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Street Lighting Infrastructure Assessment Using Discriminant and GIS Method on Mount Merapi Evacuation Road

R P Izdihar[1], M Maryono[1], W Widjonarko[1], and S Rahayu[1]

[1]Department of Urban and Regional Planning, Diponegoro University, Semarang 50275,Indonesia

Email: rakanpramoe@gmail.com

Abstract. This research aims to assess street lighting infrastructure in rural-urban of Mount Merapi Evacuation road. Three evacuation road/corridor; Mriyan-Boyolali, Wonodoyo-Boyolali and Samiran-Boyolali are selected as case study. By using discriminant this study examine 6 variables namely type of lamp, physical component, height, time, power and cons consumption. In addition this study also using GIS method to assessing geographical feature as of previous result. According to the discriminant analysis, the characteristic of street lighting could be distinguished as two characteristic, while from the GIS assessment, the study found three characteristic of geographical street lighting feature.

Keywords: street lighting infrastructure, Mt. Merapi, evacuation road corridor

1. Introduction

Study concerning to street lighting infrastructure have been conducted worldwide. Many theme have been researched such as concerning to crime [1,2], accident [3,4] energy and efficiency [5,6], smart and intelligent system [7,8]. However, research associated toward evacuation and characteristic of corridor very limited. This study aims to assess the quality street lighting infrastructure in associated with preparedness of evacuation process in mount merapi hazard. Three corridor surrounding mount Merapi namely Mriyan-Boyolali, Wonodoyo-Boyolali and Samiran-Boyolali are selected as case study. In addition this study will explore the physical and management aspect. The physical variable such as type of lamp, physical component, height, time, power and cons consumption, while the management variable such as providing and maintenance system

2. Methods and Study Area

This research utilized discriminant method to analysis street lighting characteristic in the three corridors. This method is one of the powerful method to classify the characteristic of infrastructure, since many study have been conduct by using this method at least for 27 years. For example, study of infrastructure impact [9], study to define significant urban rail infrastructure [10], Moreover, this research utilized spatial method such as GIS to explore the spatial aspect between corridors. This study also assess the management aspect namely, providing and maintenance system, in associated with community concern in preparedness. Different with previous, for example, community concern in disaster waste [11], lava flow [12], vulnerability of infrastructure [13], this study utilized interview, simple FGD and observation method during data collection. Data characteristic classified by 6 variables for discriminant analysis and classification as three group for final assessment such as good, medium, and bad.

The study area covers 3 villages spread in 3 different sub-districts, namely Mriyan - Boyolali, wonodoyo - Boyolali, and Samiran- Boyolali. The three villages have geographical characteristic such as geographical slopes, classification of disaster prone area. The length of each corridor as follow (figure 1):

a. Mriyan Village - Boyolali City corridor has length : 12,672 km;
b. Wonodoyo Village - Boyolali City corridor has a length : 14,616 km;
c. Samiran Village - Boyolali City corridor has a length : 17,724 km

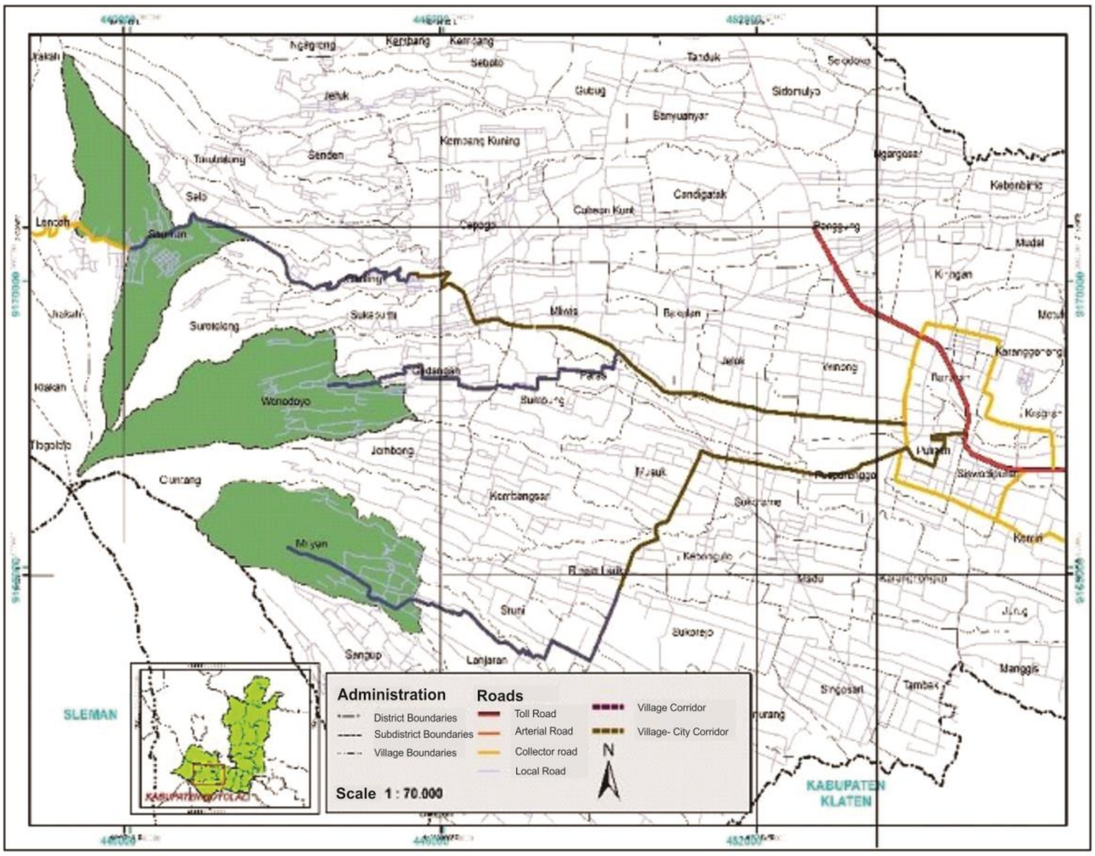


Figure 1. Study Area, Mriyan, Wonodoyo, Samiran Corridor

3. Result and Discussion

3.1. Physical Data and Characteristic of Street Lighting

Table 1. Description of Corridor, Sub Corridor, Number of Street Lighting, Average of Power and Time of Lighting in Study Area

Corridor	Sub corridors	Zone and classification of prone Area	Number of street lighting	Average of Power	Time of Lighting
Mriyan – Boyolali	Mriyan	Disaster Prone II	27 point	15 watt	12 hours
	Sruni	Disaster Prone II	13 point	15 watt	10 hours
	Ringinlarik	Disaster Prone III	16 point	20 watt	10 hours
	Musuk	Disaster Prone III	25 point	50 watt	12 hours
	Sukorame	Disaster Prone III	10 point	50 watt	10 hours
	Pusporenggo	Non – Disaster Prone	6 point	150 watt	10 hours
Lenght of corridor : 12, 672 km					
Wonodoyo – Boyolali	Wonodoyo	Disaster Prone II	17 point	15 watt	12 hours
	Gedanagan	Disaster Prone II	15 point	15 watt	12 hours
	Sambung	Disaster Prone III	20 point	20 watt	12 hours
	Paras	Disaster Prone III	9 point	50 watt	12 hours
	Jelok	Disaster Prone III	7 point	50 watt	10 hours
	Winong	Non – Disaster Prone	10 point	150 watt	10 hours
Lenght of corridor : 14, 616 km					
Samiran – Boyolali	Samiran	Disaster Prone II	10 point	15 watt	12 hours
	Selo	Disaster Prone II	10 point	15 watt	12 hours
	Genting	Disaster Prone III	15 point	20 watt	10 hours
	Mliwis	Disaster Prone III	10 point	50 watt	10 hours
	Winong	Non – Disaster Prone	10 point	150 watt	10 hours
Lenght of corridor : 17,724 km					

Source : Authors, 2017

As depicted in table 1, totally there are 17 sub corridor in with represent rural-urban region. The length of corridors are 17,724 km. The upstream corridors are dominated with area as classify for disaster prone II at while the downstream corridor are disaster prone III. Sub corridor of Mriyan and Wonodoyo are classify as rural zone, sub corridor of Sruni, Gedangan are classify as rural-urban, while Ringinlarik, Musuk Sukorame, Purporenggo, Sambung, Paras, Jelok, Winong, Samiran, Selo, Genting, Mliwis, Winong are classify urban zone [14]. The physical condition such as power of street lighting is diverse among 15-150 what. The highest power of street lighting in corridor of study area is 150 what while the highest is 150 what. The time of street lighting on tend to similar between 10-12 our per day.

Table 2. Description of Physical Characteristic of Street Lighting in Study Area

Physic			Sub Corridor and Area
Height	**Physical Component**	**Type of Lamp**	
Height of street lighting no more than 5 meters	In this areas, the physical material used for street lighting is still reasonable, for example made of wood / bamboo so that not good enough resilience	Flourescent Tube Lamp	Mriyan , Wonodoyo Samiran, Gedangan , Sambung Selo and Genting (sub corridor 1)
Quite varied, there street lighting which has a height of less than 5 meters, there is also 5 - 10 meters	In this area l-urban areas, the physical material of street lighting is good enough. Made of metal, has a lamp shield, so good enough resilience	SOX	Ringinlarik, Pusporenggo, Jelok, Mliwis, and Winong (sub corridor 2)
Cost & Energy			**Area**
Time of Lighting	**Power**	**Cost Consumption**	
The average time of street lighting lighting in the village area is for 12 hours / day.	P day : Average Power of lamp x Time of Lighting x street lighting Exist : 15 watt x 10 hours/ day x 177 street lighting : 26,550 watt/hour P month : P day x 30 days : 26,550 watt/hour x 30 : 796,500 watt/hour : 796. 5 kWh	Cost Analysis : P month x Electricity Rates : 796. 5 kWh x Rp 1,385.00 : Rp 1,103,152. 50	Mriyan, Wonodoyo Samiran, Gedangan, Sambung, Selo dan Genting (sub corridor 1)
The average time of street lighting lighting in the village area is for 10 hours / day.	P day : Average Power of lamp x Time of Lighting x street lighting Exist : 150 watt x 12 hours/ day x 53 street lighting : 95.400 watt/hour P month: P day x 30 daysi : 95,400 watt/hour x 30 : 2,862,000 watt/hour : 2,862 kWh	Cost Analysis : Cost Incurred : P month x Electricity Rates : 1,800 kWh x Rp 1,385.00 : Rp 3,963,870.00	Ringinlarik, Pusporenggo Village, Jelok, Mliwis, Winong (sub corridor 2)

Source : Authors, 2017

As depicted in table 2, Fluorescent Tube Lamp, is used in sub corridor of Mriyan, Wonodoyo, Samiran, Gedangan, Sambung, Selo and Genting. This is the sub corridors 1. In this areas, the physical material used for street lighting is still reasonable, for example made of wood / bamboo so that not good enough resilience. The height of the lamp in this area is no more than 5 meters. The average time of street lighting lighting in the village area is for 12 hours / day. The consumption of power estimated 796, 5 kWh per month with the cost of energy is IDR 1,103,152.50 per month.

In sub corridor 2 namely; Ringinlarik, Pusporenggo, Jelok, Mliwis, and Winong, type of lampt that used is SOX. In this area l-urban areas, the physical material of street lighting is good enough. Made of metal, has a lamp shield, so good enough resilience. The height of lamp is Quite varied, there PJU which has a height of less than 5 meters, there is also 5 – 10 meters. The average time of street lighting lighting in the village area is for 10 hours / day. Energy consumption per month estimated 2.862 kWh and cost of energy per month estimated IDR 3,963,870.00

According to the characteristic of physical of street lighting could be shown that there is a significant different between sub corridor 1 group of corridors Mriyan, Mriyan, Wonodoyo, Samiran, Gedangan, Sambung , Selo and Genting comparing to the physical characteristic of street lighting in sub corridors 2 group of corridors Ringinlarik, Pusporenggo, Jelok, Mliwis, and Winong.

3.2. Characteristic of Management System of Street Lighting

As depicted in table 3, In the sub corridor 1 as group of Mriyan, Wonodoyo, Samiran, Gedangan, Sambung, Selo and Genting, the providing system of street lighting is Community base. However the level of understanding toward energy efficiency is very limited. In sub corridor 2 as group of corridors Ringinlarik, Pusporenggo, Jelok, Mliwis, and Winong, they received support from the government. So in this sub corridors the role of community in providing and management system not dominant.

Table 3. Description of Management Characteristic of Street Lighting in Study Area

Provide And Maintenance		**Area**
Provide System	Management System	
- **Community based** - **The ability of the community is limited, so they need an assistance from goverment**	- Community based (People who pay their own electricity bills, and for lamp replacement by their self)	Mriyan, Wonodoyo, Samiran, Gedangan , Sambung, Selo dan Genting (sub corridor 1)
- Received a direct assistance from the goverment - The role of the community not dominant	- Rely on government assistance (both for electricity bills and cost maintenance)	Ringinlarik, Pusporenggo, Jelok , Mliwis, dan Winong (sub corridor 2)

Source : Authors, 2017

3.3. Discriminant Analysis

The discriminant analyis is used to understanding dominant faktor or variable in the clasification. The result of discriminant analysis is that the physical variable of lamp type is the most influential. The discriminant function according to sub corridor 1 and sub corridor 2 of this study are as follow:

Sub corridor 1 = -11,988 – 8,673 X1 + 0,332 X2,
Sub corridor 2 = -4,895 – 2,525 X1 + 0,139 X2

Tabel 4. Variables in the Analysis

Step		Tolerance	Sig. of F to Remove
1	Type of Lamp	1,000	,000

Source : Authors, 2017

Tabel 5. Eigenvalues

Function	Eigenvalue	% of Variance	Cumulativ e %	Canonical Correlation
1	3,694[a]	100,0	100,0	,887

Source : Authors, 2017

Tabel 6. Structure Matrix

	Function 1
type_lamp	1,000
height_street lighting[a]	,594
cost[a]	,456
power_consumption[a]	,456
time_lighting[a]	-,382
ketersediaan[a]	,071

Source : Authors, 2017

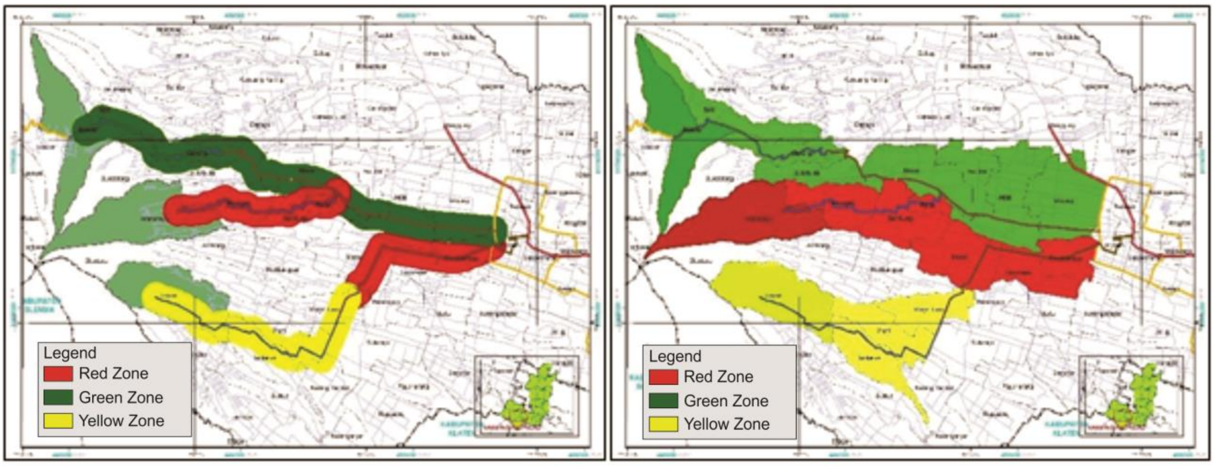
3.4. GIS analysis of Street Lighting

The GIS analysis the overall quality of street lighting. The result of assessment by using scoring system. The street lighting quality of sub corridor of Musuk Pusporenggo Sukorame Wonodoyo, Paras, Sumbung, and Gedangan is less quality. Sub corridor of Mriyan, Sruni, Lanjaran, and Ringinlarik is moderate quality. And the sub corridor of Samiran, Selo Genting, Mliwis, Manyaran, Sukabumi, Bakulan, Bolo, Jelok Village, Winong the street lighting quality is good.

Tabel 7. Street Lighting Quality

	Red Zone	***Yellow Zone***	***Green Zone***
Quality	That is a corridor which has Public Street Lighting with less quality	That is a corridor which has Public Street Lighting with medium quality	That is a corridor which has Public Street Lighting with good quality
Sub corridors	Musuk Pusporenggo Sukorame Wonodoyo Paras, Sumbung, and Gedangan	Mriyan, Sruni, Lanjaran , and Ringinlarik	Samiran, Selo Genting, Mliwis, Manyaran, Sukabumi, Bakulan, Bolo, Jelok Village, Winong

Source : Authors, 2017



Source : Authors, 2017

Figure 2. Assesment Based on Discriminant and GIS Aplication

4. Conclusions

The study have been Analysis Street lighting characteristic as follow:

a. Two characteristic of street lighting with the model could be distinguished by using discriminant parametric model:
   1) Sub corridor 1 = -11,988 – 8,673 X1 + 0,332 X2
   2) Sub corridor 2 = - 4,895 – 2,525 X1 + 0,139 X2

   With the Group of sub corridor 1 are Mriyan, Wonodoyo, Samiran, Gedangan, Sambung, Selo and Genting and Group of sub corridor 2 are Ringinlarik, Pusporenggo, Jelok, Mliwis, and Winong.

b. Three characteristic of geographical feature of street lighting are
   1) Sub corridor with less quality of street lighting quality at Musuk Pusporenggo Sukorame Wonodoyo, Paras, Sumbung, and Gedangan is less quality.

2) Sub corridor with moderate of street lighting quality at Mriyan, Sruni, Lanjaran , and Ringinlarik is.
3) sub corridor with good quality of street lighting at Samiran, Selo Genting, Mliwis, Manyaran, Sukabumi, Bakulan, Bolo, Jelok Village, Winong

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