CHARACTERISTICS OF FRACTAL LINEAMENT AND ITS RELATIONSHIP TO SEISMICITY IN SOUTHEAST PART OF WEST JAVA PROVINCE, INDONESIA

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ABSTRACT

The southeastern part of West Java Province has undergone several big earthquakes as location of several epicenters. There are many geological fault and active fault lines exist in this area. The aim of this study is to reveal the relationship between lineament patterns and the geological hazard of earthquake that might be occurred in the area. This study is intended as part of disaster mitigation efforts. Methods consist of several procedures of remote sensing (RS) and geographic information system (GIS) analyses. The characterization of the lineament used Landsat 8 OLI -TIRS satellite imagery. The lineament pattern is generated through the automatic lineament extraction method using the LINE feature of PCI Geomatica, continued by the fractal values computation. To determine the fractal value, the area is divided into four segments, where each segment is analyzed its lineament pattern and its fractal value. The data used in this study is data sourced of USGS from 1973-2017 for southeastern part of West Java Province. Results of the analysis indicate that the lineament pattern of the study area tends to be north-south (N-S) direction. The fractal values of the study area are in the range of 1.089 to 1.209. The segment one has fractal value of 1.1, two of 1.089, three of 1.207, and four of 1.209 respectively. In the area with high lineament density, the fractal values tend to be high, while in area with low lineament density has low fractal values. Areas with high fractal values tend to have high frequency of seismicity such as in segment three.

Keywords: Fractal, lineament, seismicity, West Java

1. INTRODUCTION

Studies of linear geologic features (lineaments) of both local and regional significance have been progressing rapidly (Abdullah, et al., 2013). Lineaments have long attracted the interest of field geologists with remote sensing satellite imagery that the character and extent of these features have been realized, and lineament analysis of remotely sensed data, either by visual or automatic interpretation, is a valuable source of information for studying the structural setting. A lineament is any extensive linear surface on a planet, as a fault line or fracture line. The term “lineament” is one of the most commonly used terms in geology. Hobbs (1904) first used the term lineament to define a “significant line of landscape within basement rocks. O’Leary et al., (1976) described the term lineament as a mappable simple or composite linear feature of a surface whose parts are aligned in a rectilinear or slightly curvilinear relationship and which differ from the pattern of adjacent features and presumeably reflects some sub-surface phenomenon. The purpose of this study was to test the automated lineament extraction method for detecting the lineaments over the study area, and to investigate the ability of this method in giving real results compared to the fault map.

The detection of lineaments from satellite imagery has been carried out successfully using a number of techniques including; applying sobel and gradient filters, principal component analyses (Ayday et al., 2008). Applied gradient filtering and principal component analyses on band 7 of Landsat. They first
applied gradient filters in eight directions then applied principal component analysis on each band created from the filtering. They concluded that principal component analysis using eight different gradient filtered bands was more effective than four major gradient filtered bands and recommended though that the methodology be tried and tested to the other areas for verification.

There are two general methods of extracting lineaments from satellite imagery; the first involves manual digitizing of visually identified lineaments after image processing and the second is automated lineament extraction where the satellite image is subjected to automated processing by specifying different parameters such as curve length, linking distance, kernel size (Ibrahim, 2012). The most popular automated processing tool used over the past few years has been LINE from PCI Geomatica (Hung, et al., 2012).

Landsat ETM-7 satellite data were used and band-5 was found as the most suitable band in automatic delineation (Abdullah et al., 2013). Landsat 8 satellite data were used and band-7 was found as the most suitable band in automatic delineation (Ibrahim, 2012).

Southeast West Java has a complex geological structure and lithology types including plain to steep hills morphology. Variations of this landform are affected by endogenous factors (tectonic style) as well as exogenous factors (weathering and erosion). In understanding the phenomenon of land formation, required a special instrument that is able to represent visually phenomenon. This area is eventually has higher intensity of earthquake and landslide. The Study area covering Tasikmalaya, Banjar and Ciamis and also several regency in Central Java Province Like Cilacap. The horrify Earthquake is presedence by Tsunami in Pangandaran is one of the worst disaster in this region. The aim of this study to analysis Characteristics Of Fractal Lineament And Its Relationship To Seismicity In South East West Java.

![Figure 1. Location of the study area](image)

2. METHODOLOGY
2.1. Automatic Extraction of Lineament Using Landsat 8 (OLI)

There are several techniques that were developed for determine the linear features and geomorphologic characteristics of the terrain. According to this paper the automatic lineament delineation was based on decision of the most appropriate band for edge enhancement, followed by edge sharpening enhancement technique which gives the best result of lineaments that are not delineated by human eyes, and apply LINE module of PCI Geomatica V9.1 for recognized lineaments. Landsat 8 OLI satellite data
were used and the first step was to select the band that should be used for lineament extraction (Süzen and Toprak (1998); Madani (2001). Visual inspection of the individual bands was carried out, based on the ability to identify features, and band 5 (1.55 - 1.75 μm) (SWIR) was selected and it was stretched linearly to output range 0 to 255. The second step was to select the filter type. For this purpose, different types of filters are tested. Edge sharpening filter was the best which convolved over band 5. Edge sharpening enhancements make the shapes and details for analyses (Richards, 1986). Edge sharpening was applied using PCI Geomatic software package. And finally the final image of the study area was used for automatic lineament extraction. According to Abdullah et al. (2010) the lineament extraction algorithm of PCI Geomatica software consists of edge detection, thresholding and curve extraction steps. These steps were carried out under the default parameters of the software as follows:

RADI = Radius of filter in pixels; GTHR = Threshold for edge gradient; LTHR = Threshold for curve length; FTHR = Threshold for line fitting error; ATHR = Threshold for angular difference, and DTHR= Threshold for linking distance (PCI Geomatica, 2001).

According to the six parameter above. Several lineament maps were generated using different threshold values. The most suitable threshold values were selected (below) considering these lineaments as fault lines. General properties of faults were taken into consideration such as the length, curvature, segmentation, separation and so on in order to determine the threshold values.

Landsat 8 Operational Land Imager (OLI) images consist of nine spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 and 9. The resolution for Band 8 (panchromatic) is 15 meters (USGS, March 3rd 2014). The automatic extraction involved using the LINE tool from Geomatica 2014. The tool extracts linear features from an image and records the polylines in a vector layer. The module was designed to extract lineaments from radar images; however, it can also be used on optical images to extract curve-linear features. The input in this case was optical; the mosaicked Landsat 8 Band 7 scenes (Ibrahim and Mutua, 2012).

2.2. Fractal Dimension Analysis

The methods used in the calculation of the fractal dimension using a box counting method or the dimensions of the box. This method can be applied to objects that are self-similar statistical or statistical self-affine fractal. The box counting method is done by making certain sided grid (r) on a fractal object (Nur, 2015).

We denote the cut or the set-fractal as F and its sum inside the surrounding r-sided box is Nr (F). The calculation of this value is done iteratively with until the smallest value of fractal is achieved. In this way, the small variation of F value to r can be plotted in a logarithmic graph. The dimension of this calculation can be determined from the slope of the plot.

$$D = \lim_{r \to 0} \frac{\log Nr (F)}{-\log r}$$

2.3. Earthquake

The Earthquake data used in this study is data sourced from USGS 1973-2017 for south east of West Java

2.4. Statistical Analysis

To further analysis of Characteristics Of Fractal Lineament And Its Relationship To Seismicity In South East West Java, output of each proses (lineament, fractal analysis, and earthquake data) then tested using statistical probabilistic using Kendall’s tau test &Sperman’s rho

3. RESULT AND DISCUSSIONS

The landscape is a product of tectonic processes and the formation lithology. The landscape in the study area is dominated by fine clastic lithology types. The landscape of steep and very steep hills located in the northwest, Southeast, northeast with different characteristic lithology.
3.1. Automatic Lineament Process and Fractal Lineament

The orientations of lineaments and faults lines were created by using rose diagrams (Figure 3). The main trends observed in the lineament map could be recognized in these diagrams, showing strongly major trend in N-S, and the subdominant directions were in NW-SE. Area with high density of lineament located at the SE Area. This Area also has steep slope.

to determine the fractal value of the study area, the area is divided into thirty segments where each segment is analyzed its lineament pattern and its fractal value. fractal value of the study area is in the range of 0.6986 to 1.143. high fractal values associated with high density lineament.

3.2 Statistical analysis
To analysis Characteristics Of Fractal Lineament And Its Relationship To Seismicity In South East West Java, we used Statistical Probabilistic to test the correlation Fractal Lineament and Frequency of the Earthquake (Figure 4). Kendall’s tau & Spearman’s rho correlation test have chosen as the best suites statistical analysis for this study. The number of each data (Earthquake frequency & Fractal lineament) were thirty data (N=30).
Figure 3 (a) Rose Diagram of Study Area (b) Lineament Density overlay with Lineament Fractal value

*Spearman’s rho*

If the value of sig. < 0.05, it can be concluded that there is a significant correlation between the frequency of Earthquakes with the Lineament Fractal value.

If the value of sig. > 0.05, it can be concluded that there is no significant correlation between the frequency of Earthquakes with the Lineament Fractal value.

Based on the above output it is known that N or Total of research data is 30, then sig value. (2-tailed) is 0.525. As the basis of decision making above, it can be concluded that there is no significant correlation between Earthquake frequency with the Fractal value of the alignment. Furthermore, from the above output is known correlation Coefficient of 0.121 then this value signifies a low relation between earthquake frequency with the lineament fractal value.

*Kendall’s tau*

If the value of sig. < 0.05, it can be concluded that there is a significant correlation between the frequency of Earthquakes with the Lineament Fractal value.

If the value of sig. > 0.05, it can be concluded that there is no significant correlation between the frequency of Earthquakes with the Lineament Fractal value.

Based on the above output it is known that N or Total of research data is 30, then sig value. (2-tailed) is 0.451. As the basis of decision making above, it can be concluded that there is no significant correlation between Earthquake frequency with the Fractal value of the alignment. Furthermore, from the above output is known correlation Coefficient of 0.104 then this value signifies a low relation between earthquake frequency with the lineament fractal value.
4. CONCLUSION

Based on Sperman correlation analysis it is known that N or Total of research data is 30, then sig value. (2-tailed) is 0.525, it can be concluded that there is no significant correlation between earthquake frequency with the lineament fractal value. Furthermore, from the above output is known correlation Coefficient of 0.121 then this value signifies a low relation between earthquake frequency with the lineament fractal value.

Based on the Kendall’s tau analysis, it is known that N or Total of research data is 30, then the sig value. (2-tailed) is 0.451. it can be concluded that there is no significant correlation between

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**Table 1. Correlation Test**

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<th>Correlations</th>
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<th>FracVal</th>
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<td>FracVal</td>
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<tr>
<td><strong>Spearman's rho</strong></td>
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Earthquake frequency with the Lineament Fractal value. Furthermore, from the above output known correlation Coefficient of 0.104 then this value indicates a low relationship between Earthquake frequency with Lineament Fractal Value.

from both statistical analysis above mentioned that between straightness and frequency of seismicity is not found any strong correlation between both, this could be caused by data of seismicity which is not complete or can be caused by seismic activity in Java area.

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