Morphometric and Topographic Study Of Jalna, Aurangabad, Nanded, and Beed Districts in the Marathwada Region And Their Talukas by Software Analysis

K. T. Gaikwad[1], S. M. Valvi[2], N. K. Aher[3], R. R. Ahire[4], A.V. Dudhekar[5]

[1,2,3,4] *Student, Department of Civil Engineering, KK Wagh Institute of Engineering Education and Research, Nashik, India*

[5] *Prof., Department of Civil Engineering, KK Wagh Institute of Engineering Education and Research, Nashik, India*

---***---

Abstract - *This study offers an in-depth examination of Marathwada region's morphometric characteristics, specifically focusing on its susceptibility to drought. Using Digital Elevation Models (DEMs) and administrative boundaries, the research generated river networks and assessed various morphometric properties including Elongation Ratio, Form Factor, Circularity Ratio, Relief Ratio, Bifurcation Ratio, Ruggedness Number, Stream Frequency, Drainage Density, Constant Channel of Maintenance, Length of Overland Flow, Drainage Intensity, and Drainage Texture. These metrics were then analyzed to evaluate the district's vulnerability to drought. The results yield significant insights into the hydrological dynamics of the area, aiding in the development of more efficient water management strategies and drought mitigation measures.*

Key Words: GIS, morphometric analysis, DEM

1.INTRODUCTION

This research undertakes a detailed and comprehensive analysis of the topographic and morphometric parameters of four key districts in the Marathwada region - Jalna, Aurangabad, Nanded, and Beed, along with their respective talukas. Leveraging the robust capabilities of Quantum Geographic Information System (QGIS), a wide array of parameters were meticulously derived to gain a deeper understanding of the physical characteristics of these basins.

The parameters studied encompass a broad spectrum, ranging from topographic aspects such as area, perimeter, basin length, maximum and minimum height, topographic position index, terrain ruggedness index, and roughness, to morphometric aspects like stream number, stream order, stream length, bifurcation ratio, and mean stream length. Each of these parameters, derived from rigorous software analysis and mathematical computations, provides valuable insights into the hydrological behavior of the region.

Furthermore, the study delves into areal aspects such as elongation ratio, form factor, circularity ratio, stream frequency, drainage density, constant channel of maintenance, length of overland flow, drainage intensity, drainage texture, and ruggedness number. It also explores relief aspects like slope, relief, and relief ratio. Each of these parameters, carefully calculated and analyzed, contributes to a holistic understanding of the region's geomorphology.

The implications of these parameters are manifold, influencing flood prediction, water resources management, and the assessment of land use changes on the basin's hydrology. This research, therefore, stands as a significant contribution to the field of geomorphology and hydrology, offering a detailed, data-driven examination of the Marathwada region.

The findings of this study have the potential to inform sustainable water management practices and contribute to the region's resilience against climate change impacts. By providing a comprehensive understanding of the region's topography and morphology, this research paves the way for future studies and interventions aimed at enhancing the region's water security and sustainability. This research, therefore, not only contributes to academic knowledge but also has significant practical implications for the region's development and environmental management.

2. LITERATURE REVIEW

Researchers in hydrology and geomorphology use geospatial techniques for morphometric analysis of river basins, focusing on understanding basin properties for holistic hydrological assessment.

G S Deepa Varghese et al.'s study evaluates groundwater capacity in two coastal Kerala sub-watersheds through morphometric analysis using remote sensing and QGIS. The northern sub-watershed, with higher drainage density, stream frequency, and bifurcation ratio, exhibited greater groundwater potential. The study concludes that remote sensing and GIS effectively assess groundwater potential for resource management and conservation.

Abhishek Jain et al.'s research paper analyzes Kakan Watershed's morphometric characteristics using remote sensing and GIS, emphasizing their role in watershed analysis and conservation. The study highlights the accurate assessment of lithological features and prediction of geomorphic landslides, underscoring the value of morphometric assessment in understanding water behavior in a specific region.

Research by Ramesh Kumar Patel et al., Hazir S. Çadraku, and Abrar Yousuf focuses on morphometric analysis using remote sensing and GIS techniques in different river watersheds, emphasizing the importance of watershed attributes for effective water resource management.

2. MATERIALS AND METHODS

In this study, researchers combined remote sensing data, GIS software, and morphometric analysis techniques. They utilized Digital Elevation Models (DEMs) obtained from the reliable Open Topography website. These high-resolution models provided detailed terrain information essential for morphometric analysis. Additionally, taluka level administrative boundary data from the Survey of India helped define the study area within Jalna, Aurangabad, Nanded, and Beed Districts. Using QGIS, the DEMs were clipped to obtain specific taluka and district extents. River networks were derived, revealing drainage patterns. Morphometric properties (e.g., Elongation Ratio, Bifurcation Ratio) were calculated, aiding in understanding hydrological behavior and drought vulnerability. The study contributes to effective water resource management.

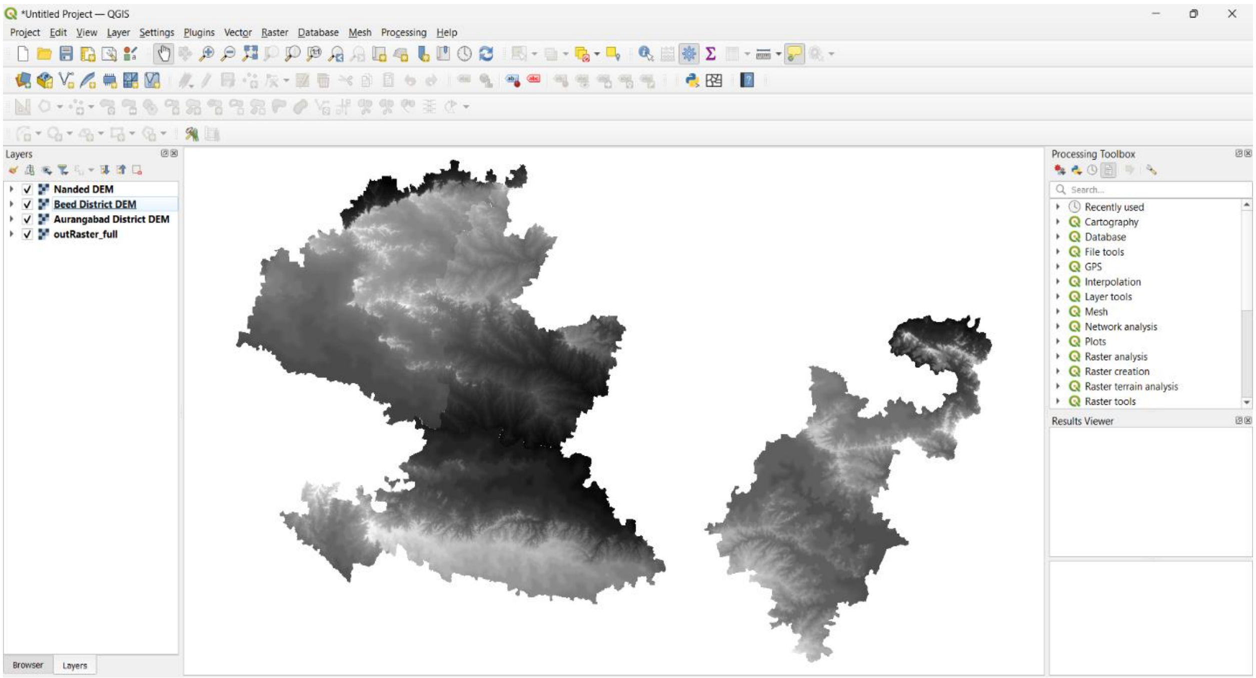

Fig -1: DEMs of Various Talukas of Jalna District in QGIS

3. RESULTS AND DISCUSSION

Following are the parameters studied in this study:
Topographic Parameters:

- Area (A) (Schumm (1956) [7]): The total surface area of the basin, measured in square kilometers. It is determined through software analysis. Larger areas can contribute to higher runoff volumes.

- Perimeter (P) (Schumm (1956) [7]): The total length of the boundary of the basin, measured in kilometers. It is also determined through software analysis. A larger perimeter can indicate a more irregular shape, which can affect the timing of runoff.
- Basin Length (Lb) (Schumm (1956) [7]): The maximum length of the basin, measured in kilometers. It is determined through software analysis. The length of the basin can influence the time of concentration of runoff.
- Maximum Height (Z): The highest point in the basin, measured in meters. It is determined from a Digital Elevation Model (DEM). Higher elevations can lead to steeper slopes and faster runoff.
- Minimum Height (z): The lowest point in the basin, measured in meters. It is also determined from a DEM. The minimum height can indicate the base level for the basin.
- Topographic Position Index (TPI): A dimensionless measure of a location's elevation relative to its neighbors. It is determined through software analysis. Higher values can indicate hilltops, while lower values can indicate valleys.
- Terrain Ruggedness Index (TRI): A dimensionless measure of terrain roughness. It is determined through software analysis. Higher values can indicate a more rugged or complex terrain.
- Roughness : A dimensionless measure of the variation in elevation in the basin. It is determined through software analysis. Higher values can indicate a more uneven or rugged terrain.

Morphometric Parameters:

a. Linear Aspects :

- Stream Number (Nu): This is the total number of streams in the basin. It is a dimensionless quantity determined through software analysis. More streams can indicate a more complex drainage network.
- Stream Order (Su) (Strahler (1957) [9]): This is a hierarchical ranking of streams based on their size and tributary relationships, as proposed by Strahler. Higher order streams are typically larger and have more tributaries.
- Stream Length (Lu) (Horton (1932) [2]): This is the total length of all streams in the basin, measured in kilometers. It is calculated as the sum of the lengths of all individual streams (Lu1 + Lu2 +....Ln).
- Bifurcation Ratio (Rb) (Horton (1945) & Strahler (1964) [10-11]): This is a dimensionless measure of the branching pattern of the stream network. A higher bifurcation ratio can indicate a more complex drainage network.

  $$Rb = \frac{Nu}{N(u+1)}$$
- Mean Stream Length (Lū) (Strahler (1964) [11]): This is the average length of streams in the basin, measured in kilometers. It is calculated as the total stream length divided by the number of streams (Lu/Nu). A longer mean stream length can indicate a more elongated basin shape.

b. Areal Aspects:

- Elongation Ratio (Re) (Schumm (1956) [7]): This is a dimensionless measure of the shape of the basin. A higher elongation ratio can indicate a more circular basin shape.

  $$Re = \frac{2\ x\sqrt{\frac{A}{\pi}}}{Lb}$$
- Form Factor (Ff) (Horton (1932) [2]): This is a dimensionless measure of the shape of the basin. A higher form factor can indicate a more circular basin shape.

  $$Ff = \frac{A}{Lb^2}$$
- Circularity Ratio (Rc) (Miller (1953) & Schumm (1956) [8-7]): This is a dimensionless measure of the roundness of the basin. A higher circularity ratio can indicate a more circular basin shape.

  $$Rc = \frac{4\pi A}{P^2}$$
- Stream Frequency (Fs) (Horton (1932) [2]): This is the number of streams per unit area, measured in inverse square kilometers (ΣNu/A). A higher stream frequency can indicate a more dense drainage network.
- Drainage Density (D) (Horton (1932) [2]): This is the total length of streams per unit area, measured in kilometers per square kilometer (ΣLu/A). A higher drainage density can indicate a more dense drainage network.
- Constant Channel of Maintenance (Schumm (1956) [7]): This is the area required to maintain a unit length of stream channel, measured in square kilometers per kilometer (1/D). A lower constant of channel maintenance can indicate a more dense drainage network.
- Length of Overland Flow (Lg) (Horton (1945) [10]): This is the average length of overland flow paths, measured in kilometers . A longer length of overland flow can indicate a slower response to rainfall.

$$Lg = \frac{A}{2\Sigma Lu}$$

- Drainage Intensity (Di) (Faniran (1968) [13]): This is a measure of the intensity of the drainage network, measured in inverse kilometers (Fs/D). A higher drainage intensity can indicate a more dense drainage network.
- Drainage Texture (Dt) (Horton (1945) [10]): This is a measure of the fineness or coarseness of the drainage pattern, measured in inverse kilometers (Nu/P). A higher drainage texture can indicate a more fine-grained drainage pattern.
- Ruggedness Number (Rn) (Melton (1957) [12]): This is a dimensionless measure of the ruggedness of the terrain. It is calculated as the drainage density times the relief (D x H). A higher ruggedness number can indicate a more rugged terrain.

c. Relief Aspects:

- Slope (S): This is the steepness of the terrain, measured in square kilometers. It is determined through software analysis. Steeper slopes can lead to faster runoff.
- Relief (H) (Strahler (1957) [9]): This is the difference in elevation between the highest and lowest points in the basin, measured in meters (Z-z). Greater relief can indicate steeper slopes and faster runoff.
- Relief Ratio (Rh) (Schumm (1956) [7]): This is a dimensionless measure of the steepness of the terrain. It is calculated as the relief divided by the basin length (H/Lb). A higher relief ratio can indicate steeper slopes.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-005
Volume: 11 Issue: 09 | Sep 2024 www.irjet.net p-ISSN: 2395-0072

Table -1: Various parameters of Jalna District

(a)

	Parameters / Name	A	P	Lb	Re	Ff	Rc	Z	z	H	Rh	Mean Rb	D	Rn	Lū	Di	Dt	C	Lg	Fs
Jalna District	Partur	757.114	183.69	48.165	0.644621	0.326361	0.281968	504	397	107	2.22153	124.6009	0.035256	3.772404	0.001167	856.6323	124.4815	28.36387	14.18194	30.20153
	Mantha	782.327	198.322	43.885	0.719173	0.406215	0.249952	580	413	167	3.8054	15.70276	0.010809	1.805122	0.00217	460.7237	19.64482	92.51453	46.25726	4.980015
	Jalna	1188.99	212.122	55.004	0.707375	0.392997	0.33206	670	432	238	4.326958	33.09279	0.052159	12.41392	0.001826	547.6569	160.1154	19.17202	9.586012	28.56542
	Jaffarabad	728.214	185.364	44.18	0.689222	0.373085	0.266329	694	512	182	4.119511	69.67383	0.007407	1.348087	0.001705	586.3994	17.06372	135.0061	67.50305	4.343503
	Ghanswangi	1106.977	190.901	49.939	0.751769	0.443873	0.381709	526	399	127	2.543103	12.21277	0.007805	0.991288	0.001739	574.9725	26.02396	128.1162	64.0581	4.487898
	Bhokardan	1206.499	276.61	59.102	0.663157	0.3454	0.198153	728	426	302	5.10981	216.2672	0.007782	2.350171	0.001779	562.1471	19.08102	128.5013	64.25065	4.374641
	Badnapur	757.723	194.495	44.545	0.697287	0.381867	0.251712	748	472	276	6.195982	31.72487	0.008161	2.252443	0.001847	541.415	17.21381	122.5336	61.26681	4.418501
	Ambad	1148.966	189.061	50.0935	0.763532	0.457872	0.403937	624	413	211	4.212123	86.41372	0.007522	1.587181	0.001756	569.6115	26.03921	132.9401	66.47006	4.284722
	Jalna District	7676.809	712.757	142.366	0.694447	0.378764	0.189892	748	398	350	2.458452	33.09279	0.008078	2.827467	0.001826	547.6569	47.65158	123.7857	61.89285	4.424234

(b)

	Parameters	TRI			TPI			Roughness			Slope		
	Name	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
	Partur	0	2.852091	10.63015	-3	-0.00284	3.625	0	2.413952	10	0	2.754997	12.60215
	Mantha	0	3.527215	23.19483	-4.375	-0.00015	4	0	3.139491	25	0	3.750856	32.16478
	Jalna	0	3.789989	27.44085	-5.625	0.008369	5.375	0	3.364569	28	0	3.929021	36.83593
	Jaffarabad	0	3.957906	29.74895	-4.25	-0.0056	4	0	3.515435	29	0	4.04934	40.71655
	Ghanswangi	0	2.984117	31.06445	-3	0.003602	4.125	0	2.547848	34	0	2.939222	43.08193
	Bhokardan	0	3.698626	71.94442	-4.125	-0.00931	4.75	0	3.258273	79	0	3.751231	98.88044
	Badnapur	0	4.215811	33.49627	-5	-0.0119	5.375	0	3.822847	38	0	4.525291	46.11173
	Ambad	0	3.2509	38.03945	-4.25	0.00016	6.125	0	2.821007	40	0	3.278312	51.01463
Jalna District	Jalna District	0	3.519895	46.13025	-8.75	0.676446	6.625	0	3.096814	48	0	3.601815	63.73862

Table -2: Various parameters of Aurangabad District

(a)

	Parameters																		
	Name	A	P	Lb	Re	Ff	Rc	Z	z	H	Rh	Mean Rb	D	Rn	Lū	Di	Dt	C	Lg	Fs
Aurangabad District	Aurangabad	1329.932	249.913	52.46	0.784407	0.483251	0.267585	925	519.25	405.75	7.734464	349.6709	0.923771	374.8202	0.233876	4.275762	21.01931	1.082519	0.54126	3.949826
	Phulambri	666.82	159.033	35.457	0.821783	0.530401	0.331317	875	600	275	7.755873	9.359581	0.799927	219.9798	0.297163	3.36516	11.28697	1.250115	0.625057	2.691881

	Gangapur	1315.494	232.776	51.883	0.788814	0.488696	0.305086	831.52	475	356.52	6.871615	20.46784	0.242232	86.36062	1.031246	0.969701	1.327456	4.12827	2.064135	0.234893
	Kannad	1500.118	327.399	60.19	0.726095	0.414073	0.175865	910.94	325	585.94	9.73484	22.28395	0.124257	72.80708	0.248865	4.01824	2.287728	8.047843	4.023922	0.499294
	Khuldabad	495.269	151.71	32.127	0.781638	0.479845	0.27041	915.819	554.56	361.259	11.24472	9.295964	1.000656	361.4961	0.259202	3.857997	12.60299	0.999344	0.499672	3.860528
	Paithan	1419.189	279.712	57.863	0.734639	0.423876	0.227944	775	425	350	6.04877	10.90969	0.406944	142.4303	0.597239	1.674372	3.457127	2.457342	1.228671	0.681375
	Sillod	1214.824	264.368	48.387	0.812799	0.518867	0.218427	875	425	450	9.300019	14.07407	0.095671	43.05216	0.264747	3.777189	1.660564	10.45244	5.226218	0.361369
	Soegaon	633.451	361.402	37.273	0.761934	0.455957	0.060946	817.138	282.15	534.988	14.35323	5.060606	0.149843	80.16404	0.266624	3.750606	0.985053	6.673666	3.336833	0.562001
	Vaijapur	1544.8	265.221	66.885	0.663075	0.345314	0.275973	625	475	150	2.242655	11.30757	0.400506	60.07584	0.674701	1.482138	3.457494	2.496844	1.248422	0.593604
	Aurangabad District	10122.19	878.52	136.068	0.834327	0.546717	0.164809	925	285.6098	639.3902	4.699049	20.66005	0.076621	48.99082	0.260522	3.838447	3.388654	13.05123	6.525613	0.294106

(b)

	Parameters	TRI			TPI			Roughness			Slope		
	Name	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Aurangabad District	Aurangabad	0	2.545623	40.05883	-4.04456	-0.00151	5.667297	0	0.519528	38.57758	0	4.643188	74.59223
	Phulambri	0	1.558637	24.86618	-4.04456	-0.00151	5.667297	0	1.57334	25.49286	0	2.859613	48.33992
	Gangapur	0	0.23842	41.12166	-4.04456	-0.00151	5.667297	0	0.245023	45.99207	0	0.446622	78.94583
	Kannad	0	2.797931	54.48167	-4.04456	-0.00151	5.667297	0	2.829362	51.65515	0	5.148088	106.9613
	Khuldabad	0	2.635734	48.94542	-4.04456	-0.00151	5.667297	0	2.677886	52.55383	0	4.844429	91.16573
	Paithan	0	0.509931	35.8415	-4.04456	-0.00151	5.667297	0	0.519528	38.57758	0	0.936859	69.8394
	Sillod	0	1.590496	58.12337	-4.04456	-0.00151	5.667297	0	1.610906	63.7359	0	2.922817	111.0717
	Soegaon	0	3.266963	49.01715	-4.04456	-0.00151	5.667297	0	3.30908	52.23846	0	6.002512	91.8401
	Vaijapur	0	0.312036	9.359804	-4.04456	-0.00151	5.667297	0	0.318748	9.487915	0	0.58217	18.25612
	Aurangabad District	0	1.572172	99.00346	-6.54742	-0.00155	4.9729	0	1.591557	95.95703	0	2.886522	188.6777

Table -3: Various parameters of Nanded District

(a)

	Parameters																			
	Name	A	P	Lb	Re	Ff	Rc	Z	z	H	Rh	Mean Rb	D	Rn	Lū	Di	Dt	C	Lg	Fs
Nanded District	Ardhapur	293.232	130.526	32.078	0.602356	0.284968	0.216285	525	350	175	5.455452	14.18878	0.205769	36.00954	0.250365	3.994166	1.846375	4.859823	2.429911	0.821875
	Bhokar	666.36	145.495	41.783	0.697124	0.381689	0.395569	537.068	375	162.068	3.878802	19.9554	0.829164	134.381	0.238464	4.193498	15.92495	1.206033	0.603017	3.477099
	Biloli	583.923	131.231	35.013	0.77876	0.476318	0.426081	450	350	100	2.856082	40.5	0.351692	35.16919	0.346309	2.887598	4.518749	2.843398	1.421699	1.015545
	Deglur	689.393	225.236	51	0.580923	0.265049	0.170766	625	350	275	5.392157	23.53968	0.362583	99.71025	0.325048	3.076468	3.414197	2.757991	1.378996	1.115474
	Dharamabad	333.939	124.098	30.29	0.680753	0.363973	0.272488	425	335.067	89.933	2.969066	5.260417	0.175008	15.739	0.572961	1.74532	0.821931	5.714024	2.857012	0.305445

	Hadgaon	1052.799	208.622	50.877	0.719625	0.406727	0.303973	550	383.15	166.85	3.279478	19.375	0.057663	9.621143	0.186221	5.369968	1.562635	17.34201	8.671007	0.309651
	Himayatnag	484.061	138.603	36.711	0.676253	0.359176	0.316639	525	375	150	4.085969	32.04722	0.4617	69.25501	0.242925	4.116497	6.637663	2.165908	1.082954	1.900587
	Kandhar	812.742	177.049	47.113	0.682796	0.36616	0.325818	525	375	150	3.183835	44.02668	0.777676	116.6514	0.259037	3.860454	13.7815	1.285882	0.642941	3.002183
	Kinwat	1531.867	330.818	77.608	0.569061	0.254336	0.175895	625	225	400	5.154108	17.40351	0.138166	55.26642	0.201765	4.956249	3.170928	7.237668	3.618834	0.684785
	Loha	864.385	253.222	56.644	0.585672	0.269401	0.1694	500	350	150	2.648118	21.23989	0.526997	79.0495	0.304294	3.286296	5.911809	1.897545	0.948773	1.731867
	Mahoor	519.16	126.339	35.781	0.718544	0.405505	0.40873	593.499	250	343.499	9.600039	18.3125	0.168528	57.8892	0.266747	3.748871	2.59619	5.933732	2.966866	0.63179
	Mudkhed	339.178	108.023	27.932	0.74399	0.434734	0.365262	500	350	150	5.370185	9.546053	0.338801	50.82022	0.340991	2.932628	3.119706	2.951581	1.475791	0.993579
	Mukhed	955.655	211.064	41.158	0.847523	0.564147	0.269577	550	375	175	4.251907	28.56772	0.608878	106.5536	0.270892	3.691502	10.17701	1.642366	0.821183	2.247673
	Nanded	409.274	129.722	30.655	0.744665	0.435523	0.305631	459.033	350	109.033	3.556777	10.74405	0.366363	39.9457	0.690982	1.447217	1.672808	2.729531	1.364765	0.530207
	Naigaon	576.352	149.556	36.449	0.743213	0.433827	0.32381	450	350	100	2.743559	11.34939	0.44008	44.008	0.416488	2.401031	4.072053	2.272314	1.136157	1.056646
	Umri	420.026	136.719	28.315	0.816726	0.523894	0.282376	500	350	150	5.297545	24.29517	0.570472	85.57077	0.307591	3.251076	5.697818	1.752935	0.876467	1.854647
	Nanded District	10532.35	1070.138	156.904	0.738046	0.427816	0.115573	625	225	400	2.54933	92.7994	0.067521	27.00845	0.217213	4.603772	3.059419	14.81018	7.405089	0.310852

(b)

	Parameters	TRI			TPI			Roughness			Slope		
	Name	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Nanded District	Ardhapur	0	0.45061	19.57698	-3.22141	-0.00263	3.585175	0	0.460992	20.73019	0	0.822333	36.24081
	Bhokar	0	1.676947	22.22042	-3.13638	0.002973	3.650146	0	1.68778	23.7937	0	3.044998	41.22811
	Biloli	0	0.676238	17.7648	-2.07031	-0.00033	2.72998	0	0.685503	19.12146	0	1.242775	33.02724
	Deglur	0	0.636281	9.241772	-1.17053	0.0002	1.276428	0	0.653666	10.56036	0	1.175564	17.57597

	Dharamabad	0	0.197848	6.082922	-0.68094	-9.7E-05	0.549469	0	0.202413	4.976685	0	0.370001	11.78624
	Hadgaon	0	1.122073	19.49056	-2.30154	0.00099	3.028259	0	1.127008	21.39862	0	2.036141	36.48571
	Himayatnag	0	1.005903	19.96122	-2.5498	0.000734	3.049347	0	1.01037	21.4946	0	1.81848	36.80602
	Kandhar	0	1.517709	15.80112	-1.89066	0.000705	1.99527	0	1.542711	17.58249	0	2.779059	29.47951
	Kinwat	0	2.884287	30.19187	-4.25214	-0.00062	4.377625	0	2.904035	33.11859	0	5.252353	58.8378
	Loha	0	0.953881	18.49559	-2.20288	0.000136	2.418121	0	0.967088	19.2363	0	1.750733	35.80736
	Mahoor	0	2.992052	27.52614	-3.54645	0.002545	5.533325	0	3.019155	31.11472	0	5.457888	51.2065
	Mudkhed	0	0.521402	16.30884	-1.79117	-0.00109	2.878601	0	0.532636	17.26584	0	0.965734	30.46002
	Mukhed	0	1.143754	10.75124	-1.52774	0.0024	1.717621	0	1.159551	12.38654	0	2.096186	20.24812
	Nanded	0	0.277221	14.9984	-1.28799	-0.00018	2.495911	0	0.280862	15.50009	0	0.518033	28.77366
	Naigaon	0	0.625775	13.61186	-1.55356	0.000163	1.620209	0	0.638438	14.57156	0	1.155961	26.31985
	Umri	0	1.073709	15.31889	-2.07657	0.001507	3.155121	0	1.08731	16.96185	0	1.973552	29.64006
	Nanded District	0	1.348954	28.607	-4.64655	-0.00075	5.082214	0	1.362246	32.50504	0	2.463643	53.33582

Table -4: Various parameters of Beed District
(a)

	Parameters Name	A	P	Lb	Re	Ff	Rc	Z	z	H	Rh	Mean Rb	D	Rn	Lū	Di	Dt	C	Lg	Fs
Beed District	Ambajogai	862.095	264.831	50.732	0.653056	0.334959	0.154464	700	475	225	4.435071	16.92661	0.490928	110.4589	0.216484	4.619271	7.382066	2.036957	1.018478	2.267732
	Ashti	1472.008	331.144	58.843	0.735725	0.425129	0.168689	875	550	325	5.523172	18.64485	0.773901	251.5177	0.259555	3.852744	13.25405	1.292155	0.646078	2.981641
	Beed	1418.236	318.175	59.76	0.71108	0.397125	0.176046	775	450	325	5.43842	13.23534	0.566567	184.1343	0.211343	4.731645	11.9494	1.765016	0.882508	2.680795

	Dharur	357.1	157.275	29.06	0.733761	0.422862	0.181418	750	435.6559	314.3441	10.81707	14.32368	0.992313	311.9278	0.143813	6.953479	15.66683	1.007746	0.503873	6.900028
	Georai	1454.104	261.885	46.736	0.920664	0.665721	0.266431	675	425	250	5.349195	85.26807	0.342912	85.72788	0.541988	1.845059	3.512992	2.916204	1.458102	0.632692
	Kaij	1184.967	238.266	56.243	0.690621	0.374601	0.262296	750	625	125	2.222499	12.13777	0.415602	51.95029	0.276516	3.616427	7.474839	2.406147	1.203073	1.502995
	Majalgoan	905.882	209.082	47.256	0.718677	0.405656	0.260404	475	400	75	1.5871	9.448333	0.286955	21.52159	0.790112	1.265643	1.573545	3.484872	1.742436	0.363182
	Parli	781.262	265.162	51.739	0.609587	0.291851	0.139632	650	377.08	272.92	5.274938	33.16244	0.604481	164.9749	0.203735	4.908334	8.741826	1.654312	0.827156	2.966994
	Patoda	768.851	242.652	47.111	0.664131	0.346416	0.164091	875	550	325	6.898601	20.90909	0.081048	26.34067	0.129282	7.735019	1.986384	12.33833	6.169167	0.62691
	Shirur	646.943	237.42	38.314	0.749084	0.440708	0.144225	800	500	300	7.830036	19	0.10349	31.04694	0.223173	4.480822	1.263584	9.662788	4.831394	0.463719
	Wadwani	755.851	282.673	47.535	0.652619	0.33451	0.118871	725	431.3549	293.6451	6.17745	15.76188	0.859123	252.2773	0.19361	5.165014	11.8653	1.163978	0.581989	4.437382
	Beed District	10607.3	946.217	201.159	0.577721	0.262136	0.148879	875	376.9944	498.0056	2.475681	22.33758	0.059821	29.79123	0.173182	5.774262	3.872262	16.71652	8.358259	0.345423

(b)

	Parameters	TRI			TPI			Roughness			Slope		
	Name	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Beed District	Ambajogai	0	23.38857	1.067297	-2.90808	-0.0002	3.653259	0	1.065221	24.474	0	1.922716	43.23098
	Ashti	0	28.75503	1.666993	-3.52484	0.00125	4.348877	0	1.696389	32.32275	0	3.062889	53.22574
	Beed	0	27.4079	1.420951	-3.74072	0.000797	4.473145	0	1.42417	30.31146	0	2.574525	53.46561
	Dharur	0	26.07636	3.365719	-3.83435	-0.0087	4.126465	0	3.330783	28.91467	0	6.003824	49.97718
	Georai	0	21.98356	0.482531	-1.68561	0.000347	2.456787	0	0.494144	24.75769	0	0.893169	41.31954
	Kaij	0	21.35493	0.770313	-2.88232	-0.00065	3.200256	0	0.772469	23.01355	0	1.39881	41.19627
	Majalgoan	0	3.175632	0.237826	-0.46506	2.19E-05	0.339569	0	0.244783	3.678345	0	0.446492	5.961999
	Parli	0	19.93802	1.395316	-2.87372	3.095093	3.095093	0	1.397695	22.21466	0	2.526357	38.04466
	Patoda	0	27.37329	2.192213	-3.76599	0.003542	4.247986	0	2.202138	28.50812	0	3.970078	53.09391
	Shirur	0	22.94627	1.808688	-2.77478	-0.00165	3.042053	0	1.827823	25.50507	0	3.296707	44.35032
	Wadwani	0	32.22334	2.288701	-8.23389	0.000299	4.921631	0	2.282698	30.35712	0	4.109054	56.91376
	Beed District	0	27.65002	1.333749	-4.92303	0.000403	5.169495	0	1.343248	31.18036	0	2.421805	51.51793

3. CONCLUSIONS

Based on above results, following are the conclusions for Jalna district:

1. Jafferabad, having the minimum area and drainage density, is likely to have higher water retention and thus, lower drought risk.
2. Bhokardan, having the maximum area, circularity ratio, and basin relief, is likely to have quicker drainage and thus, higher drought risk.
3. Partur, having the minimum perimeter, mean TRI, mean roughness, elongation ratio, form factor, basin relief, relief ratio, and stream length, is likely to have higher water retention and thus, lower drought risk.
4. Badnapur, having the maximum mean TPI, mean TRI, and relief ratio, is likely to have quicker drainage and thus, higher drought risk.
5. Ambad, having the maximum elongation ratio, form factor, and circularity ratio, is likely to have quicker drainage and thus, higher drought risk.
6. Ghansawangi, having the minimum mean bifurcation ratio, ruggedness number, and stream order, is likely to have higher water retention and thus, lower drought risk.
7. Jalna, having the maximum mean TPI, ruggedness number, stream length, drainage density, and drainage texture, is likely to have quicker drainage and thus, higher drought risk.
8. Mantha, having the minimum drainage intensity, is likely to have higher water retention and thus, lower drought risk.

Following are the conclusions for Aurangabad district:

1. Khuldabad, having the minimum area, drainage density, and length of overland flow, is likely to have higher water retention and thus, lower drought risk.
2. Vaijapur, having the maximum area, elongation ratio, and form factor, is likely to have quicker drainage and thus, higher drought risk.
3. Soegaon, having the maximum perimeter, mean TRI, mean roughness, circularity ratio, relief ratio, and drainage texture, is likely to have quicker drainage and thus, higher drought risk.
4. Gangapur, having the minimum mean TRI, mean roughness, stream frequency, drainage intensity, is likely to have higher water retention and thus, lower drought risk.
5. Phulambri, having the maximum elongation ratio, form factor, and circularity ratio, is likely to have quicker drainage and thus, higher drought risk.
6. Kannad, having the maximum basin relief, is likely to have quicker drainage and thus, higher drought risk.
7. Ghansawangi, having the minimum mean bifurcation ratio, is likely to have higher water retention and thus, lower drought risk.
8. Sillod, having the minimum ruggedness number, drainage density, and maximum constant channel of maintenance, is likely to have higher water retention and thus, lower drought risk.
9. Aurangabad, having the maximum ruggedness number, stream order, stream length, stream frequency, drainage intensity, and drainage texture, is likely to have quicker drainage and thus, higher drought risk.

Following are the conclusions for Nanded district:

1. Ardhapur, having the minimum area, perimeter, and mean TPI, is likely to have higher water retention and thus, lower drought risk.
2. Kinwat, having the maximum area, elongation ratio, form factor, and basin relief, is likely to have quicker drainage and thus, higher drought risk.
3. Mudkhed, having the maximum perimeter, is likely to have quicker drainage and thus, higher drought risk.
4. Bhokar, having the maximum mean TPI, ruggedness number, and drainage texture, is likely to have quicker drainage and thus, higher drought risk.
5. Dharamabad, having the minimum mean TRI, mean roughness, stream frequency, mean bifurcation ratio, and drainage texture, is likely to have higher water retention and thus, lower drought risk.
6. Mahoor, having the maximum mean TRI, mean roughness, and relief ratio, is likely to have quicker drainage and thus, higher drought risk.
7. Mukhed, having the maximum elongation ratio and form factor, is likely to have quicker drainage and thus, higher drought risk.
8. Loha, having the minimum circularity ratio and relief ratio, is likely to have higher water retention and thus, lower drought risk.
9. Biloli, having the maximum circularity ratio, is likely to have quicker drainage and thus, higher drought risk.
10. Kinwat, having the maximum basin relief and minimum stream order, is likely to have quicker drainage and thus, higher drought risk.

11. Kandhar, having the maximum mean bifurcation ratio, is likely to have quicker drainage and thus, higher drought risk.
12. Hadgaon, having the minimum ruggedness number, stream order, stream length, drainage density, and maximum length of overland flow, is likely to have higher water retention and thus, lower drought risk.
13. Nanded, having the maximum stream length and minimum drainage intensity, is likely to have higher water retention and thus, lower drought risk.
14. Bhokar, having the maximum stream frequency, drainage density, drainage texture, and minimum constant channel of maintenance, is likely to have quicker drainage and thus, higher drought risk.

Following are the conclusions for Beed district:

1. Dharur, having the minimum area, perimeter, mean TPI, mean roughness, constant channel of maintenance, and length of overland flow, is likely to have higher water retention and thus, lower drought risk.
2. Ashti, having the maximum area, perimeter, and basin relief, is likely to have quicker drainage and thus, higher drought risk.
3. Parli, having the maximum mean TPI, elongation ratio, form factor, and circularity ratio, is likely to have quicker drainage and thus, higher drought risk.
4. Majalgoan, having the minimum mean TRI, mean roughness, basin relief, relief ratio, mean bifurcation ratio, ruggedness number, stream frequency, drainage intensity, and drainage texture, is likely to have higher water retention and thus, lower drought risk.
5. Wadwani, having the maximum mean TRI and minimum circularity ratio, is likely to have higher water retention and thus, lower drought risk.
6. Georai, having the maximum elongation ratio, form factor, and mean bifurcation ratio, is likely to have quicker drainage and thus, higher drought risk.
7. Beed and Patoda, having the maximum basin relief, are likely to have quicker drainage and thus, higher drought risk.
8. Dharur, having the maximum relief ratio, ruggedness number, stream frequency, drainage density, drainage texture, and minimum length of overland flow, is likely to have quicker drainage and thus, higher drought risk.
9. Patoda, having the minimum stream length, drainage density, and maximum constant channel of maintenance, is likely to have higher water retention and thus, lower drought risk.
10. Shirur, having the minimum drainage texture, is likely to have higher water retention and thus, lower drought risk.

ACKNOWLEDGEMENT (Optional)

The authors are thankful to Dr. K. N. Nandurkar, Principal, KKWIEER, Dr. S. Y. Kute, Dean, KKWIEER, and Dr. P. D. Jadhao, HOD, Department of Civil Engineering, KKWIEER. The authors are also thankful to the people who knowingly and unknowingly helped them with this paper.

REFERENCES

[1] Mohd.Sayeed Ul Hasan, Kalyan Adhikari and Soumya Bhattacharyya. Morphometric Analysis using Remote Sensing and GIS. JCEET. 2017; 4(1): 17-22p
[2] R. E. Horton. Drainage basin characteristics. Eos. 1932; 13:350–361p
[3] Rabu, P. P., & Askaran, R. B. Drainage Morphometry of Upper Vaigai River Sub-basin , Western Ghats , South India Using Remote Sensing and GIS.GEOSOCINDIA. 2013; 82:519–528p
[4] Gajbhiye, S., & Ashish, S. K. M. Prioritizing erosion prone area through morphometric analysis : an RS and GIS perspective. Applied Water Science 2014; 4: 51–61p. http://doi.org/10.1007/s13201-013-0129-7
[5] Agarwal, R., Garg, P. K., & Garg, R. D. (2013). Remote Sensing and GIS Based Approach for Identification of Artificial Recharge Sites. Water Resources Management volume 2013; 27: 2671–2689p http://doi.org/10.1007/s11269-013-0310-7
[6] Shrudha, V. K. , Hafeezunnisa. ESTIMATION OF MORPHOMETRIC PARAMETERS AND RUNOFF USING RS & GIS TECHNIQUES. IRJET 2013; IC-RICE Conference Issue : 449–455p
[7] S. A. Schumms. Evolution of drainage systems and slopes in Badlands at Perth Amboy, New Jersey. Geol. Soc. Am. Bull. 1956; 67: 597–646p
[8] Miller VG (1953) .A quantitative geomorphic study of the drainage basin characteristics in the Clinch Mountain area, Virginia and Tennessee. IJG 1953 ; 5(13): 389-042p
[9] A. Strahler. Quantitative analysis of watershed geomorphology. Eos 1957; 38: 913–920p
[10] R. E. Horton. Erosional development of streams and their drainage basins: hydrophysical approach to quantitative morphology. Geol. Soc. Am. Bull. 1945; 56:275–370p

[11] A. N. Strahler. Quantitative geomorphology of drainage basins and channel networks. Handbook of Applied Hydrology 1964; V.T. Chow, Ed: section 4–11
[12] Melton MA. An analysis of the relation among elements of climate, surface properties and geomorphology. Technical Office of National Research 1957; project NR: 389–642p
[13] Faniran, A. The Index of Drainage Intensity - A Provisional New Drainage Factor. AJBAS. 1968 ;31: 328-330p
[14] G S Deepa Varghese, Mohandas Chadaga, U A Lathashri, Surumi Rasia Salim. Morphometric Analysis by Using Remote Sensing & QGIS Approach to Evaluate the Aquifer Response of Two Sub Watersheds of Coastal Kerala. IOP Conf. Series: Earth and Environmental Science 987 (2022) 012018
[15] Abdul Qadir, Mohammad Yasir, Ismail Ahmad Abir, Naseem Akhtar, Lim Hwee San. Quantitative Morphometric Analysis Using Remote Sensing and GIS Techniques for Mandakini River Basin. IOP Conf. Series: Earth and Environmental Science 540 (2020) 012021
[16] Abhishek Jain, Manjeet Singh, P. K. Singh and K. K. Yadav. Morphometric Analysis of Kakan Watershed using Remote Sensing and GIS. IJCMAS 2020; 9(12)
[17] N. Sahoo, B. Panigrahi, J.C. Paul and B.P. Behera. Assessment of Morphometric Parameters in Baitarani Basin using Remote Sensing and GIS. IJCMAS 2019; 8(08)
[18] Mohamed ElKashouty. Watershed delineation and morphometric analysis using remote sensing and GIS mapping techniques in Qena-Safaga-Bir Queh, Central Eastern Desert. IJCMAS 2020; 12(2): 22-46p
[19] Sandeep Adhikari. Morphometric Analysis of a Drainage Basin: A Study of Ghatganga River, Bajhang District, Nepal. The Geographic Base 2020; 7: 127-144p
[20] Asaad A. M. Al-Hussein, Abdulrahman A. Yahyaa. Morphometric Characteristics of Wadi Koysenjaq Basin In Erbil Using GIS. INJES 2019; 19(2): 15-40p
[21] R. S. Shelar and S. S. Mane. Morphometric Analysis of the Nira River Basin in Maharashtra State, India using Geographical Information System. IJCMAS 2019; 8(11)
[22] Mahmoud H. Ashmawy, Mohamed A. Abd El-Wahed, Samir Z. Kamh and Aly Shebl. Comparative study of the drainage basin morphometry extracted from topographic maps and SRTM DEMs: an example from Ghadir watershed, Eastern Desert, Egypt. Sci JBAS 2018;39: 52- 64p
[23] B.D. Premanand, U. Satishkumar, B. Maheshwara Babu, S.K. Parasappa, Mallikarjuna M. Dandu, Ibrahim Kaleel, N.L. Rajesh and S.A. Biradar. Morphometric Analysis of Patapur Micro-watershed in North-Eastern Dry Zone of Karnataka Using Geographical Information System: A Case Study. IJCMAS 2018; 7(04)
[24] Keshav Basnet, Er. Ram Chandra Paudel and Bikash Sherchan. Analysis of Watersheds in Gandaki Province, Nepal Using QGIS. TECHNICAL JOURNAL 2019; 1(1)
[25] Imelida Torrefranca & Roland Emerito Otadoy. GIS-based watershed characterization and morphometric analysis in Bohol Watersheds, Philippines. Geol. ecol. Landsc. 2022; DOI:10.1080/24749508.2022.2158554
[26] Mujtaba Ismail, Harmeet Singh, Ishfaq Farooq, Nahida Yousuf. Quantitative morphometric analysis of Veshav and Rembi Ara watersheds, India, using quantum GIS. Appl. Geomat. SIFET 2022 https://doi.org/10.1007/s12518-022-00417-3
[27] Abrar Yousuf, Shabnam Ara, Shaik Iftikhar Ahmad, Ramashray Prasad, BR Thakur. Remote Sensing and GIS based Morphometric Analysis of a Microwatershed. 2020
[28] HAZIR S. ÇADRAKU. MORPHOMETRIC ANALYSIS OF LLAP RIVER WATERSHED (KOSOVO)", Rev. Roum. Géogr./Rom. Journ. Geogr. 2023; 67(1): 33–49p, 2023. DOI: 10.59277/RRG.2023.1.04
[29] Dr. Sahil Salvi, Dr. Sudarshan Bobade, Mrs. Anuja Rajgopalan, Suraj Ahire, Anuj Jadhav, Shubhangi Waghmare, Shravani Patil. MORPHOMETRIC ANALYSIS OF SINA RIVER BASIN AT MIDSANGAVI USING RS & GIS. Eur. Chem. Bull. 2023;12(Special Issue 5): 2630-2652p
[30] Ramesh Kumar Patel, Vineet Kumar Rai, Dhiraj Kumar Sharma, and Satya Prakash. Evaluation of Morphometric Analysis of Kharag River Basin, Odisha Using Geospatial Techniques. 2023. DOI: 10.1007/978-981-99-3660-1
[31] R.R. Ahire, S.G. Wagh, A.V. Dudhekar. Study of Morphometric and Topographic Parameters of Nashik District and Its Talukas Using GIS Tool. International Journal of Water Resource Engineering and Management. 2023; 10(2): 39–49p.