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MORPHOMETRIC ASSESSMENT OF THE MULA–PAVANA BASIN USING LINEAR PARAMETERS

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Abstract:

I studied the linear morphometric characteristics of the Mula–Pavana River basin to understand how its drainage network is organized and what that means for runoff and erosion. Using Strahler's method and ArcGIS, I mapped 93 stream segments from 1st to 4th order and measured stream number, stream length, mean stream length, bifurcation ratio, drainage density, and length of overland flow. The basin area is 1297.71 km² with elevations ranging from 534 to 1241 m. Total stream length is 422.65 km and mean stream length is 105.66 km. The average bifurcation ratio is 4.87, suggesting limited structural control, while a low drainage density (0.32 km/km²) and short overland flow (0.16 km/km²) point to gentle slopes and higher infiltration. Overall, the dominance of 1st-order streams indicates a relatively youthful drainage network with potential for rapid runoff concentration. These results provide a basic framework for future watershed management and more detailed hydrological studies.

Introduction:

"A river doesn't just carry water, it carries life" (Amit Kalantri). The Pavana–Mula river basin in the Pimpri Chinchwad and Pune metropolitan region is no exception. The basin sustains agriculture, industry, domestic needs, and biodiversity, while also facing increasing pressures from urban expansion and environmental change. Morphometric analysis offers a scientific way to understand the geometry and drainage characteristics of a basin, providing insights into runoff, erosion, and flood potential.

The Mula–Pavana basin covers about 1297.71 km² and has an elevation range from 534 to 1241 m, which creates varied terrain for stream development. I identified 93 stream segments, most of which are 1st order, and calculated a total stream length of 422.65 km. The predominance of first-order streams suggests the basin is in a relatively youthful stage of geomorphic development, where many small channels feed into a few larger ones. The bifurcation ratio of 4.87 falls within the normal range and implies that structural controls are not strongly shaping the network. Low drainage density and short overland flow indicate gentler slopes and greater potential for infiltration, which affects runoff and erosion patterns.

In this study I present the methods used for mapping and measurement, report the calculated morphometric values, and discuss what these values imply for

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watershed behavior and management. The goal is to provide clear baseline information that can support flood risk assessment, soil conservation planning, and future studies that might include more detailed hydrological modeling.

Research Methodology:

The present study involves the integration of morphometric analysis of the Pavana-Mula River Basin using geospatial techniques. The methodology adopted for the study is structured into the following key steps:

1. Delineation of the Study Area

- The Pavana-Mula River Basin was delineated using ArcGIS software.
- The drainage network and watershed boundaries were extracted using hydrology tools in ArcGIS.
- Manual corrections were made to ensure accurate representation of stream segments and watershed extents.

2. Morphometric analysis

a) Linear Aspects:

These parameters were computed using formulas based on standard morphometric principles and derived using the ArcGIS toolbox and manual calculations.

3. Map Preparation and Visualization

All maps were prepared using ArcGIS Pro including:

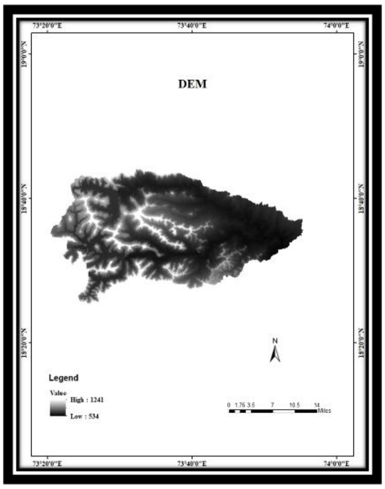
- Watershed boundary
- Drainage network
- Morphometric parameter maps

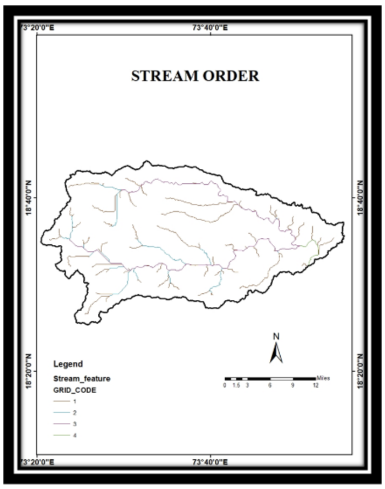
Objectives:

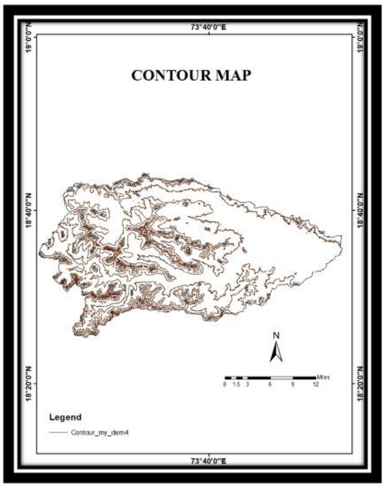
- To map and classify stream segments in the Mula–Pavana basin into stream orders using Strahler's method and GIS mapping.
- To specify basic linear parameters including stream number, stream length, mean stream length, basin area, basin length, and basin perimeter.

Maps of Study Area:

I prepared several GIS-based maps for the Pavana–Mula basin using a DEM as the base. They include DEM, Aspect, Contour, Flow Direction, Flow Accumulation, and Stream Order maps. These layers together show elevation, slope direction, drainage paths, and where water collects—useful for planning, flood assessment, and watershed management.







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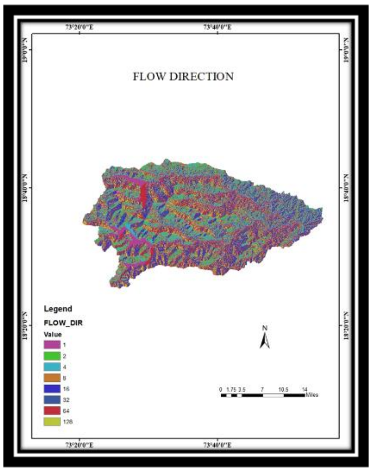

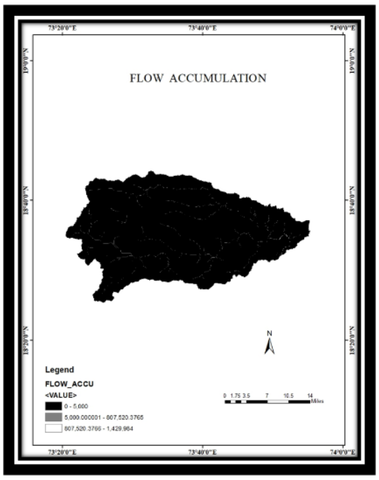

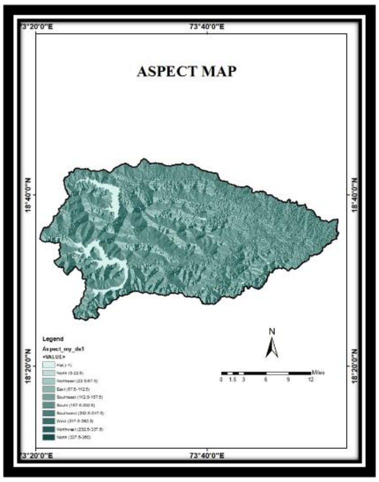

Morphometric Analysis

a) Linear Aspects:

Linear aspects are stream-related measures like stream order, number, length, mean length, bifurcation ratio, and overland flow. They describe the structure and pattern of the drainage network.

Stream Order (U)

In this study, stream ordering was carried out using Strahler's method (1952), a widely adopted approach in morphometric analysis. The Mula–Pavana basin consists of 93 streams ranging from 1st to 4th order, forming a relatively simple drainage network. The dominance of 1st-order streams indicates a youthful stage of landscape development with limited branching, reflecting early geomorphic evolution and higher susceptibility to rapid runoff.

Stream Number (Nu)

In the Mula–Pavana basin, a total of 93 streams were identified using ArcGIS. Most are 1st-order streams (74), with numbers decreasing sharply as order increases. This pattern, typical of youthful drainage basins, reflects simple hierarchical stream formation where surface flow is concentrated into a few larger channels.

Stream Length (Lu)

In the Mula–Pavana basin, the total stream length is 422.65 km, calculated using Strahler's method in ArcGIS. Stream length decreases with increasing order, with longer 1st-order streams reflecting moderate slopes and varied terrain, while shorter higher-order streams indicate steeper slopes and faster runoff. This pattern highlights differential erosion and flow accumulation across the basin.

Basic parameters Derived from the Mula-Pavana River Basin :-

Basin Area = 1297.71 sq km

Basin length = 62.12 km

Basin perimeter = 200.69 km

Maximum elevation = 1241 m

Minimum elevation = 534 m

Stream Order (U).	Stream Number (Nu).	Stream Length (Lu). km
1.	74	225.99
2.	16	70.31
3.	02	115.45
4.	01	10.90
Total -:	93	422.65 km

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Mean Stream Length (LSM)

The mean stream length of the Mula–Pavana basin is 105.66 km. It represents the average size of stream segments within the drainage system, reflecting overall basin geometry and watershed characteristics, though it may mask local variations in stream length patterns.

Therefore, Lsm = Lu / Nu.

Where, Lu = Stream length of order 'U';

Nu = Total no. of stream segments of order 'U'.

Lsm = 422.65 / 4 = **105.66 km**.

The mean stream length is 105.66 km, showing moderately extended flow paths. It reflects slope, lithology, and stream integration, which are important for understanding sediment transport and watershed behavior.

Bifurcation Ratio (Rb)

The bifurcation ratio of the Mula–Pavana basin is 4.87, which falls within the normal range of 3–5. This indicates no major geological or structural control over the drainage pattern. The value reflects a homogeneous lithology and a well-developed drainage network, with moderate runoff potential and balanced stream integration.

Stream Order (U).	Stream Number (Nu).	Bifurcation ratio.
1.	74	-
2.	16	4.62
3.	02	8
4.	01	2
Total -:	93	14.62

Therefore,

Rb = Nu / Nu + 1.

Where, Nu = Total number of stream segments of order 'U';

Nu + 1 = Number of stream segments of next higher order.

Rb = 14.62 / 4 = **4.87**

With an average of **4.87**, the basin has a well-organized stream network, showing minimal geological control and confirming natural evolution in a stable lithological setting.

Length of Overland Flow (Lg):

The length of overland flow in the Mula–Pavana basin is 0.16, showing low structural control. It represents the distance water travels over the ground before joining stream channels and is inversely related to drainage density. This value indicates longer flow paths with gentle slopes, influencing runoff, erosion, and overall watershed behavior.

Therefore,

Lg = ½ Dd.

Whereas,

Dd = Drainage density.

Lg = ½ x 0.32 = **0.16 km/km²**

The **0.16 km/km²** value indicates gentle slopes, longer flow paths, more infiltration, and reduced runoff.

Conclusion:

In this study I analyzed the linear morphometric characteristics of the Mula–Pavana River basin using Strahler's stream ordering and GIS mapping. I identified 93 stream segments (1st–4th order) with a total stream length of 422.65 km across a basin area of 1297.71 km². The dominance of 74 first-order streams shows that the drainage network is largely made up of small headwater channels, which suggests a relatively youthful stage of landscape development and a tendency for rapid concentration of runoff. The calculated mean stream length (Lsm = 105.66 km) and

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bifurcation ratio (Rb = 4.87) fall within expected ranges, indicating a fairly organized drainage pattern with limited structural control. A low drainage density (0.32 km/km²) and short length of overland flow (Lg = 0.16 km/km²) point to gentler slopes and higher infiltration potential, which can reduce surface runoff and erosion under normal conditions.

Overall, the basin shows a balance between quick runoff from many small channels and moderate infiltration due to low drainage density. These findings provide a useful baseline for watershed management: areas dominated by first-order streams may need attention for erosion control and flood mitigation, while the general infiltration potential suggests opportunities for groundwater recharge measures.

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