

SPATIAL DISTRIBUTION OF GEOMORPHOLOGICAL UNITS IN THE GUNUNGSUNGGING AREA, SUKABUMI REGENCY, WEST JAVA

Mitra Priyayi^{1*}, Santi Dwi Pratiwi¹

¹Faculty of Geological Engineering, Universitas Padjadjaran
Jl.Ir. Soekarno KM 21, Sumedang Regency, West Java 45363, Indonesia.

*Corresponding author: mitra22001@mail.unpad.ac.id

ABSTRACT

The geomorphological landscape of southern Java has developed through long-term interactions between tectonic activity, lithological diversity, and surface processes related to the convergence of the Eurasian and Indo-Australian plates. One of the regions that records this complex evolution is the Ciletuh–Jampang area, which displays a variety of landforms associated with uplifted terrains and differential erosion. This study focuses on the Gunungsungging area, Sukabumi Regency, West Java, with the objective of identifying geomorphological characteristics and defining geomorphological units based on landform attributes and lithological control. Geomorphological analysis was conducted using an integrated approach combining morphographic, morphometric, and morphogenetic methods. Digital elevation data derived from SRTM were processed using ArcGIS and Global Mapper, and the results were validated through systematic field observations. Morphographic analysis indicates that the study area is dominated by low hill landforms with elevations generally ranging between 50 and 175 m above sea level. The drainage system exhibits two primary patterns: parallel drainage, developed on moderate slopes and elongated ridges, and dendritic drainage, commonly associated with more homogeneous lithology and gentler slopes. Morphometric analysis reveals that flat to gently sloping terrain (0° – 4°) predominates across the study area, with steeper slopes occurring locally. Morphogenetic interpretation suggests that exogenous processes, particularly weathering and dissolution, play a dominant role in shaping the landscape, while the influence of tectonic activity is relatively limited, as evidenced by minimal structural deformation. Karstification features, including caves and dissolution forms, are well developed within limestone unit. Based on the integration of geomorphological parameters, the study area is divided into three geomorphological units: gently sloping structural low hills, gently sloping denudational low hills, and gently sloping karst low hills. These results contribute to a better understanding of landscape development in the Ciletuh region and provide a geomorphological framework for further geological and environmental studies.

Keywords: DEM, Geomorphology, Gunungsungging, Spatial, West Java

INTRODUCTION

Indonesia is an extensive archipelagic nation located at the convergence of major lithospheric plates, with its physiography fundamentally controlled by the Sunda and Sahul continental shelves. This tectonic configuration has generated a highly diverse landscape shaped by the combined effects of tectonism, volcanism, sedimentation, and prolonged surface processes (Darman, 2000).

The geological evolution of the archipelago involved the accretion of Gondwana-derived crustal fragments along the Eurasian margin, followed by intense Cenozoic subduction and collision that reshaped the surface morphology (Hall, 2009). These processes are clearly expressed in the geomorphological landscape, where variations in relief, slope, and drainage patterns reflect differences in lithology, structural framework, and dominant surface processes. Continuous interaction

between endogenous forces, such as uplift and faulting, and exogenous processes, including weathering, erosion, and fluvial reworking, has produced spatially diverse geomorphological units across the Indonesian region. Consequently, the study of geomorphological units and their spatial distribution provides critical insight into the evolution of Indonesia's dynamic landscapes, particularly in tectonically active regions such as southern West Java.

A prominent example of this complex evolution is the Ciletuh–Jampang area in Southern Java, which features a distinctive horseshoe-shaped amphitheater morphology and the Jampang Plateau, the latter formed by Pliocene tectonic uplift reaching 700 meters above sea level (Hardiyono et al., 2015; Haryanto et al., 2018). Analyzing this region through a geomorphological lens—which focuses on the physical and chemical processes that modify Earth's surface—reveals that its rugged topography is a product of both historical tectonic activity and varying rock resistance (Thornbury, 1970; Versteppen, 1985; Firmansyah et al., 2023).

Physiographically, the study area is part of the Southern Mountains physiographic zone (van Bemmelen, 1949). 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 Balekambang sheets (Sukamto, 1973), the research area is composed, from oldest to youngest, of the Cikarang Formation (Tmjc), Cibodas Formation (Tmci), Bentang Formation (Tmbu), and the Citanglar Coastal Deposits (Qpcb) (Figure 2). The geological structures that developed in the Southern Mountains Zone have undergone three tectonic phases (Baumann, 1973) starting from the Oligocene epoch up to the Quaternary period; these tectonic phases

were frequently accompanied by volcanism. Integrated petrographic, petrological, and biostratigraphic studies have enhanced the understanding of carbonate sedimentation, volcanic influence, and stratigraphic evolution in southern West Java, particularly within the Cibodas Formation and the Jampang Formation (Prinaldi et al., 2023; Pratiwi et al., 2023; Maulana & Pratiwi, 2024; Pratiwi et al., 2024; Ramdhani et al., 2024). Recent geomorphological research highlights that the spatial distribution of landform units is governed by the combined effects of lithology, tectonic framework, and surface processes. In tectonically active regions, such as southern Java, geomorphological patterns commonly reflect denudational and structural controls acting upon heterogeneous rock units (Sulaksana et al., 2015; Haryanto et al., 2018). Advances in geomorphological mapping techniques, particularly the use of digital elevation models and integrated morphometric analysis, have enhanced the interpretation of landform variability and landscape evolution at local to regional scales (Goudie, 2018; Bishop et al., 2019). This study is conducted in the Gunungsungging area, Sukabumi Regency, West Java, which is geographically situated between 106°32'32.11"–106°35'17.74" E and 7°21'56.04"–7°19'11.76" S (Figure 1.). The research applies an integrated geomorphological approach, incorporating morphographic, morphometric, and morphogenetic analyses, to investigate the spatial distribution of geomorphological units. By examining landform characteristics, geomorphological processes, and lithological controls, this study seeks to identify and classify geomorphological units and to generate a detailed geomorphological map illustrating their spatial relationships. The final objective is to produce a geomorphological map that integrates landform characteristics with the distribution of their constituent lithology. The findings provide insight into landscape evolution in southern West Java and offer a scientific basis for further geological, environmental, and land-use studies.

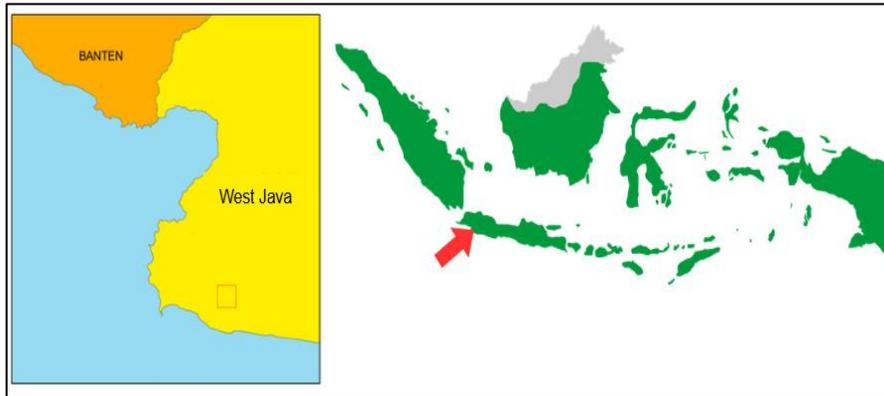


Figure 1. Study area located in Surade Subdistrict

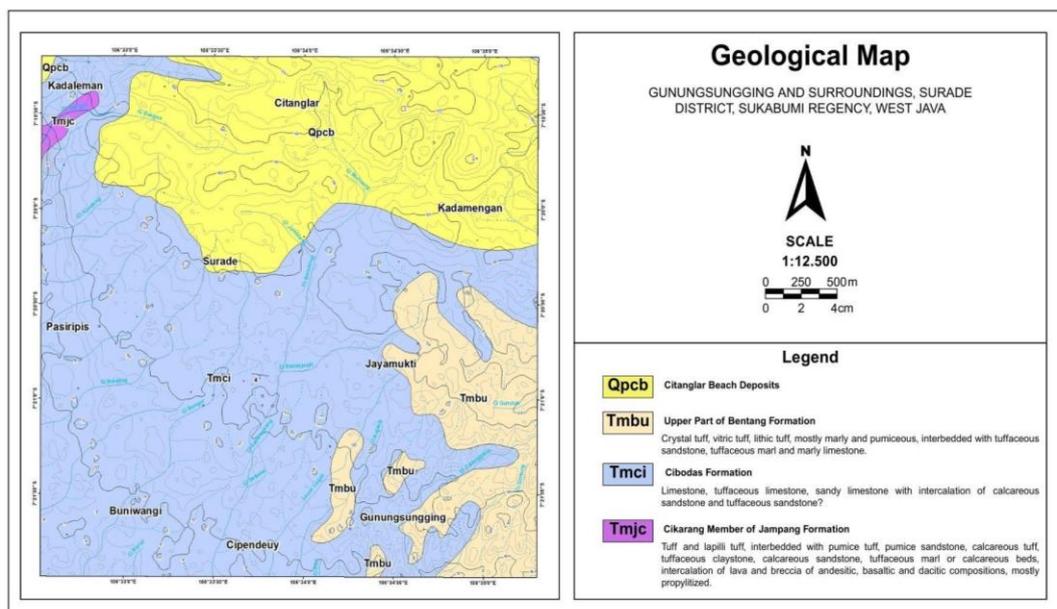


Figure 2. Geological map of the study area. Modified from the Regional Geological Map of the Jampang and Balekambang Sheets (Sukanto, 1975)

RESEARCH METHOD

The identification of the research area's geomorphological characteristics was based on remote sensing analysis of SRTM DEM data, which was processed using ArcGIS and Global Mapper software. Subsequently, this was based on field observations to correlate or validate the results of the remote sensing analysis. The research stages conducted can be observed in the following research flowchart (Figure 3).

The determination of geomorphological units is based on the following geomorphological aspects:

Morphography

Morphographic analysis includes landforms, valley shapes, and drainage patterns. The analysis of drainage patterns is conducted based on topographic maps, examining the incisions of intermittent and main river channels within the research area. These are then compared with the modified drainage patterns (Howard, 1967) as cited in Van Zuidam (1985). After this analysis is completed, a morphographic map is produced that interprets the elevation intervals in the research area.

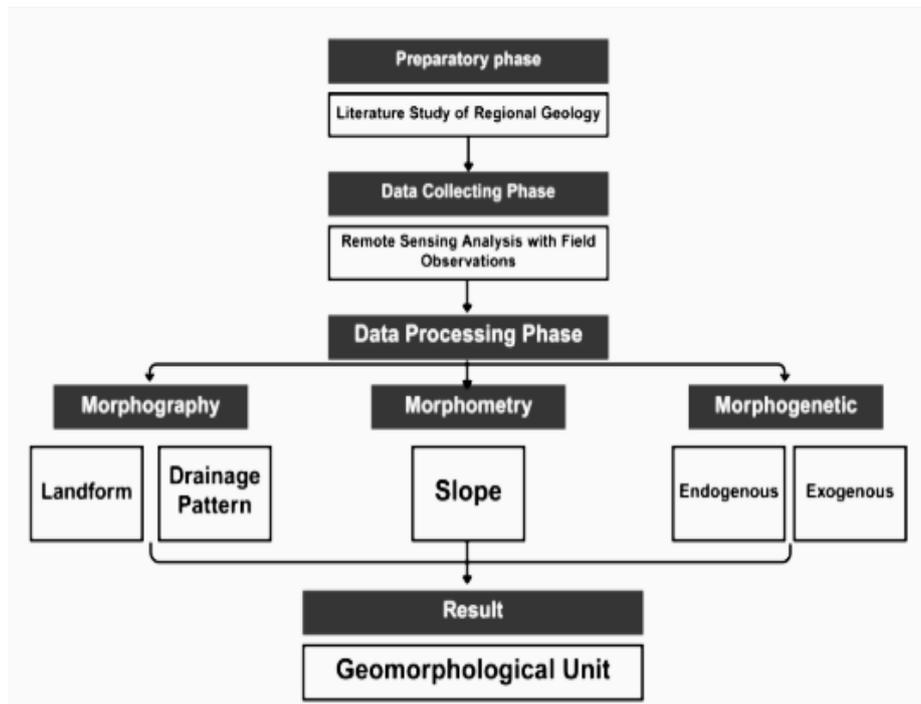


Figure 3. Research Flowchart

Morphometry

Morphometric analysis is conducted by calculating the slope gradient, which is then classified based on the percentage and angle of the slope. To determine these values, calculations are made based on the difference in elevation versus the horizontal distance. Once the slope gradient is determined using the established methods, the calculation results are obtained and subsequently displayed as a morphometric map.

Morphogenetics

Morphogenetics refers to the influential factors in the formation of a landform or morphology. The morphogenetic analysis in the research area involves a comparison between the data on the developing drainage patterns and the constituent lithology data of the area.

RESULT AND DISCUSSION

Based on integrated morphographic, morphometric, and morphogenetic analyses, the research area is subdivided into several geomorphological zones. According to the landform classification of Van Zuidam (1985), as modified by Bermama (2002), the study area is characterized by a single dominant morphographic unit, namely low hills with

elevations ranging from 50 to 100 m above sea level (Figure 4).

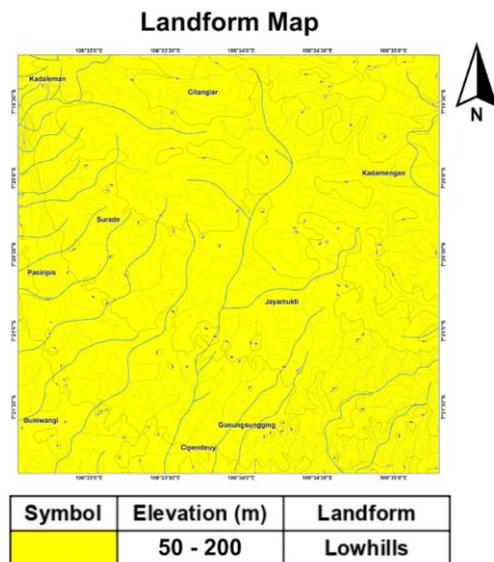


Figure 4. Landform map of study area

Two main drainage patterns are identified, consisting of parallel and dendritic patterns (Figure 5). The parallel drainage pattern occupies approximately 65% of the total study area and is predominantly developed in the western part of the area, including the Ci Pari, Ci Kujang, Leuwicagak, Ci Jambegirang, Ci Selaawi, Ci Badakputih, Ci Barethong, Ci

Muncang, Ci Jamblang, Ci Burial, Ci Bungur, Ci Beledug, Ci Kondang, and Ci Gangsa rivers. This pattern reflects moderate to steep regional slopes and is typically associated with elongated, parallel ridge-and-valley landforms. In contrast, the dendritic drainage pattern covers about 35% of the study area and is mainly observed in the eastern sector, including the Ci Gintung, Ci Calenggang, and Ci Gurutuk rivers (Figure 5).

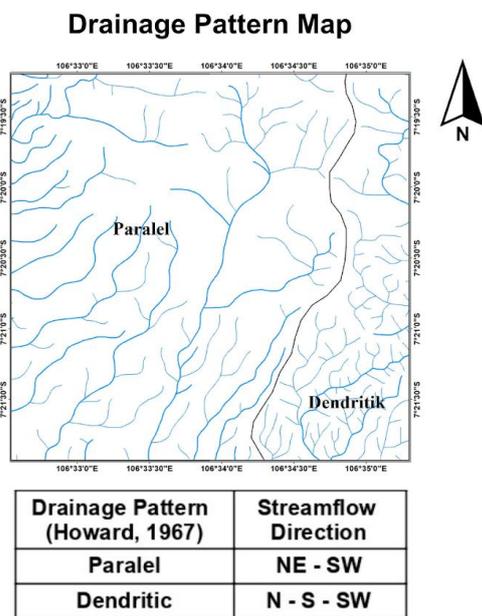


Figure 5. Drainage pattern map of study area

This pattern, characterized by a branching network resembling of tree limbs, commonly develops on limestone lithology and fluvial deposits, where relatively homogeneous and less resistant rocks promote drainage dispersion. Morphometrically, dendritic drainage occurs on flat to gently sloping terrain, indicating a strong lithological control on valley development. Morphometric analysis reveals that the study area is characterized by relatively gentle topography, as illustrated by the distribution of slope gradients shown in Figure 6. Flat areas with slope angles ranging from 0° to 2° constitute approximately 20% of the research area and are commonly developed on valley floors and low-relief surfaces. Gently sloping terrain, with gradients of 2°–4°, represents the dominant morphological condition and is widely distributed throughout the study area. Areas with moderate slopes, ranging from 4° to 8°, account for about 20% of the total area and are generally confined to hill flanks and transitional geomorphic zones. The overall

geomorphological character of the area is influenced by the interaction of endogenous and exogenous morphogenetic processes. Endogenous processes, mainly tectonic activity, have contributed to the regional geological framework; however, their geomorphic expression within the study area is relatively weak. This is evidenced by the limited structural deformation, the presence of nearly horizontal stratification, and the scarcity of major fractures. Exogenous processes, on the other hand, exert a stronger control on landscape evolution. Physical and chemical weathering are widely developed, as indicated by changes in rock colour and mechanical strength in both limestone and sandstone, particularly in the southern sector of the study area. Furthermore, dissolution processes play a significant role in carbonate terrains, as demonstrated by the development of karst features such as stalactites and stalagmites, which reflect active karstification within the Gunungsungging karst cave.

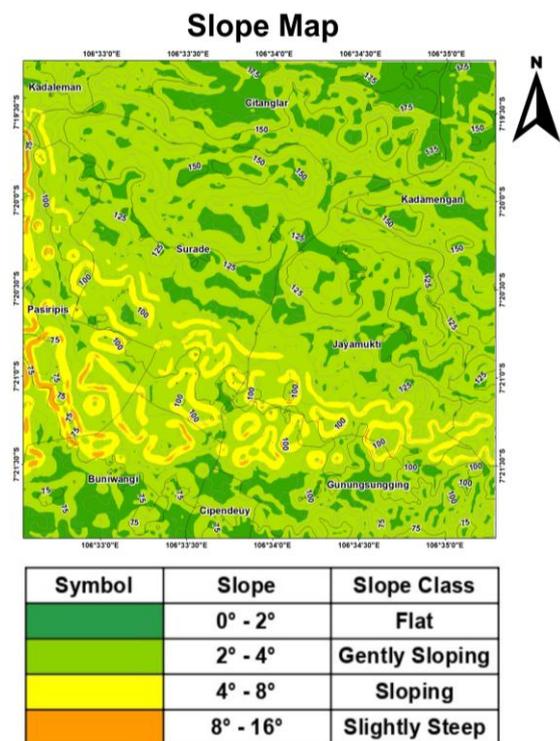


Figure 6. Slope map of study area

GEOMORPHOLOGY

Based on the analysis conducted on topographic maps, supported by morphographic, morphometric, and morphogenetic aspects, the geomorphology of the research area is divided into 3

Geomorphological units (Figure 7 and Table 1), as follows

Gently Sloping Structural Low Hills

This unit occupies approximately 25% of the total research area, distributed in the western to northwestern parts of the research area (Cigangsa river, Kadaleman).

Morphographically, this area has a low hill landform with elevations ranging from 50-100 masl. Based on morphometric analysis, this area has a slope gradient ranging from 2-4%, which indicates a gently sloping slope (Van Zuidam, 1985). This unit has blunt U-shaped to V-shaped valleys. The drainage pattern developing in this unit is parallel. In this unit, the exogenous process contributing to the landform's formation is weathering. The lithology composing this unit is carbonate sandstone and limestone.

Gently Sloping Denudational Low Hills

This geomorphological unit occupies approximately 40% of the total research area and is dominantly distributed in the research area (Pasiripis, Kademangan, Citanglar, Surade, Kadaleman, Jagamukti, and Pasiripis). Morphographically, this unit has a low hill landform with elevations ranging from 75-175 masl (meters above sea level). Based

on morphometric analysis, this area has a slope gradient ranging from 2-4%, which indicates a flat slope (Van Zuidam, 1985). The drainage patterns developing in this unit are dendritic and parallel. In this unit, the exogenous process contributing to the landform's formation is weathering. The lithology composing this unit is limestone and carbonate sandstone.

Gently Sloping Karst Low Hills

This unit occupies approximately 35% of the total research area, distributed from the southeast to the southwest of the research area (Gunungsungging, Cipeundeuy, and Buniwangi). Morphographically, this area has a lowland landform with elevations ranging from 50-125 masl. Based on morphometric analysis, this area has a slope gradient ranging from 2-4%, which indicates a gentle slope (Van Zuidam, 1985). This unit has blunt U-shaped to blunt V-shaped valleys. The drainage patterns developing in this unit are dendritic and parallel. In this unit, the exogenous processes contributing to the landform's formation are weathering and dissolution. The lithology composing this unit is dominated by limestone and some carbonate sandstone.

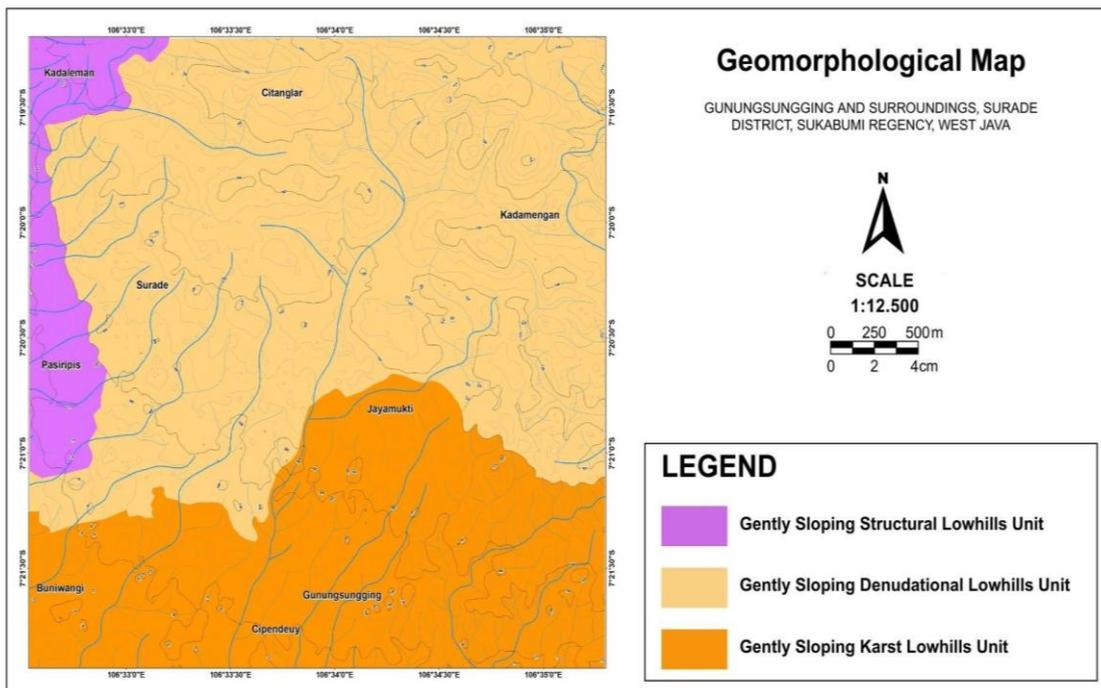


Figure 7. Geomorphological map of the study area

No	Geomorphological Unit	Symbols	Geomorphological Aspect						Lithology
			Morphography			Morphometry	Morphogenetic		
			Drainage Pattern	Landform	Valley	Slope	Endogenous	Exogenous	
1	Gently Sloping Structural Lowhills		Paralel	Lowhills (50 - 100 m)	U-V	Gently Sloping (2 - 4°)	Tectonism	Weathering & Erosion	Limestone, Fine Sandstone, Medium Sandstone, Coarse Sandstone
2	Gently Sloping Denudasional Lowhills		Paralel - Dendritic	Lowhills (75 - 175 m)	U	Gently Sloping (2 - 4°)			Limestone, Fine Sandstone, Coarse Sandstone, Alluvium
3	Gently Sloping Karst Lowhills		Paralel - Dendritic	Lowhills (50 - 125 m)	U	Gently Sloping (2 - 4°)		Karst Dissolution	Limestone, Fine Sandstone

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

CONCLUSION

The geomorphological configuration of the Gunungsungging area reflects a spatially variable landscape shaped by lithological diversity and surface processes operating within the Southern Mountains of West Java. The area is dominated by low hill morphology, with drainage systems exhibiting parallel and dendritic patterns that vary spatially in response to slope gradients and rock characteristics. Slope analysis indicates that flat to gently sloping terrains are widespread and form the principal geomorphic setting of the area. These conditions strongly influence drainage development and landform expression.

In terms of morphogenesis, surface processes such as weathering and dissolution play a major role in controlling present-day morphology, particularly in areas underlain by limestone. Tectonic activity, while significant in establishing the regional structural framework, shows limited direct expression in surface landforms within the study area. By integrating morphographic, morphometric, and morphogenetic data, three geomorphological units were identified and mapped: gently sloping structural low hills, gently sloping denudational low hills, and gently sloping karst low hills. The spatial distribution of these units corresponds closely with lithological variations and dominant geomorphic processes. This research funding contributes to a better understanding of landscape development in the Gunungsungging area and may serve as a reference for future geological, environmental, and land-use studies in southern West Java.

ACKNOWLEDGEMENT

This study is a part of the study from research fund by HRU Riset Kompetensi Dosen Unpad, Universitas Padjadjaran, Indonesia with grant number 1955/UN6.3.1/PT.00/2024. We sincerely thank our colleagues for their technical assistance during fieldwork and discussions throughout this study.

REFERENCES

- Baumann, P., 1973. The Ciletuh Formation, a stratigraphic and structural anomaly of West Java. Proceedings of the Indonesian Petroleum Association, 2nd Annual Convention, pp. 145–158.
- Bermana, I., 2006. Klasifikasi geomorfologi untuk pemetaan geologi yang telah dibakukan. Bulletin of Scientific Contribution, 4(2), 161-173.
- Bishop, P., Hoey, T. B., Jansen, J. D., Lexartza-Artza, I., Moyersons, J., & Whittaker, A. C., 2019. Knickpoint recession rate and landscape response timescale in fluvial systems. Earth Surface Processes and Landforms, 44(3), 555–567.
- Darman, H., 2000. An outline of the geology of Indonesia. Indonesian Association of Geologists (IAGI), Jakarta.
- Firmansyah, Y., Khoirullah, N., & Yahya, M. F., 2023. Analysis of geomorphological aspects of Surade Sub-district, Sukabumi District, West Java. Journal of Geological Sciences and Applied Geology, 7(1).
- Goudie, A. S., 2018. Geomorphology in the Anthropocene. Cambridge: Cambridge University Press.

- Hall, R., 2009. Indonesia, geology. Encyclopedia of Islands, 454-460.
- Hardiyono, A., Syafri, I., Rosana, M. F., Yuningsih, E. Y., & Andriany, S. S., 2015. Geotourism potential in the Ciletuh Bay area, Sukabumi, West Java. Bulletin of Scientific Contribution: Geology, 13(2).
- Haryanto, I., & Sudradjat, A., 2018. On the Geomorphology and Tectonic Position of Ciletuh-Jampang Area, West Java, Indonesia. Universal Journal of Geoscience, 6(2), 47-54.
- Maulana, M. H., Pratiwi, S. D., 2024. Characteristics of Limestones From The Cibodas Formation and Cikarang Member of Jampang Formation in Cikangkung Area, Sukabumi Regency, West Java. Bulletin of Scientific Contribution: GEOLOGY, 22(3), 255 - 264.
- Pratiwi, S. D., Chiyonobu, S., & Oktavia, D., 2023. Lingkungan Pengendapan Purba Berdasarkan Sphenolithus Dan Reticulofenestra Kala Miosen Pada Formasi Jampang, Ciletuh, Jawa Barat. Bulletin of Scientific Contribution: GEOLOGY, 21(3), 137-146.
- Pratiwi, S. D., Nurdrajat, N., Pratiwy, F. M., & Chiyonobu, S., 2024. Calcareous nannofossil assemblages and age determination in Leuwi Kenit, Ciletuh Palabuhanratu Geopark, Indonesia. Biodiversitas Journal of Biological Diversity, 25(7).
- Prinaldi, D. R., Pratiwi, S. D., & Rosana, M. F., 2023. Karakteristik Petrologi dan Petrografi Satuan Batugamping Terumbu dan Batupasir Karbonatan Pada Formasi Cibodas Daerah Pasiripis dan Sekitarnya, Kabupaten Sukabumi, Provinsi Jawa Barat. Padjadjaran Geoscience Journal, 7.
- Ramdhani, M. A. G., Pratiwi, S. D., & Patonah, A., 2024. Umur Batuan Sedimen Anggota Cikarang Formasi Jampang di Sungai Cigangsa, Kecamatan Surade, Kabupaten Sukabumi Berdasarkan Nannofosil Gampingan. Bulletin of Scientific Contribution: GEOLOGY, 22(1), 65-70.
- Sukamto, R., 1975. Peta geologi lembar Jampang dan Balekambang, Jawa, skala 1:100.000. Pusat Penelitian dan Pengembangan Geologi, Direktorat Jenderal Geologi dan Sumberdaya Mineral, Departemen Pertambangan dan Energi.
- Sulaksana, N., Haryanto, I., Sukiyah, E., & Sudradjat, A., 2015. On the geomorphology and tectonic position of the Ciletuh-Jampang area, West Java, Indonesia. Proceedings of the Asia Oceania Geological Society (AOGS) Conference.
- Thornbury, W. D., 1969. Principles of geomorphology (2nd ed.). John Wiley and Sons, Inc.
- van Bemmelen, R. W., 1949. The Geology of Indonesia, Volume I. A. Netherland: The Hague Martinus Nijhoff
- van Zuidam, R. A., 1979. Terrain analysis and classification using aerial photographs: A geomorphological approach. ITC Text Book of PhotoInterpretation, 1. Enschede.
- van Zuidam, R. A., 1983. Guide to Geomorphologic Aerial Photographic Interpretation and Mapping. International Institute for GeoInformation Science and Earth Observation, Enschede, The Netherlands, 325.
- van Zuidam, R. A., 1985. Aerial Photo Interpretation in Terrain Analysis and Geomorphological Mapping. Smite, The Hague.