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Morphotectonic analysis approach for active fault identification of the Cikandang Watershed, Southern part of West Java, Indonesia

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Abstract

This study aims to find possible active faults by analysing the morphotectonic features of the Cikandang Watershed in West Java, Indonesia. Morphometric indices including drainage density (Dd), lineament density (Ld), and bifurcation ratio (Rb) were computed using digital elevation models, topographic maps, and geological maps using Geographic Information System (GIS) software. As demonstrated by the different drainage patterns and lineament alignments that show tectonic activity, the analysis shows that tectonic forces substantially impact the watershed's shape. Higher Rb levels in sub-drainages suggest tectonic activity, while elevated Dd and Ld values indicate areas that are more susceptible to tectonic movements. These indices show possible active fault zones and strongly correlate with those shown on regional geological maps, especially in the watershed's centre and northern regions. In line with earlier studies that connected geomorphic indices to tectonic activity, the findings support the importance of these indicators in identifying active faults. This study highlights the importance of comprehensive morphotectonic assessments in determining earthquake hazards, providing vital information for disaster risk management and spatial planning in tectonically active areas. Through the alignment of geomorphic indices with geological features, the study pinpoint's fault zones that need continuous observation, promoting safer community development and more resilient infrastructure in West Java's earthquake-prone areas.

Keywords:
morphotectonics, active faults, Cikandang Watershed, geomorphic indices

1. Introduction

Morphotectonic studies are very important in geology because they analyse the relationship between the shape of the Earth's surface and tectonic activity. Morphotectonic characteristics include river patterns, valley shapes, and topography produced by tectonic activities, such as fault displacements and earthquakes (**Dehbozorgi et al., 2010**). Morphotectonic analysis is very helpful in identifying the presence of active faults that can be a source of natural hazards, specifically due to earthquakes (**Wu et al., 2019**). Active faults have the potential to release energy in the form of earthquakes; identifying and understanding the distribution and nature of active faults is key to earthquake hazard assessment. Through morphotectonic studies, researchers can identify areas with high potential for damaging earthquakes by mapping deformation patterns, geological structures and geomorphologic indices of their activity (**Ren et al., 2023**). This is especially relevant in regions such as Indonesia, which are located in a tectonic plate collision zone, making it one of the areas with high tectonic activity.

Varieties of quantitative tools for examining landforms and topography are included in geomorphometric methods, which are frequently used in research on river patterns and valley shapes. **Pike (1995)**, **Rasemann et al. (2004)**, and research employing sophisticated algorithms (**Eakins & Grothe, 2014; Seenath et al., 2016**) that concentrate on hydrological modelling and flow patterns are examples of recent examinations of river patterns. Research by **Gesch (2009)** and **Murdukhayeva et al. (2013)** sheds light on the geomorphometric features of valleys for the purpose of valley shape analysis, highlighting the significance of Digital Elevation Models (DEMs) in capturing topographic variations. With the advancement of specialized software such as SAGA GIS and GRASS GIS, along with GIS tools like ArcGIS and QGIS, researchers are now able to derive key topographic parameters, including slope, aspect, and curvature, from Digital Elevation Models (DEMs). These resources improve knowledge of landscape dynamics and help guide environmental management plans, especially in low-lying and coastal regions that are susceptible to the effects of climate change (**Poulter & Halpin, 2008**; **Yunus et al., 2016**; **Antonioli et al., 2017**).

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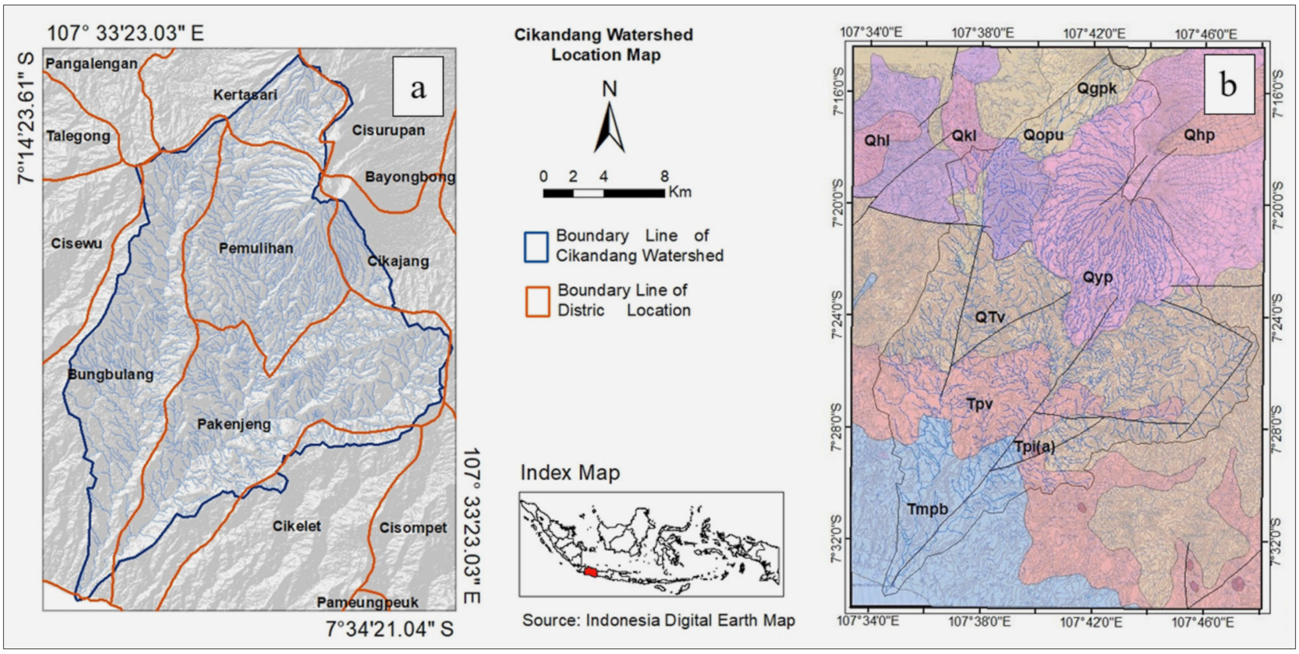

Figure 1. a) Location of Cikandang Watershed as study area. (modified from Indonesia Digital Earth Map/Peta Rupa Bumi Indonesia (RBI)) **b)** Regional Geological Map of the Research Area (modified from Garut and surrounding area geological map by **Alzwar & Akbar, 1992**).

Morphotectonic research was carried out in the Cikandang River Basin in West Java, Indonesia, to comprehend how tectonic processes impact and affect the region's geomorphology and river flow patterns. Flow patterns and watershed surface shapes can be indicators of subsurface tectonic activity, such as the presence of active faults that may be hidden or previously unidentified (**Sedrette et al., 2022**). The study area is located in the Garut Regency (see **Figure 1a**), an area known for its diverse geomorphological and tectonic features, making it a significant region for studying geological processes, including fault activity. This watershed flows through volcanic and tectonic landscapes, which influence its morphology and the potential presence of active fault lines, especially given the area's location on the tectonically active Sunda Arc (**Zubaidah et al., 2014**).

The geological setting of Cikandang Watershed is presented in the geological map (see **Figure 1b**) that illustrates several key geological units in the study area. Each unit represents different rock types and formations from the oldest (Late Miocene) to the youngest (Holocene): (1) Tmpb - Bentang Formation (Late Miocene): Sedimentary rocks in the form of tuffaceous sandstone, pumice tuff, mudstone, conglomerate and lignite, (2) Tpv - Tuffaceous Breccia (Pliocene): Breccia, tuff and sandstone, (3) Tpi(a) - Andesite (Pliocene): Consists of hornblende andesite (Tpah) and pyroxene andesite (Tpap), (4) QTv - Undecomposed Old Volcanic Rock (Pleistocene): Tuff, tuff breccia and lava, (5) Qwb - Waringin-Bedil Andesite, Old Malabar (Pleistocene): Alternating lava, breccia and tuff, composed of pyroxene andesite and hornblende, (6) Qgpk - Volcanic Rocks of Mt. Guntur-Mt. Pangkalan and Mt. Kendang (Pleistocene): Loose spices and lava composed of andesite-basalt, sourced from the old volcanic complex of Mt. Guntur-Mt. Pangkalan and Mt. Kendang (Qgpk), (7) Qopu - Loose Spice Deposits of Undecomposed Old Volcanic (Pleistocene): Fine-coarse dacitic crystal tuff, tuffaceous breccia containing pumice and old lava deposits are andesite-basalt, (8) Q(k,h)l - Lava Kancana and Huyung (Pleistocene): Andesite andesite-basalt lava, Mt. Kencana (Qkl), Mt. Huyung (Qhl), (9) Qyp - Young Volcanic Rock (Holocene): Efflata and lava flows composed of andesite-basalt; source Mt. Papandayan (Qyp) and the last (10) Qhp - Papandayan Volcanic Loose Ash (Holocene): Volcanic ash, andesite and basalt chunks.

The hills and mountains that characterize the Cikandang Watershed's geomorphology range in slope from flat to steep, defining the basin's borders. On mountain slopes, there is a broad range of drainage patterns, such as subdendritic, sub-parallel, sub-rectangular, sub-trellis, and sub-radial to radial. These drainage patterns imply that their origin was impacted by tectonic and volcanic activity.

The purpose of this study is to analyse the morphotectonic characteristics of the Cikandang Watershed as a method of identifying and mapping the potential existence of active faults in the area by involving the examination of landforms and their relationship to tectonic processes. Studies have shown that morphotectonic indicators such as drainage patterns, valley shapes, and slope characteristics can provide insight into fault activity (**Winarto et al., 2019; Torrefranca & Otadoy, 2024**).

This is important due to high tectonic activity of the West Java region, which is geologically located in an active tectonic plate collision zone (**Aribowo et. al, 2022**). Active faults have a direct impact on the safety of the community and local infrastructure (**Pribadi et al., 2021**). Therefore, the results of this study are expected to provide significant contributions to seismic hazard assessment and subsequent spatial planning and disaster mitigation strategies in areas prone to earthquakes.

2. Methods

Utilizing digital imagery from DEMNAS, topographic maps at a 1:25,000 scale from Rupa Bumi Indonesia (RBI) digitalized maps, and geology regional maps at a 1:100,000 scale, various morphometric parameters were measured using Geographic Information System (GIS) technology. Data processing was held at the Geomorphology and Remote Sensing Laboratory, Geological Engineering in Jatinangor Campus, using Arc GIS 10.8 and Google Earth software.

2.1. Bifurcation Ratio (Rb)

The segmentation method can be used to examine Rb by stream order (**Verstappen, 1983; Sukiyah et al., 2017; Asykarulloh et al., 2023**). First-order streams are any portion of a stream that lacks branching or ramification. Two first orders make up a second order, two second orders make up a third, and two third orders make up a fourth. The ratio between the number of streams of order u (Nu) and stream of order u+1 (Nu+1) is known as the bifurcation ratio (Rb), and it defined by using Equation 1:

$$Rb = \Sigma Nu / \Sigma Nu + 1 \quad (1)$$

where:

Rb – Bifurcation Ratio,

Nu – the number of streams of order u,

Nu+1 – the number of streams of order u+1.

If the bifurcation ratio (Rb) is less than three or greater than five, it is not considered normal. This suggests that there has been a deformation, which may have been caused by tectonic activity (**Sukiyah et al., 2015; Nugroho et al., 2020**).

2.2. Drainage Density (Dd)

The drainage density is a numerical value that represents the drainage basin's amount of dissection. It measures how well or ineffectively a drainage basin is drained by stream channels.

$$Dd = \Sigma L / A \quad (2)$$

where:

Dd – Drainage Density,

L – sum of all stream lengths in the drainage basin (km),

A – area of the drainage basin (km^2).

According to Equation 2, drainage density is calculated by dividing the area of the drainage basin (A) by the sum of all stream lengths in the drainage basin (L) (**Doornkamp, 1986; Sukiyah et al., 2016; Winarto et al., 2019**). An area's drainage pattern could reveal its geological state. Drainage analysis is a tool for geologic interpretation from satellite data or aerial images, especially in low-relief regions. It could reveal hints about dormant structural elements that are visible at the surface, rising structural elements, and potentially hidden structural elements (**Sukiyah et al., 2018; Riswandi et al., 2020; Siahaan et al., 2023**).

2.3. Lineament Density (Ld)

A technique for evaluating highly structured density regions created by the interconnection of faults and fractures or lineaments is called Lineament Density (Ld). This technique defines the lineaments' morphology, which emerges as a reaction to active tectonics, using digital topographic data. The line intensity can be determined using a straightforward mathematical formula that is based on the total length of straightness (F) divided by the calculated area (A) (**Soengkono, 1999; Gentana et al., 2019**). With the formula given:

$$Ld = \Sigma F / A \quad (3)$$

where:

Ld – Lineament Density,

F – total length of straightness (km),

A – calculated area (km^2).

Morphological lineaments such as river lineaments, escarpments and ridges are fracture zones and faults expressed in the field. These morphological lineaments can be identified through aerial photographs or satellite imagery. Geological lineaments are a reflection of the morphology observed on the Earth's surface as a result of geological force processes from within the earth (**Radaideh et al., 2016).** Lineament density analysis aims to identify the surface structure of the research area. The density map will inform the density values related to the level of rock resistance to the deformation.

3. Results

The Cikandang Watershed is shaped like a fan (see **Figure 2a**). This reveals that it has several drainage patterns, such as trellis, parallel, dendritic, and rectangular.

3.1. Bifurcation Ratio (Rb)

Rb values ranging from 1.26 to 4.50 in ranges from ratio stream order 1 and 2 reflect the overall Rb calculation outcomes from 45 subdrainage basins that are deformed and not deformed. Furthermore, Rb values in the ratio stream order 2 and 3 range from 0.40 to 9.0. This suggests that the water catchment was influenced by de-

Table 1. Bifurcation Ratio (Rb) values calculated in the 45-water catchment area (WCA)

No.	Sum of river orders			Sum of river segment			Rb 1_2	Rb 2_3
	1	2	3	1	2	3		
1	8	2	1	8	4	4	2.00	1.00
2	10	3	1	10	7	2	1.43	3.50
3	26	7	1	26	16	9	1.63	1.78
4	11	3	1	11	5	5	2.20	1.00
5	4	2	1	4	2	1	2.00	2.00
6	21	6	1	21	9	9	2.33	1.00
7	9	3	1	9	5	3	1.80	1.67
8	17	4	1	17	6	9	2.83	0.67
9	12	2	1	12	9	1	1.33	9.00
10	6	2	1	6	3	2	2.00	1.50
11	13	3	1	13	8	4	1.63	2.00
12	17	3	1	17	8	7	2.13	1.14
13	29	4	1	29	23	5	1.26	4.60
14	17	4	1	17	11	4	1.55	2.75
15	5	2	1	5	3	1	1.67	3.00
16	13	4	1	13	6	6	2.17	1.00
17	46	10	1	46	22	23	2.09	0.96
18	11	3	1	11	7	2	1.57	3.50
19	7	2	1	7	5	1	1.40	5.00
20	19	4	1	19	8	9	2.38	0.89
21	6	2	1	6	2	3	3.00	0.67
22	6	2	1	6	4	1	1.50	4.00
23	9	2	1	9	7	5	4.50	0.40
24	14	3	1	14	5	8	2.80	0.63
25	8	2	1	8	6	1	1.33	6.00
26	28	2	1	28	13	14	2.15	0.93
27	7	2	1	7	4	2	1.75	2.00
28	7	2	1	7	4	2	1.75	2.00
29	12	4	1	12	5	6	2.40	0.83
30	7	3	1	7	4	3	1.75	1.33
31	6	2	1	6	4	1	1.50	4.00
32	17	3	1	17	6	10	2.83	0.60
33	9	3	1	9	5	2	1.80	2.50
34	14	4	1	14	5	6	2.80	0.83
35	5	2	1	5	2	2	2.50	1.00
36	6	2	1	6	4	1	1.50	4.00
37	7	2	1	7	3	3	2.33	1.00
38	5	2	1	5	2	2	2.50	1.00
39	21	2	1	21	9	11	2.33	0.82
40	6	3	1	6	3	2	2.00	1.50
41	18	4	1	18	10	7	1.80	1.43
42	17	4	1	17	9	7	1.89	1.29
43	14	3	1	14	8	5	1.75	1.60
44	9	3	1	9	4	4	2.25	1.00
45	9	3	1	9	3	5	3.00	0.60

formation. Eleven water catchment basins at various locations and with ratio stream order 1 and 2: 21 (3.00), 23 (4.50), and 45 (3.00) and with ratio stream order 1 and 3: 2 (3.50), 13 (4.60), 15 (3.00), 18 (3.50), 19 (5.00), 22 (4.00), 31 (4.00), and 36 (4.00) are examples of non-deformed areas scattered throughout the northern, middle, and southwestern portions of the study area. Bifurcation Ratio (Rb) values (see **Table 1**) are calculated in the 45-water catchment area (WCA). The Rb value reflects the condition of partially consolidated rock, which is influenced neither by tectonic activity nor by climatic factors, but rather by deformation processes (**Gentana et al., 2018**).

3.2. Drainage Density (Dd)

In order to calculate the tectonic activity value in the study area, the Dd is an indicator of the quantity of tributaries in a watershed. A geomorphic index called drainage density can show how many tributaries there are and it reveals landform texture in a watershed. The ratio of the total length of river segments to a watershed or sub-watershed area is known as the drainage density (Dd). The watershed or sub-watershed has a higher drainage density when the Dd number is higher (**Biswas et al., 1999; Shekar & Mathew, 2023**).

Drainage density (Dd) is divided into six grades of landform texture (**Sukiyah et al., 2009**): class 1 consists of grade 5 - fine (5.520-6.899) to grade 6 - very fine (6.9-8.279), class 2 consists of grade 3 - medium (2.760-4.139) to grade 4 - smooth (4.140-5.519) and class 3 consists of grade 1 - very rough (0-1.379) to grade 2 - rough (1.380-2.759). In the research area, class 2 (grade 3 and 4) is the dominant one, its values range from 2.24 to 4.70 (see **Table 2** and **Figure 2b**).

3.3. Lineament Density (Ld)

Lineament density is influenced by active geological processes in an area. Geological process in this case may be an endogenous process that is also impacted by exogenous factors. Tectonic activity and other endogenous processes can result in various kinds of surface natural morphologies, such as ridge lineaments, which indicate the existence of a fault or fold. A lineament, however, may also be connected to the existence of exogenous mechanisms that facilitate the development of linear valley areas and other lineaments. High lineament density

Table 2. Drainage density (Dd) values calculated in 45-water catchment area (WCA)

No.	Total length (∑L) (km)	Area watershed (A) (km^2)	Drainage density (Dd)	Class	No.	Total length (∑L) (km)	Area watershed (A) (km^2)	Drainage density (Dd)	Class
1	11.44	4.67	2.45	3	24	14.38	4.41	3.26	2
2	22.58	9.10	2.48	3	25	11.69	3.90	3.00	2
3	50.98	22.77	2.24	3	26	31.62	12.76	2.48	3
4	20.49	7.49	2.73	3	27	8.10	2.67	3.04	2
5	5.64	1.38	4.09	2	28	5.79	1.28	4.51	2
6	43.03	11.52	3.74	2	29	14.66	4.29	3.41	2
7	13.00	3.54	3.67	2	30	8.60	2.09	4.10	2
8	24.13	6.84	3.53	2	31	9.90	4.41	2.24	3
9	23.28	5.94	3.92	2	32	27.82	10.28	2.71	3
10	5.98	1.42	4.21	2	33	10.96	2.64	4.15	2
11	21.22	5.43	3.91	2	34	16.59	5.46	3.04	2
12	35.55	8.90	4.00	2	35	8.05	2.04	3.94	2
13	41.83	15.01	2.79	2	36	9.73	3.20	3.04	2
14	18.28	5.22	3.50	2	37	7.35	1.96	3.75	2
15	8.64	3.63	2.38	3	38	3.91	0.87	4.50	2
16	19.83	7.15	2.77	2	39	17.72	5.79	3.06	2
17	52.91	16.48	3.21	2	40	8.56	2.86	3.00	2
18	7.58	1.61	4.70	2	41	16.90	4.59	3.68	2
19	4.30	1.12	3.86	2	42	18.89	6.81	2.77	2
20	15.25	3.64	4.19	2	43	15.06	4.64	3.25	2
21	5.72	1.82	3.15	2	44	23.94	8.55	2.80	2
22	7.16	1.87	3.84	2	45	7.69	1.76	4.36	2
23	7.47	2.20	3.39	2					

could be related to the tectonic activity of an area (**Fantah et al., 2022**). Based on this, the research area was studied and analysed for its lineament density conditions, which produced a Lineament Density Map (see **Figure 2c**). It appears that areas with high lineament density are located in most of the research area, which occupy around 10 - 20% of the area of the watershed.

4. Discussion

To analyse tectonic activity within the Cikandang Watershed, the morphometric results—lineament density (Ld), drainage density (Dd), and bifurcation ratio (Rb)—were overlayed on a regional geologic map. Fault zones on the geologic map correlate with the high Ld values, mostly found in the northern and central regions. This suggests that active tectonic processes may impact these locations (**Gentana et al., 2019; Sukiyah et al., 2018**). Areas with high Dd and Rb values also show deformation, which suggests tectonic activity and maybe active faults because these indices point to a drainage network that is structurally controlled (**Doornkamp, 1986**). As noted in earlier research by **Wu et al. (2019) and Ren et al. (2023)**, these results highlight the watershed's susceptibility to tectonic pressures.

Active tectonics are supported by additional examination of the watershed's geological formations, particularly the preponderance of sedimentary and volcanic rocks in areas prone to deformation. According to the map, the watershed's more recent volcanic rocks have high Rb values, indicating structural control and potentially active geological deformation. High Dd values were associated with drainage patterns like trellis and dendritic, which are typical in tectonically disturbed terrains. These findings are in line with **Sedrette et al. (2022)**, which show that tectonic influences on drainage are present in locations that have recently experienced tectonic uplift. This distribution confirms the existence of active faults in accordance with the morphotectonic analysis by **Fantah et al. (2022)** and emphasizes the usefulness of geomorphic indices in identifying tectonic signatures.

The alignment of Ld, Dd, Rb, and the geological map allows us to consider faults as most likely active. It is consistent with the idea that active faults influence local morphotectonic features since fault lines that cross the

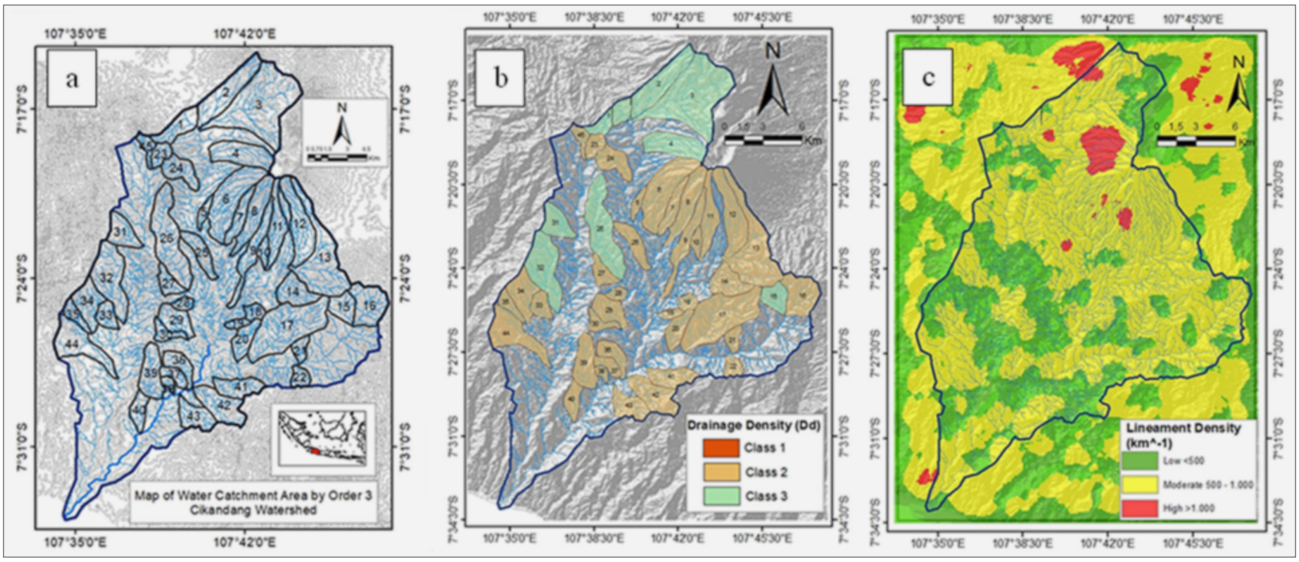

Figure 2. a) Map of water catchment area (WCA) by order 3 of Cikandang Watershed, **b)** Result of study area's sub-watersheds are categorized using drainage density (Dd) index measurements and **c)** Distribution of lineament density (Ld) classification. As seen on the map, the moderate Ld classification dominates the Cikandang Watershed.

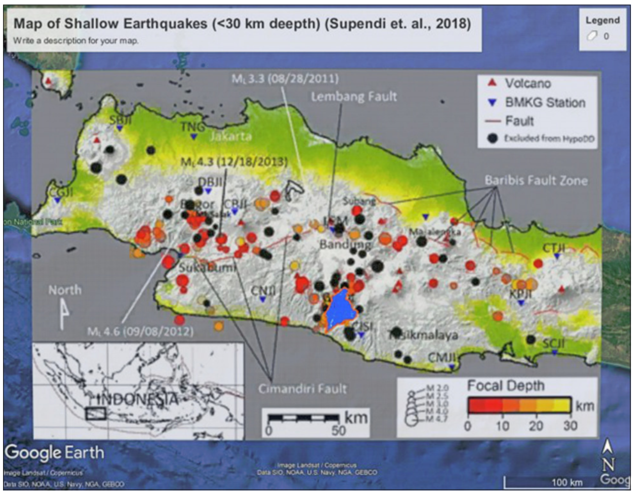

Figure 3. Map of shallow earthquakes (<30 km depth) in the study area, compiled from **Supendi et al. (2018)**

watershed, especially those in volcanic rock-dominant areas, are highly correlated with elevated Ld and Rb values (**Radaideh et al., 2016**). A map of shallow earthquakes (<30 km depth) in the study area, was compiled from **Supendi et al. (2018)**. This map (see **Figure 3**) illustrates the distribution of seismic events, focal depths, and their relationship with major fault systems, including the Cimandiri Fault and Baribis Fault Zone. The seismicity data provides additional context for tectonic activity in the region and supports the morphotectonic interpretation of active fault zones in the Cikandang Watershed. The clustering of earthquakes along fault lines aligns with the conclusions of this study, confirming the tectonic influence on geomorphic processes. These geomorphic indicators, which support active fault identification, offer insight for seismic hazard assessment and emphasise the significance of ongoing tectonic monitoring in West Java to reduce the danger of earthquakes in inhabited regions (**Pribadi et al., 2021**).

5. Conclusions

The morphotectonic analysis of the Cikandang Watershed reveals significant tectonic activity, as indicated by the high values of drainage density (Dd), lineament density (Ld), and bifurcation ratio (Rb). These indices correlate with fault zones depicted on the regional geological map, particularly in the northern and central parts of the watershed. The data suggests that these zones are highly influenced by tectonic processes, indicating potential active faults that pose a seismic hazard in the region. This aligns with previous studies that demonstrate the relationship between geomorphic indices and tectonic structures reinforcing the study's relevance in earthquake-prone areas. Further examination of the watershed's geological composition supports the evidence of active tectonics. Younger volcanic rock formations, observed alongside elevated Rb values, suggest structural control and possible deformation processes. Additionally, the prevalence of trellis and dendritic drainage patterns, common in tectonically disturbed terrains, further confirms tectonic activity. These findings align with similar studies that link drainage patterns to tectonic uplift, highlighting the applicability of morphotectonic analyses in detecting active faults. The results emphasize the potential role of these indices as reliable indicators of tectonic influence on surface morphology. Overall, the study underscores the importance of detailed tectonic monitoring and mapping for seismic hazard assessment, especially in the tectonically active region of West Java. The alignment of geomorphic indices with the geological map enables the identification of specific fault zones that require continuous observation for earthquake mitigation efforts. This research contributes to understanding the dynamics of active fault systems. It offers valuable insight for spatial planning and risk assessment in earthquake-vulnerable regions, supporting informed strategies for community safety and infrastructure resilience in high-risk zones.

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6. References

Alzwar & Akbar. (1992). Geological Map of Garut and Pameungpeuk Sheet, Java, scale 1:100,000. Pusat Survei Geologi, Bandung.

Antonioli, F., et al. (2017). Sea-level rise and potential drowning of the Italian coastal plains: Flooding risk scenarios for 2100. Quaternary Science Reviews, 158, 29–43.

Aribowo, S., Husson, L., Natawidjaja, D. H., Authemayou, C., Daryono, M. R., Puji, A. R., & Lorcery, M. (2022). Active back-arc thrust in north west Java, Indonesia. Tectonics, 41(7), e2021TC007120.\

Asykarulloh, A.W., Sukiyah, E., Muslim, D., Endyana, C., Tawil, S. (2023). Morphometric And Morphotectonic Characteristics Of The Watersheds In Paleleh Region, Buol, Indonesia. Journal of Engineering Science and Technology, 2023, 18, pp. 69–76

Biswas, S., Sudhakar, S., & Desai, V. R. (1999). Prioritisation of subwatersheds based on morphometric analysis of drainage basin: A remote sensing and GIS approach. Journal of the Indian society of remote sensing, 27, 155-166.

Dehbozorgi, M., Pourkermani, M., Arian, M., Matkan, A. A., Motamedi, H., & Hosseiniasl, A. (2010). Quantitative analysis of relative tectonic activity in the Sarvestan area, central Zagros, Iran. Geomorphology, 121(3-4), 329-341.

Doornkamp, J.C., (1986). Geomorphological Approaches to The Study of Neotectonics. Journal of Geological Society, Vol.143:355-342.

Eakins, W.B., & Grothe, P.R. (2014). Challenges in building coastal digital elevation models. Journal of Coastal Research, 30(5), 942–953.

Fantah, C. A. C., Mezoue, C. A., Mouzong, M. P., Tokam Kamga, A. P., Nouayou, R., & Nguiya, S. (2022). Mapping of major tectonic lineaments across Cameroon using potential field data. Earth, Planets and Space, 74(1), 59.

Gentana, D., Sulaksana, N., Sukiyah, E., & Yuningsih, E. T. (2018). Index of active tectonic assessment: quantitative-based geomorphometric and morphotectonic analysis at Way belu drainage basin, Lampung Province, Indonesia. International Journal of Advanced Science Engineering Information Technology, 8(6), 2460-2471.

Gentana, D., Sulaksana, N., Sukiyah, E., & Yuningsih, E. T. (2019). Morphotectonics of Mount Rendingan Area Related To the Appearances of Geothermal Surface Manifestations. Indonesian Journal on Geoscience, 6(3).

Gesch, D.B. (2009). Analysis of Lidar elevation data for improved identification and delineation of lands vulnerable to Sea-Level Rise. Journal of Coastal Research, SI 53, 49–58.

Murdukhayeva, A., et al. (2013). Methodological considerations for the reliable construction of DEMs.

Nugroho, A. R. B., Sukiyah, E., Syafri, I., & Isnaniawardhani, V. (2020). Identification of tectonic deformation using morphometrical analysis of Lamongan volcano complex. GEOMATE Journal, 19(71), 55-60.

Pike, R.J. (1995). Geomorphometry: A brief guide. In Hengl, T., & Reuter, H.I. (Eds.), Geomorphometry

Poulter, B., & Halpin, P.N. (2008). Raster modelling of coastal flooding from sea-level rise. International Journal of Geographical Information Science, 22(2), 167–182.

Pribadi, K. S., Abduh, M., Wirahadikusumah, R. D., Hanifa, N. R., Irsyam, M., Kusumaningrum, P., & Puri, E. (2021). Learning from past earthquake disasters: The need for knowledge management system to enhance infrastructure resilience in Indonesia. International Journal of Disaster Risk Reduction, 64, 102424.

Radaideh, O. M., Grasemann, B., Melichar, R., & Mosar, J. (2016). Detection and analysis of morphotectonic features utilizing satellite remote sensing and GIS: An example in SW Jordan. Geomorphology, 275, 58-79.

Rasemann, F., et al. (2004). Algorithms for the analysis of surface flow patterns.

Ren, Z., Zhang, P., Oguchi, T., & He, Z. (2023). Remote Sensing Perspectives on Geomorphology and Tectonic Processes. Remote Sensing, 15(9), 2327.

Riswandi, H., Sukiyah, E., Syah Alam, B. Y. C., & Hadian, M. S. D. (2020). Morphotectonic identification utilizing satellite imagery processing on the Southern Part of Merapi Mount in Yogyakarta. International Journal on Advanced Science, Engineering and Information Technology, 10(3), 1326-1333.

Sedrette, S., & Rebai, N. (2022). A GIS Approach Using Morphometric Data Analysis for the Identification of Subsurface Recent Tectonic Activity. Case Study in Quaternary Outcrops—North West of Tunisia. Journal of Geographic Information System, 14(1), 94-112.

Seenath, A., et al. (2016). Hydrodynamic versus GIS modelling for coastal flood vulnerability assessment. Ocean and Coastal Management, 120, 99–109.

Shekar, P. R., & Mathew, A. (2023). Morphometric analysis of watersheds: a comprehensive review of data sources, quality, and geospatial techniques. Watershed Ecology and the Environment.

Siahaan, M. R. P., Sukiyah, E., Sulaksana, N., & Haryanto, A. D. (2023). The impact of digital elevation models resolution on tectonic activity assessment based on morphotectonic indices: a case study of Seulawah Agam Volcano, Indonesia. Journal of Degraded & Mining Lands Management, 10(3).

Soengkono, S., (1999). Assessment of Faults and Fracture at The Mokai Geothermal Field, Taupo Volcanic Zone, New Zealand. Proceedings WorLd Geothermal Congress 2000. Kyushu-Tohoku, Japan. pp 1771-1776.

Sukiyah, E., Syafri, I., Sjafrudin, A., Nurfadli, E., Khaerani, P., & Simanjuntak, D. P. (2015). Morphotectonic and satellite imagery analysis for identifying Quaternary fault at Southern part of Cianjur-Garut region, West Java, Indonesia. ACRS 2015 - 36th Asian Conference on Remote Sensing: Fostering Resilient Growth in Asia, Proceedings, 2015

Sukiyah, E., Syafri, I., Winarto, B. J., Susilo, B., Saputra, A., & Nurfadli, E. (2016). Active faults and their implications for regional development at the southern part of West Java, Indonesia. In Proceeding of the 24th Annual scientific conference and exhibitions. Federation International Surveyors, Christcurch, New Zealand, May (pp. 2-6).

Sukiyah, E., (2017). Sistem Informasi Geografis: Konsep dan Aplikasinya dalam Analisis Geomorfologi Kuantitatif. Bandung: Unpad Press. *(In Bahasa Indonesia)*

Sukiyah, E., Sunardi, E., Sulaksana, N., & Rendra, P. R. (2018). Tectonic geomorphology of upper Cimanuk drainage basin, West Java, Indonesia. International Journal on Advanced Science, Engineering and Information Technology, 8(3), 863-869.

Supendi, P., Nugraha, A. D., Puspito, N. T., Widiyantoro, S., & Daryono, D. 2018. Identification of active faults in West Java, Indonesia, based on earthquake hypocenter determination, relocation, and focal mechanism analysis. Geoscience Letters, 5, 1-10.

Torrefranca, I., & Otadoy, R. E. (2024). GIS-based watershed characterization and morphometric analysis in Bohol Watersheds, Philippines. Geology, Ecology, and Landscapes, 8(4), 527-538.

Verstappen, H. Th. 1983. Remote Sensing in Geomorphology. First Edition, Elsevier Scientific Publishing Company, Amsterdam

Winarto, J., Sukiyah, E. M. I., Haryanto, A. D., & Haryanto, I. (2019). Morphotectonic study of a watershed controlled by active fault in Southern Garut, West Java, Indonesia. Journal of Himalayan Earth Sciences, 52(2), 96.

Wu, Z., & Hu, M. (2019). Neotectonics, active tectonics and earthquake geology: terminology, applications and advances. Journal of Geodynamics, 127, 1-15.

Yunus, A., et al. (2016). Incorporating DEM Uncertainty in Coastal Inundation Mapping. PLoS ONE, 9(9).

Zubaidah, T., Korte, M., Mandea, M., & Hamoudi, M. (2014). New insights into regional tectonics of the Sunda–Banda Arcs region from integrated magnetic and gravity modelling. Journal of Asian Earth Sciences, 80, 172-184.

SAŽETAK

Morfotektonska analiza s ciljem identifikacije aktivnih rasjeda slijeva Cikandang, južni dio Zapadne Jave, Indonezija

Cilj je istraživanja pronaći moguće aktivne rasjede analizom morfotektonskih značajki slijeva Cikandang u Zapadnoj Javi, Indonezija. Morfometrijski indeksi, uključujući gustoću drenažne mreže (Dd), gustoću lineamenata (Ld) i omjer bifurkacije (Rb), izračunani su pomoću digitalnih modela reljefa, topografskih i geoloških karata korištenjem Geografskoga informacijskog sustava (GIS). Kao što je prikazano različitim oblicima drenažne mreže i orijentacijom lineamenata koji upućuju na tektonsku aktivnost, analiza pokazuje da tektonske sile znatno utječu na oblik slijeva. Više Rb vrijednosti u pojedinim dijelovima drenažne mreže upućuju na tektonsku aktivnost, dok povišene vrijednosti Dd i Ld upućuju na područja koja su podložnija tektonskim pokretima. Ti indeksi upućuju na moguće aktivne rasjedne zone i jako koreliraju s onima prikazanima na regionalnim geološkim kartama, posebno u središnjemu dijelu slijeva i sjevernim regijama. U skladu s ranijim studijama koje su povezivale geomorfološke indekse s tektonskom aktivnošću rezultati podupiru važnost tih pokazatelja u identificiranju aktivnih rasjeda. Ovo istraživanje naglašava važnost provedbe sveobuhvatnih morfotektonskih analiza u određivanju opasnosti od potresa pružajući ključne informacije za upravljanje rizikom od katastrofa i prostorno planiranje u tektonski aktivnim područjima. Usklađujući geomorfološke indekse s geološkim značajkama, ovo istraživanje uputilo je na rasjedne zone koje je potrebno kontinuirano promatrati promičući sigurniji razvoj zajednice i nužnost otpornije infrastrukture u potresnim područjima Zapadne Jave.

Ključne riječi:
morfotektonske značajke, aktivni rasjedi, slijev Cikandang, geomorfološki indeksi

Author's contribution

Ghina H. Fahira (Master graduate student, Bachelor of Engineering, GIS) provided the GIS analysis, geomorphological interpretations and presentation of the results. **Emi Sukiyah** (Prof., professor, geomorphology quantitative) in charge of the manuscript's framework, methods and writing. **Dicky Muslim** (Dr., associate professor, engineering geology, neotectonics) is responsible for authoring the paper, organizing the data from morphotectonic and neotectonics analyses, and creating the overall framework of the manuscript.
All authors have read and agreed to the published version of the manuscript.