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GEOMORPHOLOGICAL RESPONSE VARIABLE OF UPSTREAM OF PROGO DRAINAGE AREA

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ABSTRACT

Geomorphological study of landform has been developed for any goal of research, such as by understanding of quantitative geomorphology. This paper is written from the research of response variables measurements for knowing geomorphological characteristics of Progo Drainage Area, particularly by geomorphological mapping. Analysis of geomorphological response variables include elevation (h) and slope (α); valley cross section (V_{ratio} or V_r); valley floor – height ratio (V_f); and river gradient index (S_L). Result of the research show that there are many variety of response variables of geomorphology developed from upstream to the middle of drainage area. This variety are also related with different physiographic of West Progo Hill and Merapi Quaternary physiography. There are weak correlation between elevation and other reponse variable like V_f, V_r and S_L.

Key words: Progo Drainage Area, response variable, quantitative geomorphology.

INTRODUCTION

The landforms of the earth's surface are the end result of a combination of geological and denudational processes. The relief of the lithosphere surface is controlled by rocks, geological structures, and geomorphological processes sequentially in space and time frames (Davis, 1942, in Yudowiyono, 1995). In this concept, rocks and geological structures have an important influence in geomorphological analysis, where past processes that occur through them are followed by construction and destruction processes.

Knowing geomorphology is important for several applications, namely in stratigraphy, structural geology, engineering geology and others. To understand geomorphology quantitatively, there are several response variables that can be analyzed. Here, the geomorphological characteristics of the Progo watershed can be found by analyzing several response variables.

The research area boundarized in the northern part of Progo drainage, included in Sleman and Kulon Progo District (Figure 1). This area include in Dome & Ridges of Java Central Depression and Quaternary Volcanic physiography after Van Bemmelen (1949). Usually, this area include in the upstream of Progo drainage area.

METHOD

The research has been done by surface geological mapping, focused in geomorphology. The primary data have been collected by gridding location sampling in whole area. Several response variables which have been analyzed as follows:

a. Elevation/height (h) and slope (α).
b. Ratio of valley floor – height (V_f).
c. Valley cross section ratio (V_r or V_{ratio}).
d. Index of river gradient (S_L).

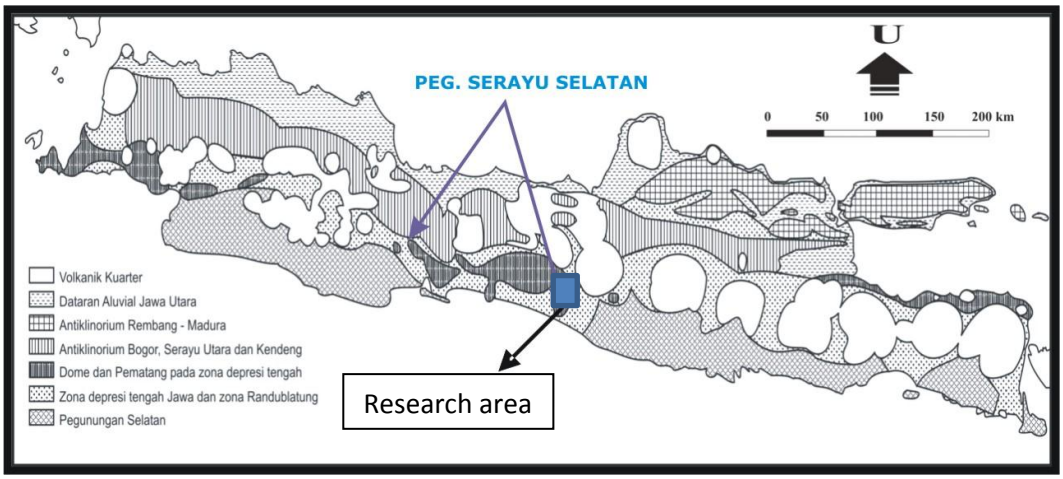
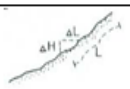


Figure 1. Physiography of Kulon Progo Mountain and the vicinity area (after Van Bemmelen, 1949).

These variable responses were directly collected from field together with geological mapping. Some of these variable response can be looked at Table 1.

Table 1. Some variables of geomorphological index (Wells *et al*, 1988).

Variable	Notes	Formula	Sketch
V_f	Valley floor – height ratio	$\frac{Vfw}{\left[(Eld - Esc) + (Erd - Esc)\right]/2}$	
V_r or V_{ratio}	Valley cross section	Av/Ac	
S_L	Valley cross section	$(\Delta H/\Delta L) \times L$	

THEORY

Todd (1980) studied about relation between river flow and groundwater table. When there is connection of stream and free aquifer, this stream can be lossing stream or gaining stream, depends on relative water level. Sometime, gaining stream can changes to be losing stream, or reverse.

Whereas, Freeze and Cherry (1979) explained about topographic effect to regional flow system. Even at the homogenous geological area, topographic would build complex groundwater flow. Usually, higher area becomes recharge area, whereas lower area would be discharge area. At the topographic configuration, hinge line is located nearer to valley floor compared with hill peak.

REGIONAL GEOMORPHOLOGY

Van Bemmelen (1949) stated that the study area is located in Central Depression Zone of Java physiography, namely West Progo Mountain and Solo Zone (represented as Yogyakarta Graben). Landform of Yogyakarta Graben show gently slope to plain area, accompanied by gently to steep cliff river.

JICA (1980, in Syaiful, 2000) made geomorphological map of Mt. Merapi and its surrounding area. Refers to this map, the northern part of Progo drainage area include in foot and slope geomorphological units with slope of 8 – 10%. Their surface composed by alluvial, lahar and pyroclastic sediments. The middle and southern part of eastern Progo drainage area is fluvio volcanic plain geomorphologic unit, located in 0 – 8% slope area, which covered by flood plain from rivers whose upstream come from Mt. Merapi summit.

Budiadi and Listyani (2007) have analyzed the morphotectonics of the Yogyakarta Graben Quaternary and showed variations in the response of geomorphic variables. From the valley floor height ratio index (V_f), valley cross section (V_r) and river gradient (S_L) it shows that Quaternary tectonics is more controlling in the upper to middle part of the Progo drainage area. Morphological development of the Progo watershed is influenced by Quaternary tectonic (neo tectonic). This active tectonics is indicated by the straightness of the river slopes, the narrow V valley and the deepening of the valley.

GEOMORPHOLOGY OF RESEARCH AREA

The study area show hilly to mountaineous topography of West Progo Dome at westernpart, whereas the eastern part is gently slope to plain of Mt. Merapi foot (Fig. 2). West Progo of Dome topography shows steep slope and high dissected morphology.

Figure 2. The research area morphology seen from band 321 of Landsat image in 1995.

Streams condition usually are intermittent or ephemeral flow, even dry for long time. Progo river flows along north – south relatively on bedrock of West Progo stratigraphic rocks series, such as Nanggulan, Old Andesite, Sentolo, and Jonggrangan Formations.

Generally, Progo River flow from north to south pass the two landform units. Rock and structure of these two units should influence to the river morphology or drainage pattern.

RESPONSE VARIABLE OF PROGO DRAINAGE AREA

Some response variable have been analyzed in the area such as elevation, slope, valley floor-height ratio, ratio of valley cross section and river gradient index. Detail of these variables can be explained as below.

a. Elevation (h) and slope (α).

The upstream of Progo Drainage Area can be devide as into two morphogenetic landform, there are West Progo Hills and slope of volcanoes (Merapi). The area at West Progo Hills usualy show moderate to steep morphology (Figure 3), where as slope of Mt. Merapi show the high to moderate elevation with gently morphology.

Figure 3. Photograph of westernpart (left) and easternpart (right) of research area.

The westpart of research area include in regional area of Mungkid and Sumberagung. These area have average height of 291.3 and 433.8 m (Table 1). West Progo area, especially at Sumberagung and surrounding area has height differences as high as 112 m, it means that the area has coarse relief. On the other hand, the southeast part of Progo Drainage Area has high elevation but low height difference value. This area usually show as a slope of volcano, wity gentle to steep slope.

Table 1. The average value of response variable (h, ΔH, α) of morphometry at study area.

No	Part	Elevation / h (m)	Height difference / ΔH (m)	Slope /α (%)
1	Northwest (Mungkid)	291.3	30.1	17.2
2	Southwest (Sumberagung)	433.8	112.3	44.6
3	Northeast (Muntilan)	503.1	12.9	55.7
4	Southeast (Sleman)	236.4	23	25.6

b. Variables of V_f, V_{ratio} and S_L

The three response variables of V_f, V_r and S_L at study area can be noticed at Table 2 as below. That table that V_f in the study area usually have more than 3 except at the northwest part. While, value of V_r vary from 1 to 3.

Generally, V_f in the western part show less value than that in the east. West Progo Hills has smaller V_f compared with slope of Merapi. It means that river in West Progo have narrow floor but high scarp relatively.

Conformable with V_f then V_r value are also smaller in West Progo. It means that rivers at the slope of Merapi usually have wider valley.

On the other hand, S_L value show more variable in the research area. Northwest and southeast parts of these area show high S_L which means that river gradient have high variety from up to downward of Progo Drainage Area. This characteristics may be controlled by structure or volcanic aspects.

Table 2. Response variable of V_f, V_r and S_L

No	Part	V_f	V_r	S_L
1	Northwest (Mungkid)	1.8	1.2	212.6
2	Southwest (Sumberagung)	3.8	2.2	63.6
3	Northeast (Muntilan)	3	3.1	44.6
4	Southeast (Sleman)	3.9	2.7	181.0

RELATION BETWEEN RESPONES VARIABLES

Sometimes there can be found correlation between response variables. This fact can be understood as depending aspect. Unfortunately, the correlation show low/very low correlation coeficient between elevation to V_f, V_r and S_L (Figure 4-6).

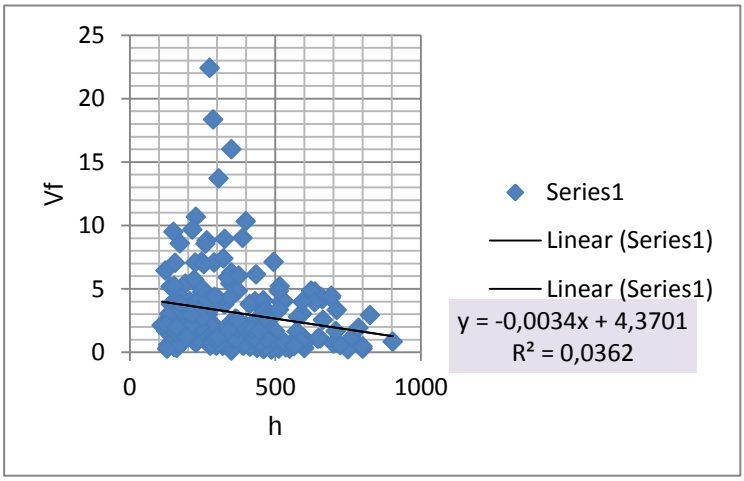


Figure 4. Relationship between elevation and V_f.

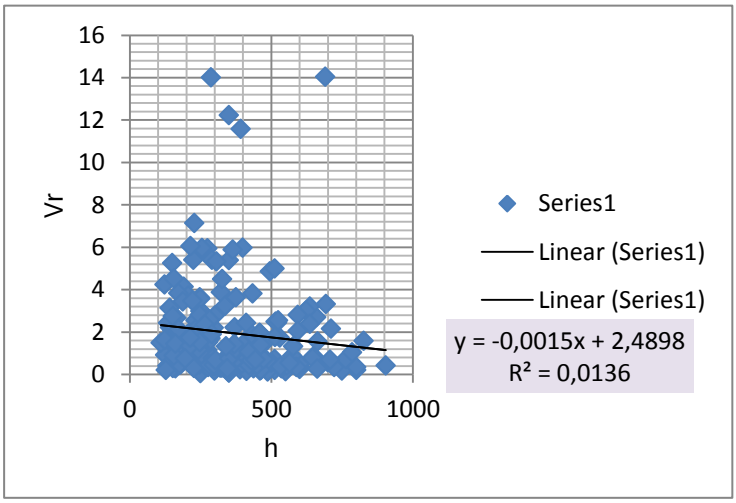


Figure 5. Relationship between elevation and V_r.

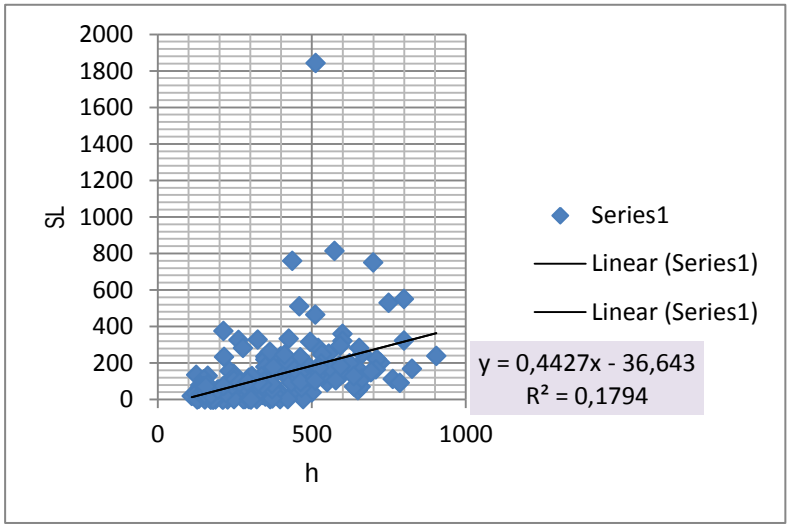


Figure 6. Relationship between elevation and S_L.

The poor correlation as shown at Figure 4 – 6 above prove that V_f, V_r, and S_L can varry at every level of landform. Shallowness and width of valley are nor depending to elevation of area.

SUMMARY

Progo River generally flows through structural landform in western part and volcanic one at the east. The western part of Progo Drainage Area usually has moderate to high elevation with high height differences. The easttern part show high elevation but low height differences although the slope also high relatively.

V_f and V_r value generally lower at the westtern part, but S_L still show more variable from up to downward of river flow. This fact should be controlled by rocks and structures of the area. Unfortunately, there are very weak or no correlation between elevation to V_f, V_r and S_L in the research area.

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