Google Chrome and Opera, but is not compatible with the Microsoft Edge.

6.2 Suggestion

Suggestions are given for further research are:

1. The data used like building map and building attribute data should be newer data version, so the represented data will be more relevant with the current condition.
2. Add the building data sample, so the results of spatial analysis will be more general and not too specific to certain spatial pattern.
3. Rebuilding the system in a mobile version, so it can be used anytime when needed by the people.

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