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Research Article

Risk Level Analysis of Lightning Strike with Simple Additive Weighting Method in Gowa Region

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Abstract

Gowa regency is one of the areas in the province of South Sulawesi that has a high potential of lightning events. This is influenced by its geographical location which is close to the mountainous area. This research purpose to analyze the risk level of lightning strike hazard in Gowa regency using Simple Additive Weighting (SAW) method. This research uses lightning strike data from lightning detector boltek sensor recorded by LD2000 software. The data used is event data in 2015 with sensor coordinates of 5.218° S and 119.470° E and using a density grid of 0.01°. The results for Gowa district have a total density of 26797 strikes/kilometers with clustered areas are Tinggi Moncong subdistricts and Bungaya subdistricts which each have a density value of 10443 strikes/kilometers and 5197 strikes/kilometers. The results of this study are expected to represent the level of lightning vulnerability as a reference for making adequate grounding system in areas with high lightning activity in Gowa regency.
Keywords: *lightning, Simple Additive Weighting, vulnerability, level of hazard risk*

Analisa Tingkat Kerawanan Petir Menggunakan Metode Simple Additive Weighting di Wilayah Kabupaten Gowa

Abstrak

Kabupaten Gowa merupakan salah satu wilayah di provinsi Sulawesi Selatan yang memiliki potensi kejadian petir yang cukup tinggi. Hal ini dipengaruhi oleh letak geografisnya yang berada dekat dengan wilayah pegunungan. Penelitian ini bertujuan untuk menganalisis tingkat resiko bahaya sambaran petir pada wilayah kabupaten Gowa dengan menggunakan metode Simple Additive Weighting (SAW). Penelitian ini menggunakan data sambaran petir dari sensor lightning detector boltek yang direkam oleh software LD2000. Data yang digunakan adalah data event pada tahun 2015 dengan kordinat sensor 5.218° LS dan 119.470° BT serta menggunakan grid kerapatan sebesar 0.01°. Didapatkan hasil untuk kabupaten Gowa memiliki jumlah kerapatan sebesar 26797 sambaran/kilometer dengan daerah terawan adalah kecamatan Tinggi Moncong dan kecamatan Bungaya yang masing-masing memiliki nilai kerapatan sebesar 10443 sambaran/kilometer dan 5197 sambaran/kilometer. Hasil penelitian ini diharapkan dapat merepresentasikan tingkat kerawanan petir sebagai acuan pembuatan sistem grounding yang memadai pada wilayah dengan aktivitas petir yang tinggi di kabupaten Gowa.
Kata Kunci: *petir, Simple Additive Weighting, kerawanan, tingkat resiko bahaya*

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I. INTRODUCTION

Lightning is a process of discharging an electrical charge from a charged cloud that is in the atmosphere [1]. Lightning usually occurs when it rains, but that does not mean when the rain will always be accompanied by lightning. Lightning only happen when there is Cumulonimbus cloud (Cb) [2]. Lightning happens because of the potential difference between the two mediums [3]. In this case the two mediums are between clouds and the earth or clouds with clouds. Under normal weather conditions the potential difference between the earth's surface and the ionosphere is about 200.000 to 500.00 volts, with a current density of about $2x10^{-12}$Ampere/m^2[4].

Lightning can be classified into several types. Based on [5] process lightning can be divided into 4 types of lightning ground cloud to ground (CG), lightning inner cloud (IC), lightning cloud to cloud (CC), and cloud to air (CA). Among the four types of lightning is the type of lightning cloud to ground [6] is the most dangerous and destructive type of lightning because it has a single stroke with energy millions of volts.

The release of the charge that leads to a particular object is called lightning strike. Lightning strike can make damage to the object that was struck and could potentially make a victim. The degree of vulnerability of the lightning strike region is closely related to the number of population densities [7]. The more densely populated the more vulnerable the region to lightning strikes [8]. According to population census data of 2011, 2012, and 2013 conducted by Badan Pusat Statistik (BPS) of Gowa Regency there is an increase of population [9] in Gowa district of 659.513 people, 670.465 soul, and 691.309 inhabitants. This indicates an increase in the number of people each year. In addition to the amount of population density, the level of lightning in the district of Gowa is also influenced by the growth of infrastructure that is actively developing such as building and tower of BTS [9]. The existence of rapid development of infrastructure is then the danger of lightning strikes are increasing.

In previous research, researchers perform processing and data analysis using GIS software for digital [10] map model of lightning strikes vulnerability. The map model [5] is the result of lightning strike analysis using Simple Additive Weighting (SAW) method using lightning data and population density data by [11] in case study of Lampung Province. The results of this study will more or less produce the same lightning strike risk map in the study in Lampung province but with a more local scale.

The research ever conducted by Arafat [12] in the regency and municipality regions in determining the level of lightning strike vulnerability [12] using simple additive weighting method and data factors in the same analyzes but in use different study areas in the hope to increase the quality of reference to reduction risk of disasters caused by lightning strikes, especially in the area of Bogor

Regency and surrounding areas that are known to have a very active lightning activity. Another study was conducted in Bali Province [10], where the level of danger hazard lightning strain was analyzed by using Simple Additive Weighting method (SAW).

This research using Simple Additive Weighting (SAW) method as a description of threat level vulnerability of lightning strikes each district that is included with thematic [13] map as a mitigation effort on the danger of lightning strike. Simple Additive Weighting (SAW) method used to make the calculation easier [14]. This method is used to combine several factors [15], causing the level of lightning strike vulnerability to obtain the value of preference to determine the level of vulnerability in the study area.

In previous study of the determination lightning strain in Bali area [15] still use a large grid of 1^0 so it still allows interpolation of less good data, so in this study the data grid is further reduced to 0.01^0 in order to map the level the vulnerability of lightning strikes is more local than ever before.

This research purpose to analyze the risk level of lightning strike hazard in Gowa regency using Simple Additive Weighting (SAW) method. By knowing the level of risk of lightning strikes in the Gowa region can represent safe and dangerous areas of lightning strike activity.

II. RESEARCH METHOD

The data used is record of lightning activity data for a year by Lightning detector with sensor coordinates 5.218^oS-119.47^oW is in the geophysics station BMKG Gowa. Processed data is data of lightning activity during 2015 in Gowa regency.

The LDC data obtained from the Lightning detector is converted to *ldc extension [16] by running data using LD 2000. After the *kml data is converted back to *csv. Furthermore, data *csv is processed using lightning data processing. To obtain a lightning density in a region it is necessary to include a range of area boundaries and grid components x and y [17]. Grid components x and y components are obtained from the following formula:

$$Grid\ X\ component = \frac{Long_{max}}{Long_{min}}\ x\ 111 \qquad (1)$$

$$Grid\ Y\ component = \frac{Lat_{max}}{Lat_{min}}\ x\ 111 \qquad (2)$$

with:

$Long_{max}$ = Upper longitude limit
$Long_{min}$ = Lower longitude limit
Lat_{max} = Upper latitude limit
Lat_{min} = Lower latitude limit

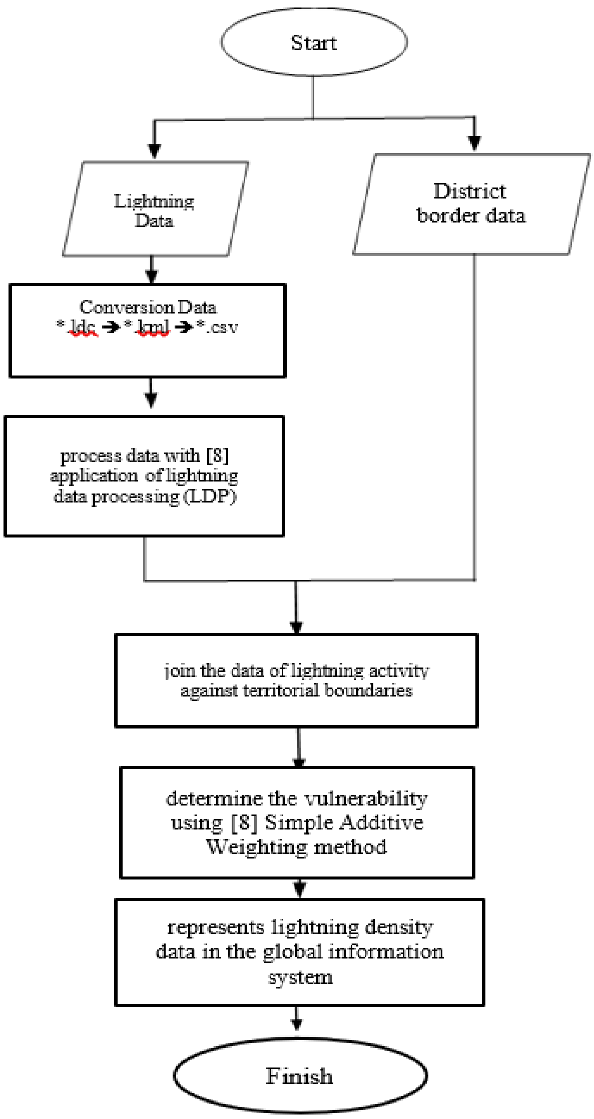

Figure 1. Diagram Flow of the Research

Assuming that 1° is equal to 111 km, the difference between the upper and lower limits of the longitude of [12] the longitude and latitude will be the number of grids to be used on the coverage of the desired area.

Simple Additive Weighting (SAW) method requires the process of normalizing the decision matrix (X) into a scale so that it can be compared with all existing alternative ratings [10]. Normalized performance ratings can be explained the following equations:

$$r_{ij} = \begin{cases} \frac{X_{ij}}{Max\, X_{ij}} \\ \frac{Min\, X_{ij}}{X_{ij}} \end{cases} \quad (3)$$

j is a benefit attribute (benefit)
i is a cost attribute (cost)

Where [11]:

r_{ij} = normalized performance rating from alternative Ai and attribute Cj

X_{ij} = value on the i-th alternative and j-attribute

Max Xij = the maximum value of the j attribute

Min X_{ij} = the minimum value of the j attribute

i =1,2 ,...,m

j =1,2,...,n

In determining the value of lightning strike density then calculated the number of strokes per year per area [11] formulated as follows:

$$d = \frac{X}{A_{reg}} \quad (4)$$

Where

d = lightning strike density / year

X = average number of strokes in the year of each region

A_{reg}= wide of the sub-district

Figure 1 shows the diagram flow of the research. Input data is a converted CSV file from KML and regional boundary data. After the lightning data is done grid then the next processed using software lightning data processing to obtain the value of density in the research area [18]. After that cut the lightning data according to the desired area, then plot the lightning data in Gowa district using GIS software. Data on lightning activity that has been in the grid then combined with boundary data of the district in Gowa. Then interpolated the data to obtain areas that have the same lightning density value. Lightning density is written in units of strokes/km [19].

III. RESULTS AND DISCUSSION

In processing using a density grid of 0.01° aims to obtain a more dense and good data. From the data processing of lightning activity using Simple Additive Weighting (SAW) method, the following results are obtained in Table 1.

Table 1. Frequency of Lightning Activity and Population [9] Density of Gowa Regency

Region	Lightning Frequency	Population, Density/Km²
Bajeng	350	1098
Bonto Marannu	659	629
Bontonompo	138	136
Bungaya	5197	96
Pallangga	989	2167
Parangloe	3614	79
Somba Opu	362	4911
Tinggi Moncong	10443	164
Tompobulu	5045	231
Result	26797	9511

Table 1 shows that the areas with the largest lightning strike activity in 2015 are Tinggi Moncong district and Bungaya district, each having a density value of 10443 strikes/kilometers and 5197 strikes/kilometers. The lowest lightning strike activity in 2015 is in Bontonompo and Bajeng areas with consecutive density values of 138 strokes/kilometer and 350 strikes/kilometer. Tinggi Moncong area is area with the largest lightning strike activity because Tinggi Moncong area is a high land that often occurs extreme weather in the area [20]. While the region Bontonompo and Bajeng is the lowest lightning activity because it is a low land with relatively slow weather changes [21].

From Figure 2, it can be seen if the territory in Gowa region for 2015 is Tompo Bulu district and Tinggi Moncong district. Tompo Bulu district with lightning density of 5045 strikes/km and a population of 231 density/km² makes this subdistrict a vulnerable area of lightning strike activity.

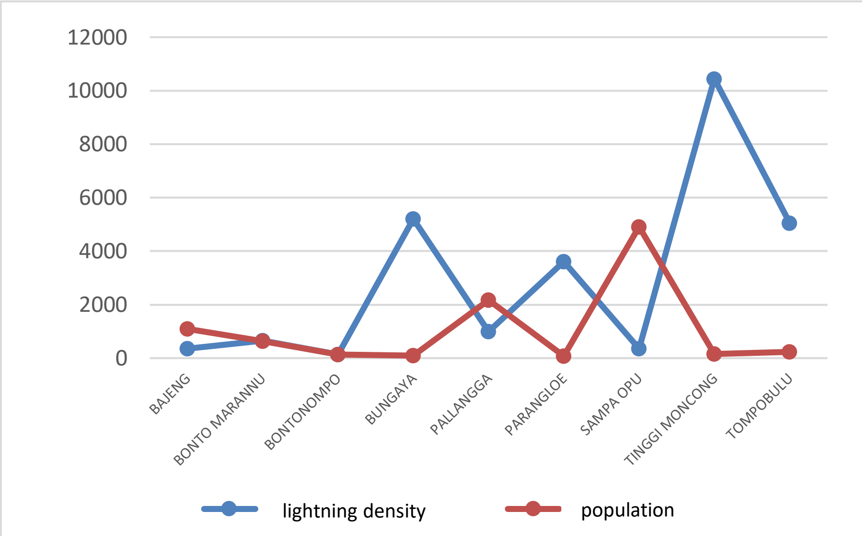

Figure 2. The level of Threat of Lightning Activity in Gowa District on 2015

The vulnerability can be compared with the district lightning strike map shown by Figure 3. On the lightning strike map, interpolation of lightning activity data so that the coordinates having the same density value will form contours based on the same values. The interpolation used is kriging interpolation to determination the results [22].

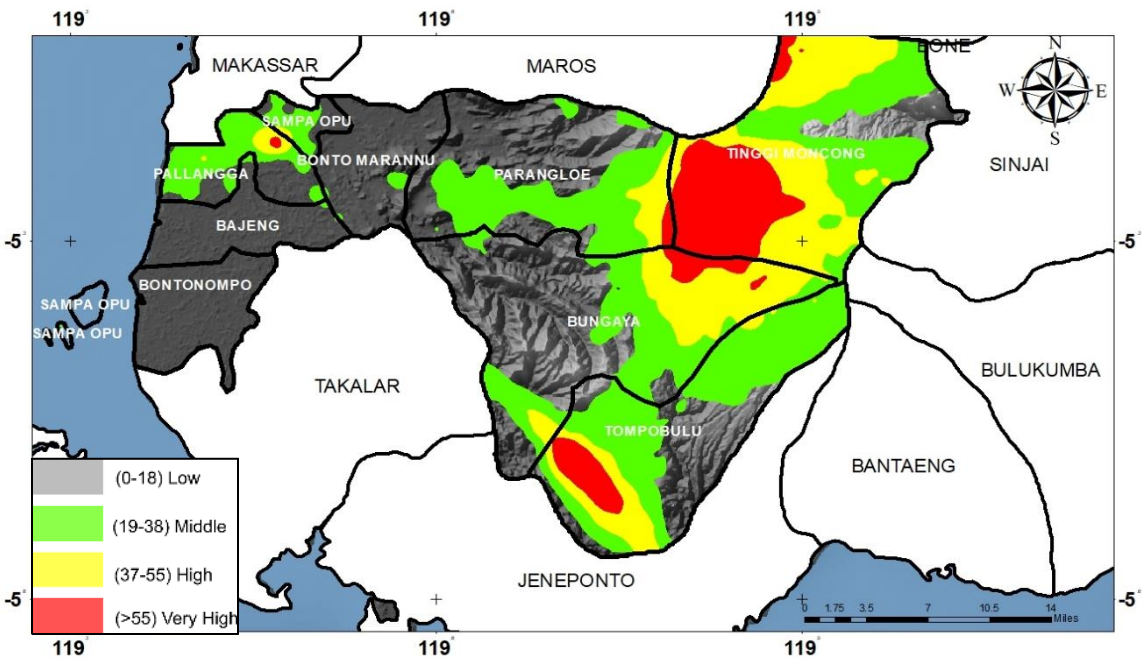

Figure 3. Map of Gowa District Lightning Strikes 2015

Kriging interpolation is based on the assumption that every point in the landscape is interconnected and has a trend mathematical equations [23] used to predict points with no data or information. In areas where no color spectrum is identified as an area with rarely lightning activity. While in areas that have a color spectrum from green to red is indicated as a region with frequent lightning activity. Figure 3 show the degree size of the color spectrum divided according to the magnitude of the lightning threshold in a coordinate. The distribution of color spectrum lightning level [24] is divided into 4 levels for the gray color for lightning density 0-18 strikes/km, green for lightning density 19-36 strikes/km, yellow for lightning density 37-55 strikes/km, and red for a lightning density of more than 55 strikes/ km. When comparing data table and interpretation on the map then Somba Opu area is a densely populated area with a population of 4911 density/km^2 but with low lighting intensity with lightning strike frequency of 362 strikes/km.

From the map also shows if the Somba Opu region included into the Area safe from the risk of lightning strikes because the Somba Opu region map is on the green color spectrum that shows the safe area from the lightning strike. From the map it can be seen if Tompo Bulu area has contour area with green, yellow, and red spectrum which means Tompo Bulu area with population of 231 density/km^2 has medium to very high [25] degree of vulnerability.

The district High snout with a population density of 164 density/km^2 is dominate by high to very high lightning activity. The lightning density in Tinggi Moncong area is very high among other areas which are 10443 strikes/kilometer. However, because the population only 164 density/km^2 then it can be stated if the Tinggi Moncong area still in safe zone of lightning activity.

In previous research conducted by Sugiyono [11] in Lampung area grid data used to find the density of lightning strikes is 1 to 0.1 while in this study used grid 0.01 increasing the level of data accuracy. With the use of a scale of lightning density range only 4 levels can be easier to determine the classification of areas prone to lightning strikes than if it should use a large scale range as in Arafat's research [12]. So for areas with low lightning strain levels are not given the color spectrum to make it easier to identify areas with a high-risk level of lightning strikes. in a mapping study of lightning-prone areas in Surabaya area conducted by Umaya [26] classification of areas with lightning strain level is done by not displaying the result of interpolation of the lightning strike and only showing the description of the region with the classification of vulnerable and safe, but not clearly represent the local condition in the research area. So in this study still displays the results of interpolation of lightning strike data to depict exactly the areas with high lightning activity. In Figure 3, if not all regions have a color spectrum it aims to separate the data of lightning strikes significantly and clearly. This lightning shock data can be used in anticipation and manufacture of adequate grounding system in lightning-prone areas, especially for high rise buildings. In addition, it can also be used by partners to create safe base stations from high lightning strike levels.

IV. CONCLUSION

The results of this study were obtained if Gowa district has a density number of 26797 strikes/kilometers with the cloudy area is Tinggi Moncong sub-district and Bungaya sub-district which each has density value of 10443 strikes/km and 5197 strikes/km. The results of vulnerability analysis indicate if for Bungaya, Tompobulu, and Tinggi Mongcong areas are categorized as vulnerable. For the Pallangga region is categorized as quite vulnerable, while for the region Bajeng, Bonto Marannu, Parangloe, and Somba Opu is categorized as the safe category.

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Information: Raw data is provided in the Supplementary Files (in the JPFA website only).
Keterangan: Data mentah tersedia di Material Tambahan (hanya terdapat di website JPFA).