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Drainage Pattern and Its Influence on Landforms in the Sumedang Regency, West Java

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Abstract: The research area is located on Sumedang Regency, West Java Province. This research aims to determine the landforms in the Sumedang Regency based on drainage pattern analysis. This research was carried out through studio analysis and field observation. Stream network and topography data were obtained from Indonesia Topographic Maps and Digital Elevation Model (DEM). Compilation of data from these media becomes the basis for determining the landforms. Based on the results, the research area has varied slopes and different landform. The very steep to steep slopes can be identified in the central, west, and south of the research area whereas the gentle slope to flat area can be identified in the north, east, and some parts of the research area. The research area consists of various types of landform, namely volcanic, fluvial, and tectonic landform. Volcanic cones and hills are part of volcanic landform that can be identified by very steep to steep slope area which has some elongate topographic features and relatively hard-resistant rocks in the west, central, and south of the research area. It can be proven from radial, subradial, parallel, and subparallel drainage patterns. Fluvial landform can be identified by gentle slope to flat area which has erosion and sedimentation process in central, north, east, and northeast of the research area. It can be proven from dendritic and anastomotic drainage patterns. Tectonic landform can be identified by steep to gentle slope area which has tectonic process in the north, central, east and southeast of the research area. It can be proven from subdendritic, recurved trellis, and rectangular drainage patterns. The results of field observation also show that the geological structures developed in the north, east, and southeast of the research area. It can be concluded that the drainage pattern analysis is able to show the general geological characteristic, especially landforms of the research area. However, field observation is also necessary to find out the actual condition in the field.

Key words **–** Drainage pattern, slope, landform, geological structure, Sumedang

I. INTRODUCTION

The research area is located on Sumedang Regency, West Java Province (Figure 1) at coordinates 6°33'19,0" S - 7°3'59,6" S and 107°43'29,6" E - 108°14'0,6" E. It consists of districts such as Rancakalong, South Sumedang, North Sumedang, Tanjungsari, Situraja, Cimalaka, Paseh, Tomo, etc. This research aims to determine the landforms in the Sumedang Regency based on drainage pattern analysis. There are several things that need to be considered in determining the description and classification of landform such as geomorphological agent, mechanical process, source, scale, and material (Buzek, 1986; Strahler and Strahler, 2000). Therefore, this research would be done properly.

Landforms are specific features of the earth's surface that occur everywhere which have sizes from the smallest to the largest and lifespans from days to millenia to aeons (Hugget, 2011; Mokarram and Sathyamoorthy, 2018). It makes landforms can be found anywhere and anytime. The landforms process rates had been affected by the environmental change (Twidale, 2004; Sharma, 2011) or natural process in a long period of time (He et al., 2016). Moreover, human activities are indicated to be associated with changes in landforms (Ikemi, 2017; Migoń and Latocha, 2018; Kubalikova et al., 2019). In this research, the landform classification is made as simple as possible where the classification is based on the geological or natural processes such as volcanic, fluvial, tectonic, karst, aeolian, etc. On the other hand, landforms on the earth's surface can be interpreted early by using drainage pattern analysis (Zernitz, 1932; Schumm et al., 2000; Twidale, 2004).

According to Twidale (2004), river or drainage patterns are the spatial arrangements of streams. Drainage pattern can reflect geographical characteristics of a river network (Zhang and Guilbert, 2013) such as topography, porosity, permeability, geological structure, and chemical composition of soils and rocks (Hills, 1963; Argialas et al., 1988). The drainage pattern in each area may differ from one area to another. Hence, it is important to study drainage pattern as a geographical factor in river network generalisation (Touya, 2007; Jiang et al., 2009; Stanislawski, 2009; Stanislawski and Buttenfield, 2011).

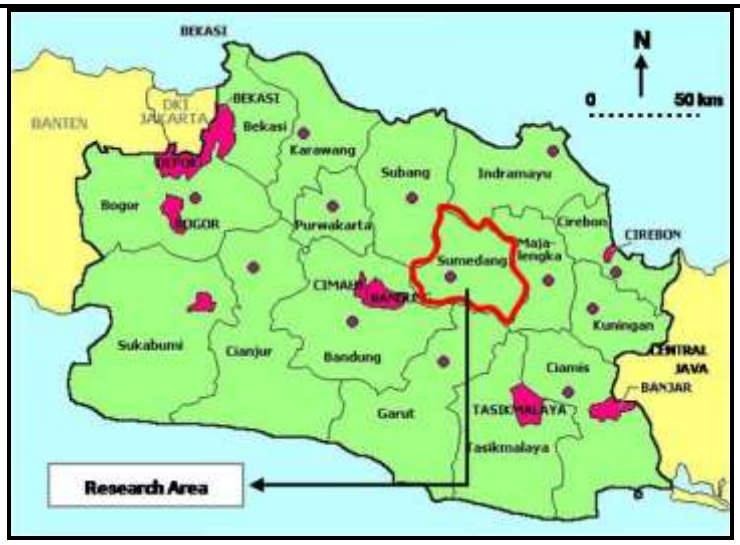

Figure 1. The research area in Sumedang Regency

II. METHOD

This research was carried out through studio analysis and field observation. Data used in the studio analysis consist of stream network that can be obtained from Indonesia Topographic maps and Digital Elevation Model (DEM). Geographical Information System (GIS) and Digital Elevation Model (DEM) are widely used to extract drainage networks or drainage basins as well as for landform classification (Vogt et al., 2003; Iwahashi and Pike, 2007; Nardi et al., 2008; Florinsky, 2009; Ortega and Rueda, 2010; De Reu et al., 2013). The extracted stream network data is then identified and analyzed using description and classification of drainage pattern (Zernitz, 1932; Howard, 1967; Twidale, 2004). The classification of drainage pattern is based in their shape and texture according to slope and structure (Zhang and Guilbert, 2013).

III. RESULTS AND DISCUSSION

Slope characteristics in the research area can be seen in Figure 2 and compared to drainage pattern analysis that have been carried out. Based on the slope map (Figure 2), the research area has varied slopes and indicates different landform from one places to another. The very steep to steep slopes can be identified in the central, west, and south of the research area whereas the gentle slope to flat area can be identified in the north, east, and some central parts of the research area. It will be related to the drainage pattern in the research area (Zernitz, 1932; Howard, 1967; Twidale, 2004; Zhang and Guilbert, 2013)..

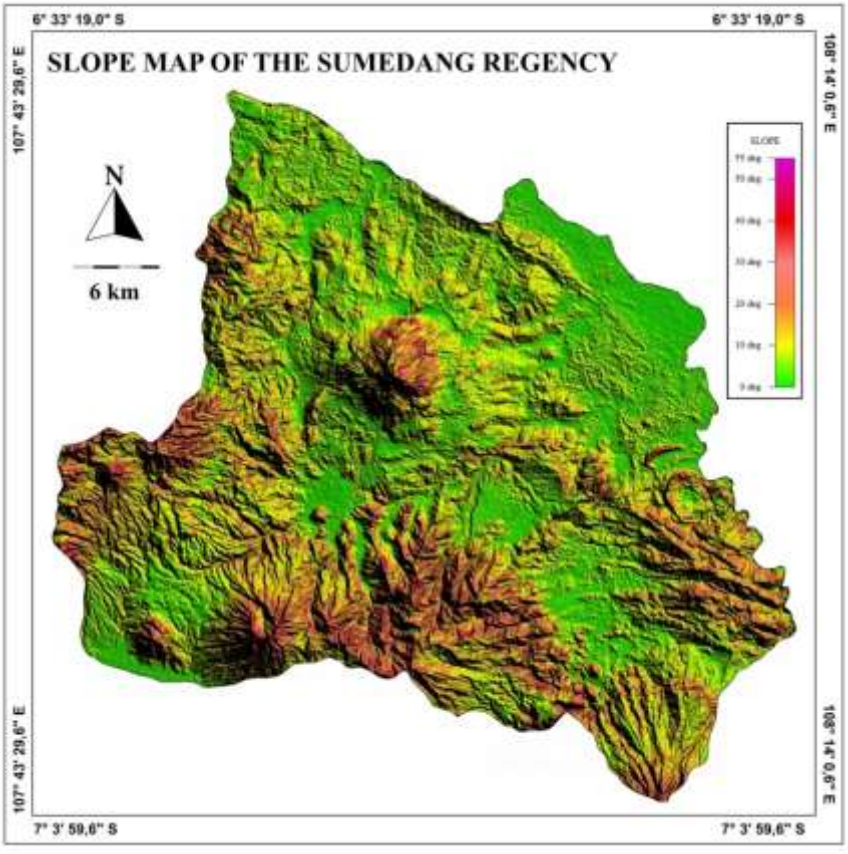

Figure 2. Slope map of the Sumedang Regency

The drainage pattern of the research area can be seen in Figure 3. In general, the research area has varied characteristics. It is because the research area consists of basic and modified drainage patterns, namely radial, subradial, parallel, subparallel, dendritic, subdendritic, anastomotic, recurved trellis, and rectangular drainage pattern. Each of these patterns has its own unique geological characteristics. Several

aspects such as slopes, rock types, and geological structures can be identified through drainage pattern analysis. Moreover, all of these aspects are related to landform. The research area consists of various types of landform, namely volcanic, fluvial, and tectonic landform.

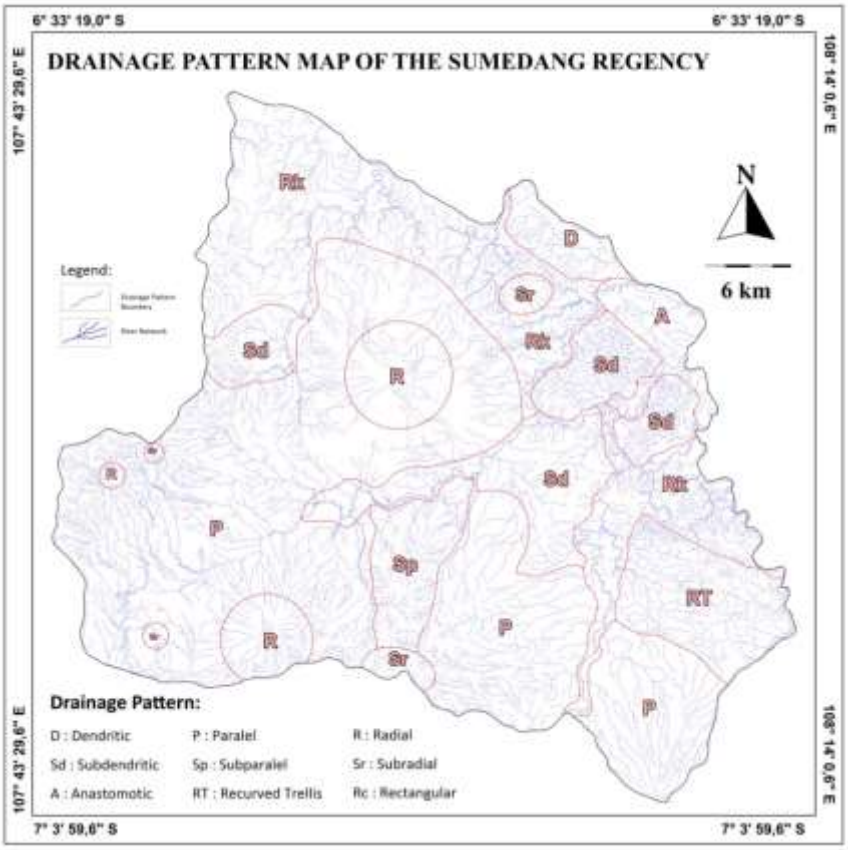

Figure 3. Drainage pattern map of the Sumedang Regency

Volcanic Landform

Volcanic cones and hills are part of volcanic landform that can be identified by very steep to steep slope area which has some elongate topographic features and relatively hard-resistant rocks in the west, central, and south of the research area. It can be proven from radial, subradial, parallel, and subparallel drainage patterns that can be found in the research area (Figure 4 and 5). Radial and subradial drainage patterns have a stream network originating from a volcanic peak and flowing outwards from a central volcanic peak (Zernitz, 1932; Howard, 1967). Both of the drainage patterns can be distinguished by the total of stream network originating from a volcanic peak and the perfection of stream network. This drainage pattern can be found in the volcanic cones of the research area, namely Mount Tampomas, Mount Kareumbi, Mount Calancang, and Mount Geulis. Parallel and subparallel drainage pattern dominate nearly half of the research area. It has moderate to steep slopes in elongated landform areas (Schumm et al., 2000). Both of the drainage patterns can be found at Wado, South Sumedang, Darmaraja, Buahdua, and Situraja area.

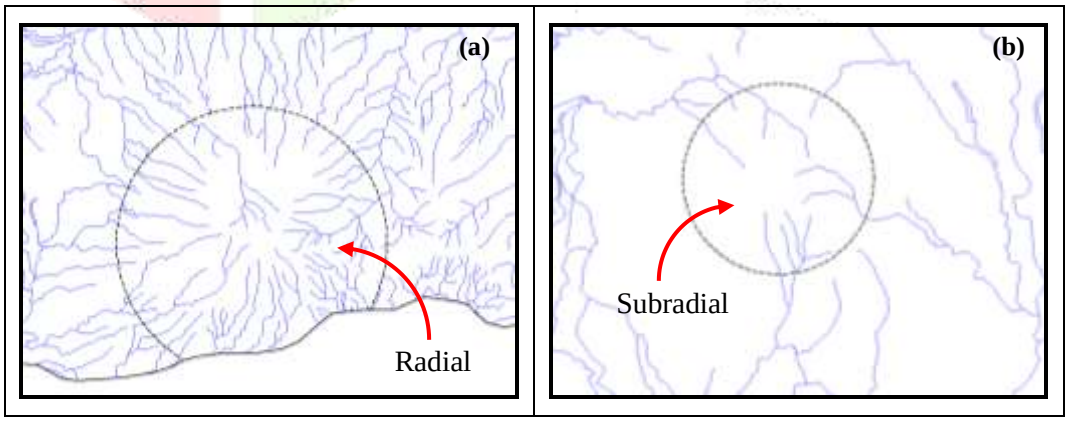

Figure 4. Radial and (b) subradial drainage pattern

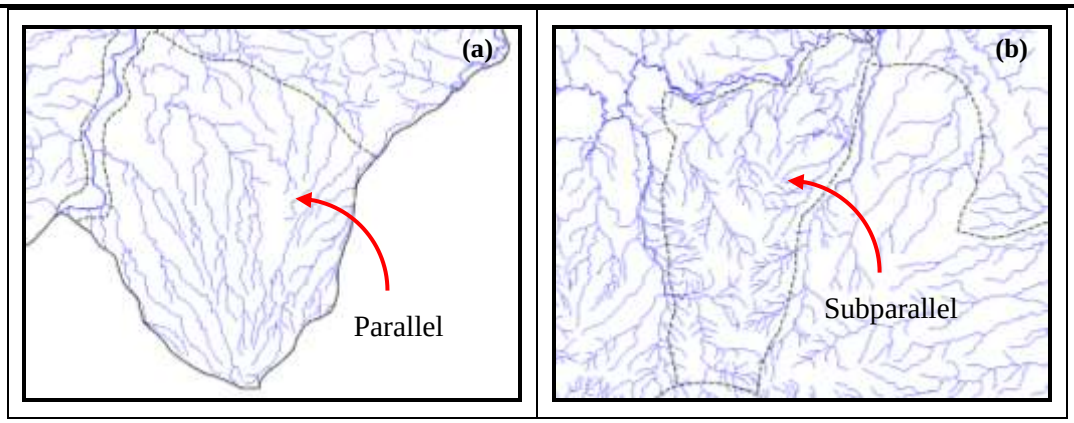

Figure 5. (a) Parallel and (b) subparallel drainage pattern

Figure 6. Volcanic landform in the research area

Fluvial Landform

Fluvial landform can be identified by gentle slope to flat area which has erosion and sedimentation process in central, north, east, and northeast of the research area. It can be proven from dendritic and anastomotic drainage patterns that can be found in the research area (Figure 7). Dendritic drainage patterns indicate areas composed of relatively uniform sedimentary rocks. It is characterized by irregular branching in all directions of streams. According to Charlton (2008), dendritic pattern can be found in areas without strong geological structure control. It can be found at Ujungjaya, Tanjungkerta, Situraja, and Tomo area. The anastomotic drainage pattern shows a network of interlocking streams and has relatively wide streams compared to other drainage patterns. Anastomotic or anastomose types have developed where flow strength, bank erodibility and gradients are low but load is moderate to high (Twidale, 2004). Sediment deposits and alluvium are also commonly found along this streams. This drainage pattern usually occupies a floodplain at the Ujungjaya area.

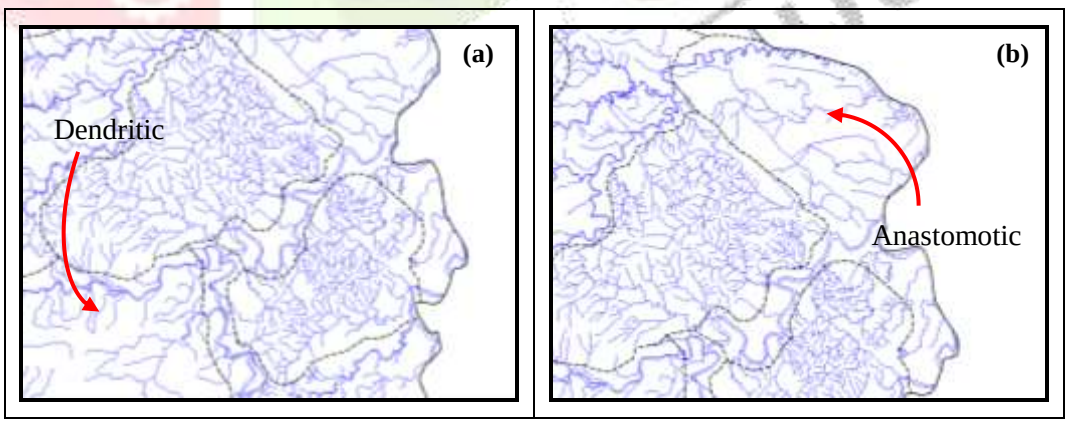

Figure 7. (a) Dendritic and subdendritic (b) anastomotic drainage pattern

Figure 8. Fluvial landform in the research area is characterized by (a) valley and (b) alluvium along the river

Tectonic Landform

Tectonic landform can be identified by steep to gentle slope area which has tectonic process in the north, central, east and southeast of the research area. It can be proven from subdendritic, recurved trellis, and rectangular drainage patterns that can be found in the research area (Figure 9). Subdendritic pattern shows that the research area is influenced by the geological structure (Zernitz, 1932; Howard, 1967). It is also confirmed by the presence of recurved trellis and rectangular drainage pattern. The recurved trellis, which is a modification of the trellis pattern (Howard, 1967), shows an elongated and slightly curved shape that can be found at Jatinunggal area. It indicates the influence of the elongated fold structure from Jatinunggal to Jatigede area. On the other hand, the rectangular shows right-angled bends in the main stream and its tributaries (Zernitz, 1932; Howard, 1967) that can be found at Buahdua and Jatigede area. It indicates the influence of fault structure in the research area. Hence, the elongated, folded, and faulted hills can be found in the research area.

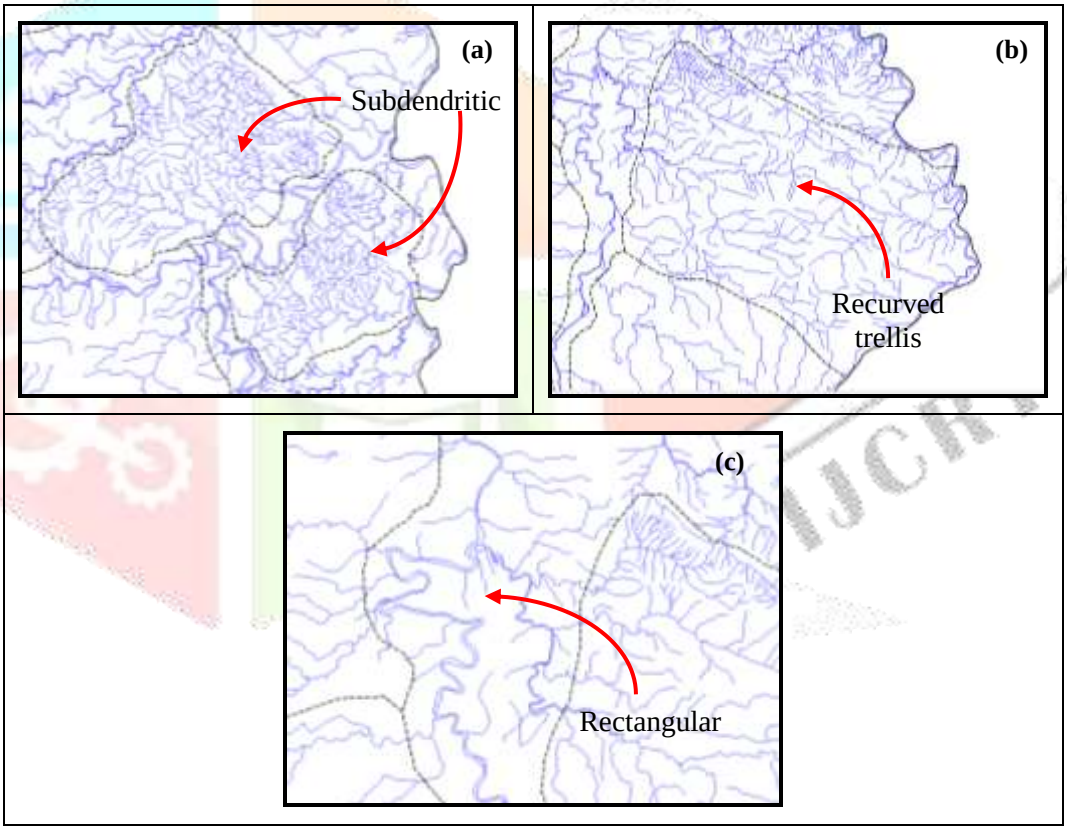

Figure 9. (a) Subdendritic, (b) Recurved trellis, and (c) Rectangular drainage pattern

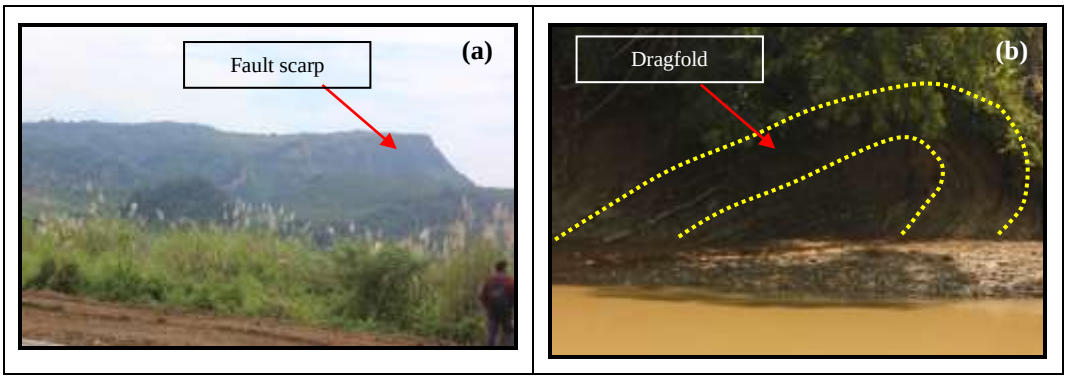

Figure 10. Tectonic landform in the research area is characterized by (a) fault scarp and (b) dragfold

IV. CONCLUSION

Based on the results, it can be concluded that the drainage pattern analysis is able to show the general geological characteristic, especially landforms of the research area. Several aspects such as slope, rock type, and geological structure can be estimated early based on the drainage pattern analysis. It can help researchers to determine the initial conditions of the research area so that the researchers can plan the field activities appropriately and efficiently. However, field observation is also necessary to find out the actual condition in the field.

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