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Drainage Patterns and River Sinuosity in Padang, West Sumatra

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ABSTRAK

Padang City is the capital of West Sumatra Province. This city has several rivers, each of which is a watershed. Watershed management can be done through geomorphological analysis by taking a landscape approach to finding out the tectonics working in the area. The morphotectonic analysis carried out in this study was an analysis of the drainage pattern and the river's sinuosity. The purpose of this study was to determine the characteristics of the watershed in the Padang City associated with tectonic activity based on morphometric analysis. The parameters used are the drainage pattern and the river sinuosity index. The results of the research that has been carried out, it is found that the genetic types of rivers found in the Padang City, West Sumatra are dendritic, trellis, and parallel types. Meanwhile, after analyzing the average value of the sinuosity index on river flows in Padang City, it was obtained a value of 1.56 or categorized as a meandering river type with active tectonics. The results of this study can be used as new information in watershed management in Padang City, West Sumatra Province.

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KATA KUNCI
Meander; Tectonic; Watershed

1. Introduction

Padang City is the capital of West Sumatra Province. The city has 6 watersheds, are Air Dingin Watershed, Air Timbalun Watershed, Batang Arau Watershed, Batang Kandih Watershed, Batang Kuranji Watershed, and Sungai Pisang Watershed (BPPD Kota Padang, 2007). Watershed is an area that is bounded by a ridge and functions as a store and distributor of water, sediment and nutrients in the river system, all of which exit through a single point (Vienastra, 2018; Wajedy et al., 2021). A watershed has an important role in investigating the morphology of an area. Watershed management can be done through geomorphological analysis by taking a landscape approach as a basic reference in knowing the tectonics working in the area (Astuti et al., 2021; Vienastra, 2018; Wajedy et al., 2021). Watershed management is very important so that local governments have data and can identify flood-prone river areas so that local communities can avoid development in the area (Astuti et al., 2021; Pamuji et al., 2020).

Watershed morphometry is closely related to geomorphological aspects of an area which is a quantitative measure of watershed characteristics. The first analysis carried out is the drainage pattern (Astuti et al., 2021; Massinai, 2015; Mejıa & Niemann, 2008) for a wide coverage, such as a district consisting of several watersheds. Rock types and structures in an area can be analyzed through watershed drainage patterns. This drainage pattern is required for various civil building construction plans.

Tectonic geomorphological research is basically examining the landscape of an area associated with the tectonics that caused the landscape. Tectonic are processes when a force acts on a part of a plate that causes the plate part to move both vertically and horizontally. The approach taken in tectonic geomorphological research in an area can be done by analyzing morphotectonic parameters.

Morphotectonic is a landscape character associated with tectonic processes. Quantitative landscape characteristics can provide knowledge about morphotectonics. At the local and regional tectonic scales, it can be seen from the appearance of typical landscapes such as escarpments, valley shapes, lineament of hills, lineament of rivers, drainage patterns and others (E Sukiyah et al., 2012; Emi Sukiyah et al., 2018). Morphotectonic analysis is needed to analyze the relationship between landscape characteristics and the level of tectonic activity (Wahyudi et al., 2015; Wajedy et al., 2021).

These analyses include river sinuosity (Massinai, 2015; Timár, 2003; Wajedy et al., 2021; Xiao et al., 2020). This analysis is one that is often widely used (Wajedy et al., 2021; Xiao et al., 2020).

The purpose of this study was to determine the characteristics of the watershed in the city of Padang associated with tectonic activity based on morphometric analysis. The parameters used are the drainage pattern and the river sinuosity index. The results of this study can be a supporting aspect in efforts to manage watersheds in Padang City, West Sumatra Province

2. Research Material and Method

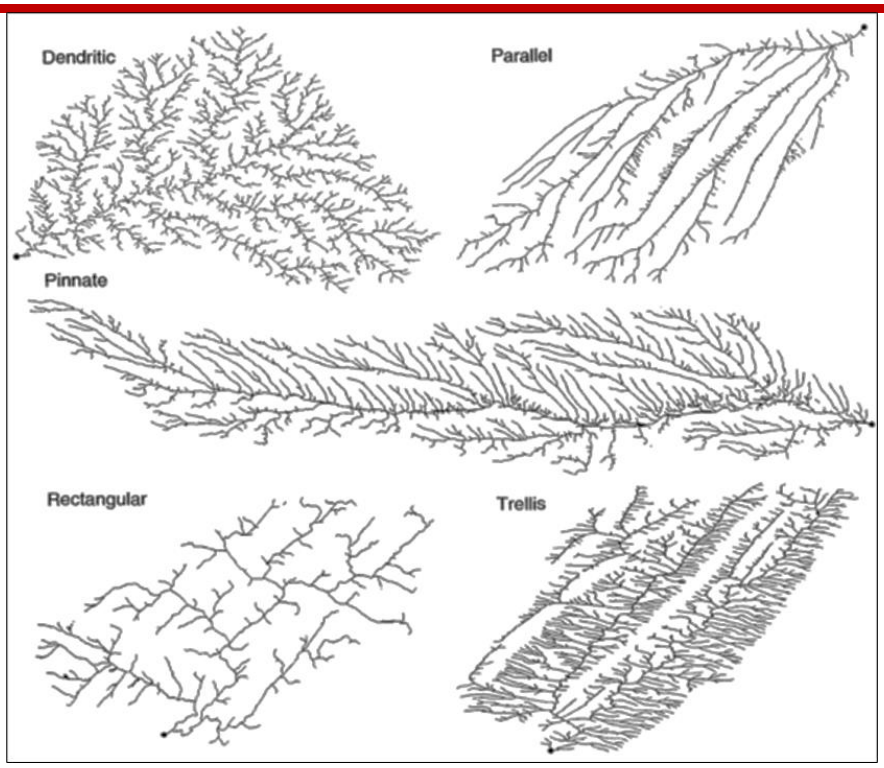

Figure 1. Several forms of drainage pattern (Astuti et al., 2021; Mejıa & Niemann, 2008; Wajedy et al., 2021)

The drainage pattern is the relationship between one river and another or the relationship between surface water flowing through valleys. Rivers in all watersheds follow a rule, that river flows are connected by a one-way network, where branches and tributaries flow into a larger main river and form a certain pattern. The pattern depends on the topography, geology, climate, and vegetation conditions in the relevant watershed. Overall these conditions will determine the characteristics of the river in its pattern (Astuti et al., 2021; Massinai, 2015; Wajedy et al., 2021).

The drainage pattern of a watershed can be an initial indication of the type and structure of existing rocks. These instructions are required for various civil building construction plans. Figure 1 shows the various flow patterns. The drainage pattern of dendritic is shaped like tree branches that spread with various sizes, irregular grooves, along the path in many directions and the tributaries tend to join at sharp angles. Parallel drainage patterns have straight and parallel main flows and their tributaries join at very sharp angles. The pinnate flow pattern looks like a feather with the main stream is very straight and oriented in one direction only and most of its tributaries join the main stream at regular intervals and sharp angles. The rectangular drainage pattern has sinusoidal river channel with a large angle that tends to be 90o and its tributaries are joined at the closest angle. The trellis flow pattern resembles a geometrically regular grid because its tributaries are many and short when compared to the main river channel (Astuti et al., 2021; Mejıa & Niemann, 2008; Wajedy et al., 2021).

Drainage patterns have a relationship with bedrock, soil, tectonics, climate, and erosion processes. Dendritic tend to occur in areas with small slopes and relatively uniform lithology. Parallel usually occurs in areas with moderate to steep slopes. Pinnate can occur in areas with very steep slopes. Rectangular occurs in areas where joints and/or faults meet at right angles. These joints and/or faults are in weak zones used by water to develop river flows. Trellis usually occurs in areas of folds or folded layers that form parallel fault units (Mejıa & Niemann, 2008; Wajedy et al., 2021).

River sinuosity are a parameter used in analyzing tectonic processes that occur in an area. Sinuosity from river flow can be found using the following equation (Massinai, 2015; Wajedy et al., 2021):

$$Sinuosity = \frac{length\ of\ river\ channel}{length\ of\ the\ straight\ line\ of\ the\ river} \quad (1)$$

The results of the calculation of the value of river sinuosity, the tectonic processes of an area can be classified as follows:

Table 1. Tectonic Classification is Based on The Value of River Sinuosity.

No.	Sinuosity	Type	Tectonic
1.	< 1.0	Straight	Low
2.	1.05 – 1.5	Sinuses	Moderate
3.	> 1.5	Meander	Active

Table source: (Massinai, 2015; Wajedy et al., 2021)

Table 1 shows the relationship of the river sinusitis index with the implications of the tectonic process. The higher the sinuosity index, the higher the tectonic process. Meandering rivers are usually influenced by geomorphological processes such as ground movement (Massinai, 2015; Wajedy et al., 2021) and erosional activity (Augustio & Setiawan, 2019; Wajedy et al., 2021).

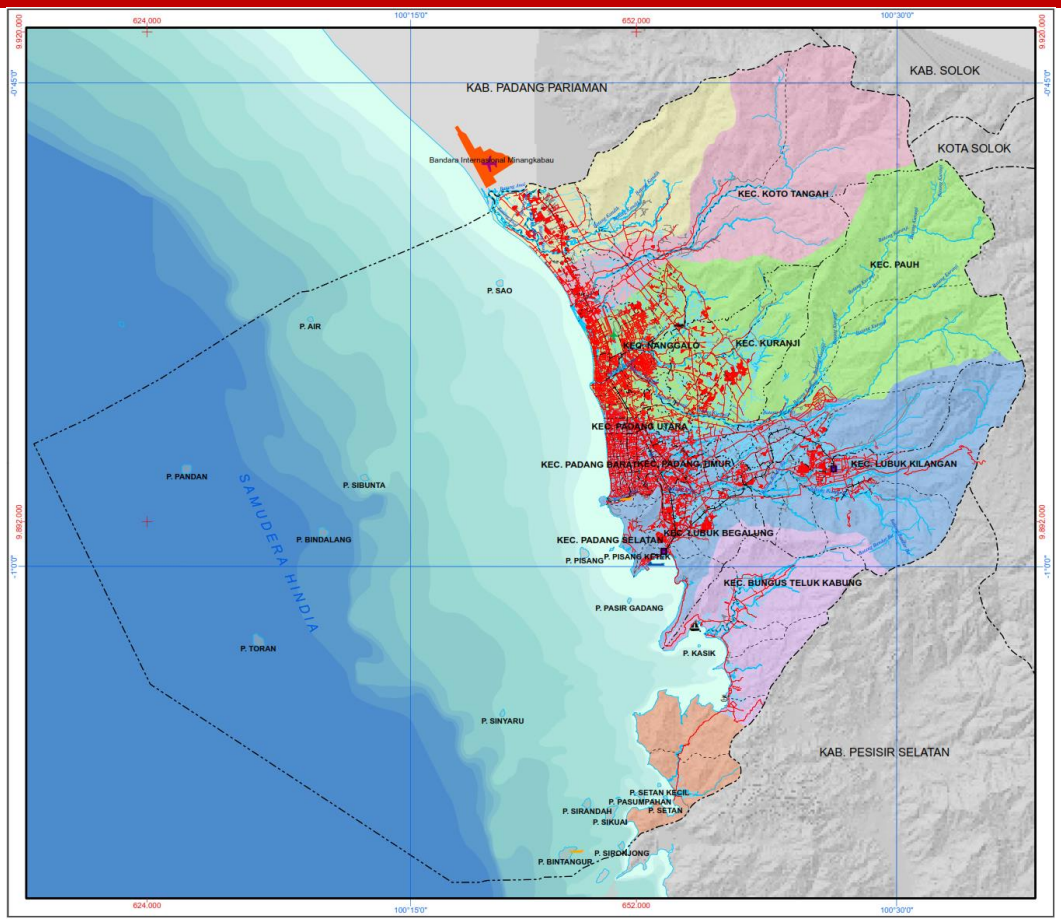

Figure 2. Map of the Padang City watershed. Each color represents 1 watersheds so there are 6 watersheds in Padang City (BPPD Kota Padang, 2007).

This study focuses on a watershed located in Padang City (Figure 2). This research begins with a literature study which is the initial stage in seeking information about the study area. The aim is to obtain information about the condition of the watershed in the study area. The data used in this study is secondary data sourced from the Geospatial Information Agency (BIG). The data that has been downloaded from the BIG website will be processed to map the boundaries of the Padang City and find out the river flows in the area. After that, the length of the river and the straightness of the river were

measured and then the river sinuosity was calculated using the tabulation application. Interpretation is carried out by linking the results with Table 1 and several other relevant references.

3. Result and Discussion

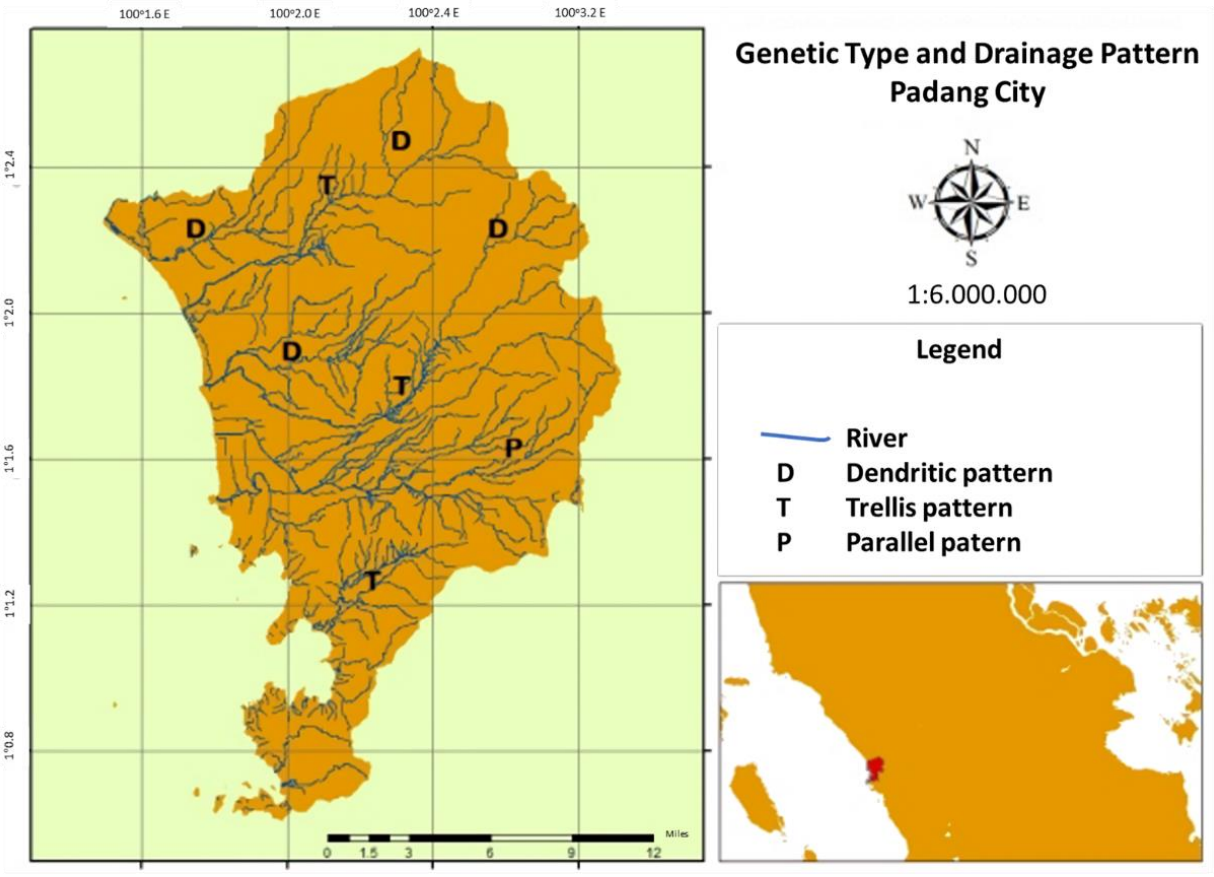

Figure 3. Map of river drainage patterns and river genetic types in Padang City.

The drainage pattern seen in general in Padang City is dominated by dendritic (D), trellis (T), and parallel (P) drainage patterns. The results can be seen in Figure 3. The dendritic pattern tends to be in the north and west which is connected with a trellis patterned river in the middle to the south. While in the eastern area there is a parallel patterned river.

The northern and western regions have dendritic patterned rivers. This drainage pattern shows the physical condition of the area in the form of water-resistant material and the texture is relatively smooth (Astuti et al., 2021; Massinai, 2015). The pattern resembles tree branches with irregular shapes and has various directions and angles. This pattern is formed inhomogeneous rocks and is not controlled by structure, generally in sedimentary rocks with horizontal layers, or homogeneous igneous or crystalline rocks (Astuti et al., 2021; Ningkeula, 2016). Dendritic tends to occur in areas with small slopes and relatively uniform lithology (Astuti et al., 2021; Mejıa & Niemann, 2008; Wajedy et al., 2021).

In the middle to the south, there are some trellises patterned rivers. This pattern usually occurs in areas of folds or folded layers that form parallel fault units (Astuti et al., 2021; Mejıa & Niemann, 2008). On the other hand, in the east, the topography tends to be rather steep. This condition causes the water to move quickly and not have time to merge, thus forming a parallel pattern. This pattern reflects the existence of a fault or fracture phenomenon. It develops on medium-fine-textured rocks, as well as in areas with moderate to steep slopes such as mountain slopes (Astuti et al., 2021; Massinai, 2015; Mejıa & Niemann, 2008).

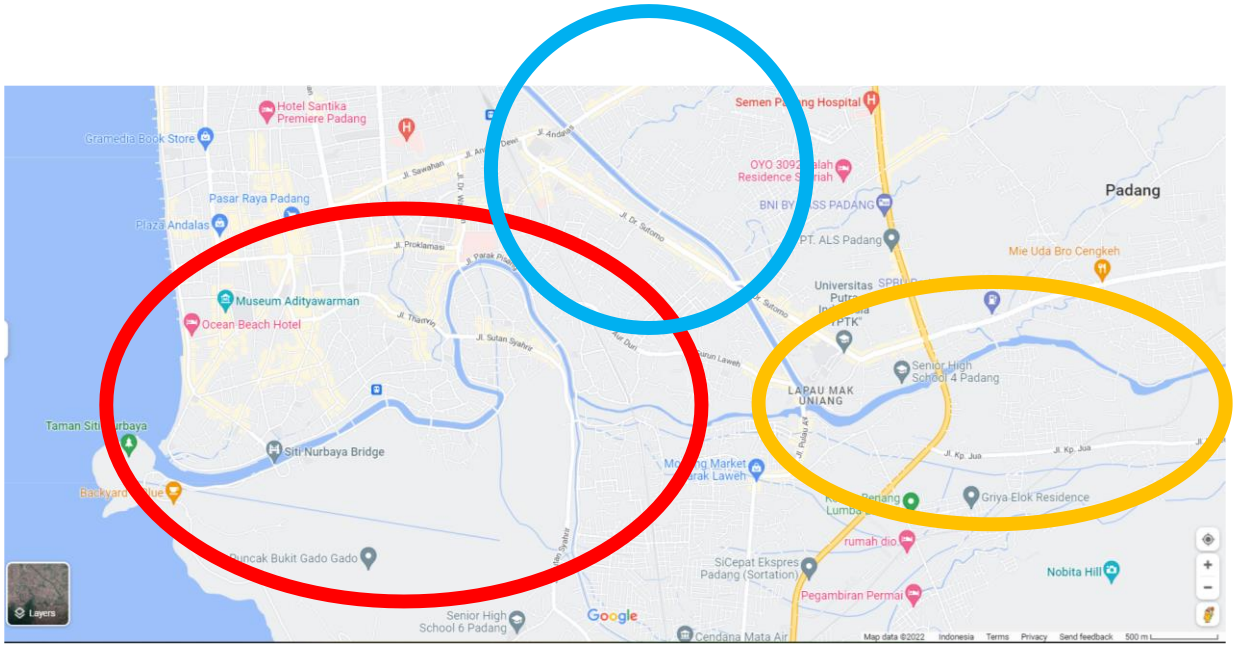

Figure 4. River sinuosity in Padang City.

Furthermore, the results of the calculation of the morphotectonic parameters of the river sinuosity in Padang City obtained an average value of 1.56. Except for the huge progressive sinking, the sinuosity at the fault zone increases from 1.17 to 1.3 for all subsidence runs. The sinuosity had increased to 1.35 at the area, which was mostly in the vicinity of the fault zone (Woolderink et al., 2022). That average value can be categorized as a meandering river type. Meanwhile this average value is a little more than 1.5. It means in Padang City can be found sinuses river type. Figure 4 inform the meandering river is in red circle, sinuses river is in yellow circle, and straight river is in blue circle. The red circle show the carved or engrained-meanders, as well as knick-points, are a common phenomenon or a good indicator of tectonic disturbance (Kumar et al., 2022).

This tectonic activity can be related to the presence of geological structures in this area. The role of active tectonics in managing a fluvial system via longitudinal and lateral tilting is crucial. The nature and amount of vertical displacement in a river basin, as well as the fault trend with relation to river flow, determine how rivers respond to active tectonics. Meandering rivers are formed by the interactions of flow, sediment, bed topology, and channel curvature, and they travel over their flood basins, forming a characteristic morphology (Hosseinitoudeshki, 2012). Many meandering rivers pass through tectonically active areas, thus it's important to know how they react to tectonic deformation in order to notice and predict changes in river dynamics and shape. The morpho-dynamics of rivers are influenced by faulting, which causes local changes in the topographic gradient of the river valley and channel (Woolderink et al., 2022).

4. Conclusion

Dendritic, trellis and parallel drainage patterns are found in this area. The northern and western areas have gentle slopes indicated by dendritic patterned rivers. In the middle to the south, there are some folds marked by a trellis-patterned river. While in the eastern area there is a parallel patterned river. The average value of river sinuosity in Padang City has a value above 1.5, which means that the Padang City area has active tectonic activity. This is also supported by the high earthquake activity in this city. The results of this study are expected to be able to help watershed management in Padang City, West Sumatra Province in particular and other areas in general.

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