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Geomorphological Characteristics Based on Morphography, Morphometry, and Geomorphic Processes of the Silungkang Area, Sawahlunto City, West Sumatra

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ABSTRAK

Geomorfologi menyediakan informasi penting mengenai evolusi bentang alam melalui analisis bentuklahan, proses-proses permukaan, serta faktor-faktor yang mengontrol perkembangannya. Penelitian ini dilakukan di daerah Silungkang dan sekitarnya, Kota Sawahlunto, Sumatera Barat, yang berada dalam Cekungan Ombilin, suatu cekungan intramontana yang diinterpretasikan sebagai cekungan oblique-rift hingga pull-apart yang berkaitan dengan Sistem Sesar Sumatra. Tujuan penelitian ini adalah mengidentifikasi dan mengklasifikasikan geomorfologi daerah penelitian melalui analisis morfografi, morfometri, dan proses geomorfik, serta mendelineasi satuan bentuklahan yang menyusunnya. Metode penelitian mengintegrasikan observasi lapangan sebagai data primer dengan interpretasi data sekunder berupa Model Elevasi Digital Nasional (DEMNas), sedangkan delineasi satuan bentuklahan dilakukan menggunakan skema klasifikasi bentuklahan genetik yang telah baku. Hasil penelitian menunjukkan bahwa wilayah penelitian didominasi oleh perbukitan (sekitar 70%), dengan ketinggian berkisar antara 185,49 hingga 873,29 m dan kemiringan lereng dari datar (0–2%) hingga sangat curam (56–140%). Pola aliran sungai yang berkembang terdiri atas pola subdendritik (62%) dan dendritik (38%), sementara gerakan massa yang teramati berupa aliran rombakan (debris flow) dan longsoran rombakan (debris slide). Berdasarkan integrasi parameter-parameter tersebut, teridentifikasi sebelas satuan bentuklahan yang mencakup dataran fluvial hingga perbukitan denudasional, karst, dan intrusif. Satuan-satuan bentuklahan tersebut menunjukkan bahwa evolusi bentang alam daerah penelitian dikendalikan oleh kombinasi litologi, aktivitas tektonik, serta proses eksogen berupa pelapukan dan erosi.

ABSTRACT

Geomorphology provides essential information on landscape evolution through the analysis of landforms, surface processes, and their controlling factors. This study was conducted in the Silungkang area and its surroundings, Sawahlunto City, West Sumatra, which lies within the Ombilin Basin, an intramontane basin interpreted as an oblique-rift to pull-apart basin associated with the Sumatra Fault System. The objective of this research is to identify and classify the geomorphology of the study area through morphographic, morphometric, and geomorphic-process analyses, and to delineate the landform units that compose it. The method integrates primary field observation with secondary interpretation of the National Digital Elevation Model (DEMNas), and the landform units were delineated

using established genetic landform-classification schemes. The results show that the area is dominated by hills (about 70%), with elevations ranging from 185.49 to 873.29 m and slopes spanning flat (0–2%) to very steep (56–140%). Two main drainage patterns developed: subdendritic (62%) and dendritic (38%), while debris flow and debris slide are the observed mass movements. Based on the integration of these parameters, eleven landform units were identified, ranging from fluvial plains to denudational, karst, and intrusive hills. These units demonstrate that the landscape evolution of the study area is controlled by the combination of lithology, tectonic activity, and exogenic processes of weathering and erosion.

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1. INTRODUCTION

Geomorphology is the study of landforms and the processes that shape and modify the Earth's surface. As a fundamental component of geological investigations, geomorphological analysis provides important information about the relationships among topography, lithology, geological structures, and surface processes, thereby contributing to the understanding of landscape evolution and environmental dynamics (Huggett & Shuttleworth, 2022). Through the analysis of morphography, morphometry, and geomorphic processes, landforms can be identified and classified according to their origin and development, allowing a more comprehensive interpretation of regional geological conditions.

Recent studies have shown that integrating field observations with national digital elevation data, particularly the Indonesian National Digital Elevation Model (DEMNas), enables detailed and genetically based landform mapping at large scales (Adamsyah & Rochmana, 2024; Gusti et al., 2026; Lin et al., 2022; Ramadan & Rochmana, 2025). A clear understanding of geomorphology therefore provides an essential basis for interpreting landscape evolution, surface-process dynamics, and the geological hazards that may develop within a region (Utama & Mulyasari, 2024).

The study area is located in the Silungkang area and its surroundings, Sawahlunto City, West Sumatra, and is administratively distributed across the Districts of Kupitan and Silungkang (Sawahlunto City) and the District of IX Koto Sei Lasi (Solok Regency). The area shows a variation of landforms ranging from low hills to high hills. Regionally, the study area belongs to the Ombilin Basin, which is composed of Pre-Tertiary to Tertiary rocks consisting of clastic sedimentary, carbonate, and igneous rocks (Koesoemadinata & Matasak, 1981). The Ombilin Basin is an intramontane basin that developed under transtensional tectonic conditions and is widely interpreted as an oblique-rift to pull-apart basin associated with the evolution of the Sumatra Fault System (Noeradi et al., 2005; Putra et al., 2021). Morphotectonic studies along the margin of the basin in West Sumatra confirm that this active tectonic setting drives intense denudational and erosional processes that promote slope movement and landsliding (Putri & Setiawan, 2023).

Geological and geomorphological investigations within the wider Sawahlunto area have increasingly addressed site-specific landform development and geoheritage potential. Apriliana and Rochmana (2024) characterized the geomorphic units of the Batang Manyuruk area in the Talawi District of Sawahlunto City, identifying four landform units controlled mainly by denudational and fold–fault processes, while Rahman et al. (2024) inventoried the geological and geomorphological components of geosites across the Sawahlunto National Geopark — including limestone exposures in the Silungkang area — for geotourism development. In addition, recent regional geomorphological mapping has been carried out in adjacent parts of Sumatra and in other Indonesian terrains, demonstrating the effectiveness of integrated geomorphological approaches for landform characterization and geomorphic-unit delineation (Gusti et al., 2026; Ruhimat et al., 2024; Utama & Mulyasari, 2024). However, detailed, genetically based geomorphic unit mapping at the 1:25,000 scale specifically covering the Silungkang area and its surroundings, where contrasting sedimentary, carbonate, and intrusive lithologies are juxtaposed, has not yet been undertaken. This gap is important because the diversity of lithology and the intensity of tectonic deformation in the Silungkang area are expected to produce a complex assemblage of landforms, ranging from fluvial plains to denudational, karst, and intrusive hills. Detailed geomorphological mapping is therefore required to document these landform units and to clarify the surface processes that control them, including the frequent mass movements observed across the study area.

Based on this background, the objectives of this study are: (1) to identify and classify the geomorphology of the study area through morphographic, morphometric, and geomorphic-process analyses; and (2) to delineate the landform (geomorphic) units that compose the Silungkang area and its surroundings, together with the processes that influence their development.

2. METHODS

2.1 Study Area and Data

This research was conducted in the Silungkang area and its surroundings, Sawahlunto City, West Sumatra. Geomorphological analysis was carried out using two approaches, namely primary and secondary observation. Primary observation was performed directly in the field observation stations to identify the physical characteristics of the land units, while secondary observation was performed through the visual interpretation of the National Digital Elevation Model (DEMNas, Geospatial Information Agency), and supporting imagery. This combination of field data and DEMNas interpretation follows the approach increasingly applied in detailed Indonesian geomorphological mapping (Gusti et al., 2026; Ramadan & Rochmana, 2025) and enabled morphological analysis at the level of detail required for the mapping scale.)

2.2 Geomorphological Analysis

Geomorphological identification was based on three main aspects: morphography, morphometry, and geomorphic processes. Morphography describes the shape of the surface based on topographic appearance and was classified by elevation following Widyatmanti, Wicaksono, & Syam (2016). Morphometry analyses the quantitative aspects of landforms, such as slope gradient and elevation, which are among the most influential geomorphometric variables for landform classification (Dyba, 2024); the slope classification also follows Widyatmanti et al. (2016), dividing slopes into classes

from flat to very steep. Geomorphic-process analysis evaluates the constructive (endogenic) and destructive (exogenic) processes — weathering, erosion, and mass movement — as well as the relative relief and the drainage patterns that develop in the area.

The fluvial geomorphology was further quantified using the sinuosity ratio (SR) of the main rivers (Batang Ombilin and Batang Lawas), a widely used hydro-geomorphic metric for quantitative fluvial-landscape analysis (Bernard et al., 2022), calculated per channel segment as shown in Equation (1):

$$SR = S / L \quad (1)$$

Where SR is the sinuosity ratio, S is the actual length of the river channel along a segment, and L is the straight-line (valley) length of that segment. A channel is classified as straight (SR < 1.05), sinuous (SR = 1.05–1.5), or meandering (SR > 1.5) after Charlton (2007). The determination of geomorphic units was performed through the integration of image interpretation and field data, following approaches commonly applied in contemporary landform-classification studies (Lin et al., 2022; Ouyang et al., 2022) with the landform classification referring to Van Zuidam and Cancelado (1985), Verstappen (1985), Brahmantyo and Bandono (2006), Widyatmanti et al. (2016), and Huggett and Shuttleworth (2022). Lithological and structural conditions encountered in the field were also taken into account to produce a landform classification consistent with the actual conditions of the study area.

3. RESULT AND DISCUSSION

The geomorphology of the study area was analysed through morphography, morphometry, and geomorphic processes, which were then integrated to delineate the landform units. The Silungkang area (Figure 1), located in Lembah Segar and its surroundings, displays a variation of landforms from low hills to high hills that is controlled by lithology, tectonic activity, and weathering–erosion processes.

3.1 Morphographic Analysis

Morphographic classification based on the interpretation of topographic and elevation data, following Widyatmanti et al. (2016), divides the study area into three main morphographic units: a low-hill unit with elevations of 185.49–200 m, a hill unit with elevations of 200–500 m, and a high-hill unit with elevations of 500–873.29 m (Figure 2). The area is dominated by the hill unit, which covers about 70% of the total area. The high-hill unit covers approximately 20%, generally distributed in the southwest and in parts of the central to southern study area, whereas the low-hill unit occupies only about 10%, mainly developing in valleys and along river channels. This morphographic variation reflects the influence of lithology, tectonic processes, and erosion–weathering in shaping the landscape, consistent with the dominance of hilly denudational terrain reported in comparable Sumatran and Indonesian settings (Ramadan & Rochmana, 2025; Utama & Mulyasari, 2024).

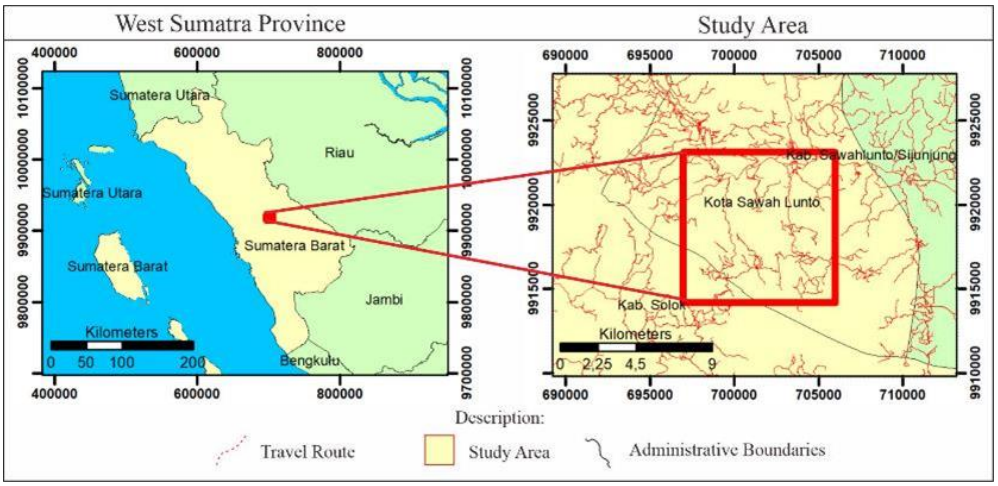


Figure 1. Location and accessibility map of the study area.

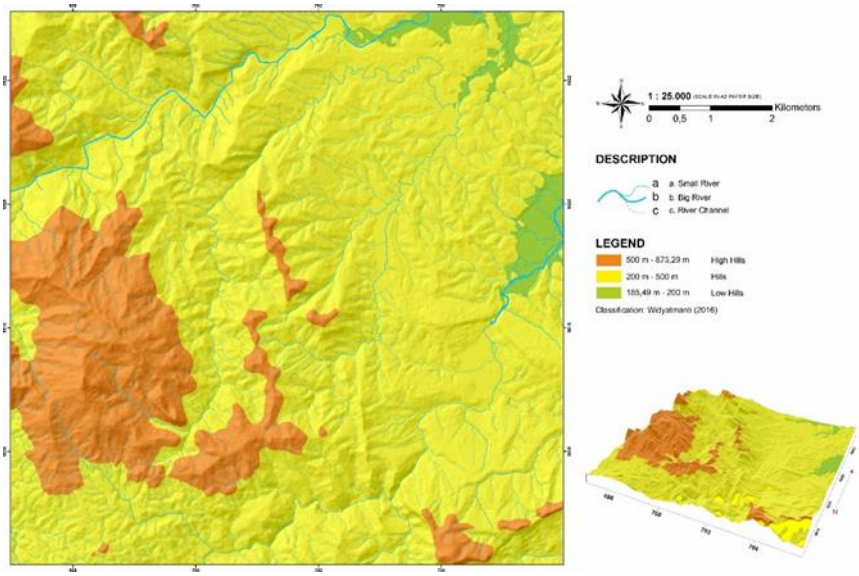


Figure 2. Morphological elevation map of the study area, divided into low hills (185.49–200 m), hills (200–500 m), and high hills (500–873.29 m).

3.2 Morphometric Analysis

Morphometric analysis evaluates the quantitative aspects of landforms, particularly slope gradient, which strongly conditions surface processes and landform classification (Dyba, 2024). Based on the slope map (Figure 3) and the classification of Widyatmanti et al. (2016), six slope classes were identified (Table 1). The study area is dominated by gentle to moderately steep slopes that are distributed across almost the entire area. Steep to very steep slopes generally develop in the western, southwestern, and several central parts of the area, marked by elongated ridges and steeper relief, whereas flat to very gentle slopes commonly occur around the valleys and the main river channels. This slope variation indicates the influence of lithology, geological structure, and the intensity of erosion and weathering operating in the area.

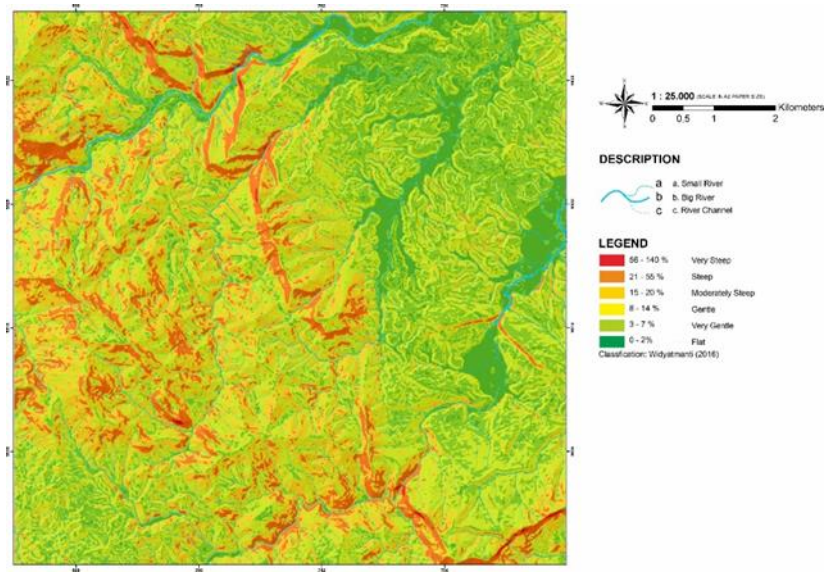


Figure 3. Slope gradient map of the study area showing six classes from flat (0–2%) to very steep (56–140%).

Table 1. Slope (morphometric) classification of the study area after Widyatmanti et al. (2016).

Slope class	Gradient (%)	Distribution
Flat	0–2	Valleys and main river channels
Very gentle	3–7	Around valleys and lower topography
Gentle	8–14	Dominant across the study area
Moderately steep	15–20	Dominant across the study area
Steep	21–55	Western, southwestern and central parts
Very steep	56–140	Elongated ridges, western–southwestern parts

The relative-relief map (Figure 4) shows variations in relief that are closely related to topography, slope, and the potential geomorphic processes. Areas of low relief generally develop in valleys and lower topographic positions, medium relief dominates most of the area in the form of hills, and high relief develops in the eastern and some southwestern parts. These relief differences indicate variations in geomorphic energy, where high-relief areas tend to have steeper slopes and greater erosion potential.

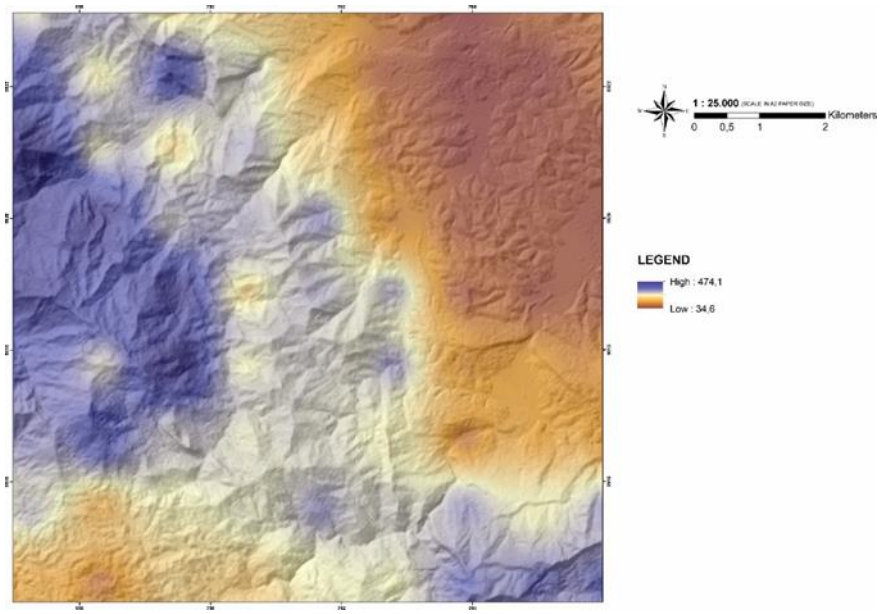


Figure 4. Relative-relief map of the study area.

3.3 Geomorphic Processes

Geomorphic processes are those that change the Earth's surface through endogenic and exogenic forces. Constructive processes are generally related to endogenic activity such as tectonism, whereas destructive processes include weathering, erosion, and mass movement driven by water, gravity, and slope conditions. The intensity of these processes is strongly influenced by the constituent lithology, the degree of rock weathering, slope gradient, and surface-water conditions. Highly weathered material has low resistance and is therefore more susceptible to erosion and landsliding. Field observation identified two main types of mass movement in the study area, namely debris flow (Figure 5) and debris slide (Figure 6).

The debris flow is characterized by the movement of a mixture of soil, weathered material, rock fragments, and vegetation that moves like a flow, generally developing along narrow channel-like paths and influenced by the high-water content of the material. It commonly occurs on steep slopes with intensely weathered material. The debris slide (translational slide) is characterized by the movement of weathered soil and rock fragments along a relatively planar slip surface. It develops on moderate to steep slopes and is the most dominant type of mass movement in the study area, particularly on open slopes along road cuts. The high frequency of landslides is controlled by the combination of high rainfall intensity, steep slopes, and the low resistance of weathered material — especially soils derived from the intense weathering of shale and slate — against gravitational force, which increases pore-water pressure and reduces material cohesion until slope failure occurs. Similar controls have been widely recognized in landslide-prone mountainous regions and are considered key factors governing slope instability (Basharat et al., 2023; Uno et al., 2025). Such denudational and erosional processes leading to slope movement are characteristic of the active-tectonic margin of the Ombilin Basin (Putri & Setiawan, 2023).



Figure 5. Mass movement of the debris-flow type observed in the study area.



Figure 6. Mass movement of the debris-slide (translational) type observed in the study area.

Morphodynamic analysis, focusing on fluvial activity, was carried out by examining drainage patterns and their relationship with topography, lithology, and structure (Figure 7). Two main drainage patterns were interpreted: dendritic, which covers about 38% of the area (mainly the eastern and part of the southern area) and develops on relatively homogeneous lithology with irregular tree-like branching; and subdendritic, which covers about 62% of the area (from the northwest to the southeast) and reflects the control of slope and differing lithological resistance to erosion. The subdendritic pattern generally develops in hilly terrain with steeper relief, whereas the dendritic pattern dominates more homogeneous, gently undulating topography. Comparable dendritic–subdendritic associations controlled by lithology and slope have been reported in other Indonesian terrains (Gusti et al., 2026; Ruhimat et al., 2024).

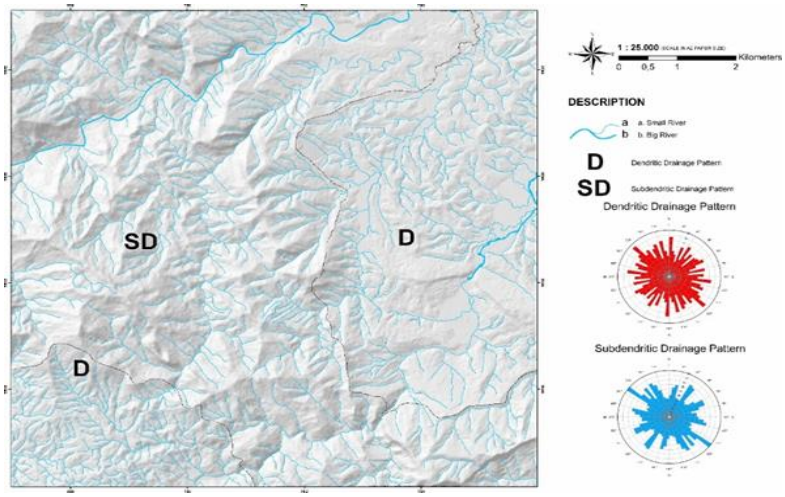


Figure 7. Drainage-pattern map of the study area (dendritic 38%, subdendritic 62%).

3.4 Landform (Geomorphic) Units

Geomorphic processes are those that change the Earth's surface through endogenic and exogenic forces. Constructive processes are generally related to endogenic activity such as tectonism, whereas destructive processes include weathering, erosion, and mass movement driven by water, gravity, and slope conditions. The intensity of these processes is strongly influenced by the constituent lithology, the degree of rock weathering, slope gradient, and surface-water conditions. Highly weathered material has low resistance and is therefore more susceptible to erosion and landsliding. Field observation identified two main types of mass movement in the study area, namely debris flow (Figure 5) and debris slide (Figure 6).

By integrating morphography, morphometry, morphodynamics, drainage patterns, and field observation, and referring to the classifications of Huggett and Shuttleworth (2022), Van Zuidam and Cancelado (1985), Verstappen (1985), Brahmantyo and Bandono (2006), and Widyatmanti et al. (2016), the study area is divided into eleven landform units (Figure 8; Table 2). Five fluvial units — Channel Irregular Meander (CIM), Alluvial Plain (DA), Floodplain (DB), Point Bar (PB), and Channel Bar (CB) — develop along the main rivers and are composed of fluvial sediments. Four denudational hill units with different erosion levels dominate the area, accompanied by a Karst Hill unit (PK) and an Intrusion Hill unit (PI). A similar coexistence of fluvial, denudational, karst, and intrusion landforms within a single mapped area has been documented in comparable Indonesian studies (Gusti et al., 2026; Ramadan & Rochmana, 2025; Ruhimat et al., 2024).

Table 2. The eleven landform units of the study area and their genetic groups.

Code	Landform unit	Genetic group
CIM	Channel Irregular Meander	Fluvial
DA	Alluvial Plain	Fluvial
DB	Floodplain	Fluvial
PB	Point Bar	Fluvial
CB	Channel Bar	Fluvial
PRD	Low Denudational Hills, weakly eroded	Denudational
PDS	Denudational Hills, moderately–weakly eroded	Denudational
PDK	Denudational Hills, strongly–moderately eroded	Denudational
PTDK	High Denudational Hills, strongly eroded	Denudational
PK	Karst Hills	Karst
PI	Intrusion Hills	Intrusive

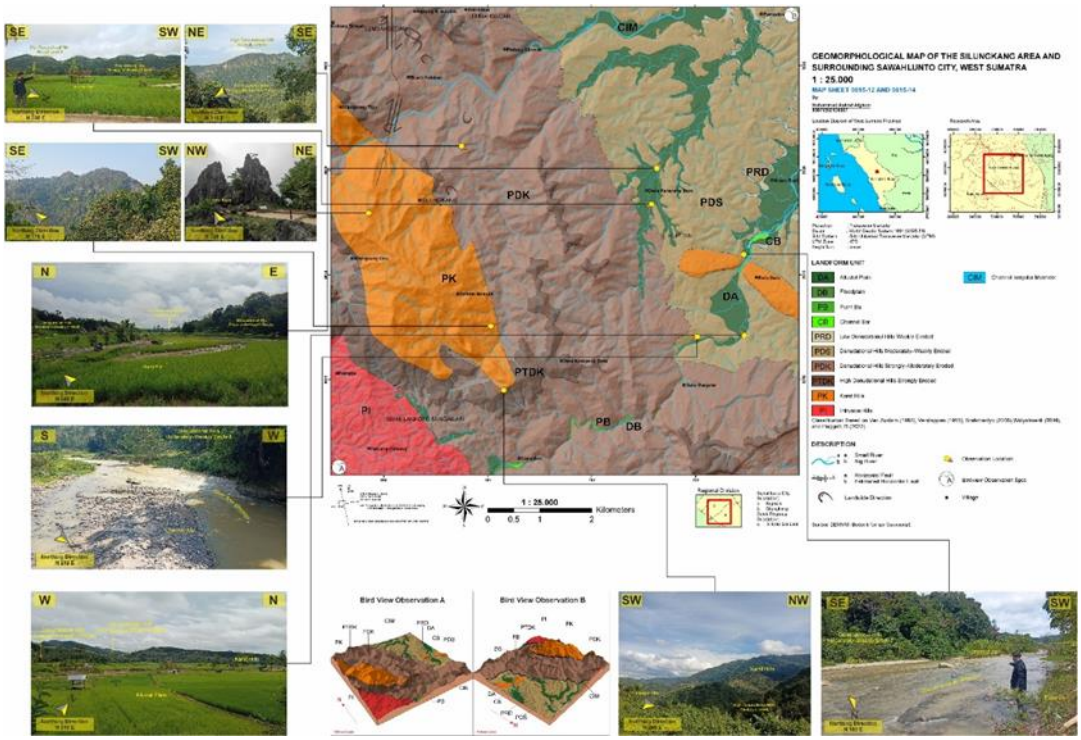


Figure 8. Geomorphological map of the Silungkang area and its surroundings, Sawahlunto City, West Sumatra, showing the eleven landform units.

The CIM unit comprises a meandering channel type distinguished by markedly irregular bend geometry, in which loop size, spacing, and symmetry vary considerably along the channel course. According to Charlton (2007), such irregular meander patterns develop where erosion and sedimentation proceed inconsistently along the channel, commonly reflecting local variation in sediment supply, bank material, and underlying geological control. It develops along the Batang Ombilin (W–E) and the Batang Lawas (S–NE) rivers and occupies about 5% of the area. The channels are relatively wide with well-developed meanders that indicate an old (mature) river stage. Sinuosity computation (Table 3) yields average values of 1.25 (Batang Ombilin) and 1.17 (Batang Lawas) (Figure 9), classifying both segments as sinuous (Charlton, 2007), a pattern consistent with comparable morphometric analyses of meandering rivers elsewhere along the Ombilin Basin margin (Nasution & Sutriyono, 2022).

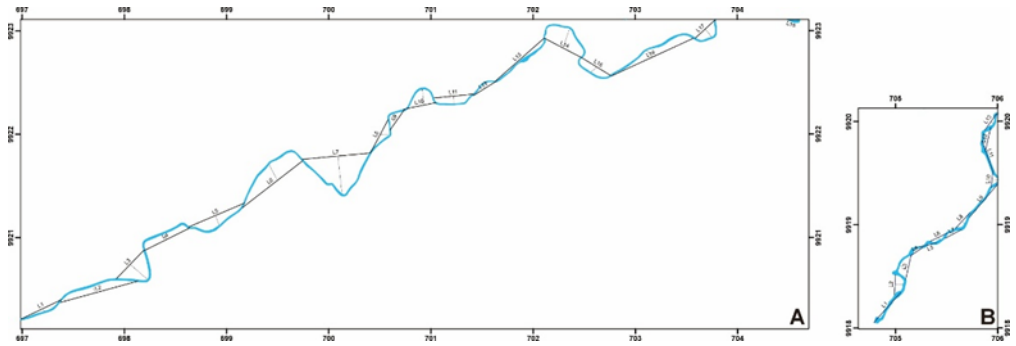


Figure 9. Sinousity calculation a) Batang Ombilin River, b) Batang Lawas River

Table 3. Channel-segment sinuosity (SR = S/L) of the Batang Ombilin and Batang Lawas rivers.

Batang Ombilin	Batang Lawas

Seg.	S (m)	L (m)	SR	Class	Seg.	S (m)	L (m)	SR	Class
1	445.63	436.25	1.02	Straight	1	411.88	386.14	1.07	Straight
2	812.26	786.09	1.03	Straight	2	281.53	193.83	1.45	Sinuous
3	602.45	382.20	1.58	Meander	3	324.54	244.60	1.33	Sinuous
4	562.30	484.97	1.16	Sinuous	4	188.03	172.43	1.09	Straight
5	646.13	592.96	1.09	Straight	5	185.30	137.42	1.35	Sinuous
6	891.86	745.54	1.20	Sinuous	6	207.19	185.82	1.11	Sinuous
7	1039.36	671.60	1.55	Meander	7	185.63	181.30	1.02	Straight
8	424.93	370.73	1.15	Sinuous	8	230.59	210.49	1.10	Sinuous
9	295.83	240.81	1.23	Sinuous	9	432.71	417.20	1.04	Straight
10	513.17	322.08	1.59	Meander	10	192.63	144.27	1.34	Sinuous
11	444.41	392.53	1.13	Sinuous	11	324.95	324.83	1.00	Straight
12	269.24	258.66	1.04	Straight	12	286.75	236.12	1.21	Sinuous
13	640.89	623.04	1.03	Straight	13	214.17	198.42	1.08	Straight
14	709.97	417.98	1.70	Meander					
15	403.21	328.52	1.23	Sinuous					
16	927.82	883.38	1.05	Straight					
17	367.57	259.89	1.41	Sinuous					
18	161.18	123.68	1.30	Sinuous					
	Average		1.25	Sinuous		Average		1.17	Sinuous

The DA unit is a fluvial landform produced by the repeated deposition of fine- to coarse-grained sediment transported by river activity across flat to gently sloping terrain (Brahmantyo & Bandono, 2006). It typically develops in river valleys and the downstream reaches of the drainage system, where reduced transport energy favors sediment accumulation rather than erosion. According to Rajakumari, Meenambikai, Divya, Sarunjith, and Ramesh (2021), alluvial plains form through long-term sediment accumulation derived from higher terrain upstream, producing broad, relatively flat surfaces. In the study area, the DA unit develops along the lower courses of the Batang Ombilin and Batang Lawas and is closely associated with the DB, PB, and CIM units. Owing to its gentle topography and comparatively fertile sediment, the unit is intensively cultivated for paddy fields and other agricultural uses.

The DB unit develops on flat to gently sloping terrain along the active river courses and is periodically inundated by overbank flow. Following Lewin (1978), floodplains form through repeated alluvial sedimentation driven by overbank flow and channel migration, producing a surface built from successive increments of fine- to coarse-grained, unconsolidated sediment. In the study area, the DB unit develops along the margins of the Batang Ombilin and Batang Lawas and is closely associated with the CIM, PB, and CB units. Its low elevation and flat morphology indicate ongoing lateral erosion, sediment transport, and overbank deposition during periods of high discharge, making the unit susceptible to seasonal flooding despite its agricultural value.

The PB unit consists of sediment deposited on the inner bend of meandering rivers, where a reduction in flow velocity promotes the accumulation of sand, gravel, and finer material (Charlton, 2007). This depositional process operates simultaneously with active lateral erosion on the outer bank, so that point-bar accretion and bank erosion together drive the progressive lateral migration of the meander belt (Van Zuidam & Cancelado, 1985). It is associated with the CIM, CB, and floodplain units and indicates dominant deposition on the inner bend while lateral erosion occurs on the outer bend. Its gently sloping, low-relief morphology and unconsolidated alluvial composition confirm the dominance of fluvial deposition at these specific channel positions.

The CB unit comprises elongated sediment bodies within the river channel, composed of sand, gravel, to boulders, formed when flow energy decreases and transported material is deposited within the channel (Charlton, 2007). These bar deposits commonly develop incrementally into elongated forms aligned with the flow direction and exert an active influence on local channel hydraulics. It develops in the middle reach of the Batang Lawas and is closely associated with the PB, DB, and CIM units. Its presence demonstrates the interaction between sediment transport capacity and fluctuating flow energy, which helps drive local flow deflection and continued meander development.

The PRD unit is a denudational landform produced by relatively low-intensity weathering, erosion, and mass movement (Huggett & Shuttleworth, 2022; Van Zuidam & Cancelado, 1985), in which denudation has gradually subdued the original topography into gentler relief rather than sharply incised terrain. It develops in inter-hill valleys and is closely associated with the alluvial plain and the PDS unit, occupying a transitional position between the active fluvial lowlands and the surrounding denudational hills. It shows low to weakly undulating relief with gentle slopes and a comparatively advanced stage of weathering. These favourable topographic conditions make the unit one of the principal areas used for paddy fields and smallholder plantations.

The PDS unit forms under moderate-to-weak denudation, in which differential lithological resistance, slope gradient, and the cumulative intensity of denudation have produced rolling-to-hilly relief without generating sharply incised topography (Huggett & Shuttleworth, 2022). It develops extensively and surrounds the alluvial plain, acting as a morphological transition zone between the lowland fluvial units and the more strongly eroded hill units toward the interior of the area. It shows undulating to hilly relief with moderate slopes and moderate erosion that has not produced very steep relief, reflecting an intermediate stage of denudational development relative to the PDK and PTDK units.

The PDK unit forms under moderate-to-strong denudation, resulting in markedly more intensive surface lowering than the PDS unit and expressed in steeper slopes, deeper valley incision, and a coarser overall hill morphology. It develops widely in the central to western parts of the area and is associated with the PDS, PTDK, and part of the DA units. It is characterized by hilly relief with moderate-to-steep slopes, clear ridge patterns, and narrow valleys produced by intensive surface runoff and erosion — features marking a transitional erosional stage comparable to other denudational hill sequences mapped in Sumatra (Huggett & Shuttleworth, 2022; Ramadan & Rochmana, 2025).

The PTDK unit is a high-relief denudational landform formed by intensive, long-term weathering and erosion (Huggett & Shuttleworth, 2022; Van Zuidam & Cancelado, 1985), representing the most advanced stage of denudational development recognized in the study area. It occupies the highest hills in the central to western parts, with elongated ridges, steep to very steep slopes, high erosion levels, and narrow inter-ridge valleys. The intensity of denudation affecting this unit reflects the combined influence of steep slope gradients, susceptible lithology, and sustained weathering and erosion, consistent with its spatial association with the structurally controlled PI unit. Such high-relief denudational landscapes illustrate the strong coupling between long-term erosion and topographic evolution that characterizes actively evolving terrains (Marder & Gallen, 2023).

The PK unit forms by the dissolution of carbonate rocks, mainly limestone, through mildly acidic infiltrating water acting over a long geological timescale (Verstappen, 1985). According to

Ford and Williams (2007), karstification proceeds through the interaction of water chemistry, rock structure, and fracture intensity, generating distinctive landforms such as tower karst and steep limestone outcrops. It develops in the western to northwestern parts as steep hills with tower-karst morphology, massive limestone outcrops, and abundant fractures and solution features reflecting intensive karstification — consistent with the limestone exposures of the Silungkang Formation documented elsewhere within the Sawahlunto Geopark (Rahman et al., 2024).

The PI unit is a structural–denudational landform controlled by intrusive igneous rocks that are more resistant to weathering and erosion than the surrounding rocks (Huggett & Shuttleworth, 2022; Van Zuidam & Cancelado, 1985). Such intrusion-related landforms typically develop as positive relief features through differential denudation, in which the resistant intrusive body persists as a topographic high after the surrounding, less resistant rock is progressively stripped away. It develops in the southwestern part, associated with the PTDK unit, and stands out as prominent relief through differential denudation — a relationship comparable to other intrusion-controlled hill units described elsewhere in Indonesia (Ruhimat et al., 2024).

Compared with previous geomorphological studies in the wider Sawahlunto area, the present classification reveals a markedly more diverse landform assemblage. In the nearby Batang Manyuruk area of Talawi District, Apriliana and Rochmana (2024) identified only four geomorphic units — denudational steep high hills, denudational rather steep low hills, fault-fold hills, and point bar — reflecting a terrain dominated by clastic sedimentary lithology with fold-and-fault control and limited fluvial development. In contrast, the Silungkang area comprises eleven units spanning five fluvial sub-environments, four denudational hill classes differentiated by erosion intensity, and — distinctively — a karst hill unit and an intrusion-controlled hill unit, neither of which was reported in the Batang Manyuruk classification. This contrast indicates that, despite their proximity within the same Ombilin Basin margin, the Silungkang area preserves a more heterogeneous lithological framework, incorporating carbonate and igneous components in addition to the clastic sedimentary sequence, producing a correspondingly more complex landform inventory. The result also extends previous tectonic and stratigraphic studies of the Ombilin Basin (e.g., Koesoemadinata & Matasak, 1981; Putra et al., 2021) which characterized the basin's structural evolution at a regional scale but did not address the detailed geomorphic expression of this lithological diversity at the sub-catchment level. More broadly, the observed geomorphic diversity reflects the interaction between tectonic evolution, lithological variability, and long-term surface processes, consistent with conceptual models linking fault evolution and landscape development in tectonically active regions (Zwaan et al., 2022).

4. CONCLUSION

The geomorphology of the Silungkang area and its surroundings, Sawahlunto City, West Sumatra, was characterized through morphographic, morphometric, and geomorphic-process analyses. The area comprises three morphographic units (low hills, hills, and high hills) with elevations of 185.49–873.29 m and is dominated by the hill unit (~70%); slopes range from flat (0–2%) to very steep (56–140%) and are dominated by gentle to moderately steep classes. Geomorphic processes are reflected by subdendritic (62%) and dendritic (38%) drainage patterns and by debris-flow and debris-slide mass movements, the latter being the most dominant. Based on the integration of these parameters, the study area is divided into eleven landform units: Channel Irregular Meander, Alluvial Plain, Floodplain, Point Bar, and Channel Bar (fluvial); Low Denudational Hills

(weakly eroded), Denudational Hills (moderately–weakly eroded), Denudational Hills (strongly–moderately eroded), and High Denudational Hills (strongly eroded) (denudational); Karst Hills; and Intrusion Hills. These units demonstrate that the landscape evolution of the study area is controlled by the combined influence of lithology, tectonic activity, and exogenic processes of weathering and erosion.

REFERENCES

Adamsyah, B., & Rochmana, Y. Z. (2024). Analisis Geomorfologi Pada Daerah Pagergunung, Kabupaten Pangandaran, Jawa Barat. *Innovative: Journal of Social Science Research*, *4*(4), 7378–7390. https://doi.org/10.31004/innovative.v4i4.12553

Apriliana, V., & Rochmana, Y. Z. (2024). Kajian Geomorfologi Daerah Batang Manyuruk dan Sekitarnya, Kabupaten Sawahlunto, Sumatera Barat. *Jurnal Penelitian Inovatif (JUPIN)*, *4*(3), 1591–1602. https://doi.org/10.54082/jupin.624

Basharat, M. ul, Khan, J. A., Abdo, H. G., & Almohamad, H. (2023). An Integrated Approach Based Landslide Susceptibility Mapping: Case of Muzaffarabad Region, Pakistan. *Geomatics, Natural Hazards and Risk*, *14*(1). https://doi.org/10.1080/19475705.2023.2210255

Bernard, T. G., Davy, P., & Lague, D. (2022). Hydro-Geomorphic Metrics for High Resolution Fluvial Landscape Analysis. *Journal of Geophysical Research: Earth Surface*, *127*(3), e2021JF006535. https://doi.org/10.1029/2021JF006535

Brahmantyo, B., & Bandono. (2006). Klasifikasi bentuk muka bumi (landform) untuk pemetaan geomorfologi pada skala 1:25.000 dan aplikasinya untuk penataan ruang. *Jurnal Geoaplika*, *1*(2), 71–78.

Charlton, R. (2007). *Fundamentals of Fluvial Geomorphology*. Routledge.

Dyba, K. (2024). Explanation of the influence of geomorphometric variables on the landform classification based on selected areas in Poland. *Scientific Reports*, *14*, 5447. https://doi.org/10.1038/s41598-024-56066-6

Ford, D., & Williams, P. (2007). *Karst Hydrogeology and Geomorphology*. John Wiley & Sons.

Gusti, U. K., Pramana, A. H., & Sutriyono, E. (2026). Analisis geomorfologi pada Daerah Kinal dan sekitarnya, Kabupaten Kaur, Provinsi Bengkulu. *Jurnal Pendidikan, Sains, Geologi, Dan Geofisika (GeoScienceEd Journal)*, *7*(1). https://doi.org/10.29303/goescienceed.v7i1.1750

Huggett, R. J., & Shuttleworth, E. L. (2022). *Fundamentals of Geomorphology* (5th ed.). Routledge.

Koesoemadinata, R. P., & Matasak, T. (1981). Stratigraphy and sedimentation of the Ombilin Basin, Central Sumatra (West Sumatra Province). *Proceedings of the Indonesian Petroleum Association, 10th Annual Convention*, 217–249.

Lewin, J. (1978). Floodplain geomorphology. *Progress in Physical Geography*, *2*(3), 408–437. https://doi.org/10.1177/030913337800200302

Lin, S., Xie, J., Deng, J., Qi, M., & Chen, N. (2022). Landform Classification Based on Landform Geospatial Structure: A Case Study on Loess Plateau of China. *International Journal of Digital Earth*, *15*(1), 1125–1148. https://doi.org/10.1080/17538947.2022.2088874

Marder, E., & Gallen, S. F. (2023). Climate Control on the Relationship Between Erosion Rate and Fluvial Topography. *Geology*, *51*(5), 424–427. https://doi.org/10.1130/G50832.1

Nasution, I. K., & Sutriyono, E. (2022). Karakteristik Morfometri dan Morfodinamika Sub Daerah Aliran Sungai Batang Sukam, Kabupaten Sijunjung, Sumatera Barat. *OPHIOLITE: Jurnal Geologi Terapan*, *4*(2), 83–93. https://doi.org/10.56099/ophiolite.v4i2.27472

Noeradi, D., Subroto, E. A., Wahono, H. E., Hermanto, E., & Zaim, Y. (2005). Basin evolution and hydrocarbon potential of intra-montane Ombilin Basin, West Sumatra, Indonesia. *Proceedings of the Indonesian Petroleum Association, 30th Annual Convention*, 297–308.

Ouyang, S., Xu, J., Chen, W., Dong, Y., Li, X., & Li, J. (2022). A Fine-Grained Genetic Landform Classification Network Based on Multimodal Feature Extraction and Regional Geological Context. *IEEE Transactions on Geoscience and Remote Sensing*, *60*, 1–14. https://doi.org/10.1109/TGRS.2022.3203606

Putra, A. F., Abdullah, C. I., & Noeradi, D. (2021). Ombilin Basin as inverted oblique rift in Barisan Mountains, Sumatra: considerations on subsidence mechanisms and fault development. *IAGI Journal*, *1*(2), 89–102. https://doi.org/10.51835/iagij.2021.1.2.32

Putri, A. N., & Setiawan, B. (2023). Analisis tektonik relatif menggunakan metode morfotektonik daerah Lintau Buo dan sekitarnya, Tanah Datar, Sumatera Barat. *Journal of Applied Geoscience and Engineering*, *2*(1). https://doi.org/10.34312/jage.v2i1.19921

Rahman, H. A., Ahyuni, A., Burhamidar, A., Fadhly, A., Swantry, N., & Adeko, W. (2024). Pengembangan Jalur Geowisata Berbasis Komponen Geologi di Kawasan Geopark Nasional Sawahlunto, Provinsi Sumatera Barat. *Jurnal Geosains Dan Teknologi*, *7*(2), 94–110. https://doi.org/10.14710/jgt.7.2.2024.94-110

Rajakumari, S., Meenambikai, M., Divya, V., Sarunjith, KJ., & Ramesh, R. (2021). Building spatial database and geomorphological mapping of coastal landforms. *The Egyptian Journal of Remote Sensing and Space Science*, *24*(3 (2)), 1071–1081. https://doi.org/10.1016/j.ejrs.2021.10.008

Ramadan, I. R. M., & Rochmana, Y. Z. (2025). Integrated DEMNas and morphogenetic analysis of geomorphological diversity in Salopa, Tasikmalaya, West Java. *Jambura Geoscience Review*, *7*(2), 31022. https://doi.org/10.37905/jgeosrev.v7i2.31022

Ruhimat, N. A., Arifin, Y. I., & Kasim, M. (2024). Geomorfologi Daerah Lombongo dan sekitarnya, Kecamatan Suwawa Tengah, Kabupaten Bone Bolango. *Journal of Applied Geoscience and Engineering*, *3*(2). https://doi.org/10.37905/jage.v3i2.30321

Uno, D. A. N., Uno, I., Saputra, A., Arum, D. A., Mumin, R. P., & Alfaed, M. R. F. (2025). Analysis Slope Stability Using RMR and SMR Method in Nupaomba Area Tanantovea Donggala. *Jambura Geoscience Review*, *7*(1), 60–67. https://doi.org/10.37905/JGEOSREV.V7I1.30388

Utama, H. W., & Mulyasari, R. (2024). Geomorphological structure of landform characteristics as a reference for development recommendations in active volcanic and faulting areas, a case study in Kerinci region, Jambi Province, Indonesia. *Indonesian Journal on Geoscience*, *11*(1), 123–139. https://doi.org/10.17014/ijog.11.1.123-139

Van Zuidam, R. A., & Cancelado, F. I. (1985). *Aerial Photo-interpretation in Terrain Analysis and Geomorphologic Mapping*. Smits Publishers.

Verstappen, H. T. (1985). *Applied Geomorphology: Geomorphological Surveys for Environmental Development*. Elsevier.

Widyatmanti, W., Wicaksono, I., & Syam, P. D. R. (2016). Identification of topographic elements composition based on landform boundaries from radar interferometry segmentation (preliminary study on digital landform mapping). *IOP Conference Series: Earth and Environmental Science*, *37*, 12008. https://doi.org/10.1088/1755-1315/37/1/012008

Zwaan, F., Hughes, A., McNeill, L., Gregory, L. C., & Faure Walker, J. (2022). Editorial: Links Between Tectonics, Fault Evolution and Surface Processes in Extensional Systems. *Frontiers in Earth Science*, *10*, 1054125. https://doi.org/10.3389/FEART.2022.1054125