QUANTITATIVE GEOMORPHOLOGY OF LANDFORM AT SAMIGALUH AND SURROUNDING AREA, WEST PROGO, CENTRAL JAVA, INDONESIA

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Abstract

Samigaluh and its surrounding area in West Progo Regency is a part of West Progo Hills physiographic zone that has steep denudational hilly morphology. Field geomorphological survey has been conducted in this area to reveal the landscape characteristics quantitatively. Quantitative geomorphology study was conducted on the dimension or morphometric of landscape at some location of hills and streams. Morphometric aspects that have been analyzed include elevation (h) and slope (α) of regions or hills as well as some response variables of stream morphology that include valley floor-height ratio (Vf), valley cross section (Vr), river gradient index (SL) and drainage density (Dd). The results showed that the response variables of morphology in the study area have variation in values. Average value of elevation (h) is 415 m, slope is 42.2%, Vf is 1.04, Vr is 0.68, SL is 180.7 and Dd is 0.38 / km^2. Analysis of the relationship between several variables of morphometry showed the low to very low correlation value, with the highest correlation value is 21.29% only shown by the relationship between elevation (h) to valley floor-height ratio (Vr).

Keywords: Quantitative geomorphology, morphometry, response variable, West Progo

1. INTRODUCTION

Samigaluh landscape and surrounding area in general is steep to very steep hills. There is gentle enough morphology only in a few places surrounding of big stream. Morphogenesis of landscape of this area in general is dominated by denudational process, where the weathering and erosion processes have been quite intensive. The research area is located at topographic map of Sendangagung Quadrangle, scale 1:25.000 made of Bakosurtanal (2000), included in West Progo Regency (Figure 1). This area includes in Dome & Ridges of Central Depression of Java physiographic zone after Van Bemmelen (1949).

Landscape is a reflection of the geology of an area that we need to learn, both qualitatively and quantitatively. The approach of the quantitative assessment can be done to understand the dimensions of the landscape through the magnitude of the values of the various aspects of morphometry. Landform of earth surface is the final result of combination both of geology and denudational processes. Lithosphere's surface relief is controlled by rock, geological structure, and geomorphological processes successionally in spatial and time frame (Davis, 1942, in Yudowiyono, 1995). In this concept, rock and geological structure have important influences to geomorphological analysis, where the past processes occurred through them, then followed by constructional and destructional processes.

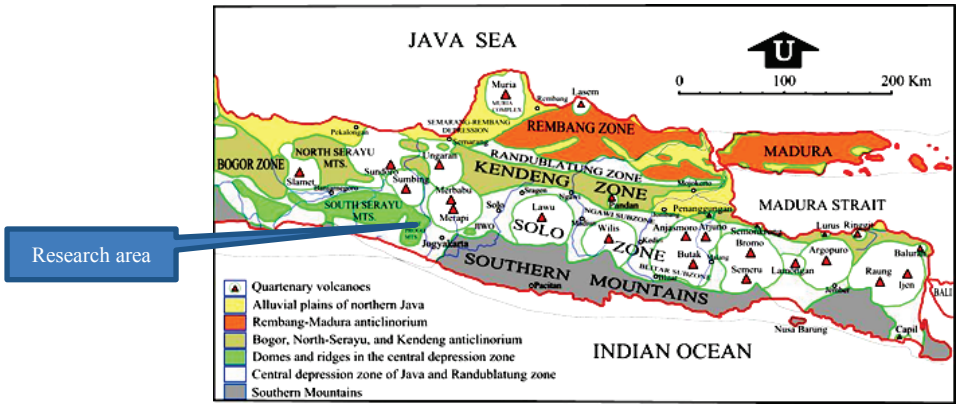


Figure 1. Research area in physiographic map after Van Bemmelen (1949).

Denudation is that group of processes which, if continued far enough, would reduce all surface inequalities of the globe to a uniform base level, usually sea level. In this context, the main process is degradation. This process involve the disintegration of rock (weathering) and the stripping of loose, weathered material from the earth surface by various processes of erosion and mass wasting (Van Zuidam, 1983).

Knowing geomorphology is important for some application, i.e. in stratigraphy, geological structure, engineering geology and etc. For understanding geomorphology quantitatively, there are some response variables can be analyzed. Here, geomorphological characteristics of Samigaluh area can be understood by analyzing of some response variables or geomorphology indexes.

This research wants to know about geomorphological characteristics of landscape such as hills and stream in several sample locations. Relation between them also analyzed to understand their correlation.

2. GEOMORPHOLOGY OF RESEARCH AREA

The research area includes in the Central Depression Zone of Java physiography, especially in West Progo Mountains or Dome according to Van Bemmelen (1949). It also includes in Progo drainage area, especially at the middle and western part of it.

Budiadi dan Listyani (2007) have analyzed Quaternary morphotectonic of Yogyakarta Graben and showed that there are some varieties on geomorphic variable responses. Based on some morphometric indexes it showed that Quaternary tectonic more controlled at upward to middle part of Progo drainage area. Development of Progo drainage area morphology is influenced by Quaternary tectonic (neo tectonic). This active tectonic is shown by river scarp lineament, narrow V valley and deepening of valley. The western part of research area show hilly to mountaineous topography of West Progo Dome (Fig. 2). Topography of West Progo Dome has steep slope and high dissected morphology.

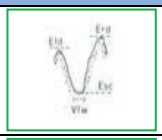
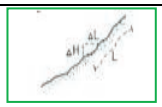
3. METHODOLOGY

Field geomorphological survey has been done at Samigaluh and surrounding area, especially the areas which include in West Progo Dome. Some location samples have been taken to represent the 2 x 2 km2 width of area grid approximately. Several morphometric variables associated with spatial can be analyzed using a simple grid method to simplify the calculation process (Sukiyah *et al*, 2007 in Sukiyah *et al*, 2012).

Figure 2. Morphology of research area showed from Landsat image band 321 in 1995 (Budiadi, 2008).

To know about morphological charcteristics of the area, some response variables of morphometry have been analyzed, include : (a) elevation (h); (b) slope (α); (c) valley floor – height ratio (Vf); (d) valley cross section (Vratio or Vr); (e) river gradient index (SL); and (f) drainage density (Dd). These variable responses have been collected from field directly as long as geomorphological mapping. The principle understanding of them can be noticed at Table 1.

Table 1. Some of geomorphological indexes (Wells et al, 1988).

Index	Definition	Formula	Measurement	Source
Vf	Valley floor – height ratio	$\frac{\text{Vfw}}{[(\text{Eld}-\text{Esc})+Erd-Esc)]/2}$		Wells *et al*, 1988
V_{ratio} or Vr	Valley cross section	Av/Ac		
SL	Stream gradient index	(ΔH/ΔL) x L		
Dd	Drainage Density	∑L/A		Van Zuidam, 1983

4. RESULT AND DISCUSSION

4.1. Landform Characteristic

The observation locations have been chosen as samples of representative landform. Usually, landform at the research area showed hilly, steep morphology. Some gently areas usually found at surrounding of big channel. (Figure 3). Forty two locations have been chosen for analyzing the morphometry of research area as shown in Figure 4.

Geomorphology of research area formed by many tipes of rocks, such as igneous rocks of lava or intrusion as old as Dukuh Formation (formerly famous as Old Andesite Formation) and sedimentary

rocks of Nanggulan, Dukuh, Sentolo and Jonggrangan Formations. The landform of course, influenced by these physic condition of rocks as well as many processes in the area.

Figure 3. Landform of research area, in Gleoran /Loc 19 (left) and at Kedunggrong /Loc. 1 (right).

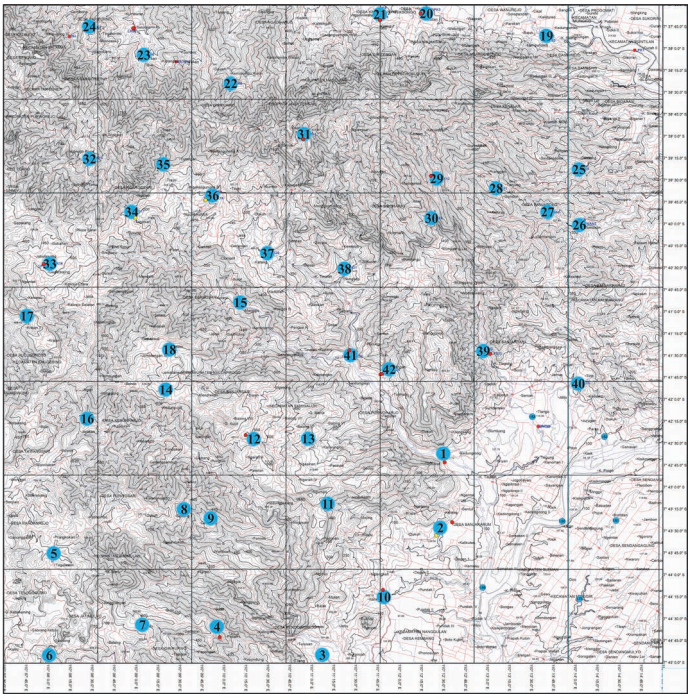


Figure 4. Location of sampling in topographic map of research area.

4.2. Variables Responses of Morphometry

The research area is located at an elevation of 136 to 850 m measured at several sampled locations, with a slope of 22 to 100%. The average elevation is 415 m, while the regional average slopes measured at observation sites by 42%. This suggests that the study area is a hilly morphology with moderate elevation above sea level. Slope area is quite steep to very steep, with a fairly high dissected morphology.

Valley floor - height ratio (Vf) of research areas range from 0.19 to 5.4, with an average value of 1.04. The average value of this Vf indicates that the width of the river valley is almost equal to the valley height. It shows that both the horizontal and vertical erosions are equally dominant in the study area.
Valley cross section (Vratio or Vr) ranges from 0.13 until 4.13 with an average of 0.68. This value indicates that the cross section of the river valley studied had a fairly wide cross-section, with quite large concavity. These Vr characteristics are supported by some factors such as fairly strong erosion,

so that the cross-sectional of the river valley became V to almost U shape, with the cross-sectional area Av is more than half of the area of Ac. The greater the value Vr showed that the cross-section of the valley tend to widen, which means that the horizontal erosion increasingly dominant. Usually horizontal erosion looks balanced with vertical erosion in the research area. V shape valley found was generally sharp formed, according to Van Zuidam (1983), it marks the type of strong vertical erosion which may occur in recently uplifted areas. Rock and climate conditions in this area must, however, also be considered. Meanwhile, the shape of the valley U indicates pause after a period of strong vertical erosion, or river has followed a gapping fracture, or has stopped when reached hard rock (for example old volcanic breccia or lava in the research area), reducing the rate of vertical erosion. Usually the U-shaped valley is partly in filled with sediment, especially in downstream part of sub watershed.

Stream gradient index (SL) indicates the river gradient value in total length of river channels. SL value obtained in the study area ranged from 27.5 to 481.5, with an average of 180.7 m. This value indicates that the river gradient is quite large, which means the elevation difference between upstream and downstream parts of piece of the river is large enough. This fact is supported by the local strong dissected, coarse relief morphology of research area.

The research area is generally included in Progo Drainage Area, with several sub-watersheds. They are include Kedungan, Sindon, Pugoh, Srandu, Tlegung, Tinalah, Nungkep, Kamal, Tangsi, Sileng and Turusan sub watersheds. Their drainage density ranged from 0.17 to 0.71 / km, with an average of 0.38. In practice, according to Van Zuidam (1983), many factors influence the drainage density, i.e.: rock type, fracturing, soil type, relief, vegetation, rainfall and also evapotranspiration. Coarse grained intrusive rocks usually show low drainage densities, while fine-grained clastic sedimentary rocks reveal relatively high drainage density. Dd value as much as 0.38 show moderate drainage density, controlled by variable rocks in research area, include coarse grained intrusive rocks and fine-grained clastic sedimentary rocks.

4.3. Relation Between Variable Responses of Region/Hill and Stream

The relationship between the response variables of area / hill to river under study showed a low - very low value. Relations of area elevation (h) to Vf, Vr, SL and Dd have correlation coefficient value respectively of 18.6; 21.29; 18.52 and 10.95%. These values indicate that the elevation of an area does not relate to the characteristics of the stream valley morphometry. The highest value obtained from the relationship only by 21.29% in relation h to the Vr (Figure 5) shows that the elevation does not affect the cross-sectional shape of the valley.

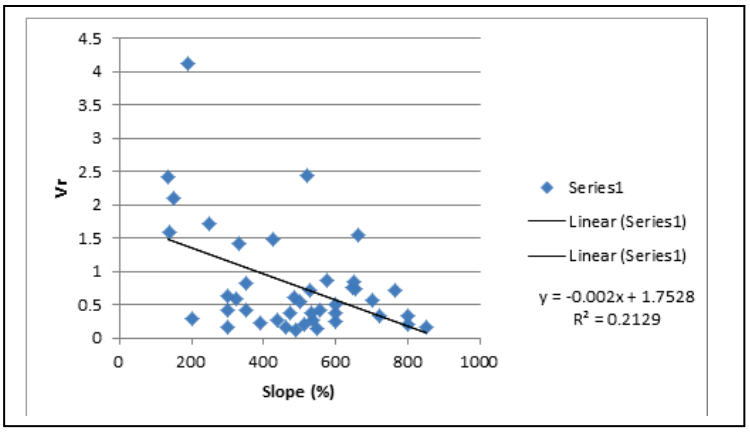


Figure 5. Relation between slope of area and Vr.

An analysis of the relationship of the variable response of slope to river valley showed a correlation value between slope to Vf, Vr, SL and Dd respectively for 6.05; 5.01; 2.02 and 0.0002% or very low.

This means that the slope of an area does not also affect to the form or stream valley. The shape and size of the river valley is more likely to be influenced by the type of rock and the process that occurs.

5. CONCLUSION

The landscape at Samigaluh and its surrounding area have coarse relief, strong dissected hilly morphology. From some sample locations selected known that the study area elevation ranges from 136 - 850 m or an average of 415 m with a slope of 22 - 100% or an average of 42%. From the calculation, the average response variable indexes of river morphometry (Vf, Vr, SL and Dd) are respectively 1.04; 0.68; 180.7; and 0.38. The response variable values are affected by the condition of the research areas that include rock type and geomorphological processes, especially erosion. In general, erosion horizontal balanced by vertical erosion, characterized by Vf at 1.04 and stream valleys shape of V to U type. The relationship between the response variable morphology of the area / hill showed no correlation with the response variable indexes on the river. The highest value of the relationship just gained at 21.29% on the relationship between slope and Vr.

ACKNOWLEDGEMENT

The author wants to give highest award on Higher Education Grant and for Dr. Ir. Ev. Budiadi, M.S. who has helped research. Our thank also provides to all assistant students include Abdi, Novi and Hadi who have collected data in the field and studio, also Danu and Hendi for preparing this paper.

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