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Index Morphotectonic Of Morphology In The Patukuki Watershed Region, Peling Tengah District, Banggai Kepulauan

Sukardan Tawil [a,1)*], Bayu Saputra [a,2], Abdul Mukaddas [a,3], Asrafil [a,4]

[a] Geological Engineering Study Program, Faculty of Engineering, Tadulako University
* Email : tawil.sukardan@gmail.com

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ABSTRACT

Introduction: The Patukuki area in the Central Peling sub-district falls administratively within the geographical coordinates of 123°01'00" – 123°01'3" longitude and 01°24'00" – 01°27'00" latitude. **Method:** Channel Sinuosity (S) measures river influence on landscapes by comparing actual river length to valley length. Mountain-front sinuosity (Smf) evaluates mountain-front curvature using base and straight-line lengths. The Valley Floor Width to Width-to-height ratio (Vf) identifies regions of rapid uplift, with lower values indicating higher activity. The Asymmetric Factor (AF) detects tectonic tilting in drainage basins by comparing the area of the right-hand side sub-basin to the total area. **Results and Discussion:** Based on the analysis conducted, the findings are as follows: Channel Sinuosity analysis shows that sub-bases 1, 2, and 3 have high tectonic activity, while sub-base 5 has moderate activity, and sub-base 3 is low. Stream Morphology Frequency (Smf) analysis shows moderate tectonic activity in sub-bases 1, 3, 4, and 5, and sub-base 2 with an average Smf value of more than 1.5. Valley floor width to height ratio (Vf) shows low tectonic activity in all sub-bases. Anisotropy of Magnetic Susceptibility (AF) shows that sub-bases 1 and 5 have high tectonic activity, sub-bases 3 and 4 are moderate, and sub-base 3 is low. The IATR values of sub-bases 1, 4, and 5 are between 1.5 and less than 2, while sub-bases 2 and 3 show moderate tectonic activity with IATR values between 2 and less than 2.5.**Conclusion:** In summary, tectonic activity in the Patukuki watershed ranges from moderate to high based on the various analyzed indices.

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1. Introduction

Tectonics in eastern Indonesia are formed as a result of the collision between the Indo-Australian, Pacific, and Eurasian plates[1,2]. This is evidenced not only by the presence of subduction zones but also by active tectonics which shape earthquake belts, active faults, chains of active volcanoes, and landslides[3,4].

In this study, the researcher will attempt to find indications of active tectonic activity and its relationship with morphotectonics, which is one of the case studies in part of the Patukuki River basin.

Morphotectonics can reveal a nuanced topographic perspective that serves as an indicator of the pattern, strength, and average movement of tectonic activities. In other words, the tectonic activity of a location can be discerned with the support of spatial and qualitative geomorphological data. The method employed in this study aims to provide a general overview of these dynamics**.**

2. Reserch Method

Channel Sinuosity (S) is a significant quantitative index used to determine the influence of river flow on the evolution of landscapes [5]. It is calculated based on the comparison between the actual river length and the valley length (Wolman and Miller, 1964)

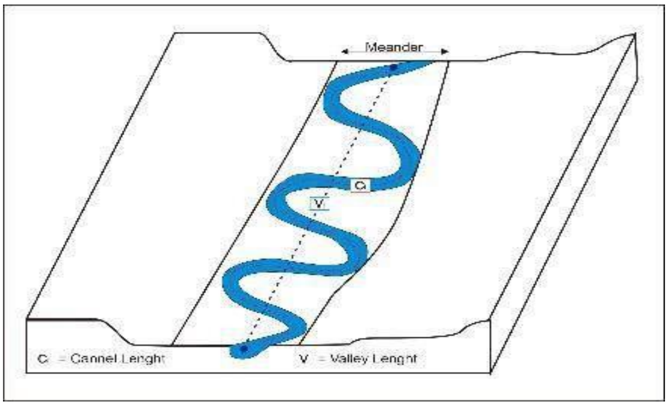

Fig 1. Channel Sinuosity (S) method

$$V = SI/VI$$

Where :
V = Chanel Sinosity
Sl = Total Length
VI = Valley Length

1.2 Mountain Front Sinousity (Smf)

Mountain Front Sinuosity (Smf) refers to the curvature of mountain ranges located at the frontal part of the mountain. The Mountain Front Sinuosity (Smf) can be calculated using the equation provided by Bull [3].

$$Smf = Lmf/Ls$$

Where :

Smf = Mountain Front Sinuosity
Lmf = Length of the mountain front along the base/valley. Ls = Straight-line length of the mountain front.

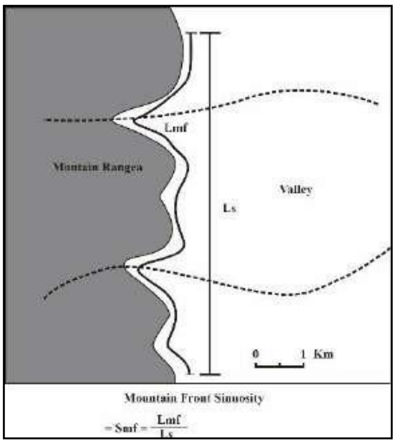

Fig 2. Mountain Front Sinuosity Method

1.2 Ratio Of valley floor width to Valley Height (Vf)

This index is based on observations of regions undergoing rapid uplift, characterized by river incisions, with narrow valley floors and V-shaped river profiles. Bull [3] described the comparison of valley width to valley height (Vf) using the equation :

$$Vf = 2Vw/[(Eld - Esc) + (Erd - Esc)$$

Where :
Vf = Index
Vw = Valley floor width
Erd/Eld = Height of the right/left valley sides measured from the riverbed Esc = Elevation of the valley floor

The Vf ratio values for highly active mountain fronts range from 0.5 to 0.05, with higher values indicating less active uplift of the mountain front [4].

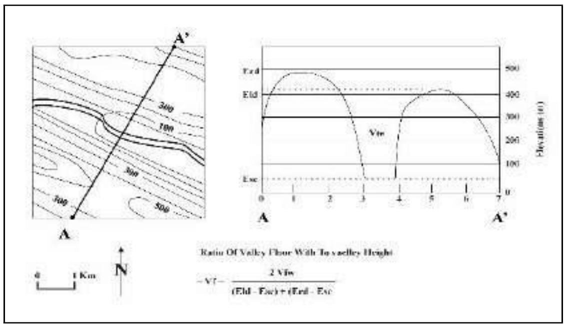

Fig 3. *Ratio Of valley floor width to Valley Height (Vf)* method [3]

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1.3 Asimetri Factor (Af)

The Asymmetric Factor (AF) is a quantitative analysis used in drainage basin studies to detect tectonic tilting, applicable both at small-scale and large-scale drainage basins [7]. The AF value is calculated by the ratio of the area of the right-hand side sub-basin (Ar) to the total area of the sub-basin (At), multiplied by 100.

Where:
Af = Asymmetric Factor
Ar = Area of the right-hand side sub-basin At = Total area of the sub-basin

The Asymmetric Factor is a method used to determine tectonic tilting within a river drainage basin unit. This calculation method can be applied over extensive areas. According to [7].

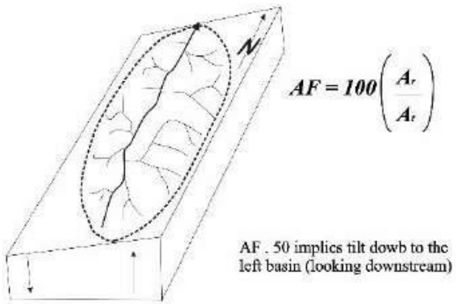

Fig 4. *Asimetri Factor (Af)* method according

3. Results and Discussion

The research area is located in Banggai Archipelago Regency, Central Sulawesi Province, with a total area of approximately 18.1 km². The data obtained includes general geomorphological aspects such as morphology, drainage patterns, morphotectonics, and the geological structures present in the area along with general Stratigraphy and Geology.

Morphotectonic analysis of the area was performed on the sub-watersheds within the Patukuki Watershed, Central Peling District (Figure 4.5), where five sub-watersheds were identified according to [8].

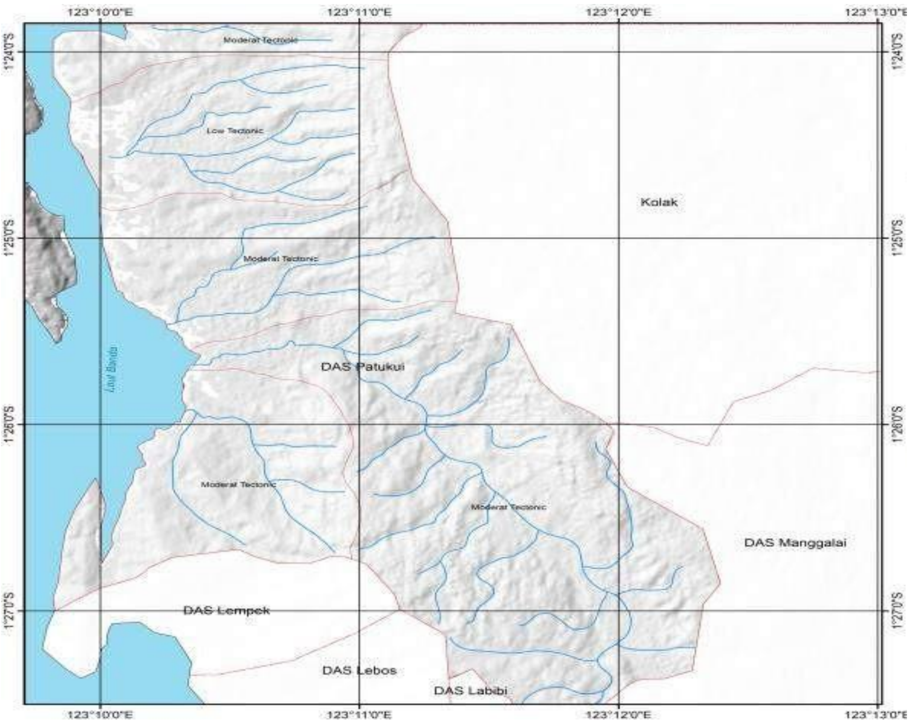

Fig 5. Map of Sub-Watershed Division in the Patukuki Watershed Area

4.1 Chanel Sinousity Analysis

Channel Sinuosity is a significant quantitative index for determining the influence of river flow on landscape evolution, calculated by comparing the river length to the valley length [9]. River meanders help understand the role of tectonics in the study area. The sinuosity index of 1 indicates a straight-flowing river, 1.0 < S < 1.5 indicates a winding river, and S > 1.5 indicates a meandering river [9]. Field data (GIS and primary data) yield S values: S < 1.2 indicates high tectonic activity (High Tectonic), 1.2 < S < 1.6 indicates moderate tectonic activity (Moderate Tectonic), and S > 1.6 indicates low tectonic activity (Low Tectonic). Data processing results in the study area show a quantitative index from High to Low Tectonic activity. Sub-watersheds 1, 2, and 3 exhibit high tectonic activity with a high rate of uplift, S < 1.5; sub-watershed 5 shows moderate tectonic activity with a moderate rate of uplift, 1.4 < S < 1.6; and sub-watershed 3 shows low tectonic activity with a low uplift rate.

4.2 Mountain Front Sinuosity Analysis

Mountain Front Sinuosity (Smf) analysis was conducted for all sub-watersheds in the study area (Figure 4.6), using data to create a table of curves that compares sub-watershed data.

Based on existing classifications, the tectonic class values are divided as follows: Smf < 1 is high tectonic (Class I), 1 < Smf < 1.5 is moderate tectonic (Class II), and Smf > 1.5 is low tectonic (Class III). The Smf analysis shows significant distribution where the tectonic index ranges from low to moderate tectonic activity, due to the morphology of the area being composed of the micro-continent Banggai-Sula. Data from sub-watersheds 1, 3, 4, and 5 show moderate tectonic activity

(Moderate Tectonic) with an average Smv > 1 < 5 and a low to moderate tectonic uplift rate, while sub-watershed 2 has an average Smv > 1.5 with a low to moderate uplift rate.

4.3 Valley Floor Width to Valley Height Ratio Analysis

Discussion of the valley floor width to valley height ratio (Vf) refers to the Vf classification by [4] where a Vf ratio values less than 0.5 indicates high uplift, between 0.5 and 1 indicates moderate uplift and greater than 1 indicates low uplift. Vf data collection is based on sub-watersheds in the Patukuki area underlain by Quaternary and Tertiary rock formations. Analysis of the valley floor width-to-height ratio (Vf) is indicated by the above data. The tectonic activity index for the five sub-watersheds shows low tectonic activity, Vf > 1, meaning the area has low tectonic levels due to the age of the rock lithology forming this formation. The uplift index only shows high values in sub-watersheds 2 and 4, while sub-watersheds 1, 3, and 5.

4.4 Asymmetry Factor Analysis

Data collection and analysis in the drainage basin were performed only using the quantitative Asymmetry Factor (Af) method, where the Transverse Topographic Symmetry Factor (T-Index) was not used because the river flow basin to the central line of the meander belt was not found in the field, being obscured and limited by the existing coastline, or could be said to be influenced by the primary characteristics of the reef limestone area, where water flow is intermittent. The AF calculation shows the distribution of watersheds that have experienced tilting from the normal position. From the AF values, more detailed information about the areas affected by the greatest lifting forces or those experiencing lowering can be obtained. This analysis is achieved by creating a cross-section of the watershed's tilt direction according to the AF values. Sub-watersheds 1 and 5 have a high tectonic index with AF > 65 / AF < 35, indicating a high rate of uplift. Sub-watersheds 3 and 4 have AF values between 57 and 65, which fall within the moderate tectonic index and moderate uplift rate. Sub-watershed 3 is included in the low tectonic index with AF < 57, indicating a low uplift rate. According to the geological map of the area [10], the northern parts of both the eastern and western blocks are composed of metamorphic rocks. This means that if there are differences in AF values between these two locations, they are likely not due to rock factors, but rather due to differences in tectonic activity levels (tectonic tilting).

4.4 Relative Tectonic Activity Index (IATR)

The analysis of the tectonic activity index is an index used to evaluate landscapes in terms of tectonic activity potential [4]. Subsequently, the author refers to [4] how the accumulation of each index will be divided into four (4) classes based on the Tectonic Activity Class Value for each sub-watershed present (Table 1).

Table 1. Weighting of Quantitative Index Results

Sub-Das	S	Smf	Af	VF
Sub-Watershed 1	0,5	1,1	24	1,5
Sub-Watershed 2	1,1	1,7	64	1,3
Sub-Watershed 3	2,0	1,3	44	1,5
Sub-Watershed 4	1,5	1,3	47	1,4
Sub-Watershed 5	1,6	1,5	38	1,7

Table 2. Relative Tectonic Activity Index

Sub-watershed	**S**	**Smf**	**Af**	**VF**	**IATR**	**Tectonic Class**
Sub-watershed 1	1	2	1	3	1,8	High
Sub-watershed 2	1	3	3	3	2,5	Medium
Sub-watershed 3	3	2	2	3	2,5	Medium
Sub-watershed 4	1	2	2	3	2,0	High
Sub-watershed 5	2	2	1	3	2,0	High

From the table above, sub-watersheds 1, 4, and 5 are areas of high tectonic activity with a Relative Tectonic Activity Index (IATR) of $1.5 \leq$ IATR < 2. Sub-watersheds 2 and 3 are characterized as having moderate tectonic activity with an IATR value of $2 \leq$ IATR < 2.5. The results indicate that the tectonic activity in the Patukuki Watershed is generally moderate to high (Figure 4.16). This is because the area consists of continental or microcontinental landmasses, which are significant geological formations in the eastern region of Sulawesi Island [11,12,13].

4. Conclusion

In the areas of sub-watershed 1, sub-watershed 4, and sub-watershed 5, there is high tectonic activity with a Relative Tectonic Activity Index (IATR) ranging from 1.5 to less than 2. In contrast, sub-watersheds 2 and 3 are characterized by a moderate level of tectonic activity, with IATR values ranging from 2 to less than 2.5. The tectonic activity in the Patukuki Watershed is generally classified as moderate to high. This is attributed to the region being part of a continental or microcontinental landmass, which is a significant geological formation in the eastern area of Sulawesi Island.

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