Analysis of Road and Bridge Conditions by Utilizing WEBGIS Technology to Support The road and Bridge Maintenance Program in Indonesia

Y Afrizal
Information System Department, Universitas Komputer Indonesia, Indonesia
Email: yasmi.afrizal@email.unikom.ac.id

Abstract. The road is one of the land transportation infrastructures that serve to serve the movement of people and goods. Roads are said to be good if they are planned so that the safety and comfort elements of road users can be guaranteed well. Each region has its regional conditions and characteristics that can distinguish road maintenance needs between regions and others. The maintenance of roads and bridges depends on an analysis of the condition of the data from the objective survey results. The problem that often occurs is the lack of technical data on roads and bridges that is suitable for the field so that the analysis of road maintenance needs is difficult. The study used survey methods to collect technical data on roads and bridges in the area. The survey was carried out by tracking the road using GPS, where at every 100 m the length of the road was documented to determine the condition and type of the road surface. The results of the survey data accumulation are then processed in the WEBGIS application to find out the analysis and visualization of tracking, road conditions, and road surface types as information for managing road improvement. The application of WEBGIS is used to be able to describe the analysis and visualization of road maps quickly, accurately and online based on survey data. Survey documentation refers to the attribute data in Regulation of the Ministry of Public Works and Housing No. 25 year 2014. The results of WEBGIS are beneficial for stakeholders in Indonesia to obtain information on the actual conditions of roads and bridges so that the road maintenance program can be carried out on target.

1. Introduction
The condition of the road and bridge infrastructure that has been developed in Indonesia is undoubtedly experiencing a decrease in quality due to various factors that resulting in road damage. Almost every year, the central and regional governments allocate large budgets to improve road infrastructure. However, the number of damaged and repaired roads is still quite long. Poor road conditions and poor maintenance management have a vital effect on the quality of the land transportation system. One of the most felt is the disruption of the smooth flow of traffic or cause congestion; even worse can cause accidents.

The maintenance of roads and bridges depends on an analysis of the condition of the data from the objective survey results. The problem that often occurs is the lack of technical data on roads and bridges that is suitable for the field so that the analysis of road maintenance needs is complicated. GIS makes it easy for users to maintain roads [1]. The identification of road condition problems can be visualized with a map that explains real-time road data. WEBGIS is applying GIS in an online application that can partially support the analysis of road conditions [3]. Using WEBGIS, users integrate all spatial and tabular data for analysis according to their needs [2]. Many studies that use WEBGIS for road
maintenance analysis have been carried out in various countries [4-8]. However, in the case of most applications, it is limited to collecting and displaying road data. The analysis results are limited because it does not involve detailed information on each actual road section.

This study aims to apply WEBGIS, which can provide a visual analysis of roads and bridges in Indonesian based on detailed survey data so that the road maintenance program can be carried out on target. The study began by collecting technical data on roads and bridges in the region by the regulation of the Ministry of Public Works and Housing Indonesia [9]. The results of the collection were then processed in the WEBGIS application to obtain visualization of road tracking, road condition analysis, and road surface type analysis.

2. Method
The method to be used for analysis of road and bridge conditions by utilizing WEBGIS Technology as in Figure 1.

**2.1. Regulation and Literature Study**
Regulation and Literature study aims to obtain information related to the basic concepts of theory and literature exploration related to roads and bridges. This stage is the exploitation of related journals, interviews with stakeholders, and studying regulations on roads and bridges in Indonesia.

**2.2. Survey Methods**
The survey is a data collection technique in research with a quantitative descriptive strategy with the aim of disclosing the problem or the actual situation and providing facts in the field. The data collection is carried out by tracking the road using GPS and recording all observations to document road technical
data. The observation process serves to record the technical data of the road segments and the condition of the segment every 100 meters, accompanied by photos. The documentation refers to data attributes from The Ministry of Public Works and Housing [9], as shown in Table 1.

| No | Road Data               | Description                                      |
|----|-------------------------|--------------------------------------------------|
| 1  | Identity                | Segment Number                                   |
|    |                         | Name of Road Section                             |
|    |                         | Data Year                                        |
|    |                         | Status                                           |
|    |                         | Function                                         |
| 3  | Locations               | Regional Administration                          |
|    |                         | Identification Point                             |
|    |                         | Benchmark Code                                   |
|    |                         | Kilometers                                       |
| 4  | Condition Road          | Condition of Road                                |
|    |                         | Road stability                                   |
| 5  | Technical Data on Road  | Distance                                         |
|    |                         | Pavement Width                                  |
|    |                         | Daily traffic                                    |
|    |                         | Volume, Capacity, Ratio                         |
|    |                         | Road Type                                        |
|    |                         | Pavement Type                                   |
| 6  | Coordinates            | Starting Point Coordinates                       |
|    |                         | End Point Coordinates                            |

2.3 Analysis and Design
Analysis and design aim to identify, design, and develop WEBGIS applications. The design and development of WEBGIS applications for roads and bridges at this stage include software architecture, database design, and interfaces. WEBGIS application development utilizes the Maps API and spatial data from several sources to be developed into a system that provides information and services for users [10]. WEBGIS is part of a Geographic Information System, a system that processes spatial data into geo-referenced details [11]. The development of geographic information systems leads to online mapping.

2.4 Product Testing
The testing of the road and bridge software application that has been designed is done by entering the road and bridge database from the results of data collection in the field and doing the processing until the presentation of data and views that will be displayed in this software.

3. Results and Discussion
3.1 Survey Results
This study took a sample in one of the districts in Indonesia, namely Malawi regency, West Kalimantan. The number of road segments surveyed is based on the Decree of the Regent's road with many regency road sections totaling 208 sections spread across 7 Districts. Table 2 and Table 3 show the results of a survey conducted in September-November 2019, where the attributes of the collected road data refers to Table 1. Road conditions are classified as good, slightly damaged, moderately damaged, and heavily damaged. The steady-state is a combination of good, and the existing conditions and unstable conditions are a combination of moderate and severe damage.
Table 2. Results of Road Condition Survey of Each Road Section

| No | Section Of Road       | Distance (KM) | Condition Of The Road (KM) |
|----|-----------------------|---------------|----------------------------|
|    |                       |               | Good | Slightly Damaged | Moderately Damaged | Heavily Damaged |
| 001| Batu Buil – Beloyang  | 3,740         | 0,740 | 3,000            | -                 | -              |
| 002| Batu Nanta – Guhung   | 10,100        | 1,200 | -                | -                 | 8,900          |
| 003| Sp. Batu Buil - Batu Ampar | 8,250 | -     | -                | -                 | 8,250          |
| 004| Upit – Langan         | 8,600         | -     | 1,600            | -                 | 7,000          |
| 005| Langan - Balai Agas   | 21,580        | -     | 18,980           | 2,600             | -              |
| 006| Laman Bukit - Nanga Kayan | 23,000 | 0,200 | 3,500            | -                 | 17,000         |

In addition to collecting data on road conditions (Table 1), technical data in the form of road surface types are also carried out. This survey aims to determine each type of road surface pavement in the road section. Types of road surface pavement are categorized as Asphalt, Concrete, Soil, and Macadam. Table 3 shows the results of the survey types of road surface pavement.

Table 3. The Results Survey of Road Surface Pavement

| No | Section Of Road       | Distance (KM) | Width (Meters) | Type Of Surface (Km) |
|----|-----------------------|---------------|----------------|----------------------|
|    |                       |               |                | Asphalt | Concrete | Soil | Macadam |
| 001| Batu Buil – Beloyang  | 3,740         | 5              | -       | 0,740    | 3,000 | -       |
| 002| Batu Nanta – Guhung   | 10,100        | 5              | 0,600   | 0,600    | 8,900 | -       |
| 003| Sp. Batu Buil - Batu Ampar | 8,250 | 4,5            | -        | 8,250    | -     | -       |
| 004| Upit – Langan         | 8,600         | 5              | -       | 2,000    | 6,600 | -       |
| 005| Langan - Balai Agas   | 21,580        | 5              | -       | 21,58    | 0     | -       |
| 006| Laman Bukit - Nanga Kayan | 23,000 | 5              | 2,500   | 3,500    | 17,00 | -       |
| No Section | Section Of Road                  | Distance (Km) | Width (Meters) | Type Of Surface (Km) |
|------------|----------------------------------|---------------|----------------|---------------------|
| 007        | Spng Nasional - Tiong Keranjik   | 16,900        | 5              | Asphalt 3,000       |
|            |                                  |               |                | Concrete 13,90       |
|            |                                  |               |                | Soil 0              |
| 008        | Smpg Keberak - Smpg Ky Bunga     | 22,000        | 5              | -                   |
|            |                                  |               |                | Concrete 15,100      |
|            |                                  |               |                | Soil 6,900          |
| 009        | Sp. Jalan Nasional - Menunuk     | 2,500         | 4              | -                   |
|            |                                  |               |                | 1,600               |
|            |                                  |               |                | -                   |
| 010        | Smpg Polres - Smpg Tubung        | 2,400         | 6              | -                   |
|            |                                  |               |                | 0,400              |
|            |                                  |               |                | -                   |
| 011        | Smpg Tubung - Ds Nusa Penyikap   | 6,550         | 5              | -                   |
|            |                                  |               |                | -                   |
|            |                                  |               |                | 6,550              |
| 012        | Beloyang - Nanga Keberak         | 0,100         | 0,100          | -                   |
|            |                                  |               |                | -                   |
| 013        | Tiong Keranjik - Jungjung Permai | 6,600         | 5              | -                   |
|            |                                  |               |                | 6,600               |
|            |                                  |               |                | -                   |
| 014        | Junjung Permai - Upit            | 9,100         | 5              | -                   |
|            |                                  |               |                | -                   |
|            |                                  |               |                | 9,100              |
| 015        | Ng.Ella Hilir - Lengkong Nyadom  | 6,950         | 5              | -                   |
|            |                                  |               |                | 6,950              |
|            |                                  |               |                | -                   |
| 016        | Ng.Ella Hilir - Simp.Landau Mumbung | 15,850       | 5              | -                   |
|            |                                  |               |                | 1,100              |
|            |                                  |               |                | -                   |
| 017        | Nanga Kalan - Nanga Kempangai    | 20,300        | 4              | -                   |
|            |                                  |               |                | 20,300             |
|            |                                  |               |                | -                   |
| 018        | Ng.Kempangai - Kerangan Kora     | 8,000         | 4              | -                   |
|            |                                  |               |                | 8,000              |
|            |                                  |               |                | -                   |
| 019        | Kerangan Kora - Penyuguk         | 14,400        | 4              | -                   |
|            |                                  |               |                | 5,670              |
|            |                                  |               |                | -                   |
| 020        | Penyuguk - Bts. Kalteng          | 6,700         | 4              | -                   |
|            |                                  |               |                | 6,700              |
|            |                                  |               |                | -                   |
| 021        | Nanga Nuak - Ella Hulu           | 6,700         | -              | -                   |
|            |                                  |               |                | 0,300              |
|            |                                  |               |                | -                   |
| 022        | Sp. Ella Hilir - Sp. Logpon Sbk  | 7,680         | 4.5            | -                   |
|            |                                  |               |                | 7,000              |
|            |                                  |               |                | -                   |
| 023        | Nanga Kalan - Penyuguk           | 7,250         | 6.000          | -                   |
|            |                                  |               |                | 1,250              |
| 024        | Jalan Poros Desa Ella            | 3,100         | 5              | -                   |
|            |                                  |               |                | 1,000              |
|            |                                  |               |                | 1,600              |
|            |                                  |               |                | 0,500              |

3.2 Utility of WEBGIS Roads and bridges
The utility of WEBGIS Roads and bridges were developed based on a compilation of survey data based on existing road data in Table 2 and Table 3. The compilation of road and bridge data entered in the database to be processed produces an analysis of the condition of each road section. Figure 1 shows the visualization of the road map and photo conditions tracked in the survey.
The analysis of the table section on WEBGIS is used to check road conditions every 100 meters of road length. The main purpose of the analysis is the stakeholder table section in understanding the position of the road km that will be repaired if it is damaged. Figure 3 shows an analysis of the road conditions for each road section.

Figure 4 shows the technical data information and the condition of the bridge on the road section. The data and road conditions are starting from the name of the bridge, year, location, construction, and conditions. The bridge maintenance process is very dependent on the construction year and the condition of the bridge.
Figure 4. Technical Data and Bridge’s Condition

Strip map analysis is a table that carries road conditions at each particular period. There are two types of analysis that show as information in the table, namely road conditions and road surface types at every 50 m. The strip map results generated from the WEBGIS application can be seen in Figure 5.

Figure 5. Strip Map Analysis

The analyst aims the condition and type of road surface in the form of graph. Graphical presentation of each condition and road surface is displayed to find out the amount of damage. This information is important for stakeholders to prioritize the road to be repaired. Roads that have a high percentage of damage are the top priority for road maintenance. Figure 6 shows a graph containing the conditions and types of road surfaces on each road section.
4. Conclusion
WEBGIS was built to analyze road and bridge maintenance needs, where the information generated is the result of road and bridge conditions in real-time. This system is very useful to overcome weaknesses due to a lack of data on roads and bridges. The study began by conducting a survey to collect technical data and condition of the bridge road. The results of the data collection are then included in the WEBGIS that was built to get an analysis of road and bridge conditions. The information in the form of Section Table analysis, Bridge Data, Strip Map, and Statistical Analysis is the main output in the WEBGIS that was built. The purpose of the analysis is to assist stakeholders in determining the priority of maintenance carried out.

Acknowledgement
The author would like to thank INCITEST member who helped in preparing this document by providing a template format and the Ministry of Public Works and Housing Indonesian and Public Works Office Malawi regional; Dr. Sabrina, Aurangabad for his guidance, and advice which helped to improve the paper.

References
[1] Hu S 2012 Multimedia Mapping on the Internet Using Commercial APIs, Online Maps with APIs and Mapservices Springer pp 61–71
[2] Peng X and Wu X 2011 Digital Campus Map Publishing Based on Google Map API J. Geomat 35, pp. 25–27
[3] Rajeshkumar A, Shashikant P and Shashikant S 2017 Web-GIS based application for Utility Management System Journal of Geomatics, 11 pp 86-97
[4] Yusoff N M Shafri H Z and Muniandy R 2014 An effective road management system using web-based GIS software IOP Conference Series: Earth and Environmental Science 20
[5] Feng X and Quanwen L 2010 Development of Highway Management System Based WebGIS Proceedings of the WASE International Conference of Information Engineering (ICIE) pp 136-138
[6] Sitányiová D and Mužík J 2013 GIS Application For Managing And Maintaining Road Network In Ulaanbaatar Architecture Civil Engineering Environment – ACEE Journal 6 pp 61-68
[7] Habte B 2014 WEBGIS Application For The Management Of The Ethiopian Road Network System
[8] Kubota S Sugawara T, Kosawada T and Abe A 2011 Web GIS-based Information Portal System for Road Maintenance Proceedings of the 19th International Conference of Geoinformatics

[9] Ministry of Public Work and Housing Indonesia 2014 Regulation Ministry of Public Works and Housing No. 25 year 2014 Regarding Data Management And Geospatial Information Infrastructure

[10] Hu S and Dai T 2013 Online Map Application Development Using Google Maps API, SQL Database, and ASP.NET International Journal of Information and Communication Technology Research 03 p. 9.

[11] Singh PS, Chutia D, and Sudhakar S 2012 Development of a Web Based GIS Application for Spatial Natural Resources Information System Using Effective Open Source Software and Standards J. Geogr. Inf. Syst 03 pp. 261–266