Terbit *online* pada laman web jurnal : https://jes-tm.org/index.php/jestm/index

Journal of Engineering Science and Technology Management

| ISSN (Online) 2828 -7886 |

Article

Map of Enviromental Road Conditions in Lereng Village Kuok District Using GIS

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DOI: 10.31004/jestm.v5i2.336

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ARTICLE INFORMATION

Volume 5 Issue 1
Received: 17 December 2025
Accepted: 27 September 2025
Publish *Online*: 30 September 2025
Online: at https:JESTM.org/

Keywords

Mapping
Road
ArcGIS

A B S T R A C T

Roads are land transportation infrastructure that includes all parts of the road system, such as connecting structures, complementary buildings, and equipment intended for traffic activities on, above, and below the ground surface, including water surfaces, excluding railways, haul roads, and cable roads. This research aims to identify the condition of environmental roads in Lereng Village, Kuok District, and to produce a spatial distribution map of the environmental road network. The study applies a survey-based quantitative descriptive method, focusing on describing actual conditions and revealing factual problems found in the field. Primary data were obtained through direct field observations and measurements, while secondary data were collected from related institutions. Geographic Information Systems were selected as the main analytical tool due to their ability to manage spatially referenced data, process complex structures, and efficiently support decision making related to road infrastructure management. The results show that most environmental roads in Lereng Village are in damaged condition, dominated by potholes, longitudinal cracks, and surface deterioration. Several roads are classified as heavily damaged, including Transad Alley 1, Transad Road 2, and other local roads within the village area. These conditions reduce driving comfort and safety for road users and indicate the urgent need for improvement. The mapping results produce an environmental road condition map with priority scores ranging from 9 to 18. Roads with priority values greater than 7 are categorized as requiring routine maintenance, providing a basis for planning maintenance and rehabilitation programs.

1. Introduction

Road infrastructure constitutes a vital element in supporting community mobility, the movement of goods, and the economic growth of a region. As the main artery connecting areas, the functional condition of roads directly correlates with transportation efficiency and safety. However, along with an increase in traffic volume, climate changes, and the aging factor, road pavements are prone to deterioration, manifesting in various forms of damage.

Lereng Village, located in Kuok District, is a territory that possesses an environmental road network playing a crucial role in the residents' daily activities. The declining quality of these environmental roads can impede accessibility and potentially lead to economic losses and safety risks for road users. Historically, the assessment of road conditions has often been conducted visually and subjectively, which makes it challenging for local or village governments to accurately and efficiently determine the maintenance priority scale.

To overcome the problem of subjective assessment, a quantitative and standardized methodology is required. This study adopts the Pavement Condition Index (PCI) method, an internationally recognized numerical index for evaluating the condition of road pavements based on the type, severity level, and extent of the damage incurred. The PCI value provides objective and measurable data, making it a robust foundation for technical decision-making.

In addition to the quantitative measurement aspect, the need for comprehensive data visualization is also essential. Therefore, this research utilizes a Geographic Information System (GIS). The integration of PCI calculation results with GIS technology allows road condition data to be presented in a thematic map format, thereby facilitating the identification of critical damage locations, monitoring road status, and planning the allocation of maintenance budgets.

2. Literature Riview

2.1 Environmental Road

An environmental road is a public road with the specific function of serving local traffic, characterized by short-distance travel and low average speeds. This type of road connects centers of activity within residential areas and the road network inside the residential environment itself. By definition, a road is a land transportation infrastructure that includes all parts of the road, including its complementary structures, except for rail tracks, trolleys, and cables.

2.2 Classification of Road Damage

Damage to road pavement can be classified based on its type and severity level. According to Shahin (1994) as cited by Abdurrahman & Adawiyah (2019), several types of pavement damage include:

1. Alligator Cracking (Retak Kulit Buaya):
   Cracks that form a network of multi-sided fields (polygons) resembling an alligator's skin.
2. Rutting (Keriting):
   Damage in the form of waves or grooves that occur transversely across the road, generally found at locations where vehicles stop.
3. Depression (Amblas):
   A localized drop in the pavement surface layer, with or without cracks, whose depth is generally more than 2 cm and has the potential to hold water.
4. Edge Cracking (Cacat Tepi Perkerasan):
   Damage that occurs at the meeting point of the pavement edge and the earthen shoulder, distinguished into edge break or edge drop.
5. Joint Reflection Cracking (Retak Refleksi Sambungan):
   Damage that commonly occurs on the asphalt surface above an older pavement layer, with a crack pattern that is longitudinal, transverse, diagonal, or block-shaped.

2.3 Determination of Maitenance Priority Level

Road condition assessment is crucial for determining maintenance and repair activities. Based on the reference from the Directorate General of Highways (*Direktorat Jenderal Bina Marga*) (1990), the level of road service and the order of maintenance priority are established as follows:

Table 1. road service levels and maintenance priority order

Priority Order	Road Category	Service Level	Maitenance Program
0-3	Good Condition	Good	Improvement Program
4-6	Moderate	Good	Periodic

	Condition		Maintenance Program
>7	Lightly Damaged Condition	Not Good	Routine Maintenance Program

2.4 Geograpich Information System (GIS)

A Geographic Information System (GIS) is an organized system consisting of hardware, software, and geographic data that functions to store, correct, manipulate, analyze, and display all forms of information that are geographic or spatial in nature.

GIS is a very useful tool due to its capability to integrate database operations with unique visualization and analysis capabilities through mapping. In the context of environmental road networks, GIS is chosen because of its ability to process complex, geographically-based data structures efficiently, and to present spatial and attribute data to aid in quick and accurate decision-making processes. The software commonly used in this spatial data processing is ArcGIS.

3. Research Methodology

3.1 Types of research

This research used a survey method with a quantitative descriptive approach. This method aims to describe the actual condition of neighborhood roads based on direct field observations and then process the data into numbers and maps. The descriptive approach was used to explain the condition of road damage, while the quantitative approach was used to assess the level of damage and determine road maintenance priorities.

3.2 Research Location and Time

The research was conducted in Lereng Village, Kuok District, Kampar Regency, Riau Province. The study period lasted from March to June 2023, encompassing field surveys, data collection, data processing, and the preparation of road condition maps.

Figure 1. Research Location

3.3 Types of Research and Data Sources

The data used in this study consisted of primary and secondary data. Primary data were obtained through field surveys to identify the physical condition of neighborhood roads, including road length, width, pavement height, type of damage, extent of damage, and coordinates of road sections using GPS. Secondary data consisted of an administrative map of Lereng Village and satellite imagery obtained from Google Earth and SAS Planet as the basis for the mapping.

3.4 Data Processing and Analysis Techniques

Field survey data was processed using ArcGIS 10.8 software. The data processing steps included georeferencing satellite imagery, creating road network shapefiles, digitizing, and inputting road attribute data.

Road condition analysis was conducted using the road damage assessment method based on the Directorate General of Highways (1990) to obtain road condition scores and determine maintenance priorities. The analysis results were then presented in the form of a map of the condition and maintenance levels of the surrounding roads.

4. Results and Discussion

4.1 Existing Condition of Neighborhood Roads

Based on a field survey conducted in Lereng Village, Kuok District, an inventory was conducted of the road network spread across several hamlets, namely Sopang Hamlet, Lereng Hamlet, Transad Hamlet, and Sungai Deras Hamlet. A total of 56 road or alley sections were surveyed to determine the physical dimensions and condition of their pavement surfaces. Measurements were conducted manually using a digital push meter to obtain accurate data on length, width, and damage dimensions. As a representative sample, Transad Road has a length of 2,096 meters with an average width of 3.84 meters. This inventory data serves as a crucial attribute database before further damage level analysis is carried out.

Figure 2. Environmental Road Measurement

Existing conditions show significant variations in damage across these road sections. Damage indicators found in the field include potholes, patching, cracking, and depressions. On Transad Road, for example, the total road area is 8,384 m², of which nearly 42% is damaged. The predominant types of damage on this section are random surface cracks, gaping potholes, and the detachment of road material due to weakened asphalt binding capacity. These physical findings indicate a decline in the quality of road services that can compromise the comfort and safety of road users.

4.2 Road Condition Value Analysis (Bina Marga Method)

Quantitative analysis was conducted by referring to the Bina Marga regulations to assign a weight value to each type of damage. In the Transad Road case study, the average daily traffic (ADR) classification is in the range of 200–500 vehicles per day, which places it in Traffic Class 3. The physical condition assessment was carried out by assigning a number to the damage parameters. Random crack type damage was given a value of 4, with a crack width of more than 2 mm which was given a weight of 3. In addition, the measured rutting had a depth of between 6–10 mm, which was converted to a numerical value of 3.

The assessment continued on other parameters such as the total area of damage and surface roughness. Because the percentage of damage on Transad Road reached 42% (greater than 30%), the maximum score was given, namely 3 for the damage area parameter. Grain detachment (raveling) was also identified, which was given a score of 3, but no patches or subsidence damage were found, so that parameter was given a score of 0. The accumulation of all damage assessment numbers on Transad Road resulted in a total Road Condition Score of 5 points, which was obtained from the sum of the damage weights converted into a standard condition assessment scale.

4.3 Spatial Visualization and Digital Mapping (GIS)

The results of the road condition analysis were then visualized using a Geographic Information System (GIS) through ArcGIS software. This process began with capturing the coordinates of the road's origin and endpoint using a Garmin GPS and utilizing satellite imagery from SAS Planet and Google Earth as base maps. The tabular survey data (road length and damage type) was integrated with the spatial data through a digitization process, producing a shapefile (SHP) that geometrically represents the neighborhood's road network.

The resulting final map presents thematic information that is easily understood by decision-makers. In the map legend, yellow lines represent road sections requiring Routine Maintenance, while red dots indicate specific locations where physical damage has occurred. Furthermore, the map also differentiates road status, with red lines representing Primary/National Roads and green lines representing unpaved dirt roads. This visualization not only displays locations but also provides a comprehensive overview of the damage distribution within the Lereng Village area, allowing for efficient allocation of maintenance budgets to the areas most in need.

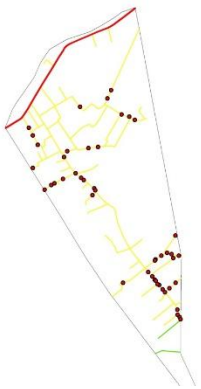

Figure 3. Final result of the Environmental Road Maintenance Level Map

5. Conclusion

Based on the results of the research and discussion carried out, it can be concluded that:

1. The condition of the neighborhood roads in Lereng Village is mostly damaged, with the most frequent being potholes and longitudinal cracks. Some of the roads in

Lereng Village are severely damaged, such as Gang Transad 1, Jalan Transad 2, and other roads in Lereng Village. These roads require repairs to ensure road users can drive comfortably.

2. The results of the neighborhood road mapping in Lereng Village produce a neighborhood road map with priority levels 9-18, where roads with priority levels above 7 are stated to be in the routine maintenance phase.

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