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Morphotectonic analysis of Arunawati drainage basin using GIS and remote sensing

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Abstract
The evolution of a landscape is the result of complex interactions involving climate, tectonic and surface progress Therefore, the study of the geomorphology assists in understanding the landscape evolution. Geomorphic indices are useful tools in evaluating the tectonic activity relating the sensitivity to rock resistance, climatic change, and tectonic processes with the production of a certain landscape. The delineation of drainage network is possible either physically from topographic sheets or with the help data of Digital Elevation Model (DEM) by methods for calculation techniques. Extraction of the basin and sub basin, stream network has been produced to evaluate the drainage characteristics in the study area. Arunawati River is the right bank tributary of Tapi basin. It is flow from Madhya Pradesh to Maharashtra state. Study completed by geomorphic indices calculation such as, Liner aspect, Areal aspect and Relief aspect. Present basin most of the area acquire by hilly region so basin shape is elongated, high runoff intensity.

Keywords: Morphotectonic analysis, DEM, GIS and remote sensing

Introduction
Earth surface is unstable. Tectonic activity is one of process of changing the earth surface. These activities have occurred from many years. Drainage basin is the significant Geomorphological features to reflect these tectonic activities due to morphological changes. Morphotectonic analysis helps us to better understand the landform evolution and behavior of landform (Prakash *et al.* 2016; Urbano *et al.* 2017) [3, 8]. Tectonic geomorphology is relatively new interdisciplinary field at the boundary between structural geology, tectonics and surface processes. The most common goal of tectonic geomorphology is to use quaternary landforms and stratigraphy to infer the nature, patterns, rates and history of near surface tectonic processes. Tectonic geomorphology is a key factor in determining land use planning, earthquake hazard management, mitigation and prediction (Rockwell *et al.* 1985) [4].

The geological setting and the lithological control of the area, formed by the trunk stream and their tributaries influence the drainage of the watershed. The geomorphic indices or landforms play a significant role in order to know the type of inducing processes especially in the case of young Orogens where the resulting sedimentation can cover young structures forming new landforms. The analysis of the drainage network and their pattern, obtained from topographical maps and aerial photographs can help us in knowing the position of active structures and rapid evaluation of large areas. (Strahler A. N., 1952) [6]. Therefore, in this research paper different morphotectonic parameters have been assessed by using mathematical equations, in order to reveal the relationship between active tectonics and erosional processes which in turn proved very helpful to know the tectonic activity of the Arunawati drainage basin.

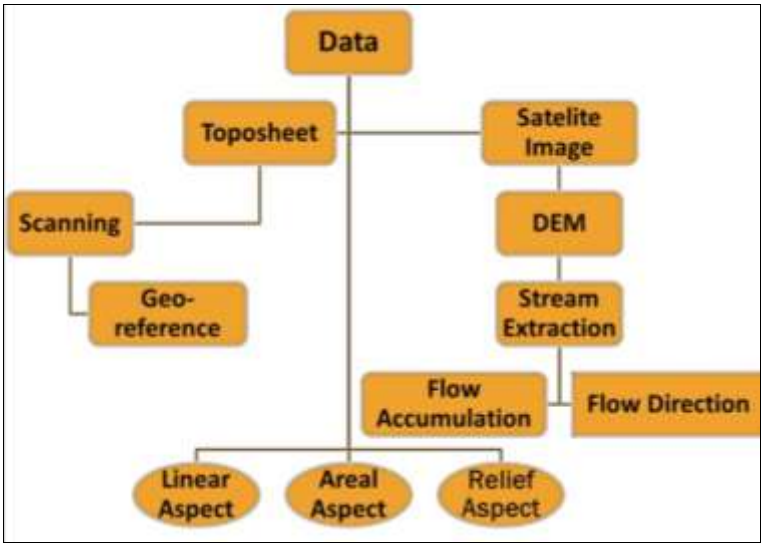
Study Area
The Arunavati River is a right bank tributary of the river Tapi. It lies between 21°18' N to 21°37'N latitude and 74°49'E to 75° 13'E longitude. Arunavati river basin covers an area of 688.026 km^2 and which is drains in Madhya Pradesh and Maharashtra state. It flows in a South-Westerly direction over a length of 67.12 km and merge in the Tapi River at Vanaval Village. The north and north east part of the study area is occupied by the hill track.

While the southern part of the study area is plain. The Arunavati rises in the slopes of inner Satpura ranges near Jhirpan village in Badawani District at an altitude of 650 m.

Methodology

Present research paper consists of morphometric analysis of Arunawati river basin. Topographical maps (46 k/14, 46 k/15, 46 o/2, and 46 o/3) of Survey of India are used to obtain various types of data. Digital Elevation Model (DEM) data acquired from Landsat-ETM+ (30 m. resolution) of the study area. Stream segments of Arunavati basin are extracted from the DEM data which has an appropriate spatial resolution. The flow direction is calculated from the DEM data using GIS tools. This grid assigns a direction to each cell based on the steepest descent. Generate a flow accumulation grid by accumulating the flow values from neighboring cells into each cell. This grid represents the contributing area for each cell.

Define a threshold value for flow accumulation to identify potential stream locations. Cell with flow accumulation values above this threshold are considered potential stream locations. Create a stream network by delineating continues flow paths from the cells exceeding the threshold. This can be achieved using GIS algorithms such as the Strahler methods. Assign stream orders to the stream segments based on their hierarchical position in the stream network. Higher order streams are formed by the confluence of lower order streams.



Results and Discussions

Arunawati drainage basin is consist seven sub drainage basins. The drainage basin is seven order streams. River basin occupied area is 956.99 sq. km. Total stream numbers in the study area are 3525 including the Arunawati basin, in that 2745 streams are of first order, 604, 133, 30, 9, 3 and 1 are of second, third, fourth, fifth, sixth and seventh order streams, respectively.

Basin Relief (R): Basin relief is the actual difference between highest and lowest points of the drainage basin. It controls the stream gradient and influences the surface runoff and sediment also (P. P. Chaudhari and *et al*., 2018) [2]. Arunawati basin relief is 685 m. Which is indicates extensive soil erosion and a structurally complex region with tectonic deformation (Prakash *et al.*, 2016) [3].

Bifurcation ratio (Rb)

Bifurcation ratio describes the branching pattern of a drainage network and is defined as ratio between the total numbers of stream segments of a given order to that of the next higher order in a basin (Schumm, 1956) [5]. Second and third-order stream displays the highest Rb is (4.54) implying greater overland flow and discharge owing to an impervious rock formation associated with steep slope (Prinsi Singh and *et al*., 2023) [9]. Total bifurcation ratio of Arunawati basin is 3.66. The value is reflecting that highly dissected or mountainous basin topography. The basin region is cover hard rock basement and tectonically unstable (Horton, 1945) [10].

Table 1: Bifurcation Ratio and Stream length Ratio

Stream order	No. of Stream	Length of stream	Bifurcation Ratio (Rb)	Lu/Nu	Stream length Ratio (Lur)
1	2745	1354.2		0.49	
2	604	554.45	4.54	0.91	1.86
3	133	260.36	4.54	1.95	2.13
4	30	136.1	4.43	4.53	2.31
5	9	62.8	3.33	6.98	1.53
6	3	26.35	3	8.78	1.25
7	1	34.63	3	34.635	3.94
Total	3525	2428.92	3.80		
Mean			3.80		

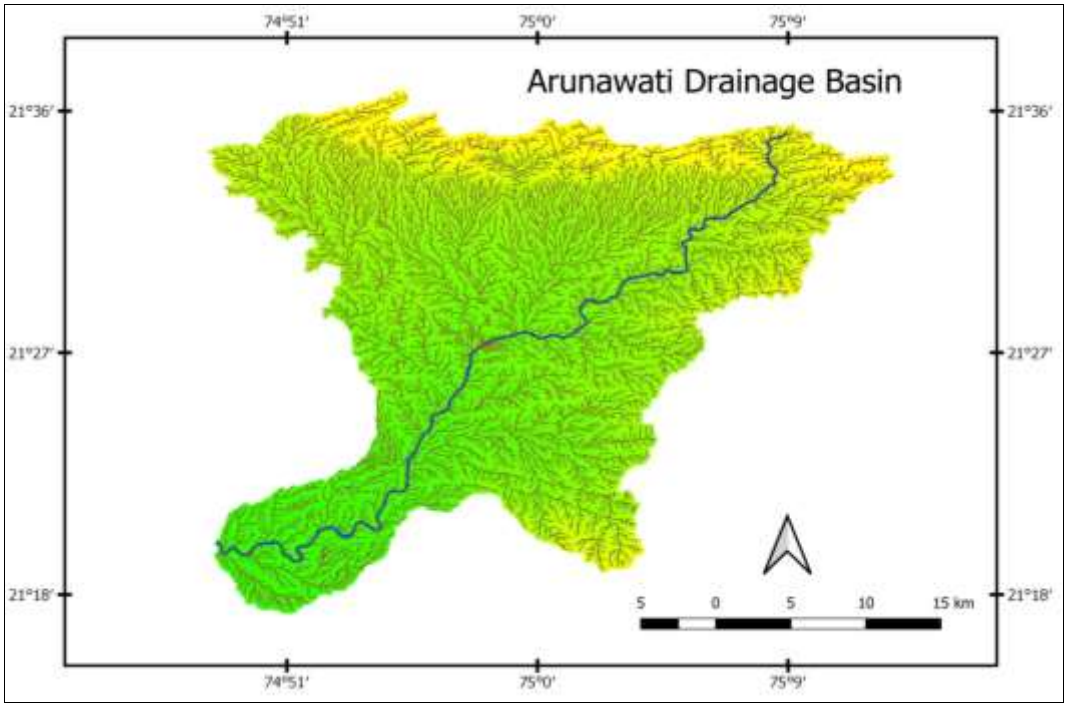
***Source*:** Computed by Author

Elongation Ratio (Re): The elongation ratio is the ratio of the diameter of a circle of the same area as the drainage basin to the maximum length of the basin (Schumm, 1956) [5]. The Arunawati basin elongation ratio is calculated 0.58 which value is indicated elongated basin. The elongated basin represents tectonic activity with prominent headword erosion.

Dissection Index (Di): For better understanding of morphometry as well as physiographic attribute, dissection index analysis is performed (Schumm, 1956) [5]. Dissection index is defined as a ratio between actual dissection made by the rivers and potential dissection up to base levels. Relative relief and maximum altitude are used to compute the dissection index. The study region Dissection Index of the Arunavati basin is 0.85 it is highly dissected. Di value of "1" indicates the presence of vertical cliffs which it might be at the vertical escarpment of hill slope (Alqahtani and Qaddah, 2019) [1].

Ruggedness number (Rn)

Ruggedness of terrain is a property of the landscape which describes the complexity of the topography and the ruggedness of terrain. Arunawati basin has 2.42 ruggedness numbers. It tends to extensive soil erosion and a structurally complex region with tectonic deformations. A watershed also shown greater amount of complexity and uneven surface.



Map 1: Arunawati Drainage Map

Sinuosity Index: Arunawati drainage basin is 1.42 sinuosity index value is calculated. It was inferred that the sinuous course of within river basin. The region is lies in moderate tectonically active.

Asymmetry Factor (Af): The asymmetry factor was used to know the tectonic tilting of drainage basins at smaller as well as larger scales (Sreedevi P. D. and *et al.*, 2005) [7]. The asymmetry factor (AF) is the ratio of area of right side of the stream facing downstream to the total area of the drainage basin. The normal value 50 is for the streams that flow in stable part of earth and a deviation from this value suggests tilting. The basin asymmetry factor value is 51.05 it is lead to river migration towards the basin's left side. Asymmetry value also indicates that watershed is tectonically active.

Conclusion

Morphotectonic Analysis is reveals that the Arunawati basin has experienced neo-tectonic activity. The Arunawati basin has high relief, high erosion and deeply incised stream. The high basin relief, low bifurcation ratio, high dissection Index and ruggedness number indicated the high gradient and erosive nature of streams. Diverse lithological variations also affect the morphotectonic characteristics in Arunawati basin.

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