GEOMORPHOLOGICAL ASPECT ANALYSIS IN CIKANGKUNG AND SURROUNDING AREA, CIRACAP SUBDISTRICT, SUKABUMI REGENCY, WEST JAVA

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ABSTRACT

The Ciletuh–Jampang area, located in the southern part of Java Island exhibits distinct geomorphological characteristics shaped by a combination of endogenous and exogenous geological processes over an extended period. This study analyzes the geomorphology of the region using field observations and remote sensing, focusing on morphographic, morphometric, and morphogenetic aspects, specifically in Cikangkung area, Ciracap Subdistrict, Sukabumi Regency, West Java. Based on those three geomorphological aspects, this area could be divided into four different units, such as marine lowland, denudational lowland, gently sloping structural lowhills, and sloping structural lowhills. These geomorphological units results form the interaction between tectonic activity, volcanism, weathering, erosion, and sedimentation processes. Tectonic uplift and volcanism, resulting in various rock resistance, significantly influence the landforms. Meanwhile, exogenous processes influence terrains, drainage patterns, and top-soil thickness. The results reveal that these processes not only define the region's unique morphological features, but also influence its diverse land use practices.

Keyword: Geomorphology, Ciletuh-Jampang, Cikangkung, Landform, Remote Sensing

INTRODUCTION

As an archipelagic country, Indonesia consist of five main islands and more than 300 smaller island groups (Darman, 2000). Physiographically, Indonesia is composed by two major continental shelves, the Sunda Shelf and the Sahul Shelf. This physiographic condition is influenced by several forming processes including tectonism, volcanism, sedimentation, erosion, and others.

Geologically, the Indonesian archipelago was formed by the amalgamated Gondawana fragments over the last 300 million years along the Eurasian subduction margin. The modern geology of Indonesia mainly controlled by subduction and collision that have been continue since the Cenozoic (Hall, 2009). These processes have led to Indonesia's diverse morphologies, including the Ciletuh–Jampang area located in the southern part of Java Island.

The Ciletuh–Jampang area is known for its unique landforms, featuring horseshoe-shaped amphitheater-like morphology surrounded by plateau (Hardiyono et al., 2015). This region characterized by rugged topography, which belongs to the Southern Mountains zone. This region consist of Miocene volcanic rocks interbedded with clastic sediments that deposited in a shallow marine environment. To the north, the region is bordered by the Cimandiri Fault, separating it from the smoother Quaternary volcanic area (Haryanto et al., 2018). The plateau, known as the Jampang Plateau, was formed as a result of tectonic uplift during the Pliocene, elevating the region to approximately 700 meters above sea level at a rate of 5.0 to 5.4 cm/year (Haryanto et al., 2018; Sulaksana et al., 2015). This region extends southward to directly bordered by the Indian Ocean.

The physiography of the Ciletuh–Jampang region can be analyzed through a geomorphological approach. Geomorphology is a field that studies landforms, the processes that influenced them, and the relationships between the forming process and the resulted morphology (van Zuidam, 1979). Geomorphological processes include a series of physical and chemical processes that modify the earth surface relief (Thornbury, 1970). Tectonic activities integrate with geomorphic processes to shape region's morphology, resulting in transformation of the earth surface (Manggara et al., 2022; Saputra et al., 2022). Additionally, the resistance level of the composing rocks influences the morphological condition, as variations in rock resistance resulting in diverse landforms (Vertsappen, 1985). Past tectonic activities are the main factor that influenced the morphology of this region (Firmansyah et al., 2023).

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Geographically, the study area is located in Cikangkung and surrounding area, Ciracap Sub-district, Sukabumi Regency, West Java (Figure 1). Astronomically, this area positioned between 106° 25' 40.707"E – 106° 28' 23.581"E and 7° 18' 30.738"S – 7° 21' 12.833"S. This study intended to analyze the geomorphological aspects of this area and to understand the dynamics of the processes that influence the landscape.

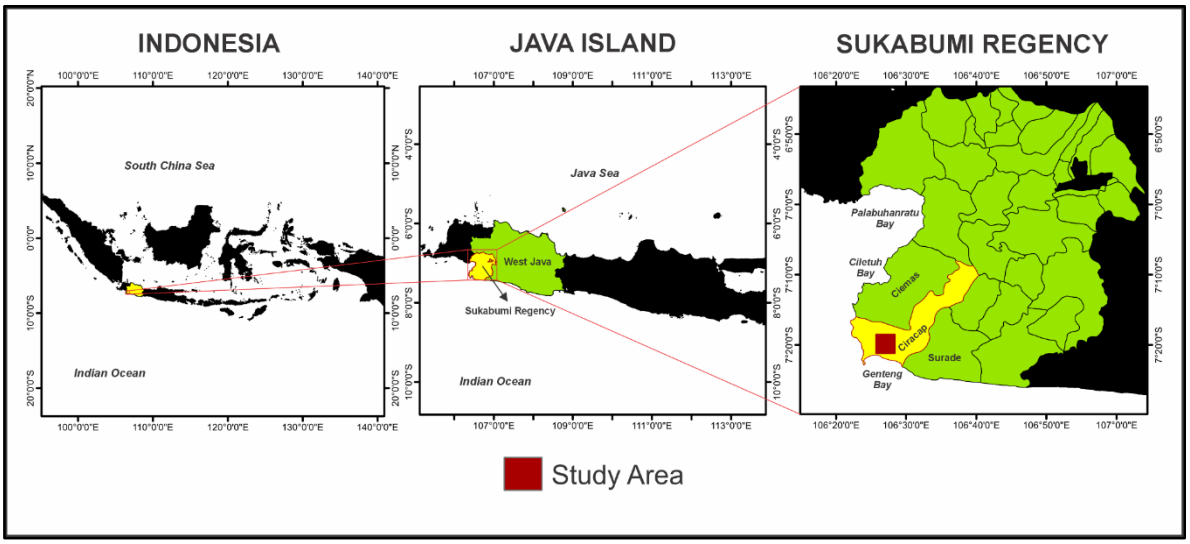

Figure 1. Study area located in Ciracap Subdistrict

REGIONAL GEOLOGY

Physiographically, the study area is part of the Southern Mountains physiographic zone (van Bemmelen, 1949) (Figure 2). This zone represents an anticlinorium formed as a result of subduction between the Eurasian Plate and the Indo-Australian Plate south of Java Island during the Late Oligocene (Katili, 1975). Regionally, the tectonic position of the Ciletuh-Jampang area lies on the southern flank of this E-W anticlinorium (Haryanto et al., 2018).

Based on the Regional Geological Map of the Jampang and Balekembang Sheets, this area predominantly composed by three rock units, such as Cikarang Member of the Jampang Formation, Cibodas Formation, and Quaternary Deposits (alluvium and coastal deposit) (Sukamto, 1975) (Figure 3). The Cikarang Member of the Jampang Formation consists of pyroclastic and volcaniclastic rocks resulting from deep-marine volcaniclastic sediment gravity flow deposits, as well as volcanic igneous rocks with distinctive characteristics (Rosana et al., 2019; Martodjojo, 1984). Based on the calcareous nannofossils occurrence, this formation was deposited during the Late Oligocene to Early Miocene (Ramdhani, 2024; Pratiwi et al., 2024). Meanwhile, the larger benthic foraminifera occurrence, reveals that this formation was deposited during the Early Miocene (Te5)(Maulana et al., 2024). The Cibodas Formation consists of sandstone, limestone, and tuff, with indications of deposition in a shallow marine bay environment during the Late Miocene to Pliocene, inferred from the discovery of megalodon teeth and the abundance of benthic foraminifera within its rocks (Prinaldi et al., 2023; Winarto, 2022).

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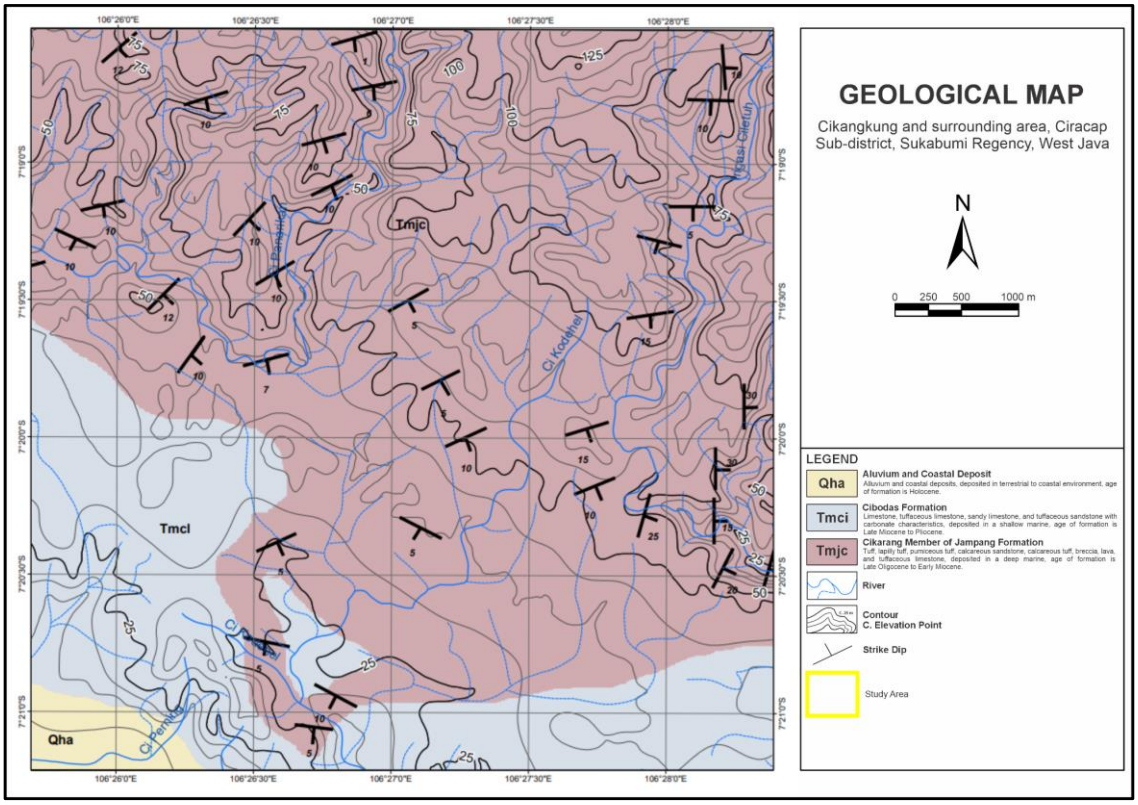

Figure 2. Modified illustration of the physiography of Western Java

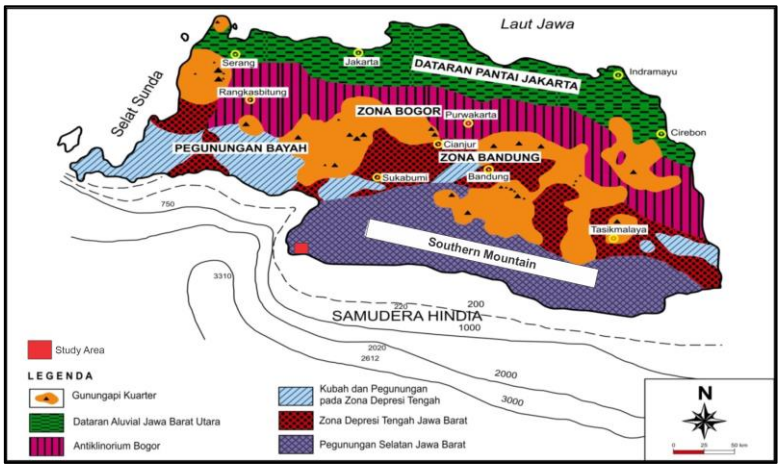

Figure 3. Geological map of the study area. Modified from the Regional Geological Map of the Jampang and Balekembang Sheets (Sukamto, 1975)

RESEARCH METHOD

The research was conducted using field observation methods and remote sensing based on geographic information systems (GIS). Field observations were conducted to observe the morphology of the study area, directly measure slope angles, map the rock type distribution, identify and measure the presence of geological structures, and other supporting aspects. The survey observation in this study is classified as a detailed survey with a mapping scale of 1:12,500 which the entire area was observed with minimum extrapolation and generalization (Bermana, 2006). Meanwhile, remote sensing was conducted using DEM SRTM data processed with several software tools such as ArcMap, ArcScene, and Global Mapper.

The geomorphology of an area can be explained by several aspects, including morphographic, morphometric, and morphogenetic. In this study, the basis for classification in determining these three aspects refers to the standardized classification established by Ike Bermana (2006), which is a modification of van Zuidam (1985).

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The analysis of the morphographic aspect involves determining landforms based on elevation differences in the study area (Bermana, 2006). In addition, the identification of drainage patterns is also conducted. Drainage patterns represent a distinctive arrangement formed within a watershed between the main river and its tributaries. The classification of river drainage patterns follows van Zuidam (1983) classification, which is a modification of Howard (1967). River drainage patterns are typically controlled by variations in rock resistance and structural factors. The analysis of the morphometric aspect includes measuring slope angles, which quantitatively describe the morphology of the study area. The analysis of the morphogenetic aspect is conducted by observing the dominant processes that shape the morphology of the study area, whether they originate from endogenous or exogenous forces. This involves directly observing the types of rocks and their resistance, geological structures, drainage patterns, and landforms.

RESULT AND DISCUSSION

MORPHOGRAPHY

The morphography analysis includes two different aspects, namely landform and drainage pattern.

Landform

Based on the landform map (Figure 4), the study area is composed of two distinct landforms. The distinction between these landforms is determined by analyzing the differences in elevation within the study area. The lowest elevation in the study area is at 0 meters above sea level (masl), and the highest is at 151 masl. Based on the classification used, the study area consists of lowland (0 - 50 m) and low hills (51 - 151 m). The lowland dominates the western and southern parts of the plot, while the low hills dominate the eastern and northern parts.

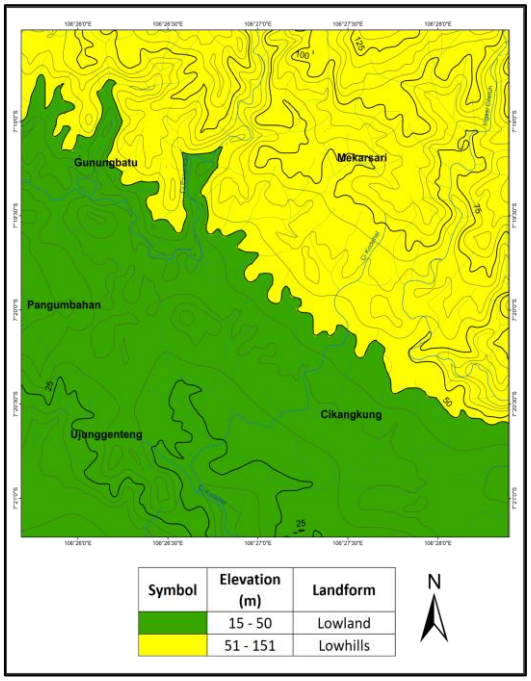

Figure 4. Landform map of study area

Drainage Pattern

Two drainage patterns were identified in the study area, such as subdendritic and dendritic (Figure 5). The subdendritic pattern, divided into two streams, is found in the northwest and northeast of the area. The first subdendritic pattern is associated with the Ci Panarikan River, flowing northeast to southwest, while the second pattern is related to the Ciletuh Irrigation River, with a shift in direction. This pattern is characterized by tributary branching resembling leaf veins, with symmetrical, uniform branches forming sharper angles than dendritic patterns. This pattern is influenced by structural controls, as evidenced by numerous fractures in the rock formations. The resistance of the rocks also plays a role in shaping this pattern, with varying rock types.

The dendritic pattern, found along the Ci Kodehel and Ci Perning Rivers, flows from northeast to southwest, ends in the south. It features irregular tributary branching and occurs in areas with relatively uniform rock hardness, such as weathered fine to coarse sandstone, limestone, and sedimentary breccia.

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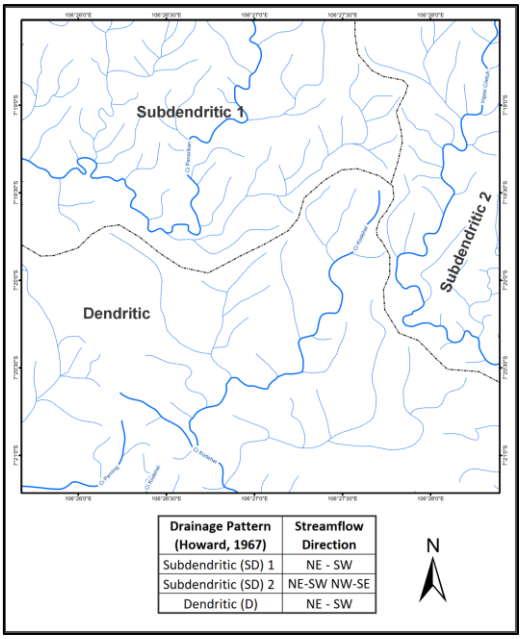

Figure 5. Drainage pattern map of study area

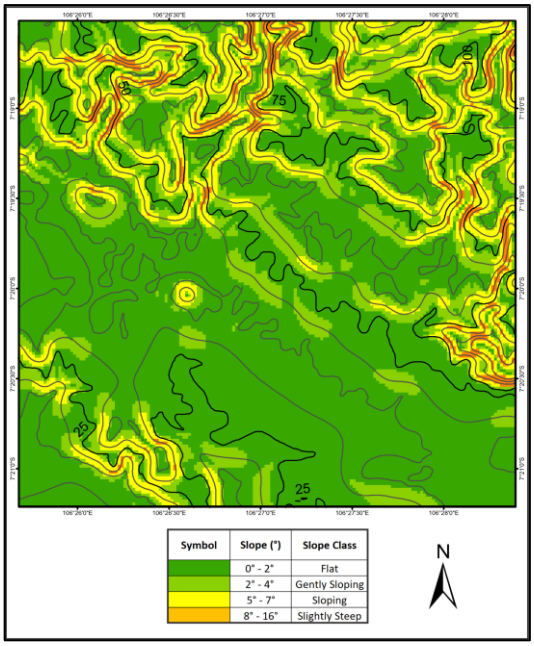

Figure 6. Slope map of study area

MORPHOMETRY

The study area is divided into three groups based on different slope classes (Figure 6).

- The flat slope (0° - 2°) is found across the southern part of the study area, characterized by lowland landforms and covering nearly half of the total area. The rocks in this region vary in hardness, from soft to hard, with a thick topsoil layer.
- The gently sloping area (2° - 4°) is found across the northern part, predominantly in low hills.
- The sloping to slightly steep area (5° - 16°) is also found in the northern part, particularly in the eastern portion of the plot. The slopes here are composed of hard to compact rocks with good resistance.

MORPHOGENETIC

Morphogenetic aspects play an important role in shaping the geomorphological characteristics of an area through both endogenous and exogenous forces. Endogenous forces in the study area are primarily influenced by tectonic activity, although their impact is relatively minor, with minimal structural deformation as indicated by rock fractures and nearly horizontal bedding. Volcanism also plays a smaller role, with basaltic lava and pyroclastic material found in several locations, indicating that volcanic activity has influenced the area's geological characteristics.

On the other hand, exogenous forces, including weathering, erosion, and sedimentation, also shape the region's morphology. Weathering is evident through changes in rock color and hardness, particularly in limestone, which exhibits extensive weathering in the southern part of the area. Weathering processes such as oxidation, carbonation, and biological activity contribute to features like spheroidal weathering. Erosion, especially along the coast, has resulted in lowlands formed by denudational processes, while abrasion and sedimentation in coastal areas continuously reshape the land, creating a dynamic and evolving landscape.

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GEOMORPHOLOGY

Based on the previous three main aspects, the study area can be divided into 4 distinct geomorphological units, such as marine lowland, denudational lowland, gently sloping structural lowhills, and sloping structural lowhills (Figure 11 and Table 1).

Marine Lowland

This unit occupies a small portion of the study area in the southwest, particularly along the coastal region of Ujung Genteng Village (Figure 7). Characterized by flat terrain and slopes, this unit is predominantly used for settlements, plantations, such as rice fields. While minor tectonic activity has influenced its formation, the impact on morphology is negligible. Instead, exogenous processes such as weathering, erosion, and sedimentation play a significant role. Weathering and erosion create flat topography, while sedimentation is evident in the thick Quaternary coastal deposits and sandy areas, highlighting sedimentation as the primary control shaping this unit.

Figure 7. Marine lowland unit in study area

Denudational Lowland

This unit occupies the central to southern part of the study area, and forms the dominant landscape characterized by flat lowlands (15 – 50 m elevation) with flat slopes (0° – 2°) (Figure 8). This unit primarily results from weathering and lateral erosion, shaping broad U-shaped valleys. Denudational processes have created flat topography, exposing moderately to highly weathered rock outcrops of varying hardness. While tectonic activity is minimal, its influence is shown by joint sets in some rock outcrops. Volcanic activity also played a role, as indicated by the volcanic composition of rocks like tuffaceous limestone, coarse sandstone, fine sandstone, and sedimentary breccia. This unit spans half the study area, encompassing the villages of Gunungbatu, Pangumbahan, Ujung Genteng, and Cikangkung. Its stable and uniform topography supports settlements and agriculture, with extensive flat rice fields requiring no terracing. Weathering and lateral erosion dominates exogenic processes, contributing to thick top soil and forming dendritic drainage patterns, particularly tributaries branching from the main Ci Kodehel River, reflecting homogeneous resistance and high weathering levels.

Figure 8. Denudational lowland unit in study area

Gently Sloping Structural Lowhills

This unit occupies the central part of the study area, and lies between two other geomorphological units. It features lowhills (51 – 75 m) with gently sloping terrain (3° – 4°), shaped predominantly by tectonic activity, erosion, and weathering (Figure 9). Tectonic evidence includes rock fractures, while vertical and lateral erosion has formed U- to V-shaped valleys that serve as subdendritic drainage paths for tributaries and the main river. Volcanic activity also influenced this unit, as indicated by its volcanic rock composition, including very fine to coarse tuffaceous sandstone. This denudational lowhill unit encompasses Mekarsari and Gunungbatu villages, where the stable morphology supports coconut plantations, rice fields, and settlements. Tectonism is evident from rock fractures, while weathering and erosion dominate as exogenous processes shaping the region.

Figure 9. Gently sloping structural lowhills unit in study area

Sloping Structural Lowhills

This unit occupies the northern part of the study area, and is characterized by low hills (51 – 125 m) with predominantly moderate slopes (5° – 8°) and occasional slightly steep slopes (9° – 16°) (Figure 10). Tectonic processes play a major role in shaping this unit, evidenced by fracture sets at outcrops, waterfalls indicating faulting, and steeper dip of the rock beddings compared to other areas indicating faulting or folding. Weathering and erosion also contribute, forming thick top soil layers and U- to V-shaped valleys. These valleys channel water into tributaries and a

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main river, creating a subdendritic drainage pattern, which further reflects structural control. The morphology is influenced by the high resistance of the rocks, such as basaltic lava and sedimentary breccia. Land use includes settlements and terraced rice fields, indicating the predominantly gentle slopes. While tectonic activity is the primary shaping force, volcanic influences remain present. Key features, including geological structures and erosion patterns, underline the combined effects of tectonic and exogenous processes in this unit.

Figure 10. Sloping structural lowhills unit in study area

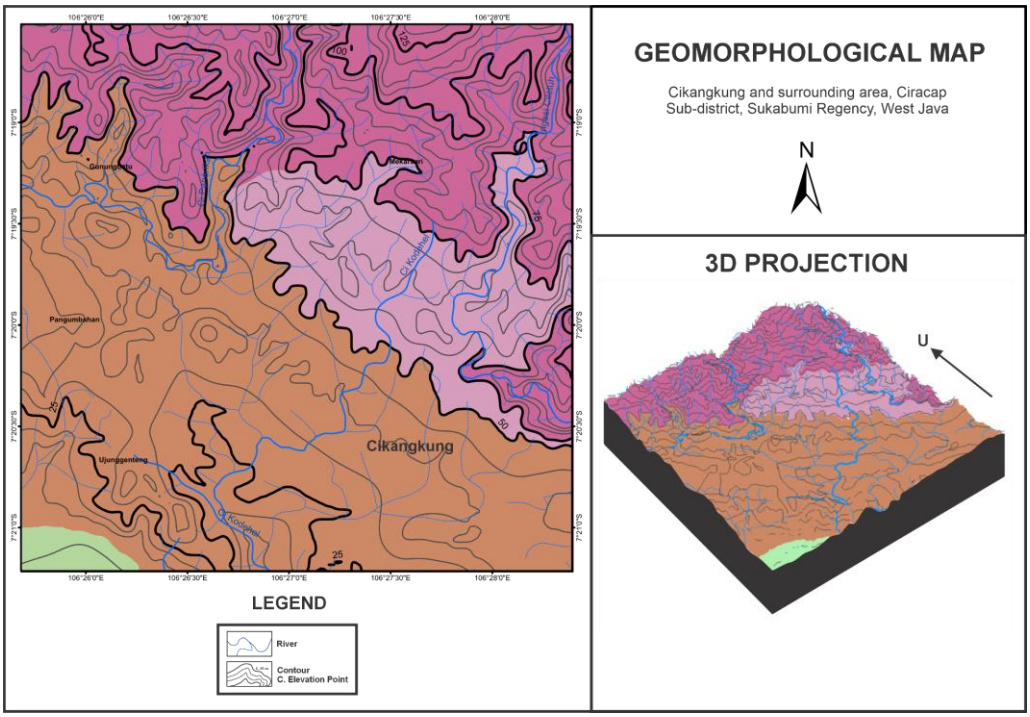

Figure 11. Geomorphological map and 3D projection of the study area

No.	Geomorphological Unit	Color	Geomorphological Aspect						Lithology
			Morphography			Morphometry	Morphogenetic		
			Drainage Pattern	Landform	Valley	Slope	Endogenous	Exogenous	
1.	Marine Lowland		-	Lowland (0-15 m)	U	Flat (0°-2°)	Tectonism	Weathering, erosion, and sedimentation	Coastal deposit
2.	Denudational Lowland		Dendritic	Lowland (15-50 m)	U	Flat (0°-2°)		Weathering and erosion	Limestone, Coarse Sandstone, Fine Sandstone
3.	Gently Sloping Structural Lowhills		Sub Dendritic	Lowhills (51-75 m)	U - V	Gently sloping (3°-4°)			Very Fine - Coarse Sandstone
4.	Sloping Structural Lowhills		Sub Dendritic	Lowhills (51-125 m)	U - V	Sloping (5°-8°) - Slightly Steep (9°-16°)			Very Fine - Coarse Sandstone, Sedimentary Breccia, Basaltic Lava

Table 1. Geomorphological units of the study area and the explanations

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CONCLUSION

This study reveals that the geomorphology of the study area is shaped over an extended period by a combination of geological processes occurring simultaneously or alternately. These processes include both endogenous factors, such as tectonism and volcanism, and exogenous factors, like weathering and sedimentation. Together, they contribute to the distinct and unique morphological characteristics of the region. Additionally, these processes also influence the varied land use practices in the area

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