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Priority mapping for handling environmental road using GIS in Gerung District, West Lombok Regency

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Abstract. Improving road access is very important to support human activities. One is improving the quality of environmental roads in Gerung District, West Lombok Regency. However, priority handling is needed to make it with the fund availability that cannot cover the entire segment simultaneously. A Surface Distress Index (SDI) survey is used in this paper to determine priority handling. An SDI survey is a method to classify road damage based on the road surface condition. This paper intends to determine the number of environmental roads in Gerung District, to know the priority of handling with an SDI survey, and create a handling priority map using GIS. The results found that the number of environmental roads in Gerung District was 987 sections spread over 11 villages and three sub-districts. The classification of road conditions determines the handling priority of environmental roads: good, medium, lightly damaged, and heavily damaged. The number of routes based on this classification is 568 segments for good conditions, 131 segments for medium needs, 200 parts for lightly damaged, and 88 sections for heavily damaged conditions. In the map, each road segment is assigned with color identity according to its requirements and handling priorities using QGIS.

Keywords: environmental road, handling priority, SDI survey, QGIS.

1. Introduction

Road infrastructure is often linked with the development of a region. The link opens underdeveloped areas and triggers growth in developing areas [1]. The road is very commonly an infrastructure that supports people's daily activities and mobility. It connects one place to another, one area to another, and even one island to another. High and repeated traffic volume will decrease road quality. It impacts traffic flow safety, comfort, and smoothness [2]. It is necessary to improve road quality by improving the road surface layer and/or the road base layer.

The increase in population will make the expansion of housing and settlements. West Lombok Regency is one of the areas experiencing significant population growth. The development of land will also create new road access. The essential new access road that will form is the environmental road. It's a road with low average speed and short distance trips. Decreasing road quality will undoubtedly reduce the comfort and safety of road users. With limited funds to handle the environmental road quality improvement, it should have a valid handling priority.

Assessing the road handling priority needs various methods that can use. A Surface Distress Index (SDI) survey was used in this paper to decide on priority handling. SDI survey is a method to classify road damage based on the road surface condition. This method requires the surveyor to understand the concept of road damage based on experience and have good instincts in determining the damage in the field. SDI classified road damage by conducting actual surveys in the area. It's elementary both in reviewing and processing data. Furthermore, the priority of handling can be determined based on the classification of road damage resulting from field data processing.

A good presentation of data is required to make it easier to read and understand for people related to the field. The presentation of data is mostly done with graphs, tabulated s, and bar charts. Not a few also present data in the form of maps. A Map is a good alternative for presenting data. Various software can be used to create a map, and QGIS is one of them. QGIS is a commonly used Geospatial Information System (GIS) based software. This software is relatively easy to use, especially for beginners though. In addition, this software is freely accessible to the public, or it is not paid. It has been widely used in various scientific fields. For example, in the Health Sector, QGIS is used for mapping the distribution of various diseases; Telecommunications field QGIS is used for inventory of telecommunications networks and many more.

The revenue source of a regency is from taxes and regional levies. Improving the quality of the whole road at one time requires very large funds. Therefore, it is necessary to improve the quality of roads gradually. Therefore, this research aims to create a handling priority map using GIS. Handling priority map. Priority maps for road handling will make it easier for users to determine which roads will be repaired based on the level of damage. Therefore, improving the road quality will be more efficient and on target. In addition, this map can be used as a data bank to find out how many roads need to be handled.

2. Methods

This research was held on February 01 – July 31 2022, with Gerung District in West Lombok Regency as the study case location. Gerung is one of a district in West Lombok Regency, which consists of 11 villages and three sub-districts with an area of 62.29 km2. It's also the capital of West Lombok Regency. This makes Gerung an attraction for location studies, where the Capital District is still dominated by rural areas, and it's still under development status.

2.1. Field Data Collection

Preliminary research is needed on road surface conditions by conducting a visual survey by viewing and analyzing the road damage that occurs as a reference to rehabilitation and maintenance activities by the level and damage type [3]. This paper's field data were taken on all environmental roads in Gerung District. The tools used to support the implementation of activities include GPS, por meter, roller meter, SDI survey form and stationery. Then the data obtained include: tracking data, the condition of the existing road surface, and vertical alignment for every 50m length.

2.2. Data Processing

Processing data was held in 2 stages. The first step is determining the classification of environmental road segments using the SDI method. And then, based on the result of the first step, a map was made using QGIS software.

2.2.1 Surface Distress Index (SDI) Method

Directorate General of Highways developed methods to determine the maintenance type. The methods are based on visual observations. Surface Distress Index (SDI) is one of the methods by visual check on the crack's total area, the width average of the cracks, the number of holes, and the depth of vehicle ruts [4]. Furthermore, based on the inspection, it will be processed using the assessment standards that have been made by The Directorate General of Highways in Figure 1,

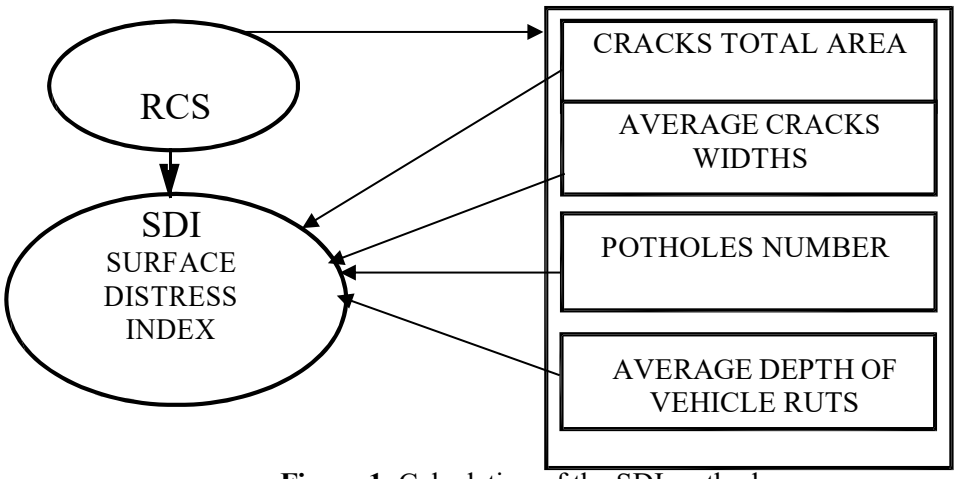

Figure 1. Calculation of the SDI method

SDI method has several types of damage, namely [5]:

a. Cracks

Cracks are a symptom of pavement surface damage. This crack will allow water to enter the layer below it and cause extensive/severe damage. Based on the shape of the cracks are divided into meanders, lines, blocks, crocodile skin and parabolas.

b. Potholes

This damage is shaped like a bowl that can accommodate and absorb water on the road shoulder. Potholes occur on the surface with poor drainage systems.

c. Rutting

This damage occurred in the trajectory of the wheels and is caused by excessive vehicle loads, causing vehicle ruts.

Standard road conditions in the Surface Distress Index (SDI) method can be seen in Table 1 below,

Table 1. Road conditions based on SDI value

No.	Road Conditions	SDI Value
1	Good	<50
2	Medium	50-100
3	Lightly Damage	100-150
4	Heavily Damage	>150

In getting the SDI value in surveying road conditions, four supporting elements are used: % of the crack area, average crack width, potholes number/km, and rut depth average [4], [6-7]. The calculation shown in Tables 2 to 5 is as follows:

Table 2. Valuation of crack area

No.	Crack Are Category	SDI[a] Value
1	None	-
2	< 10%	5
3	10% – 30%	20
4	> 30%	40

Table 3. Valuation of crack width

No.	Crack Width Category	SDI[b] Value
1	None	-
2	Fine < 1 mm	-
3	Medium 1 mm – 3 mm	-
4	Width >3 mm	SDI[a] Value *2

Table 4. Valuation of hole number

No.	Hole Number Category	SDI[c] Value
1	None	-
2	< 10/km	SDI[b] Value + 15
3	10/km – 50/km	SDI[b] Value + 75
4	>50/km	SDI[b] Value + 225

Table 5. Valuation of Rut Depth

No.	Rut Depth Category	SDI[d] Value
1	None	-
2	<1 cm depth	SDI[c] Value + 5 x 0,5
3	1 cm – 3 cm depth	SDI[c] Value + 5 x 2
4	>3 cm depth	SDI[c] Value + 5 x 4

2.2.2 QGIS Software

Today's development of information system software is no longer limited to tabular data processing, where data is stored in database tables managed by DBMS (database management system) software. Still, it has been developed for spatial or spatial data processing. [8].

GIS (Geographic Information System) is a system that presents images, analyses, and displays data based on the condition of the earth. GIS technology is very useful for various groups of people to explain events, plan strategies, and predict what will happen. [9].

GIS has several capabilities, including: [10-11]:

a. Data location mapping
   The actual location data on the earth's surface will be mapped into several layers, each representing a collection of objects that have similarities.
b. Quantity mapping
   GIS can map quantity, something to do with quantity, such as where is the most or which is the least. This is will make it easier to observe statistical data than ordinary databases.
c. Density mapping
   Density maps can change the form of concentration into units that are easier to understand and uniform. For example, dividing the area into 10 km2 wide squares using different colors to describe each density class will make it easier to read. Density mapping is very useful for large amounts of data, such as censuses or regional statistical data.
d. Change mapping
   By including time variables, GIS can be created for historical maps. This history can be used to predict future conditions and can also be used for policy evaluation. Mapping the storm's path can be used to predict where the storm will go.
e. Mapping What's Inside and Outside

An Area GIS is also used to monitor what is happening and what decisions will be made by mapping what is in and outside the area.

3. Result and Discussion

3.1 Research Location

This research was located in Gerung District in West Lombok regency. This district contains 11 villages and three sub-district. Gerung is the capital of West Lombok Regency, with 62,29 km^2 of area. And research location is shown in figure 2 as follows,

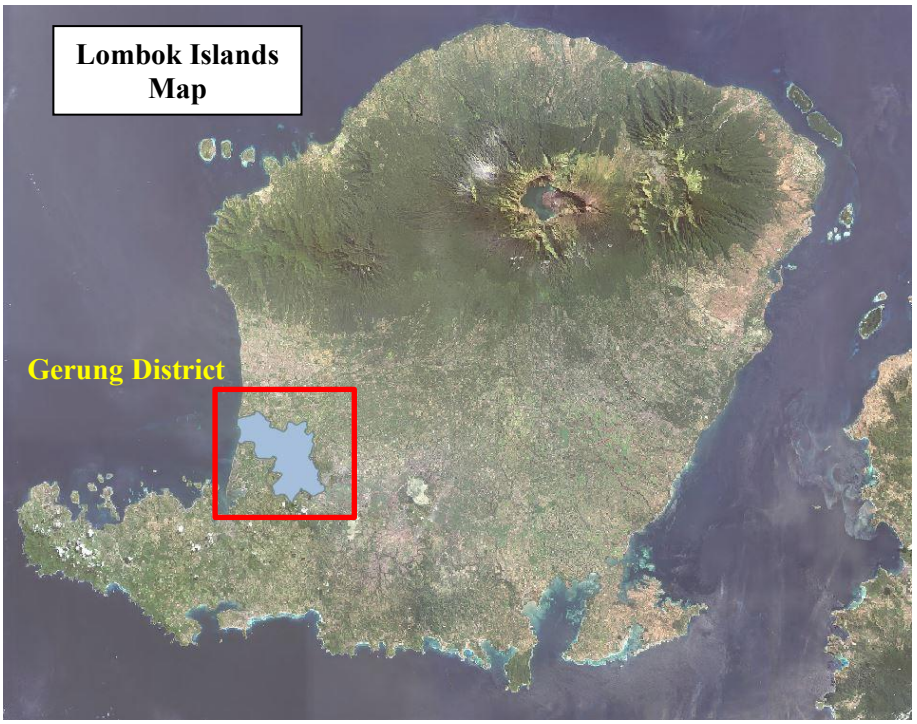

Figure 2. Research location

3.2 SDI Value

After obtaining survey and measurement data, data processing is held using the SDI method. The average value for the SDI value of environmental roads in the Gerung District is 65.01. Based on the classification of road conditions on SDI values ranging from 50-100, overall environmental roads in Gerung District are in **medium** condition.

The average SDI value for each village and sub-district is in Table 6 as follows:

Table 6. Environmental roads condition based on average SDI value

No.	Area Name	SDI Value	Average Condition
1	Mesanggok Village	89.96	Medium
2	Suka Makmur Village	63.69	Medium
3	Gapuk Village	48.38	Good
4	Taman Ayu Village	60.00	Medium
5	Kebon Ayu Village	40.98	Good
6	Banyu Urip Village	109.03	Lightly Damage
7	Tempos Village	77.92	Medium
8	Giri Tembesi Village	99.83	Medium
9	Babussalam Village	77.29	Medium

No.	Area Name	SDI Value	Average Condition
10	Beleka Village	20.19	Good
11	Dasan Tapen Village	26.48	Good
12	Gerung Selatan Sub-district	59.14	Medium
13	Gerung Utara Sub-district	69.25	Medium
14	Dasan Geres Sub-district	47.66	Good

Table 6 shows that from 14 review locations, there were 5 locations known as good conditions, 8 locations at medium conditions, and 1 location at lightly damaged conditions.

3.3 Mapping with QGIS

The components displayed on the map must be informative and clear, following map-making needs. In this paper, several main components are shown on the priority map for handling environmental roads as follows:

1. Region boundaries,
2. Environmental road network,
3. Primary road network,
4. River network,
5. Contour line,
6. Toponym,
7. Coloring the environmental road network according to field conditions.

The color gradation gives the environmental road network colors according to actual conditions. Yellow color for the good condition, orange for medium conditions; red for lightly damaged conditions; and maroon for heavily damaged condition. In this case, giving the color of the road network also pays attention to the colors for other components so that they can be seen clearly by making the priority map for handling this environmental road network. Furthermore, the environmental road network map can be seen in Figures 3 to 6 as follows,

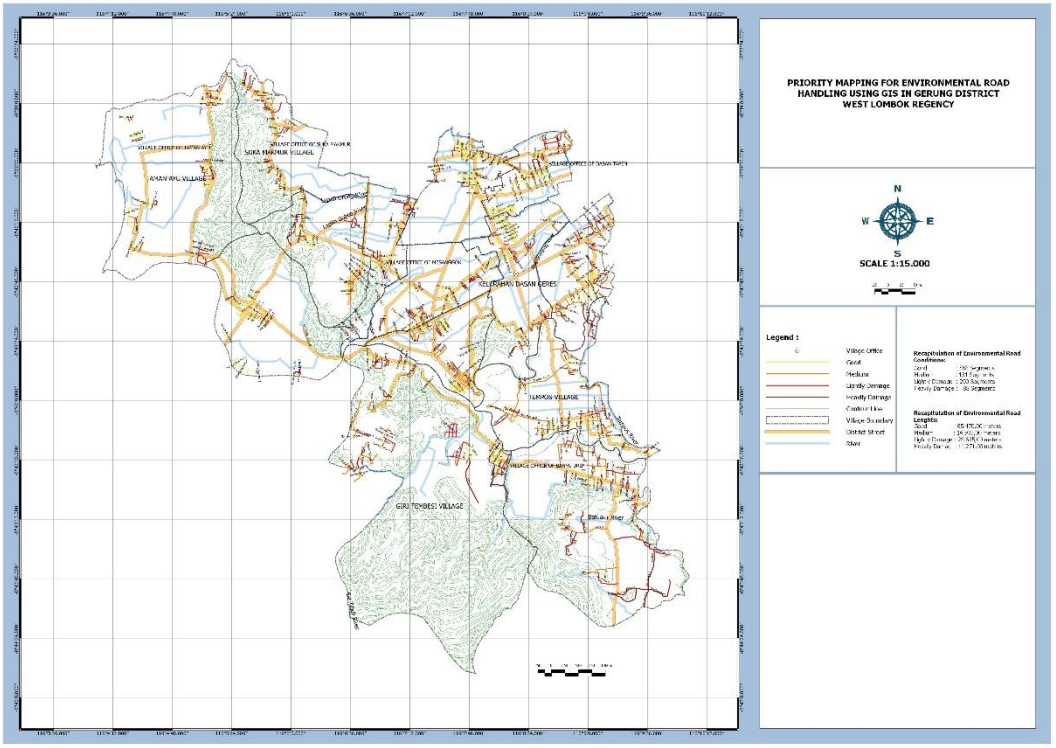

Figure 3. Priority map for handling environmental roads in Gerung District

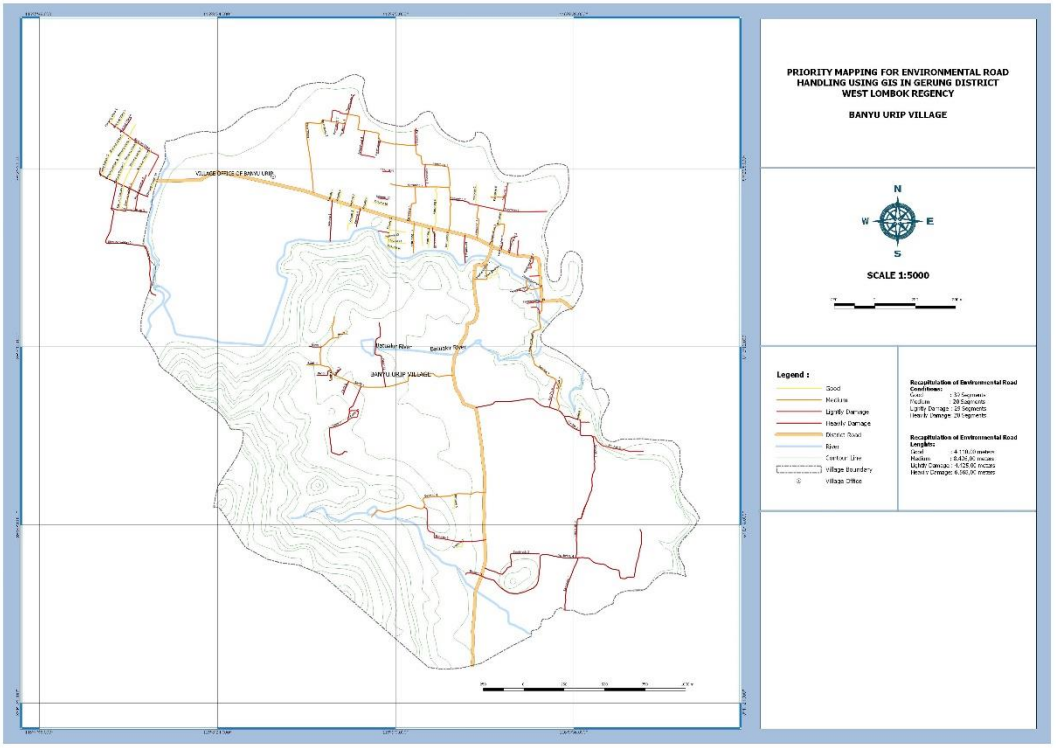

Figure 4. Priority map for handling environmental roads in Banyu Urip Village with average lightly damaged conditions

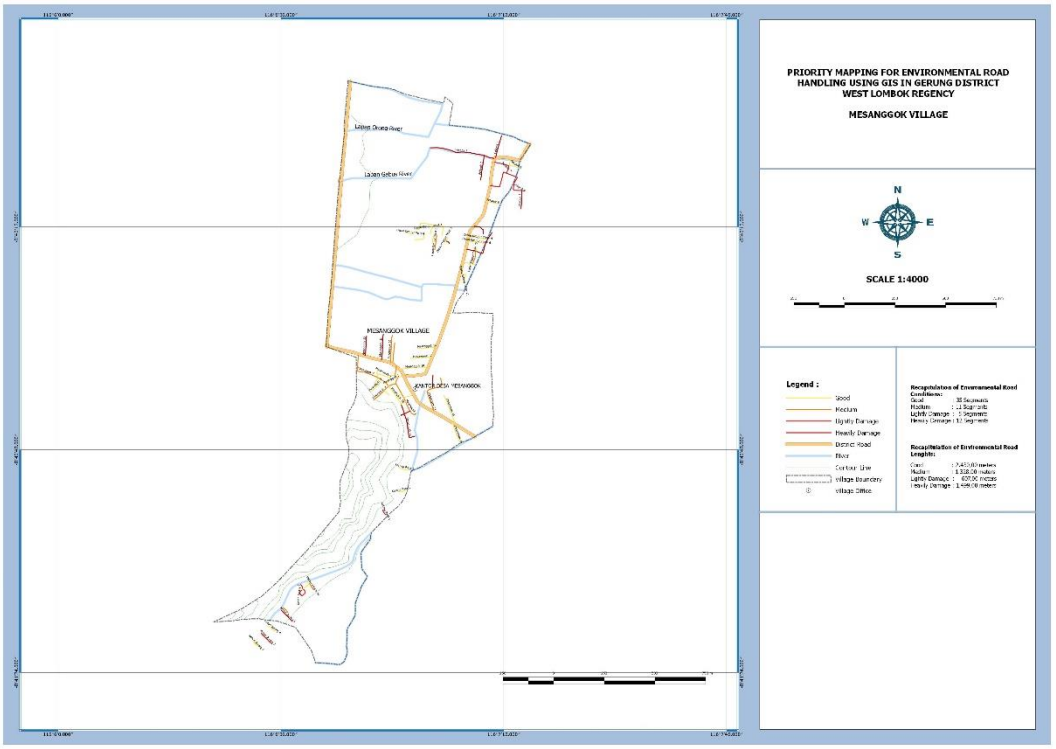

Figure 5. Priority map for handling environmental roads in Mesanggok Village with average medium conditions

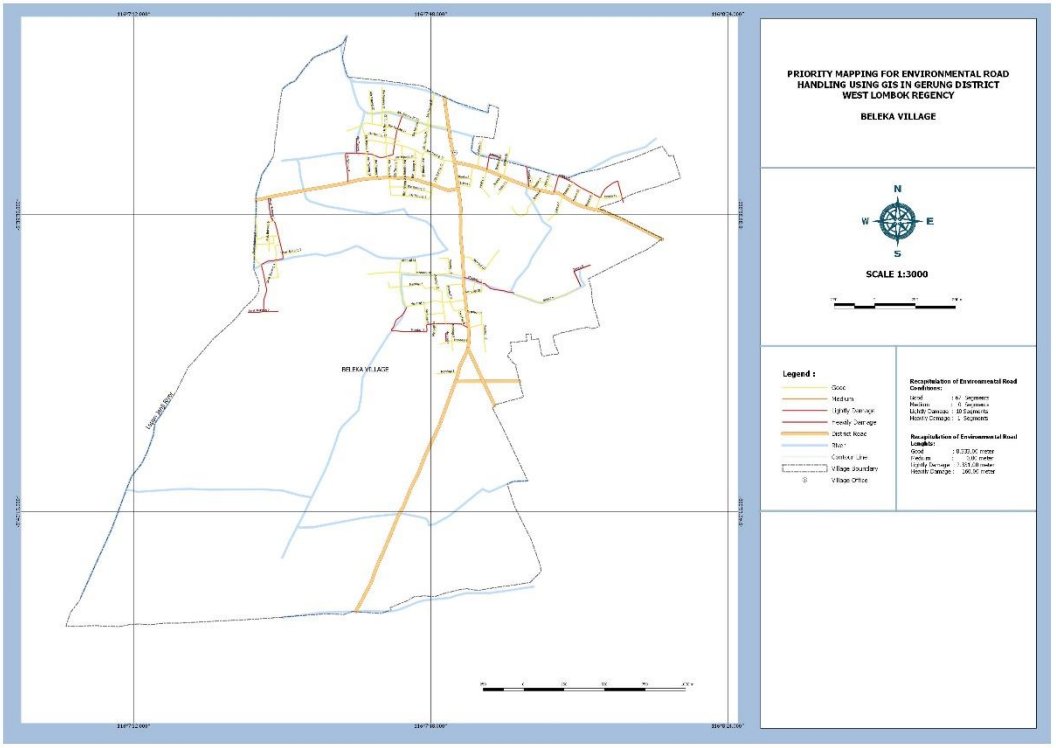

Figure 6. Priority map for handling environmental roads in Beleka Village with average good conditions

Based on Figures 3 to 6, it can be seen the condition of each road segment by referring to the color identity that has been given. The priority for handling environmental roads is roads with heavily damaged, lightly damaged, and medium. From the 987 identified roads, there were 568 segments with good condition, 131 segments in medium condition, 200 with light damage, and 88 with heavy damage. Based on the data above, the average condition of The Gerung district environmental road is medium**.** It has 88 heavily damaged and 200 lightly damaged segments to be a priority of handling (Figure 3).

Figure 4 shows that Banyu Urip village has an average lightly damaged condition of the environmental road. Banyu Urip has 108 total segments, and it contains 39 segments in good condition, 20 segments for medium conditions, 29 for lightly damaged, and 20 for heavily damaged conditions. Figure 5 shows that Mesanggok village has an average medium condition of environmental roads. Mesanggok has 63 total road segments, and it contains 35 segments in good conditions, 11 for medium conditions, 5 for lightly damaged, and 12 for heavily damaged conditions. And Figure 6 shows that Beleka village has an average good condition of the environmental road. Beleka has 77 total road segments; it contains 67 segments of good condition, 10 segments for lightly damaged, and one for heavily damaged condition.

From the previously described data, each road segment's condition is already known. To apply the priority of handling environmental roads, it can be done with two alternatives by adopting the presenting existing data, as follows:

1. Priority handling can be applied based on the condition level. In this case, priority handling will apply from the worst one. The worst condition in this paper is known as heavy damage condition. In other words, priority handling applied from the worst condition from all locations in Gerung district;
2. Priority handling can be applied based on the average condition of each sub-district and village in The Gerung district. According to Table 6, SDI value of each sub-district and village can be arranged from the highest to the lowest one to determine the priority of handling. SDI value is linear to the road surface condition. Because the higher SDI value is, the worst condition it's

going to be. The lowest SDI value is, then the road surface condition will be better. In another word, priority handling is applied from the average condition of each sub-district and village in The Gerung district.

Determination of color gradations in GIS is very useful to providing identity on the area, distribution area of a condition, or condition of a certain area and point. In F. Juniardi's (2014) research entitled Development of a Geographical Information System for Regency Transportation Infrastructure Kapuas Hulu Based on the WEB, a map is generated for all types of public transportation available in Kapuas Hulu District. Each type of transportation mode is given as a symbol and placed according to the point location. The map also gave different colors to the identity of each village and sub-district. In this paper, the use of color gradation determination is used to show the level of environmental road surface damage in each village and sub-district.

4. Conclusions

SDI method is quite easy to apply to determine the actual condition of road sections. It contains parameters that are easy to understand and used as a reference during field inspections. For environmental roads in Gerung District, there are 987 environmental roads identified with the following conditions: 568 segments with good conditions 131 segments with medium condition, 200 segments with lightly damaged, and 88 segments with heavily damaged.

Furthermore, Quantum GIS makes it very easy to create priority maps for environmental road management. Besides being free, this application also does not require high device specifications to run it. Facilitating the map reading, each road segment is assigned a color identity according to the conditions and priority of handling. The color identities are yellow for good condition, orange for medium condition, red for lightly damaged condition, and maroon for heavily damaged condition.

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