The Simple Grid Method in GIS Application for Delineation of Erosion and Flood Zones: Case study at Bandung Basin

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Abstract

GIS software usually manages vector data. When the facility for raster data is available, it usually used for display and it is not used for analysis. So, it is need the additional method to be used for geo-spatial analysis with many variables. The simple grid method with calculation of numerical info can applied for many purposes of geo-spatial analysis. This method is work by creating grids on map of area that will be analyze, creating data structure with variables have specified, filling this fields data with criteria numbers for analysis, and calculating that record data with statistic method. Finally, that grids have contain numeric data ready for analysis with various mathematical operator, i.e. add, devide, subtract, etc.

Some variables are used for applied this method, i.e. lithologic type, geological structure, slope degree, weathering grade, land use, and rain fall intensity. Result of analysis shows Bandung Basin area can be divided into five zones; very strong erosion, strong erosion, moderate erosion, low erosion, and very low erosion. Areas with very strong erosion are covering upper Cikapundung, Ciramose, Cicangkuang, Citarik, Cikeruh, etc. Areas with strong erosion are identified at Cimanggung, Cijagra, Barugbug, etc. Areas with moderate erosion are indicated at Cijo ho, Cirasea, Wangisagara, Ujungberung, etc. Areas of low erosion are at Cikitu, Wayang Mount, Rancakole, etc. Areas with very low erosion are identified upper Cimulu, upper Citarik, etc.

The similar stages can be used for delinea tion of flood zone. Flood vulnerable area at Bandung Basin are Kiaracndonong, Ciwastra, Tegaluar, Rancaek, Babakanmuara, Cijagra, Majalaya, Ciparay, Dayeuhkolot, Sapan, and Katapang. Generally, area of flood vulnerable takes place on depression terrain. At here, the run off concentrated more deep from around areas.

The data of result analysis and field survey are verified using t-test. The test shows no significant difference among them, where “\( t_{\text{calculation}} < t_{\text{table}} \)”. That phenomenon shows the simple grid method can be used for analysis of geo-spatial data related with GIS application for delineation of erosion and flood zones.

Key-words: The simple grid method, geo-spatial analysis, erosion zone, flood zone.
Introduction

The spatial data analysis commonly need a long time, more over the numerous variables and the spatial data aren’t digital format. Some models for application of the spatial analysis among other are erosion calculation, delineation of flood zone, zonation of landslide vulnerable, zonation of terrain pollution by waste mining, etc.

GIS software usually manages vector data. When the facility for raster data is available, it usually used for display and it is not used for analysis. So, it is need the additional method to be used for geo-spatial analysis with many variables. The simple grid method with calculation of numerical info can applied for many purposes of geo-spatial analysis. This method is work by creating grids on map of area that will be analyze, creating data structure with variables have specified, filling this fields data with criteria numbers for analysis, and calculating that record data with statistic method. Finally, that grids have contain numeric data ready for analysis with various mathematical operator, i.e. add, devide, subtract, etc.

The simple grid method was applied for delineation of erosion and flood zones at Bandung Basin (Figure 1). The Bandung Basin was rounded by hilly and mountainous terrain that composed of Quaternary volcanic rocks. Many scientists already made research at this area, among other Koesoemadinata (1979), Alzwar et al (1992), Dam (1994), LCLUC (2001), Roswandi (2004), Sukiyah et al (2004, 2005, and 2006), etc.

Sukiyah (2005) has been publishing that some active faults control some river basin at Bandung Basin, i.e. Barubug River Basin. Result of fractures analysis shows it, where fractures patterns no difference with rivers segment pattern. Several aspects, i.e. climate, rainfall intensity, slope, land use, stream order, rock type, and tectonic control distribution of flood area in southern part of Bandung Basin (Sukiyah et al, 2004; Sukiyah et al, 2006).

Methodology

Variables that used in erosion and flood analysis must be connected with spatial data via geographic reference. Sometimes variables have not same numerical level meanwhile mathematical operation need the same level numerical data. So, it needs weighting method on related variables for analysis.
Howard & Remson (1978) have been used rule weighting on variables for land use planning. Authors try applying this method for concord numerical variables that used in erosion and flood zonation analysis.

Mader and Remson (in Howard and Remson, 1978) had assign capability values of spatial data for analyze land-capability ratings. The weight value is given to some linked aspects in fixing the erosion and flood zonation. It is based on importance grade and aspect condition. Numerical weight extended from 0 (zero) to 5 (five), i.e. 5 (very high importance), 4 (high importance), 3 (moderate importance), 2 (low importance), 1 (very low importance), and 0 (no importance). So, condition of every data layer given value too, extended from 0 (zero) to 5 (five), i.e. 5 (very high ability), 4 (high ability), 3 (moderate ability), 2 (low ability), 1 (very low ability) and 0 (not suitable).

Figure 2 shows main stages in geo-spatial analysis. Stages of analysis are spatial data digitizing, modification of structure information field every same data layer, update information fields of spatial data that same geography coordinate reference, create grid layer with certain precision, create information fields as many as variables that manage, update information of grid layer with related information of variables data layers. Calculation all variables use sum mathematical operation on grid layer. Hereafter, calculation result classified with statistic approach, for example with normal curve. Result of analysis use the simple grid method integrated on spatial view. This way probable use difference coloring on every class.

Probabilistic approach used for verification. The data of result analysis and field survey are verified using t-test. If value of “t” from calculation more little from value of “t” from table “t distribution” then hypothesis that result analysis data by calculation no different with survey data. On the other hand, result of data analysis by calculation different with survey data. That phenomenon shows the simple grid method can be used for analysis of geo-spatial data related with GIS application for delineation of erosion and flood zones.

**Result and Discussion**

**Erosion Zones**

Some variables are used for applied this method, i.e. lithologic type, geological structure, slope degree, weathering grade, land use, and rain fall intensity. Result of
analysis shows Bandung Basin area can be divided into five zones; very strong erosion, strong erosion, moderate erosion, low erosion, and very low erosion (Figure 3). Areas with very strong erosion are covering upper Cikapundung, Ciramose, Cicangkuang, Citarik, Cikeruh, etc. Areas with strong erosion are identified at Cimanggung, CJagra, Barugbug, etc. Areas with moderate erosion are indicated at Cijoho, Cirasea, Wangisagara, Ujungberung, etc. Areas of low erosion are at Cikitu, Wayang Mount, Rancakole, etc. Areas with very low erosion are identified at upper Cimulu, upper Citarik, etc.

The highest erosion takes place at Cimonce Basin (sub Basin of Ciwidey) is 2,436.29 ton/ha/yr. On the other hand, the lowest erosion takes place at Cirenjeng Basin is 0.97 ton/ha/yr. The strong erosion at Cimonce Basin can be understood because erosion variables index commonly high, i.e. soil texture is rude, slope is steep, and land use is bad.

The total erosion at basin depends to rate of erosion value per year and dimension of water catch area. Based on spatially calculation using GIS software known the highest total erosion takes place at Cikapundung Basin is 7,425,462.6 ton/yr. That phenomenon can happen because soil erodibility index is high and support by slope is steep and catch area is extensive about 12,060 ha. Soil texture at Cikapundung Basin commonly is rude. It is weathering result of strong deformed volcanic rock (lava) because Lembang fault control.

The lowest total erosion takes place at Cilenyi Basin is 302.08 ton/yr and average erosion is 99.84 ton/ha/yr. That phenomenon can happen because that area commonly flat to gentle and fine soil texture.

**Flood Zones**

Some aspect related with flood probable at something area are lithology (rocks type and texture), land use, rainfall intensity, slope, stream characteristic (stream order), and land deformation by tectonic (morphotectonic).

The similar stages can be used for delineation of flood zones (Figure 4). Based on result analysis use the simple grid method can be known distribution of flood zones at Bandung Basin, i.e. area of flood vulnerable about 15,040 ha, area of moderate flood risk about 35,360 ha, area of low flood risk about 33,200 ha, and area of loose flood risk about
98,510 ha. Areas of flood vulnerable take place at Kiaracondong, Ciwastra, Tegaluar, Rancaekek, Babakanmuara, Cijagra, Majalaya, Ciparay, Dayeuhkolot, Sapan, and Katapang (Figure 4).

Areas of flood vulnerable commonly take place at around of downstream where at segment of upstream has high to very high erosion. Morphotectonically, areas of flood vulnerable commonly take place depression terrain.

The data of result analysis and field survey are verified using t-test. Verification result of 30 locations show no significant difference among them, where “t_{calculation} < t_{table}” with “α=0.05”. That phenomenon shows the simple grid method can be used for analysis of geo-spatial data related with GIS application for delineation of erosion and flood zones

**Conclusion**

Digitally geo-spatial analysis can use GIS software based vector data with additional method. The simple grid method with calculation of numerical info can applied for many purposes of geo-spatial analysis. Some variables related with zonation of erosion and flood can be analysis using this method.

Result of analysis using simple grid method shows Bandung Basin area can be divided into five zones of erosion; very strong erosion, strong erosion, moderate erosion, low erosion, and very low erosion. The similar stages of this method can be used for delineation of flood zones too. The flood zonation at Bandung Basin are area of flood vulnerable, area of moderate flood risk, area of low flood risk, and area of loose flood risk.

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*) in Indonesian with English Abstract
Figure 1. Location of research area
Figure 2. The geo-spatial analysis stages use simple grid method

- Research object
- Data collecting
- Determination and measurement of variables
- Variables rating and weighting
- Create grid layer with GIS software
- Data structure modification
- Data input
- Scores calculation
- Analysis of calculation result
- Classification of erosion and flood zones
- Spatial distribution of classification result
Figure 3. The map of erosion zones at Bandung Basin

Figure 4. The map of flood area distribution at Bandung Basin