Morphometric and Sedimentological Analysis of Shahnur River Basin, Amravati District, Maharashtra, India

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Abstract

The given study focuses on the morphometric and sedimentological characteristics of Shahnur River Basin. It is situated in the basalt dominated area of Deccan Traps of Amravati District, Maharashtra, India. The basin has various features to investigate the interaction between the lithological control, structural influences, and fluvial processes. Using the SRTM Digital Elevation Model (DEM) data and GIS techniques, the basin and its drainage network were delineated along with the morphometric parameters. The parameters consist of linear, areal, and relief aspects such as stream order, stream length, bifurcation ratio, drainage density, stream frequency, elongation ratio, and relief ratio. The results shows that the drainage basin shows the dendritic to sub-dendritic pattern along with the rectangular pattern. Sedimentological analysis included the sieving and GRADISTAT and ORIGIN software. The sediments are mostly fine to medium in size, moderately to poorly sorted, and positively skewed indicating varying energy conditions. This study focuses on the influence of the deccan basalt and monsoon climate on fluvial morphology and sedimentary features, which contributes to the data for geomorphic evolution, flood hazard prediction, and watershed management.

Keywords: Morphometry, Sedimentology, Shahnur River Basin, Deccan Basalt, Sieving

Introduction

The Shahnur River Basin is situated in the Amravati District of Maharashtra, India. It is a larger part of the Deccan Volcanic Province (DVP), which is known as the largest continental flood basalt province globally (Pascoe, 1982). These basalts are formed during Late Cretaceous to Early Paleogene, which is spread all over the basin forming uniform lithology. However, geomorphological diversity is introduced through variable climate, structural controls, and fluvial processes. Shahnur River Basin serves as an important place which is useful to examine the landform evolution, sediment dynamics, and the geological processes (Kale and Gupta, 2001; Burbank and Anderson, 2001).

The combination of morphometry and sedimentology provides a detailed understanding about the behaviour of the river basin. Morphometric analysis enables the classification of the landforms, understanding the drainage patterns, and calculating the morphometric parameters such as stream order, bifurcation ratio, drainage density, and relief characteristics. (Strahler, 1957; Horton, 1945). These parameters help to interpret the influence of the tectonics and lithology on basin morphology (Gregory and Walling, 1973). Sedimentology involves the study of the grain size analysis, sorting, and skewness, which collectively reveals the information about the fluvial energy conditions, sediment provenance, and transport mechanisms (Pettijohn, 1975; Miall, 1996).

Though several studies have focused on the major river systems of peninsular India, smaller tributaries in the Deccan Volcanic Province like Shahnur River Basin remain understudied (Chattopadhyay and Bhattacharya, 2006; Rao, 2003). These study combines the integrated study of morphometry and sedimentology of the Shahnur River Basin using modern GIS and remote sensing techniques and statistical analysis of the sediment samples. The outcomes of this study are important for regional watershed development, flood risk prediction, sediment budgeting, and sustainable land use planning in the semi-arid regions of central India.

Study Area

The given study focuses on the Shahnur River Basin, it is a tributary of Purna River, which itself is part of larger Tapi River Basin in Maharashtra, India. The Shahnur River Basin is in the Amaravati District of Vidarbha region of Maharashtra, and lies approximately between latitude 21°00′ N to 21°20′ N and longitude 77°30′ E to 77°50′ E. The study area is a part of the Survey of India topographic sheet numbers 55G/3, 55G/4, 55G/7, 55G/8 and 55H/1 (scale 1:50,000) (Fig. 1). The river originates from the foothills of Satpura Mountains and eventually joins the Purna River. The basin lies in a semi-arid area receiving most the rainfall in the month of June to September.

Geological Setting

The Shahnur River Basin lies within the one of the largest continental flood basalt terrains known as the Deccan Volcanic Province (DVP). It covers approximately an area of 5,00,000 km^2. The geology of the area is mostly dominated by the basaltic flow of the Cretaceous-Paleogene age, which were formed during the eruptive episodes around 66 million years ago

(Chen et al., 2022; Jay et al., 2015). These basaltic flows consist of various features like columnar joints, vesicular zones, and compact massive units.

The structural framework of the region is influenced by the proximity to the Narmada-Tapi lineament system and the fractures that trends ENE-WSW and NW-SE. These features are responsible for the drainage pattern, slopes, and valley incision in the basin (Mahoney et al., 2020). These fractures and faults create lot of weak zones that helps for the geomorphological development of the river network through fluvial incision. The remote sensing data reveals the linear valleys and the tributaries that suggest a structural imprint on the basin's evolution.

The processes such as weathering and denudation have shaped the present-day topography into the landscapes of the moderately dissected basaltic plateaus and deep valleys. The river flows and cuts through the basaltic layers, resulting in the formation of the waterfalls. Along the floodplains and the lower reaches, Quaternary alluvial deposits comprising silts, clay, and fine sand are commonly observed near the confluences and the meander loops.

Understanding the geological framework of the basin is critical, as it influences the drainage characteristics, sediment supply and geomorphic evolution.

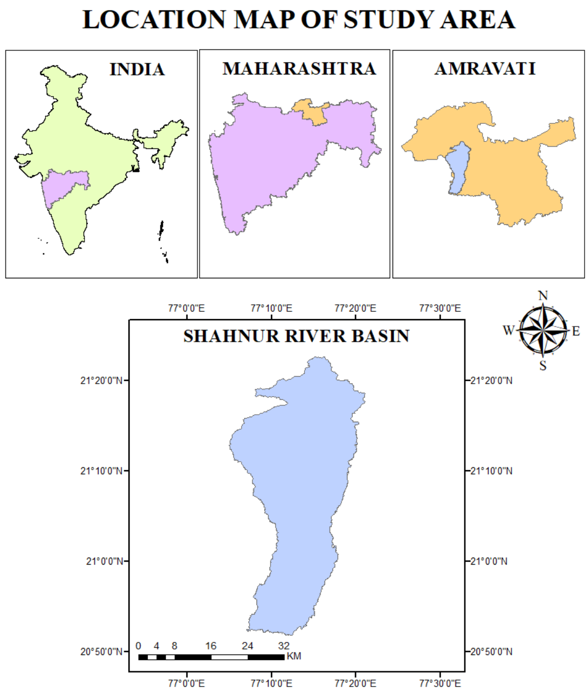

Fig. 1: Location Map of Shahnur River Basin

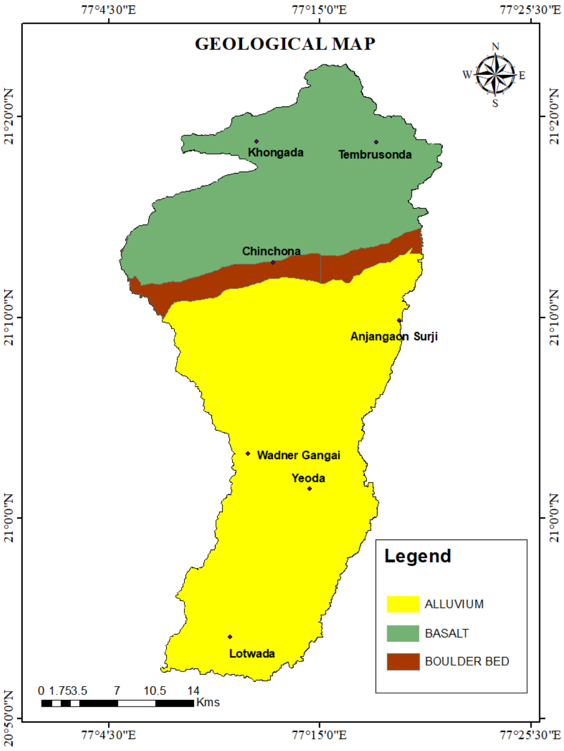

Fig. 2: Geological Map of Shahnur River Basin

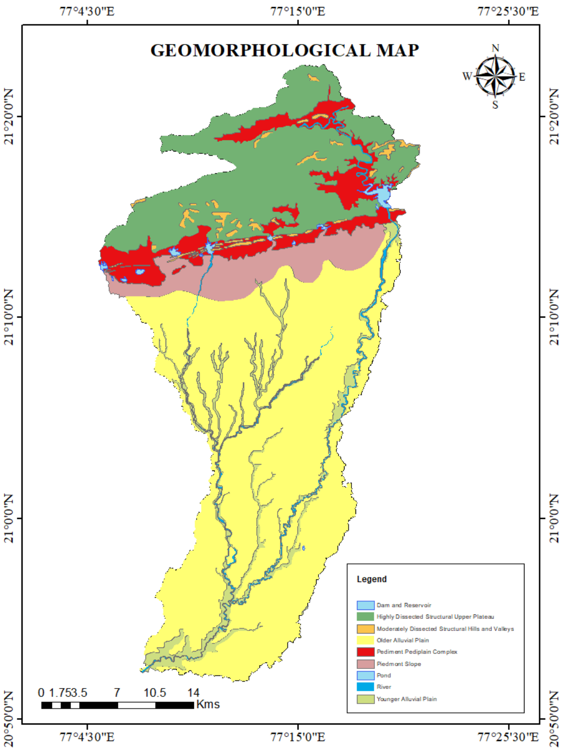

Fig. 3: Geomorphological Map of Shahnur River Basin

Materials and Methods

The data generation for the Shahnur River Basin has been carried out using Shuttle Radar Topographic Mission (SRTM) data. The drainage network has been generated by the hydrological and spatial analyst tools in ARCMAP software and used the toposheets 55G/3, 55G/4, 55G/7, 55G/8 and 55H/1 (Scale 1: 50,000) from the Survey of India (SOI). Various linear, aerial, and relief morphometric parameters such as stream order, stream length, bifurcation ratio, drainage density, stream frequency, elongation ratio, form factor, and relief ratio were calculated using standard formulas suggested by the Horton (1945), Strahler (1957), and Schumm (1956).

Field investigations were conducted to validate the geomorphological features and to collect the sediments along the Shahnur River. Sampling was done along the main river channel and total of 12 samples were collected. The collected samples were dried and then using coning and quartering method was used to extract 100gm of sample which remained representative of the original sample. The samples were subjected to the dry sieve analysis using standard set of ASTM sieves (ranging from -6 phi to 4.5 phi). Each sample was sieved for 20 minutes using a mechanical shaker. The grain size data was analyzed using GRADISTAT software (Blott and Pye, 2001), which helped to calculated the statistical parameters consisting mean size, standard deviation (sorting), skewness, and kurtosis using Folk and Ward Method (1957). The results were used to classify the sediment types and to know the depositional environments.

The frequency curve was plotted using the OriginPro software to visualize the sediment characteristics and identify the difference in the depositional energy conditions.

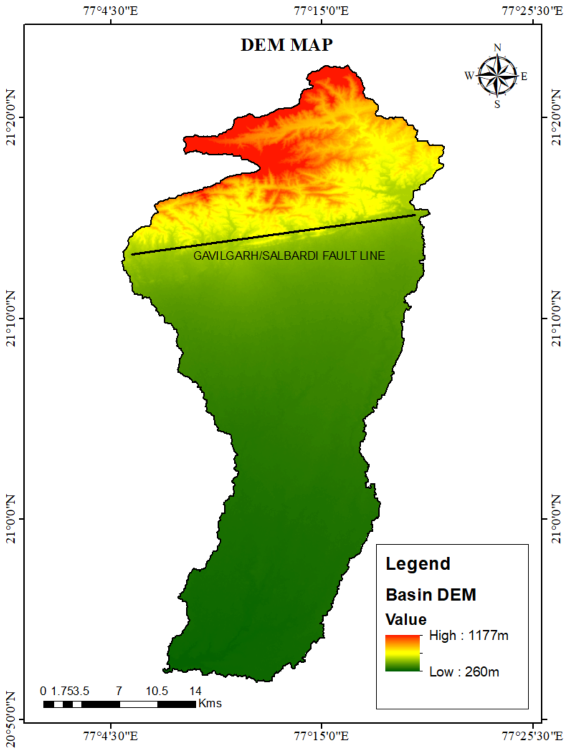

Fig. 4: DEM Map of Shahnur River Basin

Table 1: Morphometric Analysis of Shahnur River Basin

STREAM ORDER	NO OF STREAMS	STREAM LENGTH (KM)	BIFURCATION RATIO	STREAM FREQUENCY (PER KM^2)	DRAINAGE DENSITY (KM/KM^2)	CONSTANT OF CHANNEL MAINTENANCE (KM^2/KM)
1	1368	571	4.93	1.97	1.38	0.72
2	277	270	4.54			
3	61	159	2.77			
4	22	95	7.33			
5	3	90	3			
6	1	25	-			
TOTAL	1732	1210				

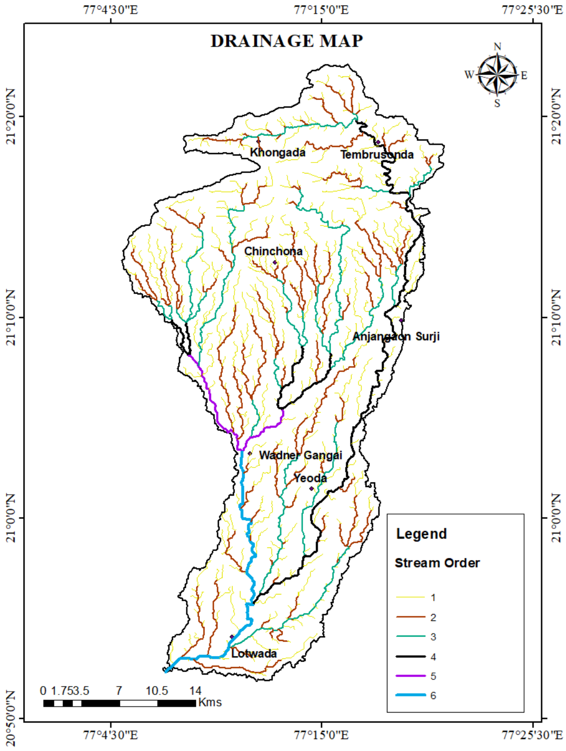

Fig. 5: Drainage Map of Shahnur River Basin

Results and Discussion

The morphometric details of the Shahnur River Basin are studied under linear, areal, and linear aspects and their results are discussed below:

Linear Aspects

Stream Order (U)

Stream ordering is the first step in for the morphometric analysis of the basin. In the given study area, based on Strahler's (1964) classification the Shahnur River Basin is a 6th order basin (Table 1). The presence of higher number of lower order streams and few higher order streams indicates that the basin have dendritic and rectangular patterns developed in the same lithology.

Stream Number (Nu)

The number of streams in each order in each basin is known as the stream number. The first order streams have the highest number of streams while it decreases as it reaches the sixth order. The 1st order stream has 1368 streams while the 2nd has 277 streams, 3rd have 61 streams, 4th have 22 streams, 5th have 3 streams and 6th have only one stream. The maximum number of the 1st order streams suggest that the basin is subjected to erosional activity (Gupta et al., 2020).

Stream Length (Lu)

The total length of the individual stream segments of each order is the stream length of that order. The total stream length of the Shahnur River Basin is 56.25 km.

Bifurcation Ratio (Rb)

It is a dimensionless parameter that express the ratio of the number of streams of any given order to the number in the next lower order (Nu+1) (Horton, 1945). It ranges from two for flat topography, 3 or 4 for mountainous or highly dissected drainage basin and greater than 5 indicates structurally controlled basin (Strahler, 1964). The Shahnur River Basin have bifurcation ratio ranging from 2.77 to 7.33. These values indicates that basin is structurally controlled forming dendritic and rectangular drainage patterns.

Table 2: Linear Aspects of Shahnur River Basin

Sr. No.	Morphometric parameters	Formulae	References	Result
Linear Aspects				
1)	Stream order (U)	Hierarchical rank	Strahler (1964)	6^{th}
2)	Stream Number (Nu)	Nu=N1+N2+..Nu	Strahler (1964)	1732
3)	Stream Length (Lu) Kms	Lu=L1+L2+…Lu	Horton (1945)	1210 km
4)	Mean stream length ratio (Lsm)	Lsm=Lu/Nu Where, Lu=Stream length, Nu=Stream Number	Strahler (1964)	0.70 km
5)	Cumulative Stream length (Csl)	Csl	Horton (1945)	1210 km
6)	Weighted stream length ratio (Lurwn)	Lurwn (Lur*Lur-r/Lur-r) Where, Lurwm= weighted mean bifurcation, Lur=bifurcation ratio of a per stream order, Lur-r=the addition of the stream length of a stream order and that of the previous order	Strahler (1952)	0.31
7)	Mean Bifurcation ratio (Rbm)	Rbm	Strahler (1957)	4.52
8)	Weighted mean Bifurcation ratio (Rbwm)	Rbwm(Rb*Nu-r/Nu-r) Rb= bifurcation ratio of a per stream order	Strahler (1952)	4.82

		Nu-r= The addition of the stream number of a stream order and that of the previous order		

Areal Aspects

Drainage Density (Dd)

Drainage Density is the ratio of the total stream length cumulated for all the orders within the basin area, and expressed in terms of km/km (Horton, 1945). The Drainage Density (Dd) value of the given basin is calculated as approximately 1.38 km/km^2. This value suggests that the area has semi-permeable lithological composition and intermediate runoff conditions.

Stream Frequency (Fs)

The term stream frequency can be defined as the ratio of the total number of streams in a catchment to the watershed area (Horton, 1932). The stream frequency (Fs) of the Shahnur River Basin was found to be 1.97 per km^2. It indicates that the drainage network is well-drained with low infiltration.

Drainage Texture

It is defined as the relative spacing of drainage lines and gets influenced by the relief, climate, lithology (Smith, 1950). In the given study area, the drainage texture is classified as the moderate to coarse as the value is 2.72 indicating balanced runoff.

Elongation Ratio (Re)

Elongation ratio is basically the shape of the drainage basin. It is described the ratio of the diameter of the circle having the same area as the basin to the maximum basin length (Schumm, 1956). On the basin of the elongation ratio, the Shahnur River Basin can be classified as the elongated basin as the value is 0.60.

Circulatory Ratio (Rc)

It is defined as the ratio of the area of the basin to the area of the circle having the same perimeter as that of the basin (Miller, 1953). The circulatory ratio value for the Shahnur River Basin is 0.27 which indicates that the basin is elongated in shape and less prone to flash floods (Table 3).

Form Factor (Ff)

It is expressed as the ratio of the basin area to the square of the basin length (Horton, 1932). The values basically range from 0.16 to 0.87. The form factor value for the given Shahnur River Basin is 0.28, indicating the basin is elongated.

Length of Overland Flow (Lg)

According to Horton (1945), the length of overland flow (Lg) is the length of runoff over the ground before it gets submerged into the main stream. The 'Lg' is affected by the rainfall intensity, infiltration rate, soil and vegetation covers. The Lg value for the Shahnur River Basin is 0.36 km (Table 3), indicating low to moderate runoff and infiltration.

Constant of Chaneel Maintenance (C)

The Constant of Channel Maintenance is a morphometric parameter that describes the area required to sustain one unit length of a stream channel. It is an inverse of drainage density (Schumm, 1956). The value for the Shahnur River Basin is 0.72. This higher value indicated that the area has a strong lithological control with high surface permeability.

Sinuosity Index (SI)

It is a measure of how much the river channel deviated from its original straight path. It can be defined as the ratio of the actual channel length to the valley length between the source and the mouth of the river. If the SI > 1 then, the channel is meandering and if SI = 1 then, the channel is straight. For the Shahnur River Basin, the value is 1.65, indicating that the river is meandering.

Table 3: Areal Aspects of Shahnur River Basin

Sr. No.	Morphometric parameters	Formulae	References	Result
Areal Aspects				
9)	Drainage density (Dd)	Dd=Lu/A Where, Lu=Stream length, A= Basin area	Horton (1932,1945)	1.38 /km
10)	Stream frequency (Fs)	Fs=Nu/A Where, Nu=Stream Number, A= Basin area	Horton (1932,1945)	1.97 /km2
11)	Drainage Texture (T)	T=Dd*Fs Where, Dd= Drainage density and Fs= Stream frequency	Smith (1950)	2.72
12)	Texture ratio (Rt)	Rt=Nl/P	Horton (1945)	8.66

		Where, P= basin perimeter		
13)	Elongation ratio (Re)	$Re=(2/Lb)\ (A/\pi)^{0.5}$ Where, Lb= Basin length A= Basin area	Schumm (1956)	0.60
14)	Circulatory ratio (Rc)	$Rc=4\Pi A/P^2$ Where, A= Basin area P= basin perimeter	Miller (1953)	0.27
15)	Form factor (Ff)	$Ff= A/Lb^2$ Where, A= Basin area, Lb= Basin length	Horton (1932)	0.28
16)	Length of Overland flow (Lg)	Lg=1/2 Dd Where, Dd= Drainage density	Horton (1945)	0.36
17)	Rho coefficient (RHO)	RHO=Rl/Rb Where, Rl= Stream length ratio, Rb= Bifurcation ratio	Horton (1945)	0.15
18)	Drainage Intensity (Di)	Di=Fs/Dd Where, Fs= Stream frequency Dd= Drainage density	Faniran (1968)	1.43
19)	Constant of channel maintenance (C)	C= 1/Dd Where, Dd= Drainage density	Schumm (1956)	0.72
20)	Shape Index (Sw)	Sw= 1/Ff Where, Ff= Form Factor	Horton (1932)	3.61
21)	Shape factor (Sf)	$Sf=Lb^2/A$ Where, Lb= Basin length A= Basin area	Horton (1945)	3.61
22)	Infiltration Number (If)	If=Dd*Fs Where, Dd= Drainage density Fs= Stream frequency	Faniran (1968)	2.72

Relief Aspects

Basin Relief (R)

Basin relief to the elevation difference between the highest and the lowest points within the drainage basin (Hadley and Schumm, 1961). It is an important morphometric parameter used to evaluate the vertical dimension of a basin and provides information about the erosional capability and steepness of the slopes. The basin relief of the given study area is 917m, indicating that the area is rugged and steep. It can influence the hydrological as well as geomorphological characteristics of the basin.

Relief Ratio (Rh)

Relief ratio (Rh) is the ratio between the basin relief and the basin length. The relief ratio is an effective measure of gradient aspects of the basin (Schumm, 1956). The value for the given study area is 0.016. This low relief indicates that the area is low lying and gently sloping as the most of that area comprises of flat alluvial plain.

Aspect Map

The Aspect Map of the Shahnur River Basin shows the varied slope directions. The North and Northeast facing slopes (red, orange, yellow) dominates the northern region of the basin with rugged and mountainous topography while the Southwest facing slopes (greenish) are more common in the gentler southern alluvial terrain. This influences the erosion, vegetation, and land use patterns.

Slope Map

The Slope Map of the Shahnur River Basin indicates the steep slopes in the northern region of the basin ranging from 16.14° to 53.42°, in orange and red. The southern and the central region of the basin have gentler slopes ranging from 0 to 3.87°, dark green. This part is ideal for agricultural development due to their flat and stable nature.

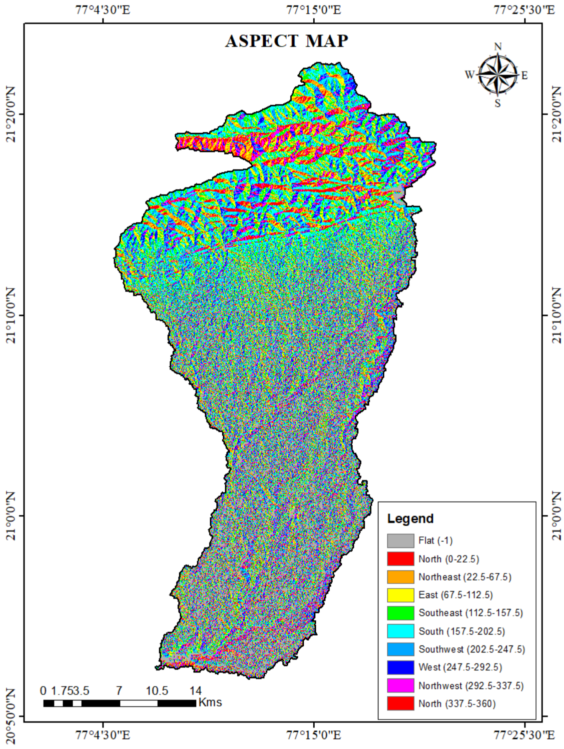

Fig. 6: Aspect Map of Shahnur River Basin

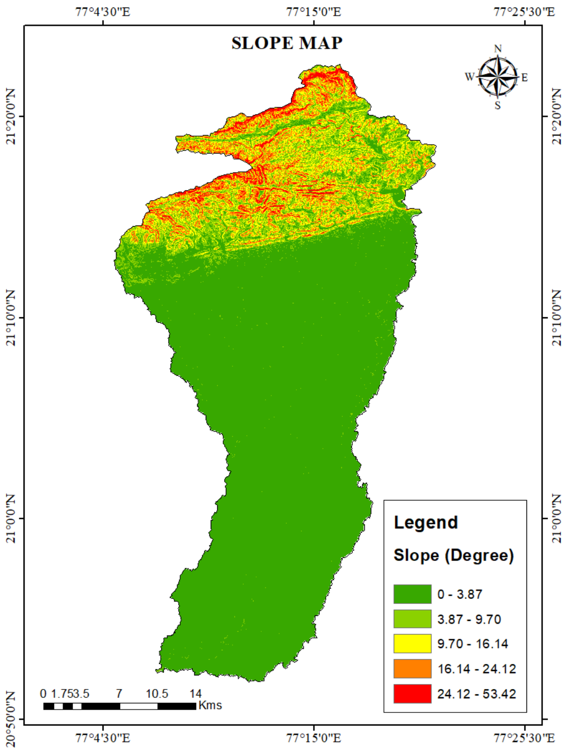

Fig. 7: Slope Map of Shahnur River Basin

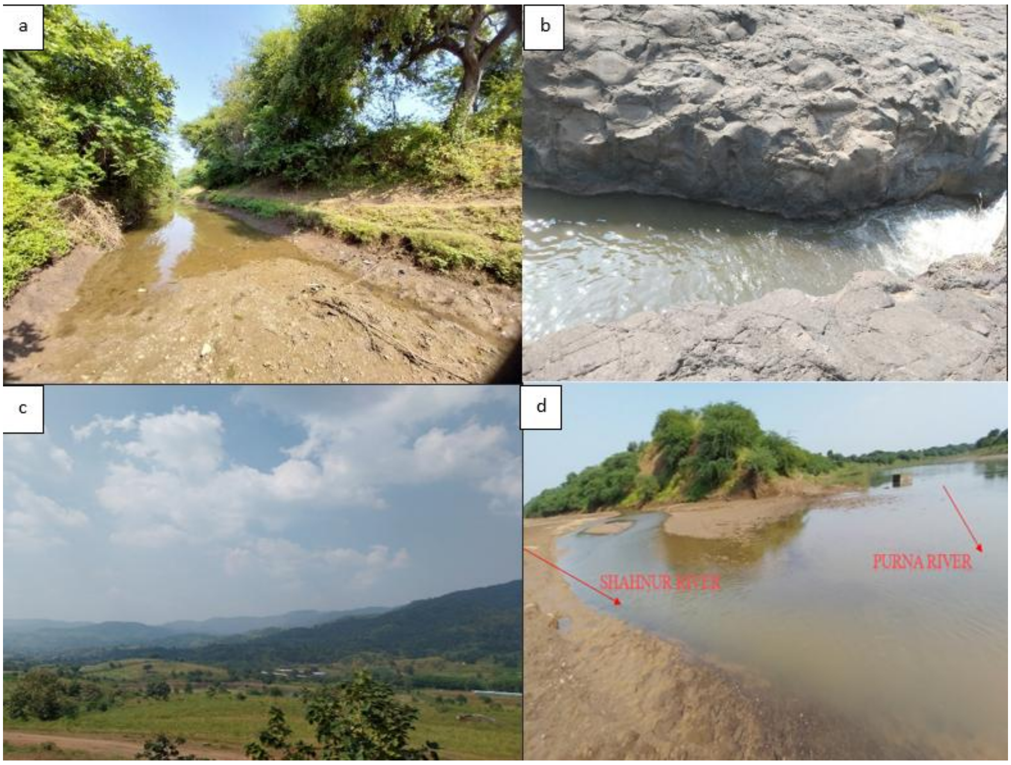

Fig. 8: Representative field photographs of the Shahnur River Basin showing (a) river terraces, (b) Deccan Trap basalt exposure, (c) Satpura Mountain Range, and (d) Shahnur–Purna confluence

Table 4: Relief Aspects of Shahnur River Basin

Relief Aspects				
Sr. No.	Morphometric parameters	Formulae	References	Result
23)	Maximum elevation (m)	H (m)	GIS Analysis/DEM	1177 m
24)	Minimum elevation (m)	h (m)	GIS Analysis/DEM	260 m
25)	Basin relief (R)	R=H-h	Hadley, Schumm (1961)	917 m
26)	Relief ratio (Rr)	Rr=R/Lb Where, R= Basin relief Lb= Basin length	Schumm (1956)	0.016
27)	Ruggedness number (Rn)	Rn=Dd*(R/1000) Where, Dd= Drainage density R= Basin relief	Strahler (1956)	1.26
28)	Melton Ruggedness Number (MRn)	$MRn=R/A^{0.5}$ Where, R= Basin relief A= Basin area	Melton (1965)	0.031

29)	Watershed Slope (Sw)	Sw = R/Lb Where, R= Basin relief Lb= Basin length	Sreedevi (2004)	0.016
30)	Relative Relief ratio (Rhp)	Rhp=R*100/P Where, R= Basin relief	Melton (1957)	0.46%
31)	Dissection Index (Dis)	Dis = R/ Ra	Singh & Dubey (1994)	0.78

Table 5: Geometric Aspects of Shahnur River Basin

Geometric Aspects				
Sr. No.	Morphometric parameters	Formulae	References	Result
32)	Basin Area (A)	A (sq.km)	Schumm (1956)	877.72 sq km
33)	Basin Length (Lb)	Lb (km)	Schumm (1956)	56.25 km
34)	Mean Basin Width (Wb)	Wb=A/Lb Where, A= Basin area Lb= Basin length	Horton (1932)	15.61 km
35)	Basin Perimeter (P)	P (km)	Schumm (1956)	200 km
36)	Relative Perimeter (Pr)	Pr=A/P Where, A= Basin area P= basin perimeter	Schumm (1956)	4.39 km
37)	Lemniscate ratio (K)	$K=Lb^2/4A$ Where, Lb= Basin length A= Basin area	Chorley (1957)	0.90
38)	Channel Length (Cl)	Main channel length (kms)	Muller (1968)	92.5 km
39)	Valley Length (Vl)	Valley length (kms)	Muller (1968)	56.25 km
40)	Compactness Coefficient (Cc)	$Cc = 0.2841 * P / A^{0.5}$ Where, A= Basin area P= basin perimeter	Gravelius (1914)	1.92
41)	Length Area Relation (Lar)	$Lar = 1.4 * A^{0.6}$ A= Basin area	Hack (1957)	89.52

Table 6: Morphometric Aspects of Shahnur River Basin

Morphotectonic Aspects				
Sr. No.	Morphometric parameters	Formulae	References	Result
42)	Sinuosity Index (Si)	Si=Cl/Vl Where, Cl= Channel Length –stream length Vl= Valley length-basin length	Miller (1964,1968)	1.65 Si = 1 (Straight Channel) Si > 1 (Meandering)
43)	Drainage basin shape (Bs)	Bs= Lb/Wb (Lb = Basin Length and Wb = Mean Basin Width)	Bull and Mcfadden (1977)	3.60

These parameters helped in analyzing the basin's shape, structural control, erosional stage, and the runoff potential.

Sedimentological Analysis

Frequency Curve

The Frequency curve of the grain size distribution for the sediment samples (SR1 to SR12) from the Shahnur River Basin shows unimodal to bimodal pattern. Most of the samples peak between -1 phi to +1 phi range, indicating medium to fine sand. The sharp peaks and narrow spread in some samples like SR4, SR6, SR10 suggests moderate to well sorting indicating consistent fluvial energy. The upstream samples i.e., SR1, SR2, SR3 from the origin of the river shows coarser amount of grain size reflecting higher energy conditions. The downstream samples i.e., SR11, SR12 tends to be finer and shows reduced flow velocity and increase in sediment deposition.

Overall, the frequency curve supports a downstream fining trend, consistent with fluvial transport and deposition processes in the rivers dependent on the monsoon. (Shankar et al., 2023; Kamble et al., 2021). The results confirm that the hydrodynamic sorting and channel morphology significantly influence the grain size distribution within the basin.

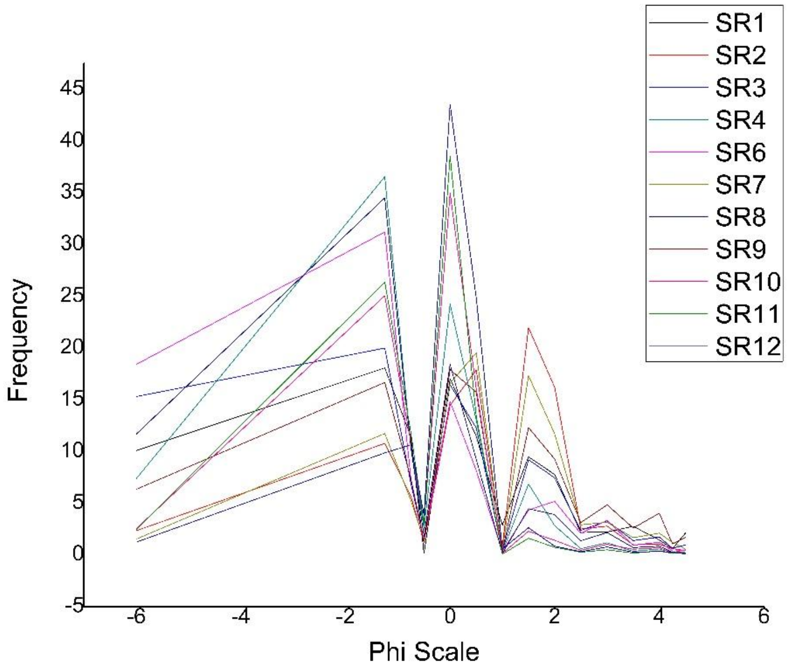

Fig. 9: Frequency Curve of Shahnur River Sediments

Table 7: Statistical Parameters of Shahnur River Sediments

SR. NO.	SAMPLE NO.	MEAN	STANDARD DEVIATION	SKEWNESS	KURTOSIS	DESCRIPTION
1	SR 1	-0.108	1.730	0.170	0.826	VCS, PS, FS, P
2	SR 2	0.315	1.437	-0.064	1.024	CS, PS, S, M
3	SR 3	-0.217	1.706	0.151	0.756	VCS, PS, FS, P
4	SR 4	-0.842	1.131	0.329	0.909	VCS, PS, VFS, M
5	SR 5	-1.824	0.760	0.646	1.743	VFG, MS, VFS, VL
6	SR 6	-0.764	1.591	0.642	1.041	VCS, PS, VFS, M
7	SR 7	0.289	1.544	0.064	1.137	CS, PS, S, L
8	SR 8	-0.952	1.260	0.515	1.047	VCS, PS, VFS, M
9	SR 9	0.173	1.820	0.156	0.842	CS, PS, FS, P
10	SR 10	-0.623	1.003	-0.159	0.919	VCS, PS, CS, M
11	SR 11	-0.694	0.816	-0.378	0.675	VCS, MS, VCS, P
12	SR 12	-0.391	0.834	-0.216	1.762	VCS, MS, CS, VL

(Note: VCS – Very Coarse Sand, CS – Coarse Sand, VFG – Very Fine Sand, PS – Poorly Sorted, MS – Moderately Sorted, S – Skewed, VFS - Very Finely Skewed, CS – Coarse Skewed, FS – Finely Skewed, P – Platykurtic, M – Mesokurtic, L – Leptokurtic, VL – Very Leptokurtic)

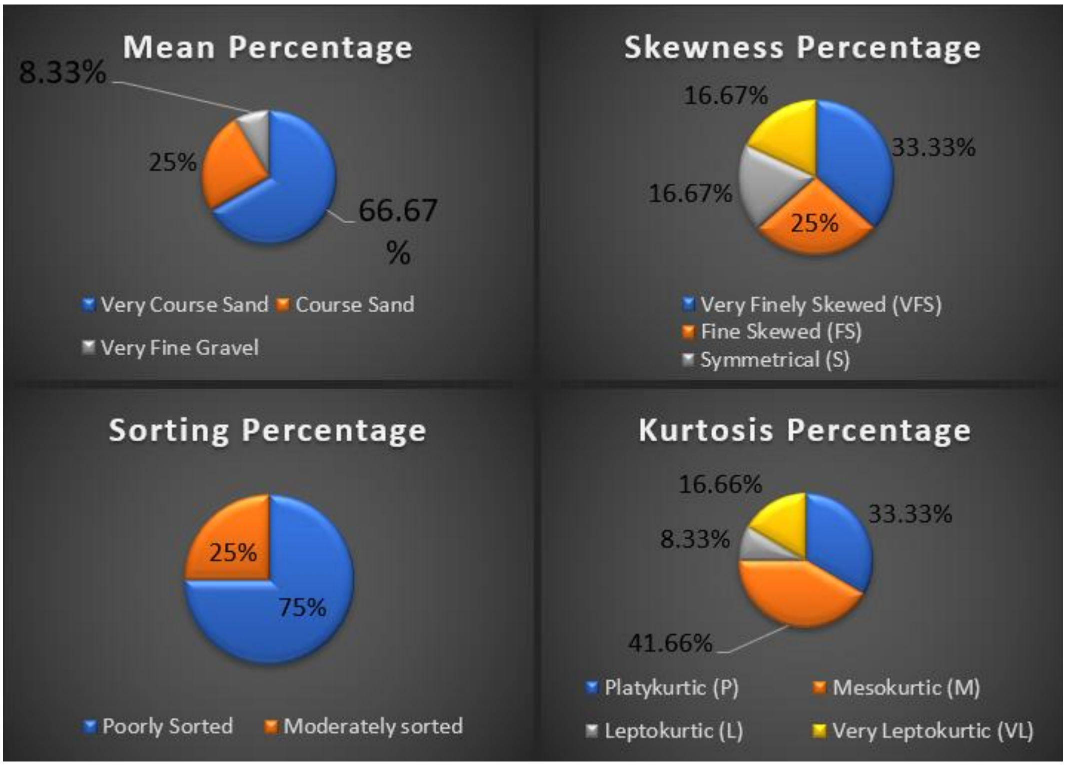

Fig 10: Statistical Parameters for Shahnur River Sediments

Mean Size (M)

Mean size is the average of the total distribution of sediments. It is the function of the total amount of sediments present, the total amount of energy applied on the sediments, and the nature of the transporting agent (Folk, 1966). The transporting agent's energy consists of the degree of turbulence and the role of waves and currents.

The Sediment analysis shows that very coarse sand (66.67%) is the most dominant grain size in the whole basin followed by the coarse sand (25%) and a very small portion of very fine gravel (8.33%). This data about the Shahnur River Basin suggests that high-energy depositional environment capable of transporting and depositing coarser materials.

Standard Deviation (SD)

The standard deviation (sorting) measures the fluctuations in the kinetic energy of the depositional agent (Sahu, 1964). In terms of sorting, 75% of the samples are poorly sorted, indicating the rapid deposition of the sediments along with the limited transportation. The remaining quantity of sediments which is 25% are moderately sorted, which suggests occasional moderate energy conditions.

Skewness (SK)

Skewness defines the irregularity of the grain size distribution in the given specific study area. In the given Shahnur River Basin, the sediments are mostly very finely skewed (33.33%) and fine skewed (25%). This data about the sediments implies a slight dominance of fine particles, while the symmetrical and coarse skewed distribution of the river sediments (16.67%) which reflects a mix of depositional sediments.

Kurtosis (K)

Kurtosis can be defined as the portion of the river sediments that have been sorted elsewhere in a high energy environment. In the given Shahnur River Basin, the kurtosis analysis revealed that the sediments are mostly Mesokurtic (41.66%). Further, the data consist of Platykurtic (33.33%) sediments, indicating a normal to flat topped grain distribution. Leptokurtic (8.33%) and very leptokurtic (16.66%) samples suggests more peaked distributions, which implies a uniform energy condition in some areas. Overall, the data reflects heterogenous sedimentary processes within the Shahnur River Basin.

Conclusions

The integrated morphometric and sedimentological analysis of the Shahnur River Basin highlights the significant role of structure, lithology, and monsoonal hydrology in shaping the basin's fluvial landscapes. The morphometric analysis reveals that the basin is an elongated basin with dendritic to sub-dendritic drainage pattern and rectangular drainage pattern, which reflects a predominantly basaltic terrain with limited and evident structural control. The morphometric parameters such as bifurcation ratio, drainage density, and relief ratio indicate a youthful to mature stage of the river basin's evolution, with moderate dissection.

Sedimentological analysis of the surface samples confirms the dominance of fine to medium sand, moderate sorting, and positive skewness, which suggests the deposition under fluctuating energy conditions but generally low to moderate energy fluvial conditions. The frequency curves further explain a downstream fining trend and sediment sorting driven by seasonal flow variation, channel morphology, and catchment dynamics.

Together these findings focus on the influence of the Deccan Trap basalt on the drainage development and the sediment dispersion within the Shahnur River Basin. The study contributes valuable data for the watershed management, environmental planning, and erosional control in these semi-arid volcanic terrains.

Author's Contributions

S. A. Patharkar: Conceptualization, Field Investigation, Software, Writing Original Draft, Reviewing and Editing, Data Curation, Formal Analysis

M. G. Trimukhe: Formal Analysis

M. A. Herlekar: Visualization, Validation, Supervision, Methodology, Reviewing and Editing

Conflict of Interest

The authors declare that they have no conflict of interest.

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References

Blott, S. J., & Pye, K. (2001). GRADISTAT: A grain size distribution and statistics package for the analysis of unconsolidated sediments. *Earth Surface Processes and Landforms, 26*(11), 1237–1248.

Emeka, N. C., Antia, V. I., Ukpong, A. J., Amah, E. A., & Ntekim, E. E. U. (2010). A study on the sedimentology of tidal rivers: Calabar and Great Kwa, S. E. Nigeria. *European Journal of Scientific Research, 47*(3), 370–386.

Folk, R. L., & Ward, W. C. (1957). Brazos River Bar: A study in the significance of grain-size parameters. *Journal of Sedimentary Petrology, 27*, 3–26.

Herlekar, M. A. (2021). A morphometric approach to understand the neotectonic controls of drainage basin from Western Ghats of India. *ResearchGate.* https://www.researchgate.net/publication/354568986

Herlekar, M. A., Kamble, P. B., Chakraborty, A., & Nannaware, R. R. (2024). Morphometric analysis of Mithmumbri–Malvan area, Sindhudurg District, West Coast of Maharashtra, India. *Gondwana Geological Magazine, 9*(2), 140–152.

Horton, R. E. (1945). Erosional development of streams and their drainage basins. *Geological Society of America Bulletin, 56*, 275–370.

India-WRIS. (2020). *Tapi Basin Report.* Central Water Commission & National Remote Sensing Centre (ISRO).

Iyer, S. D., Gujar, A. R., Sanil Kumar, V., Naik, D. K., Gaonkar, S. S., Naik, S., Shirodkar, P., Badesab, F., & Luis, R. A. A. (2021). Sedimentological responses to coastal dynamics along the Thane District, North Maharashtra, West Coast of India. *Sustainable Water Resources Management, 7*, 28. https://doi.org/10.1007/s40899-021-00515-0

Jain, N., Roy, P., Martha, T. R., Jalan, P., & Nanda, A. (2023). *Landslide Atlas of India: Mapping, Monitoring, and R&D Studies Using Remote Sensing Data.* National Remote Sensing Centre (NRSC), ISRO.

Kamble, P. B., Herlekar, M. A., Chakraborty, A., & Gawali, P. B. (2021). Seasonal variation in textural characteristics of beach sediments along Sindhudurg Coast, Western Maharashtra, India: Implications on depositional environments. *Journal of Gondwana Geological Society, 7*(1), 15–30.

Manjare, B. S., Reddy, G. P. O., & Meshram, U. P. (2024). Implications of active Gavilgarh/Salbardi fault on the evolution of the Late Quaternary landscape in Central India. *Quaternary International, 702*, 34–47. https://doi.org/10.1016/j.quaint.2022.12.014

Miall, A. D. (1996). *The Geology of Fluvial Deposits.* Springer.

Pettijohn, F. J. (1975). *Sedimentary Rocks* (3rd ed.). Harper & Row.

Schumm, S. A. (1956). Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey. *Geological Society of America Bulletin, 67*, 597–646.

Shrivatra, J. R., Manjare, B., & Paunikar, S. (2021). Morphometric analysis-based prioritization of sub-watersheds of WRJ-1 watershed of Narkhed Taluka, Nagpur District, Maharashtra using geospatial techniques. *ResearchGate.* https://www.researchgate.net/publication/353243105

Smith, K. G. (1950). Standards for grading texture of erosional topography. *American Journal of Science, 248*, 655–668.

Srivastava, A., & Kale, V. M. (2018). Purna River, Maharashtra. In V. S. Kale (Ed.), *The Indian Rivers* (pp. 479–502). Springer. https://doi.org/10.1007/978-981-10-2984-4_29

Srivastava, A. K., Bansod, M. N., Singh, A., & Kale, V. M. (2020). Model showing influence of tectonics and energy condition of the fluvial environment on facies architecture: A case history of Quaternary alluvial deposits of Purna Basin, Central India. *Journal of Earth System Science, 129*(174). https://doi.org/10.1007/s12040-020-01462-6

Strahler, A. N. (1952). Hypsometric (area-altitude) analysis of erosional topography. *Geological Society of America Bulletin, 63*, 1117–1142.

Strahler, A. N. (1957). Quantitative analysis of watershed geomorphology. *Transactions, American Geophysical Union, 38*(6), 913–920.

Strahler, A. N. (1964). Quantitative geomorphology of drainage basins and channel networks. In V. T. Chow (Ed.), *Handbook of Applied Hydrology.* McGraw-Hill.

Varade, A. M., Tidke, P. S., & Thakur, N. G. (2017). Morphometric analysis of Nagjhari Watershed of Pedhi River, Amravati District, Maharashtra. *ResearchGate.*

Verma, S., Khalkho, D., & Gupta, L. K. (2020). Morphometric analysis of a drainage basin using remote sensing and GIS. *International Journal of Current Microbiology and Applied Sciences, 9*(4), 1950–1959.