

GEOMORPHOLOGICAL CHARACTERISTICS OF THE PASIRPANJANG AREA AND ITS SURROUNDINGS, CIRACAP, CILETUH, SUKABUMI DISTRICT, WEST JAVA PROVINCE

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ABSTRACT

The study site is considered in the Pasirpanjang and its environs area of Ciracap District, Sukabumi Regency, West Java which has a geomorphologic diversity that could be affected by endogenic and exogenic processes. Therefore, the objectives of this study are to determine the geomorphological features of the area by using morphographics, morphometrics and morphogenetic aspects. We analysis DEM, obtain field data and a review of literature is made. Morphographic analysis consists of landforms and river flow patterns, morphometric analysis includes slope gradients and morphogenetic anlyasis arranges lithology, geological structure and river flow patterns. Study result indicates truly cartographic aspects of the terrain are two types: low hills and high hills; subdendritic and rectangular patterns with changes in slopes ranging from gentle to steep. The geology in the region of the outer rim is caused by tectonic and volcanic activity, as well as exterior weathering and erosion still occurring. The study area is divided into three major geomorphological units depending on combination of these 3 geomorphologic attributes. The findings contribute to a significant geomorphological interpretation that can serve as an important reference for land use planning and mitigation of potential geomorphologic disasters, as well as the advancement of applied geological researches in the Ciracap area and its adjacent locations.

Keywords: DEM, Drainage Patterns, Geomorphology, Pasirpanjang, Sukabumi

INTRODUCTION

The study of the surface of the Earth's shape and the endogenous and exogenous processes that shape it is known as geomorphology (Rafli, D., et al., 2024). This is consistent with Verstappen's (1983) claim that geomorphology is concerned with the origins and development of landforms that arise above and below sea level. In modern geomorphological research, morphographic, morphometric, and morphogenetic methods are used for both descriptive and quantitative analysis. Although the morphological method is used for analyzing topographic parameters such as elevation and slope gradient calculated using DEM (Digital Elevation Model) data, a morphographic approach is used for recognizing and describing landforms. The process of landform formation based on the result of lithology, geological structure, and

other geological processes can be clarified by morphogenetic analysis. Because it offers a more thorough and organized picture of geomorphology, this combination of three methods was selected.

As Digital Elevation Models (DEMs) offer detailed topographic information that can be used to derive terrain attributes like slope, aspect, and elevation— which are essential to landform analysis and the interpretation of geomorphic processes—the use of DEM data in geomorphological mapping has advanced in its significance (Wilson & Gallant, 2000). However, the application of DEM-based geomorphological approaches in the Pasirpanjang Village area and its surroundings, Ciracap District, Sukabumi Regency, is still limited. Astronomically, it is located at coordinates 106°30'0.52" – 106°32'47.35" East Longitude and

7°16'56.37" – 7°19'40.12" South Latitude. Therefore, this study offers novelty through the integration of morphographic analysis, DEM-based morphometry, and morphogenetic interpretation in geomorphological mapping. This study aims to identify and classify geomorphological units in the study area, with the final result being a geomorphological map equipped with lithological information on each unit.

Regional Geology

In a physiographic study, Van Bemmelen (1949) classified the West Java region into five main zones: the Jakarta Coastal Plain Zone, the Bogor Zone, the Bandung Zone, the Bayah Mountains Zone, and the Southern Mountains Zone. The study area is included in the Southern Mountains Zone, which was formed by subduction activity between the Indo-Australian Plate and the Asian Plate in the Late Oligocene. This zone stretches from west to east following the path of Java Island (Van Bemmelen, 1949).

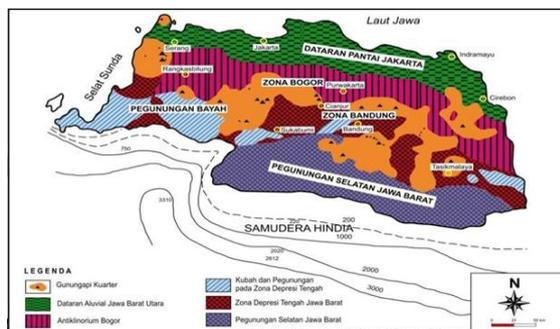


Figure 1. Physiography of the West Java Region (Van Bemmelen, 1949).

Based on Sukamto (1975), on the regional geological map of the Jampang and Balekambang sheets, the research area consists of four formations from the oldest to the youngest, namely the Jampang Formation, Cikarang member (Tmjc), which has the same age as the Cilegok porphyry (Tmcs), the Cibodas formation (Tmcs), and the Citanglar coastal deposits (Qpcb), where the research area is dominated by the Jampang Formation, Cikarang member (Tmjc) (Figure 2). The Southern Mountains Zone experienced three distinct tectonic stages between the Oligocene and Quaternary periods, as described by Van Bemmelen (1949), with tectonic activity frequently associated with volcanism. Combined petrographic, petrological, and

biostratigraphic analyses have contributed substantially to elucidating carbonate depositional systems, volcanic controls, and stratigraphic framework in southern West Java, particularly within the Cibodas and Jampang Formations (Prinaldi et al., 2023; Pratiwi et al., 2023; Maulana & Pratiwi, 2024; Pratiwi et al., 2024; Ramdhani et al., 2024).

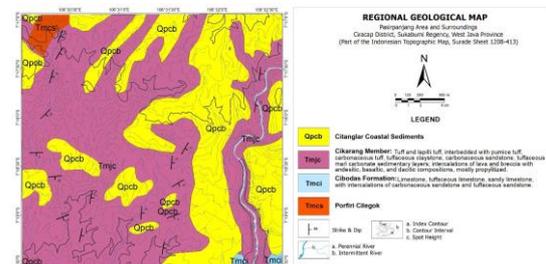


Figure 2. Regional Geological Map of the Research Area

The Jampang region in Sukabumi Regency is part of the Southern Mountains Physiography Zone of West Java, which exhibits diverse landforms and geological settings. Based on geological research in several parts of Jampang (including Central Jampang and West Jampang), the morphology of this area was developed by a combination of tectonic and exogenous processes that interacted over a long period. Local geomorphology is often seen as folded and faulted hills and alluvial plains that reflect the tectonic and sedimentary history of this region, showing the dominance of folded rock settings, faults, and various geomorphological units of varying stages of formation.

RESEARCH METHODS

Digital Elevation Model (DEM) data, geospatial data processing software, field observation data, and a review of necessary earlier studies were used to support the qualitative and quantitative methods used in this study's geomorphological analysis. In order to identify geomorphological features in the study area, geomorphological units were categorized according to morphographic, morphometric, and morphogenetic aspects to make the analysis process easier.

The first stage, morphographic analysis, was carried out by recognizing drainage patterns, valley shapes, and landforms. To improve the results, the drainage network was manually digitized after being automatically extracted from the DEM. The drainage results were

validated by comparing them to the Indonesian Topographic Map (RBI) and adjusting them to field conditions. Drainage patterns were classified according to Howard (1967) in Van Zuidam (1985).

Second aspect Morphometric analysis was performed by calculating slope gradients from the DEM using GIS software. Slope values were expressed in degrees and classified according to Van Zuidam (1985), with slope classes ranging from 0° to >55°. The analysis results were then adjusted to field conditions and manually digitized using ArcGIS, and presented as a slope map.

$$S = \left(\frac{(n-1) \cdot lc}{dx \cdot sp} \right) \times 100\% \text{ (Van Zuidam (1985))}$$

Where,

- S : Slope gradient in percent (%)
- n : Number of contours cut by the line
- lc : Interval contour
- dx : Jarak lateral
- sp : Map scale

Third aspect Morphogenetic analysis was conducted by linking the results of morphographic and morphometric analyses with lithological conditions and geological structures. Field data were obtained from 122 observation stations, including observations of lithology, valley shape, and geological structures, and were used to validate the results of the geomorphological analysis.

RESULTS AND DISCUSSION

Morphography or landscape is a primary parameter in geomorphological analysis, distinguished by variations in the relative elevation of the earth's surface. Referring to the Van Zuidam (1985) morphographic classification modified by Ike Bermana (2006), the study area has an elevation of ±50–263 masl and is divided into two landscape units: low hills (50–200 masl) and hills (200–263 masl). Spatially, low hills dominate the southern part of the study area, while hill units develop in the northern part (Figure 3).

The lithology and weather resistance of the rock are closely linked to these variations in landforms. While hill units are made up of non-carbonate sandstones and igneous rocks that typically form steeper relief, low hill units

are typically made up of relatively resistant carbonate sandstones and tuffs.

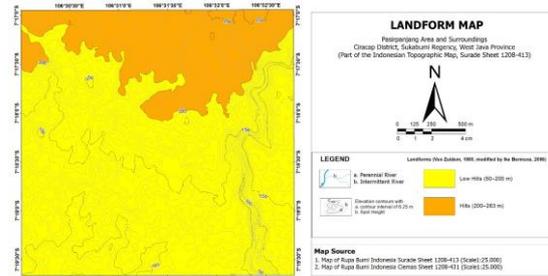


Figure 3. Landform Map of the Research Area

The relationships between landforms, slope gradients, lithology, and geological structures are reflected in river flow patterns. According to the analysis, there are two primary drainage patterns in the study area: rectangular and sub-dendritic (Figure 4)

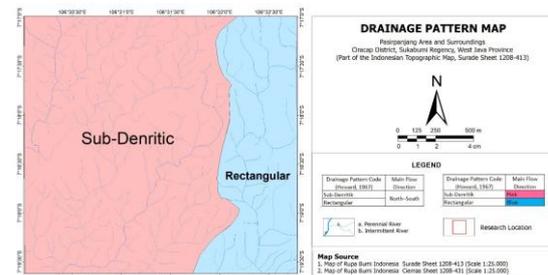


Figure 4. Map of Flow Patterns in the Research Area

The research area's central-western region, particularly the Cibalengbeno and Cidadap Rivers, is where the sub-dendritic pattern primarily forms. This pattern appears in U-shaped valleys, gentle to undulating slopes, and relatively homogeneous lithology. The lithology distribution map, which demonstrates the dominance of uniform rock units in the zone, supports this lithological homogeneity. As a result, the river flow develops freely without strong structural control and forms branches that resemble sub-dendritic.

In contrast, the eastern portion of the study area—especially the Cikarang River—develops a rectangular drainage pattern. The alignment of river flow direction with the orientation of the cracks and faults in the field (Figure 6) indicates that this pattern is governed by geological structures in the form of dominant cracks and faults. Because of structural control and the predominance of vertical erosion, rivers in this zone typically

form right-angled bends with V-shaped valleys. A parallel tendency can be seen when comparing the azimuth of river flow and the orientation of cracks and faults. The main cracks in the rose diagram, which are oriented NW–SE and NE–SW, are parallel to the structurally controlled river segments, which are primarily oriented north–south to NE–SW. This indicates that geological structures have an impact on drainage development in this zone.

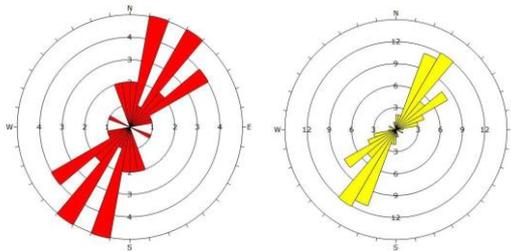


Figure 6. Valley and ridge Rosette diagram of the Research Area

Slope gradients were computed using DEM data for morphometric analysis, and the results were then categorized using the Van Zuidam (1985). The analysis's findings are displayed as a slope map (Figure 6). The study area is divided into three slope classes. The study area's central to southern regions have gentle slopes (4° – 8°), which are connected to low to undulating hill units.

Particularly in the central to northeastern and northwestern regions of the study area, zones impacted by lithological and structural controls give rise. Hard rocks and active geological structural zones are linked to extremely steep slopes (16° – 35°) that develop longitudinally in a north–south direction. Narrow valleys, steep cliffs, and intense erosion are typical characteristics of this zone.

This slope distribution indicates a strong relationship between morphometry, lithology, and structural processes in the formation of the landscape of the study area.

By contrasting information on the evolution of river flow patterns with the features of its component lithologies, morphogenetic analysis was carried out in the study area. This area is impacted by both exogenous processes like weathering and erosion, which are still going strong today, and endogenous

processes associated with tectonic activity, as shown by field structural data such as cracks, fault mirrors, and other fault indications.

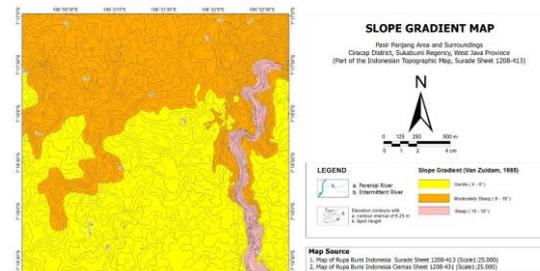


Figure 6. Slope Map of the Research Area

Endogenous processes play a role in shaping the morphology of the study area, primarily through tectonic and volcanic activity. The influence of tectonism is quite dominant, as indicated by the presence of cracks, fault mirrors, and waterfalls in several study locations. However, this tectonic control is not intensively developed, as reflected in the relatively uniform layering pattern with a nearly horizontal dip, indicating a low level of structural deformation. Volcanic processes also contribute, albeit on a limited scale, as indicated by the presence of basaltic lava in the northwest part of the study area, as well as the dominance of pyroclastic material such as lapilli tuff in the constituent rocks.

Exogenous processes are the dominant factors in the morphology of the study area, including weathering, erosion, and sedimentation. Weathering is characterized by changes in rock color and hardness, occurs primarily laterally, and forms U-shaped valleys, with mechanical, chemical, and biological types, including spheroidal weathering. Subsequent erosion and sedimentation processes form a low, undulating hilly landscape.

The geomorphology of the study area is influenced by three main aspects: morphography, morphometry, and morphogenetics, and is supported by analysis of river flow patterns, ridge and valley shapes, and lithology distribution. Based on this analysis, the study area consists of three geomorphological units: low and rather steep structural hills, gentle denudation hills, and low, gentle, and undulating hills (Figure 7 and Table 1).

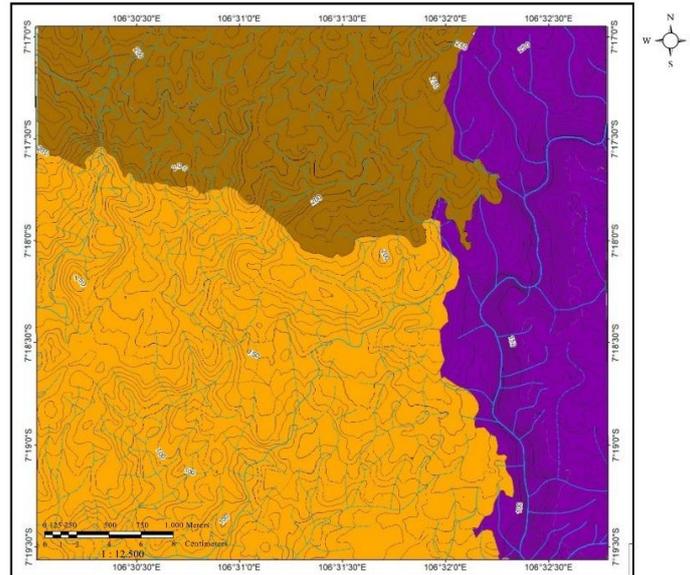


Figure 7. Geomorphological Map of the Research Area

Table 1. Geomorphological Units of the Research Area

Geomorphology								
Geomorphological Unit	Color Symbol	Morphography			Morphometry	Morphogenetic		
		Landform	Valley Shape	Drainage Pattern	Slope Gradient	Endogenic	Eksogenic	Lithology
Steep Structural Low Hills		Low Hills	v	Trellis	Steep (16-35°)	Tectonic		Carbonaceous Sandstone and Tuff
Moderately Steep Denudational Hills		Hills	u	Sub-Denritik	Moderately Steep (8-16°)		Weathering and Erosion	Non-carbonaceous Sandstone, Tuff, and Intrusive Igneous Rocks
Undulating Gentle Low Hills		Low Hills	u	Sub-Denritik	Gentle (4-8°)	Tectonic		Sandstone and Tuff

Low Hills Structural Steep

This low hills, somewhat steep structural hill geomorphological unit covers approximately 19% of the total study area and stretches from north to south, following the Cikarang River as the main river. Based on field observations, this unit is characterized by low to hilly forms with altitudes ranging from 150–260 meters above sea level and relatively steep slopes, namely around 16°–36°. The geomorphological formation process in this unit is mainly controlled by geological structural activity, especially the presence of faults or cracks that play a role in controlling river flow patterns, thus forming rectangular flow patterns. The valleys that develop in this area generally have a sharp V-shaped cross section, as a result of the dominance of

vertical erosion processes. The lithology that forms this unit is sandstone, which has the potential as a source of mining materials, especially for construction purposes. The villages included in this unit are Kadaleman, Caringinunggal, and Surade.

Denudational Slightly Steep Hills

This slightly eroded hilly geomorphological unit occupies approximately 21% of the study area and is spread from north to northwest. This unit is characterized by hills with an altitude of 200–263 meters above sea level and a relatively steep slope gradient (8°–16°). Its formation is dominated by exogenous processes such as physical, chemical, and biological weathering, as well as erosion. The valleys formed are generally blunt U-shaped due to the dominance of

lateral erosion and relatively stable morphological conditions. The drainage pattern is sub-dendritic and relatively regular, so it is utilized by the community as an irrigation system. The constituent lithology consists of sandstone and extrusive igneous rocks that have undergone mechanical weathering and oxidation. The village included in this unit is Cibenda Village.

Low, gently undulating hills

The gently undulating low hills geomorphological unit occupies approximately 60% of the study area and is distributed in the southwest to the central part. This unit is characterized by low hills with an altitude of 50–200 meters above sea level and a gentle slope (4°–8°). Its formation is influenced by endogenous and exogenous processes, but the latter is more dominant due to relatively weak tectonic activity. The formed valleys are generally blunt U-shaped due to the dominance of lateral erosion and stable morphological conditions. The drainage pattern is sub-dendritic and relatively regular, making it suitable for agricultural irrigation. The lithology consists of sandstone and tuff that have undergone mineral alteration. The villages included in this unit are Pasirpanjang, Mekarsari, and Purwasedar.

CONCLUSION

The Pasirpanjang region and its environs display geomorphological features created by the interplay of endogenous and exogenous processes that are still in effect today.

The integration of morphographic, DEM-based morphometric, and morphogenetic analyses shows that dominant denudation processes, lithology variations, and the intensity of geological structures govern landform development.

The study area can be divided into three primary geomorphological units based on these integrated results: low, gently undulating hills, moderately steep denudational hills, and low, steep structural hills. Through the use of an integrated geomorphological approach based on DEM evaluated by field data, this study contributes to scientific research by producing a more detailed and representative classification of geomorphological units. The findings are anticipated to provide a framework for future

geological research, resource management, regional planning, and disaster mitigation in the Ciracap region and surrounding area.

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