Journal of Geomatics Vol. 18, No. 1, April 2024

Investigation of Morphometric and Flood Vulnerability of the Devganga River Basin in Satpura Mountain Ranges Using Remote Sensing Techniques

Mohan Vasave, Sandip Garud
Department of Geography, Arts, Commerce & Science College Nandurbar, Maharashtra- 425413.
*Email: mohanvasavegeo@gmail.com

(Received on 30 December 2023; in final form 14 April 2024)

***DOI**: https://doi.org/10.58825/jog.2024.18.1.128*

Abstract: The investigation of morphometric factors offers a identify map regarding geomorphic features and hydrological behavior of a drainage basin, principally in regions where hydrological data are quite as less as of evaluating stations or not proper accessibility caused by challenging topographic conditions. To investigate the hydro-geomorphic features of the Devganga basin in Northern Satpura Mountains is the goal of the present study. The Devganga River Basin's morphometric features have been measured and computed using Arc GIS 10.4 environment and remote sensing techniques. Devganga river basin covers an area of 319 sq km. The Devganga River Basin has 2.95 sq. km of stream frequency. In the dendritic drainage system, there is a significant chance of flooding during periods of heavy rainfall. The primary factor in the creation of stream segments is monsoonal rainfall. With a texture ratio of 9.18, the Devganga River Basin has a very coarse drainage texture. The character of this river basin has been highly elongated. Several stream segments in the studied area demonstrate how surface runoff erodes the soil, and ravage substances accumulated at the bottom of the river, increasing the channel deepness and inducing floods during the rainy season. India has massive annual damage from floods, an alarming natural risk. The AHP approach has been applied to create a map of the Devganga River Basin, which shows flood vulnerablity . It is made by combining a few morphometric characteristics with other flood-influencing characteristics. We can conclude that there is a high risk of flooding in the lower part of river basin.

Keywords: Morphometric, Flood, Mountain, Basin, Natural risk.

1. Introduction

Morphometry could be described as the scientific quantification of the characteristics, forms, & formations of landforms on our planet. To make the conclusions for specific characteristics of a region, the investigation technique is required, which is fulfilled by the morphometry's quantitative factors. For instance; tectonic activity, flood movement, surface runoff, and soil erosion. A drainage basin's morphometry is a quantitative technique that analyzes every facet of the drainage system, including the density of stream, bifurcation ratio, relief, slope, with the strean order, length, and stream's form. It also provides a great deal of information about the basin's hydrological and geological characteristics. A drainage basin's geographical characteristics must be taken into consideration to prevent unsustainable water use and hydrological issues. When adequate hydrological and climatic condition are unavailable, morphometric analysis can be a helpful technique in a watershed for evaluating the risk of hydrological hazards and disasters like flash floods (Adnan et al., 2019).

But unforeseen construction projects disrupt the normal hydrological cycle of a river basin, leading to geo-environmental events that aren't always steady. The geophysical situations of a certain location, however, are a major factor in the regional variation in drainage basin morphology. There are a lot of river basins where human activities pose serious threats to the environment, water supply, and water quality. The Devganga river basin, a important water source for the northern part of Satpura mountain ranges in the Nandurbar district of Maharashtra, India, contributes significantly to the Narmada River. There is plenty of water in the Satpura mountain ranges in the North Nandurbar district to supply the needs of the sessional rivers. Our work centers around the hydrological and morphometric factors of the steep Devganga River, which are extensively unresearched and innovative. Therefore, the key goal of analysis is the investigation of hydrogeomorphic properties of a small mountainous river basin using morphometric parameter analysis. The work is based on the Geographical Information System (GIS) techniques and remote sensing data. Computation of all the significant hydro-morphometric aspects is very useful when deciding how to manage flooding and determine the likelihood the watershed has an excess or shortage of water.

2. The Study Region

The Devganga river basin in the north satpura mountains is the study region for hydro morphometric characteristics. The basin has a total coverage approximately of 319.84 km^2 and stretches over the northern part of Nandurbar, Maharashtra. The Devganga river is present at the left-bank basin branch of Narmada basin, flowing through the 663-meter-high Reni hill, which is a part of the Dab hills in the Satpura mountain ranges. The basin extends from longitudes 74°1′30" E to 74°10′30" E, and latitudes 21°45′00" N (Figure 1). The Devganga River flows along a deep, narrow channel for 40.49 km, from southwest to northeast. The region has hot summers and year-round dryness, except for the June to September southwest monsoon season. Usual minimum temperature is 15.8°C, while usual maximum temperature is 40.7°C. Every year, district as a whole receives about 1068 mm of rain. During the monsoon season, the total rainfall is almost 80%. The remaining duration runs from December to February, and July to September. The study area experience heavy rainfall throughout the year; it is mainly concentrated during the monsoon season. These climate factors create seasonal fluctuations in the Devganga River's and its tributaries' flow, which in turn causes seasonal variations in the basin's hydraulic force-induced denudation processes.

3. Material & Methods:

The present investigations focus on the Devganga River's morphological assessment. When it is used for morphometric analysis, data from the Shuttle Radar Topography Mission-Digital Elevation Model (SRTM-DEM) prove to be more precise and dependable. Geographical information system based morphometric analysis and Remote Sensing techniques have advanced significantly in accuracy and quality During the last several years. Using digital elevation model (DEM) stats at http://earthexplorer.usgs.gov (30m), present geometric circumstances of the Devganga stream were investigated. River basin's morphometric study may reveal the soil's permeability and perviability, rock structure type, and the geo-hydrological conditions of the area.

The SRTM-DEM has been utilized to extract data relating to morphometrics, the river, and the water channel system for the Arc GIS 10.4 software. Table 1 shows the outcomes of the evaluation of the Devganga stream's longitudinal, spatial, and terrain aspects. River Devganga was identified using Strahler's stream ordering method.

A river basin's morphometric analysis can be conducted more accurately using Strahler's segmentation method, as shown by several recent research (Rai et al., 2017).

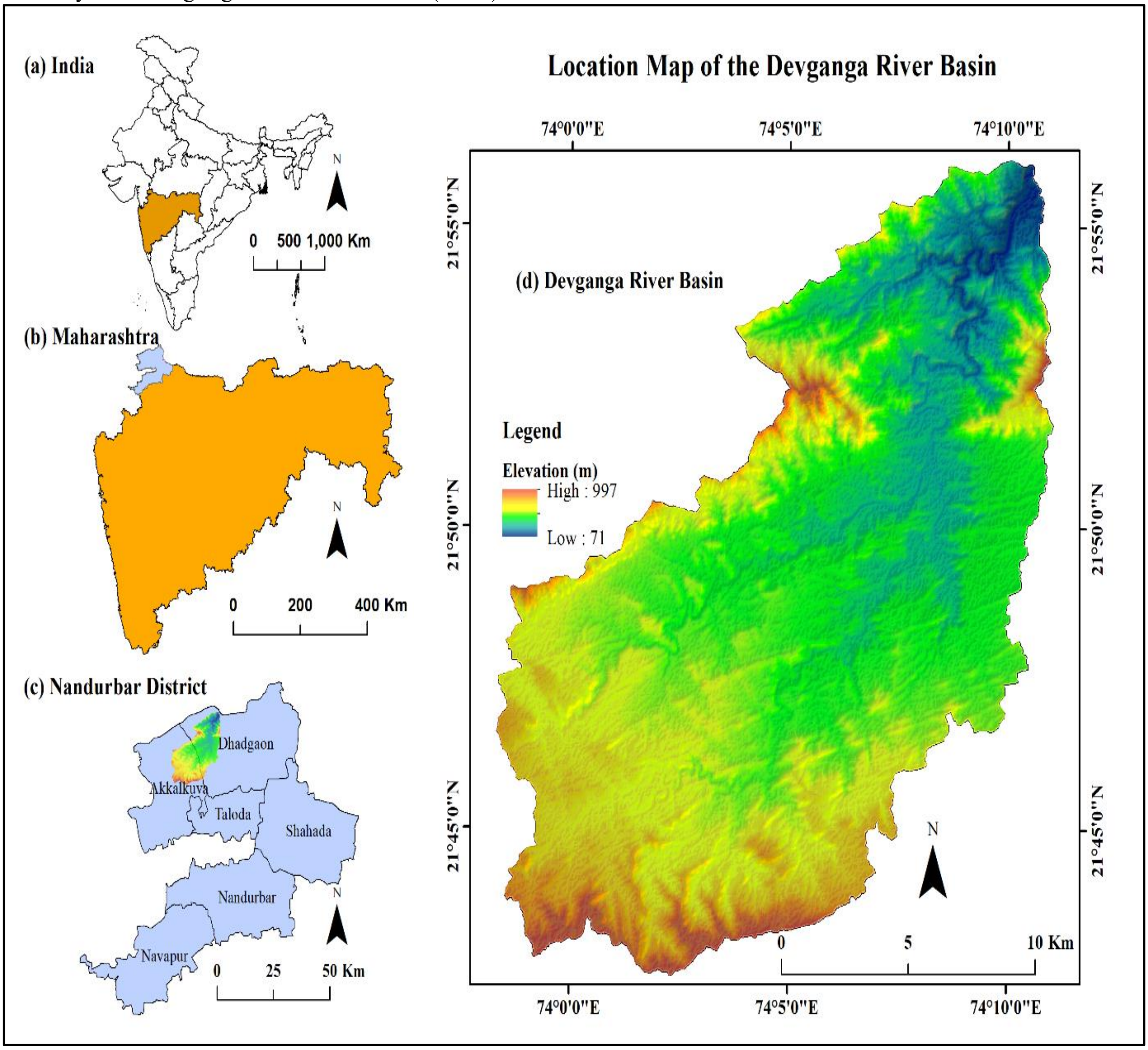

Figure 1. Location map of the study region.

Table 1. Data types, sources and uses in mapping and analysis the thenmatic layes in Devganga river basin

Sr. No	Date Type	Resulation / Types /Scale	Data utilized for Paramiter Morphometric and Flood Vulnerability	Data Sources
1	SRTM DEM	30 m	Elevation, Slope, stream order and Drainage Density	https://earthxpolar.usgs.gov
2	Landsate Satellite 8 Data	30 m	NDVI, NDWI and LULC	https://earthxpolar.usgs.gov.
3	Rainfall Data Grided binary formate	0.25 x 0.25	Average Rainfall in 2020 and 2022	The Indian Metrological Department (IMD) in Pune. https://www.imdpune.gov.in
4	Flood Inventory Map	1.250,000	Flood Hazard in 2020 and 2022	https://bhuvan.nrsc.gov.in
5	Flood Hazard Data	GPS Groud Trouth Point	Model Velidation	Garmin (30) GPS, Flied Survey in 2022

All types of data in table 1, are used for morphometric and flood vulnerability analysis. A map for flood caution was made by using the Analytical Hierarchy Process way for the Devganga river basin by merging many flood-influencing elements with a few morphometric metrics. Several morphometric parameters are measured using the methods stated by Horton (1932, 1945): stated in the table 2. Calculations have been performed using seven factors from the linear aspect, 20 from the areal aspect, and eight from the relief aspect to determine the basin features of the Devganga River.

4. Result and Discussion:

Mathematical assessment of hydrological zone by utilization of morphometric factors is the basis for the geological and morphological state of the river. Understanding the geometry of the r basin's river, its rock hardness, the rock's structure, and the present process can be informative (Strahler, 1964). To manage and use water resources properly, this analysis is crucial. The Devganga River Basin was the sigabificance part of a morphometric study using SRTM-DEM with 30*30m spatial resolution. The volume, height, gradient, and basin features of the river channel are described mathematically (Clark, 1966). Measurements of the linear, areal, and relief aspects of the basin, have been used to examine the morphometric features of Devganga River Basin. Morphometric measures, computations, and descriptions are as follows:

4.1. Linear Aspects:

This study uses a wide variety of methods developed by many authors to calculate linear parameters , shown in table 2.

4.1.1. Order of Stream and Number of Stream (Nu) :

The order of stream explains about starting and the path of a stream. In the stream hierarchy, it is sometimes referred to as stream position measurement (Horton, 1945; Strahler, 1957). Investigation regarding morphometricity begins with this vital first stage. For comprehension of features of the watershed, this parameter is essential. Stream ranks were determined using the stream ordering approach, as recommended by Strahler (1964). Consistent soil texture is revealed by the dendritic watershed way of the Devganga Basin River. Its structural control is low (Figure 2). Numerous stream order parameters are essential for basin feature research. A higher stream rank suggests a higher discharge in the lowest portion of this basin. There are 946 segments of streams in the research region, which is a sixth-order drainage basin (Table 3). The gentler topography and higher elevation of the basin make floods a greater possibility.

The current study records a maximum of 669 streams in the 1^{st} order, 205 in the 2^{nd} , 58 in the 3^{rd} , 10 in the 4^{th} , 3 in the 5^{th} , and a meager 1 in the 6^{th} . As stream order increases, there is significant decline in the stream's number. The stream count and sequence are illustrated in table 2.

4.1.2. Length of Stream (Lu) :

There are much fewer streams as stream order rises. The quantity and stream's rank are displayed in table 3. The cumulative stream length across different orders of stream, following the measurement along with computation of the stream length using Arc GIS 10.4 are shown in table 4. One of the most important hydrological measurements for comprehending runoff properties in a river basin is the length of the stream. In general, shorter streams indicate a finer-textured, steeper gradient slope, while longer streams show a flatter river plain (Strahler, 1964). The SRTM-DEM has produced a summed length of stream as 760.52

km, encompassing 371.50 km is in the first order. The second order has 197.51 km, with 94.44 km in the third order, 47.19 km i fourth order, 9.38 km in 5th order, and 40.49 km in the 6th order. Order of stream increased as stream length dropped according to the law of stream length. If this condition is violated, the river basin's terrain has a steep or moderate gradient. With the rise in the stream's number in the Devganga River the overall stream's length also increases but on different orders. The Horton (1945) method was utilized in this study to calculate the stream lengths that are shown in table 4.

Table 2. Techniques for determining various morphometric features of the Devganga river basin.

Aspect	Parameters	Formula/ Symbols	Result
Linear Aspect	Number of the stream order μ	N_μ	1-6
	Total number of the steams in the basin	$(\Sigma N)_\mu$	946
	Bifurcation ratio of river basin	$R_{b=}N_{\mu/N_{\mu+1}}$	3.0 - 5.80
	Total stream length of order μ of the river	L_μ	760.52
	Mean stream length of the stream order	$\bar{l}_\mu = L_\mu N_\mu$	8.58
	Stream length ratio of the river basin	$RL = \bar{l}_\mu, \bar{l}_{\mu-1}$	0.20 - 4.31
	Rho coefficient (Rho)	q =Rl / Rb	0.06 - 1.44
Areal Aspect	Area of the order μ	A_μ	319.84
	Length of the basin of order μ	Lb_μ	31.19
	Width of the basin of order μ	Br_μ	10.25
	Basin perimeter of order	P_μ	103.06
	Basin form factor	$F = A/Lb^2$	0.33
	Basin circulatory ratio	$R_{c=}4\Pi A/P^2$	0.38
	Compactness Coefficient (Cc)	$Cc = 0.2841^*P/A0.5$	1.64
	Basin elongation ratio	$R_e = (2\sqrt{A}/\Pi)/Lb$	0.64
	Drainage density (Dd)	$D_\mu = \left(\Sigma L_\mu \Sigma A\mu\right)$	2.38
	Stream frequency (Fs)	$F_\mu = \left(\Sigma N_\mu, \Sigma A\mu\right)$	2.95
	Infiltration Number (If)	$If\ = Fs^*Dd$	7.03
	Length of overland flow (Lg)	$Lg = 1/Dd^*2$	0.21
	Constant channel maintenance (sq Kms/km)	$C = 1/D_\mu$	0.42
	Texture ratio	$T_{\mu=}N_\mu/P_\mu$	9.18
Relief Aspect	Height of the highest point on the watershed	Z	937
	Height on basin mouth	z	12.39
	Total basin relief	H=Z-z	924.61
	Relative Relief	$Rr = H_{1-}H_2$	49-357
	Relief ratio	Rh=H/Lb	29.64
	Dissection Index	$DI = H_{1-}H_2, H_1$	0.12-0.89
	Ruggedness number	Rn=DxH/1000	2.20
	Melton Ruggedness Number (MRn)	$MRn = H/A0.5$	51.70

Table 3. A table for calculating the number of streams (Nu), the average ratio of bifurcation, order of stream (Su), and ratio of bifurcation (Rb), Nu-r number of the Devganga river basin.

Su	Nu	Rb	Nu-r	Rb × Nu-r	Rbwm
1st	669	--	--	--	3.46
2nd	205	3.26	874	2852	
3rd	58	3.53	263	930	
4th	10	5.80	68	394	
5th	03	3.33	13	43	
6th	01	3.00	4	12	
Total	946	18.93	1222	4232	

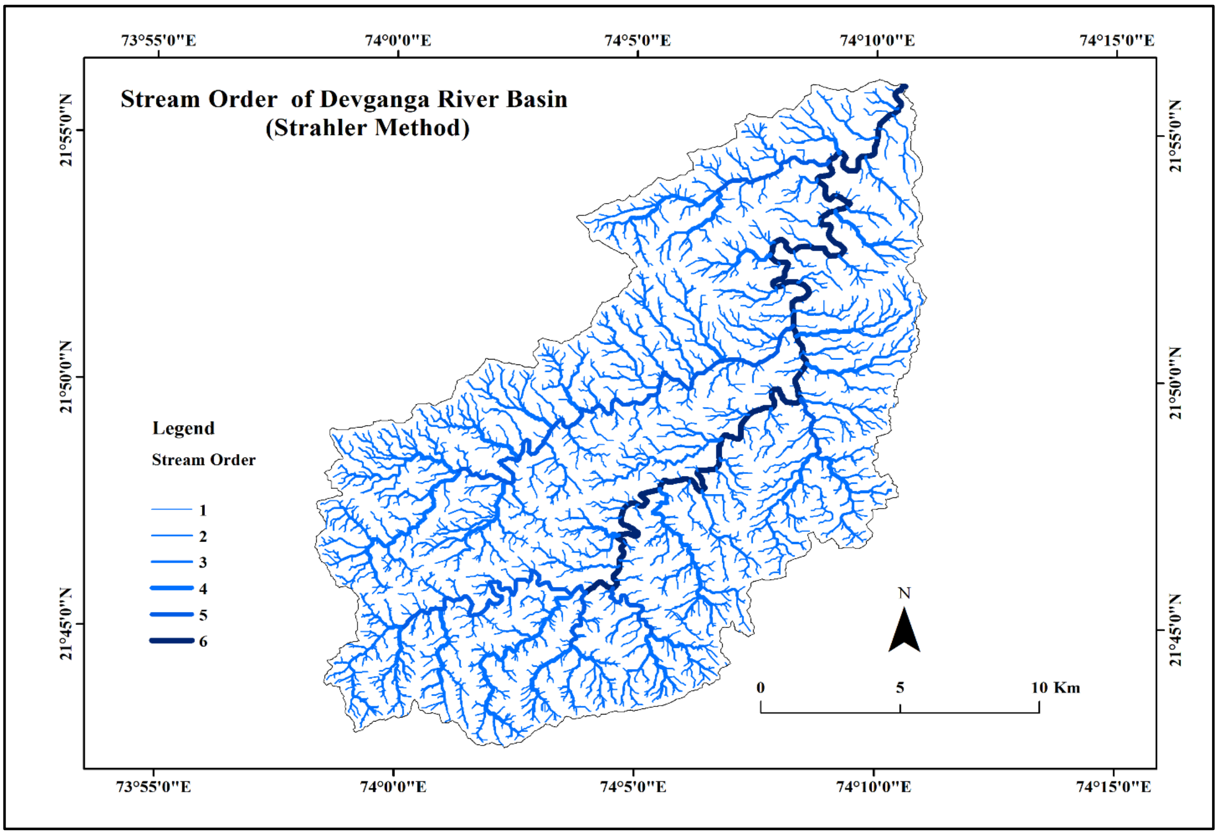

Figure 2. Stream order of Devganga river basin in Satpura mountain ranges

Table 4. Length of Stream (Lu), Stream Length ratio (Lur-r), Order of stream (Su), Weighed mean length of stream in Devganga river basin.

Su	Lu (km)	Lm	Lur	Lur-r	Lur × Lur-r	Luwm
1st	371.50	0.56	--	--	--	2.32
2nd	197.51	0.96	1.73	569.01	987.23	
3rd	94.44	1.63	1.69	291.95	493.43	
4th	47.19	4.72	2.90	141.64	410.51	
5th	9.38	3.13	0.66	56.58	37.50	
6th	40.49	40.49	12.94	49.87	645.56	
Total	760.52	51.48	19.93	1109.06	2574.24	
Mean			1.75			

4.1.3. Average Length of Stream (lm) :

As per Strahler's study in 1964, Lm is a dimensionless metric, obtained by the quotient of the summation of length of stream of each point to the summation of segment of stream. The basin's surface and distinctive features are the result of an examination of several components of the drainage network. Observe table 4 for a breakdown of the Lm values according to precedence: 0.56 for the I order, 0.96 for the II 1.63 for III, 4.72 for IV, 3.13 for V, and 40.49 for the VI. Across the river, the Lm value varies between 40.49 and 0.56.

4.1.4. Stream length Ratio (Lur) :

Stream length ratio can be determined as the quotient of the median length of each point relative to the average stream's length of the subsequent order beneath it. The appearance of newer geomorphic features correlates strongly characterised by elevated values of Lur. The change in the values of RL suggested that the landform evolution is still in its early stages, according to Rai et al. (2014). 1.75 is the average Lur value. The results shown in table 4, the Lur value was lowest for the fifth-order stream at 0.66 and greatest for the fourth-order stream at 12.94. Topographical characteristics and variations in slope yield different Lur values. (Magesh et al., 2012).

4.1.5. Bifurcation Ratio (Rb) :

For both relief and watershed dissections, the bifurcation ratio is the measurement metric (Horton, 1945). According to Schumm (1956), the ratio of bifurcation measures correlation between the stream's quantity in the initial order (Nu) and stream's volume in the following grade. When Rb values fluctuate significantly, continuous surface flow forms new segments of streams (Strahler, 1957). According to Horton (1945), the Rb number normally runs from 2 to 4 in hilly and mountain areas and is at least 2 in flat topography. An extended basin-shaped river formation is suggested by a larger bifurcation value, whereas a circular basin-shaped river formation is suggested by a lower value. The highest point of flow in a circular basin with an extended watershed is expected to rise if the amount of rainfall and other relevant regulating factors remain constant. A watershed's surface runoff and hydrograph are governed by the bifurcation value. Flooding is more likely when the mean Rb value is lower. The present work has an Rb value range of 5.80 to 3. The Rb value is greatest in 4^{th} stream's order and lowest for 6^{th} order, as shown in table 3.

Weighted Mean Bifurcation Ratio (Rbwm) :

Calculation of the Rbwm was determined by dividing the bifurcation's quotient by overall numbers of stream encompassed in Rb study. This ratio was then averaged over all outcomes (Strahler, 1953). According to table 3, which indicates Schumm's (1956) recommended methodology, the Rbwm for the research area was determined to be 3.36.

4.1.6. Coefficient of Rho (q) :

It is the important variable of longitudinal part of analysis of morphometric. This variable is determined by examining the relationship between drainage density (Dd) and basin's physiography. This helps one to understand the creation of the basin's storage capacity. Furthermore, as per Horton, 1945, the network of basin's growth is governed by it. The human activities, climate, geomorphic processes, and geological structure all have an impact on the rho coefficient (q). A Rho value between 0.06 and 1.44 is found in the Devganga River (Table 2).

4.2. Areal Aspect:

Morphometry relies on understanding the features of basins and how they affect and regulate thewater dynamics of the reseach region.

4.2.1. Density of Drainage (Dd):

The compactness of drainage is measured as a quotient of an entire basin's area divided by stream's total length (Horton (1945) and Strahler (1964)). Surface runoff and the basin's character may be quantified in this way. infiltration limit is influenced by the land surface features and vegetation type, which in turn are determined by the watershed's density of drainage. Vegetation amount along with weather conditions determine the drainage network's density. Because it regulates the quantity of surface water that may recharge aquifers, a watershed's drainage density has a major effect on its groundwater potential. The watershed has low drainage density because of its low gradient, dense vegetation cover, and permeable surface and subsurface soil; high drainage conditions, on the other hand, give the opposite condition. Figure 3. shows the Devganga River Basin drainage density map.

4.2.2. Texture of Drainage (T) :

Pattern of drainage can be determined by splitting the entire segments of every creek of watershed to half-basin width (Horton (1945)). Climate, altitude, geology, and plant life all have a role in shaping the river basin's drainage texture. Changes to the soil, controlling the flow of water at the surface, have also influenced due to the texture of drainage of the river. Temperature and flora characteristics have affected the granite's strength. The Devnand River Basin's drainage texture is very coarse, as seen by its T value of 9.18 (Table 2).

4.2.3.Length of Flow of Overland:

The geo-hydrological attributes along with physiography factors of basin region are affected by the total amount of water that flows over the area of surface surface area prior reaching the central waterway, which is called "overland flow" (Lg). (Horton, 1945). In order to fill the soil's pores, precipitation must first fall; any excess water must then flow off the surface and into the ocean. Climate, gradient, rock structure, rate of erosion, geology, and plant type are among the many variables that determine the magnitude of overland flow. (Schumm, 1956). Since concentrated overland flow is greater than unconcentrated overland flow, it has control over long time. Saturated soil with lower Lp values increases chance of floodingduring heavy precipitationThe surface runoff of study region is recorded as 0.21 (Table 2).

4.2.4.The constant of Channel Maintenance (Cm):

In Schumm's study of 1956, by dividing size of the basin to the cumulative stream distance is called channel maintenance constant. Geographical factors such as elevation, relief, and weather conditions affect the Cm value. Drainage density (km/sq.km) and measurement values of the permeability of the rocks in the basin are inversely related, according to Rai et al. (2018). This Cm value was utilized to measure the river basin's landform component (Strahler, 1957). Table 2 displays, that this constant measurement for Devganga stream is found to be 0.42 km/km^2. Channel flow allows water to discharge more quickly in areas with less thick vegetation due to the shorter overland flow caused by a lower Cm value (Samal et al., 2015).

4.2.5. Circularity Ratio (Rc) :

The ratio of circularity is defined as the division of the basin's coverage by the ring's coverage with an equivalent edge (Miller, 1953 and Strahler, 1964). According to Rai et al., 2018, ratio of circularity of river basin was affected by structure, qualities of soil, type of climate, type of land, plant cover, and geomorphic features. In case when Rc is between 0.4 and 0.7, the geological structure is expected to be favorable to permeability, and the basin is expected to be expanded, according to Miller (1953). With a value of 0.38, the Devganga River Basin is considered circular in the Satpura mountain ranges. The three different Rc values found in the basin correspond to different epochs of tributary erosion: the oldest, the most mature, and the youngest.

4.2.6. Factor of Form (Ff) :

Horton (1922) developed Ff for Basin, which is the quotient of the basin's coverage by raising to the power of two of its maximum span, dimensions, including both length and breadth. Ff's function is multifold: it carries silt, measures the frequency of floods, and identifies flood-prone locations. When the value of Ff is zero, the vastness of the river basin is quite significant; when it's one, the basin is perfectly round. The shape factor in the Devganga River basin is 0.33. The duration for water from streams to make it to the main river is indicative of an extended basin structure, low transport rate, and lower flood risk (Soni, 2016).

4.2.7. Ratio of Elongation (Re) :

The division of the diameter of the circle of basin to longest feasible basin is elongation ratio. (Schumm,1956). Runoff discharge efficiency is an important characteristic of the circular basin form, while substantial infiltration rates and delayed surface runoff are seen in the extended basin. With an elongation ratio of 0.64 (Table 2), the Devganga River Basin is considered stretched.

4.3.Relief Aspects :

An examination of the river basin's relief provides an accurate representation of the basin's topographical and geophysical setting.

4.3.1. Relief of Basin (R) :

Soni (2016) describes greatest subtraction in elevation between the lowest part to the highest part within the basin as basin relief (R). Watershed's altitudinal variability has been assessed using this method. Relief in the basin has a major effect on river capacity, sediment transport, slope steepness, and flood likelihood. An essential morphometric variable for understanding the watershed's weathering and denudation processes is relief. The Devganga River Relief DEM is used to extract the relief features.

4.3.2. Relief Ratio (Rr) :

The atio of relief is the ratio of relief to the length of basin. To compute basin slope characteristics efficiently, it is a crucial dimensionless number morphometric parameter (Schumm, 1956). It has been applied to the analysis of the river basin's rate of erosion. The ratio of relief has a direct correlation to the hydrologic organization of a river basin. As shown in table 2, there is a relief ratio of 29.64 in the Devganga River Basin.

4.3.3. Number of Ruggedness:

Unitless morphometric factor that considers aspects of the steepness of the slope, which is caused by the density of stream and basin relief is called ruggedness number (Strahler, 1958). This parameter has been used to quantify surface topography's undulation. Extremely complicated geological structures and the presence of erosion-resistant rock on the surface of basins lead them to have low toughness levels. A river basin is considered to have a high roughness level when the drainage density and relief are both high. Table 2 shows that the Devganga River Basin is 2.20 times more rough than average.

4.3.4. Dissection Index (Di) :

As stated by Pal et al. (2012) the calculation of dissection index (Di) is very easy, same as dividing the river's current dissections by its potential level up to the base level of erosionLow dissection values reflect the river basin's ancient stage, while high values highlight its young age. According to Schumm (1956), this technique has been used to study the watershed's surface topography, physiography, and morphometric features. As displayed in table 2, a dissection index ranging from 0.12 to 0.89 was recorded for the Devganga River Basin.

4.3.5. Ruggedness Number of Melton:

TA dimensionless integer that indicates how difficult the landscape is in river basins is the Melton ruggedness number (Melton, 1966). The Devganga River has a melton roughness value of 51.70 (Table 2). Lower MRn values indicate a constant flow of water that has reduced turbidity as well as less movement of debris (Soni, 2016).

5. Flood Vulnerability Zone (FVZ):

The morphometric parameters elevation, slope, drainage frequency, rainfall, NDVI, NDWI, and LULC map were utilize to create the flood vulnerability map for the Devganga River in satpura mountain region. (Table 4 and Figure 4).

Seven thematic layers or morphometric parameters were generated with the Arc GIS 10.4 program. The allocation of weights utilizing rank values was determined by the Analytical Hierarchical Process, (Table 5 and Figure 3). Based on AHP value, the study's findings were organized into four flood vulnerability zones (Figure 4), ranging from low to very high. The outcomes were illustrated on a thematic map. This region has a very high risk of flooding because the study region's geography is a deep plain valley with hills

Table 5: Thematic layers and parameter weights for flood vulnerability mapping in the Devganga river basin

Layers	Ranks	Sub-classes	Individual weight	Weight	Area (sq km)
Elevation in Meter	5	71 - 318	1.71	0.342	40.44
	4	319 - 452	1.368		86.38
	3	453 - 579	1.026		98.69
	2	580 - 725	0.684		68.46
	1	726 - 997	0.342		25.64
Slope in Degree	5	0 - 6.05	1.195	0.239	114.24
	4	6.06 - 12.11	0.956		89.88
	3	12.12 - 19.06	0.717		58.49
	2	19.07 - 27.35	0.478		40.41
	1	27.36 - 57.17	0.239		16.59
Rainfall in mm	1	955 - 981	0.166	0.166	37.23
	2	982 - 997	0.332		55.63
	3	998 - 1,014	0.498		133.67
	4	1,015 - 1,039	0.664		63.46
	5	1,040 - 1,075	0.83		29.86
Drainage Density	1	0.33 - 3.44	0.101	0.101	36.12
	2	3.45 - 6.55	0.202		123.28
	3	6.56 - 9.66	0.303		111.13
	4	9.67 - 12.77	0.404		44.47
	5	12.78 - 15.88	0.505		4.54
NDVI	5	-0.13 - 0.05	0.365	0.073	5.15
	4	0.06 - 0.13	0.292		90.09
	3	0.14 - 0.18	0.219		116.25
	2	0.19 - 0.24	0.146		78.51
	1	0.25 - 0.48	0.073		29.85
NDWI	1	-0.42 - 0.22	0.045	0.045	34.85
	2	-0.21 - 0.17	0.09		99.53
	3	-0.16 - 0.12	0.135		128.78
	4	-0.11 - 0.02	0.18		52.04
	5	-0.01 - 0.15	0.225		4.65
LULC	5	Water Bodies	0.165	0.033	1.99
	2	Bare Land	0.066		1.31
	2	Agriculture	0.066		153.85
	3	Rural settlement	0.099		3.67
	1	Forest	0.033		159.03

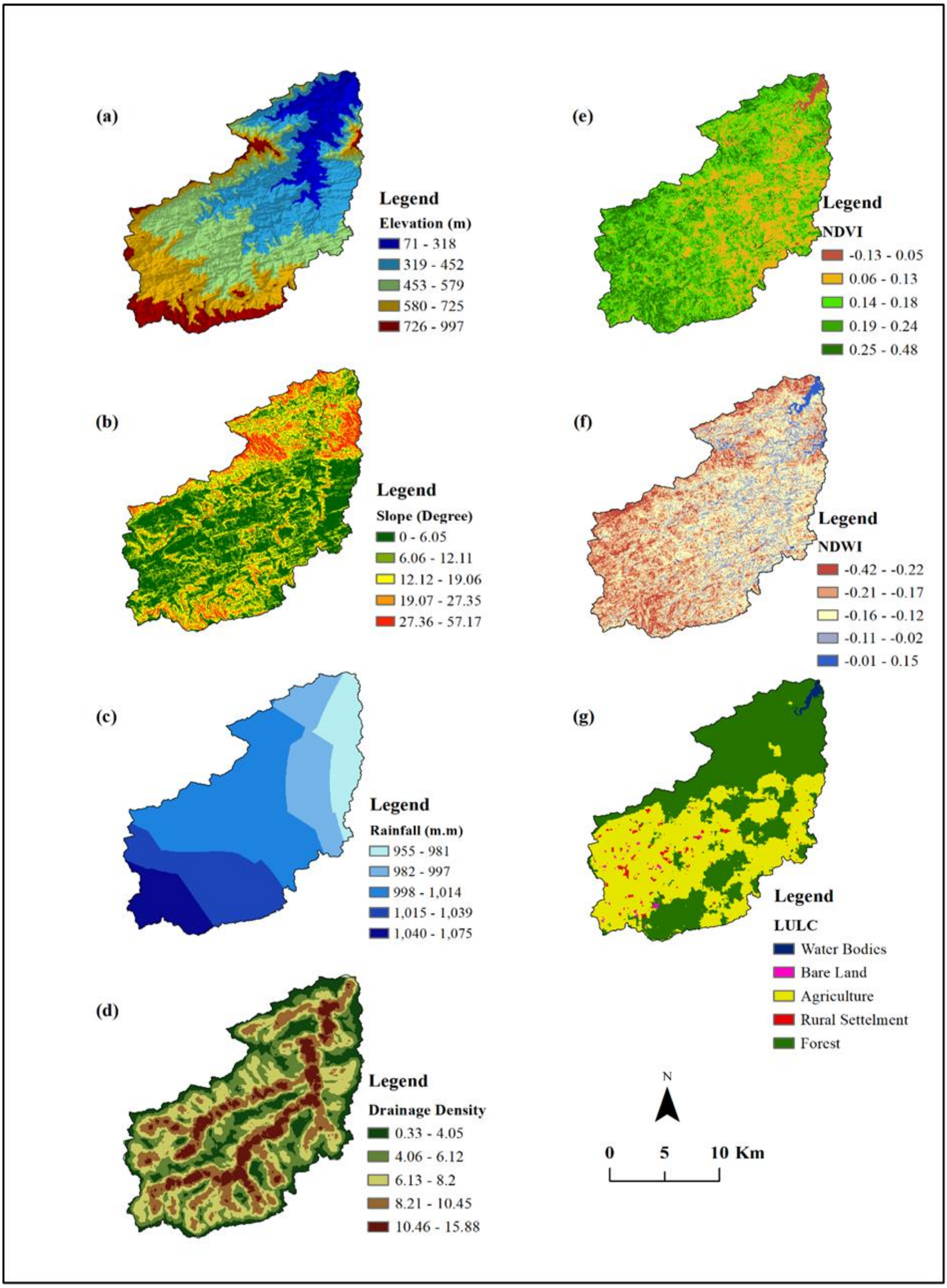

Figure 3. AHP thematic layers of flood vulenerability perperation in Devganga river basin.

The vulenerability zones of flood shown in figure 5, are classified as four distinct classes: safe, cautionary, hazardous, and critical zones. Devganga river basin can be classified into 4 parts based on their level of flood vulnerability: very low (0.77), low (40.80), moderate (204.63), and high (72.47) in sq.km. This information is shown in table 6. The Devganga river basin lower and middle regions might be determined to be extremely vulnerable to flooding.

Table 6: Investigation of the flood vulnerability zone of the Devganga river basin.

Sr. No	Class	Area (Sq. km)	Percentage of Area
1	Very Low	0.77	0.24
2	Low	40.80	12.80
3	Moderate	204.63	64.21
4	High	72.47	22.74

6. Validation of the Model:

The ROC-AUC is the basis to statistically validate the AHP output, by using statistics of the flood inventory map. The whole process was done using Arc GIS10.4 software, by its Arc SDM tool. The process involved the comparison of the Flood Vulnerability Zone (FVZ) map with the flood point and non-flood point to get ROC-AUC curve. The AUC and ROC curves for the AHP model are displayed in Figure 5. According to AUC, the accuracy rate of the FVZ may be divided into 4 categories: excellent >0.9, good from 0.8 to 0.9, accepted from 0.7 to 0.8, and considerable from 0.5 to 0.7. According to analysis, the observed accuracy of AHP investigate is 0.934 (93.4%) . The FVZ map is thus thought to be an outstanding result since the model is executed efficiently, based on the satisfaction scale.

Conclusion:

The morphometry of three drainage basin components has been computed and assessed with the use of Arc GIS 10.4 and techniques for spatial data management. On account of GIS research the quantitative morphological characteristics of the study region produced incredibly reliable and accurate results. The Devganga River is located in the Satpura mountain ranges' deep, mountainous valley plane. The basin feature is constantly changing since the morphometric parameters change at regular intervals, particularly during the monsoon season. Due to its dendritic drainage system, the Devganga River Basin experiences frequent floods during the monsoon season due to heavy precipitation.

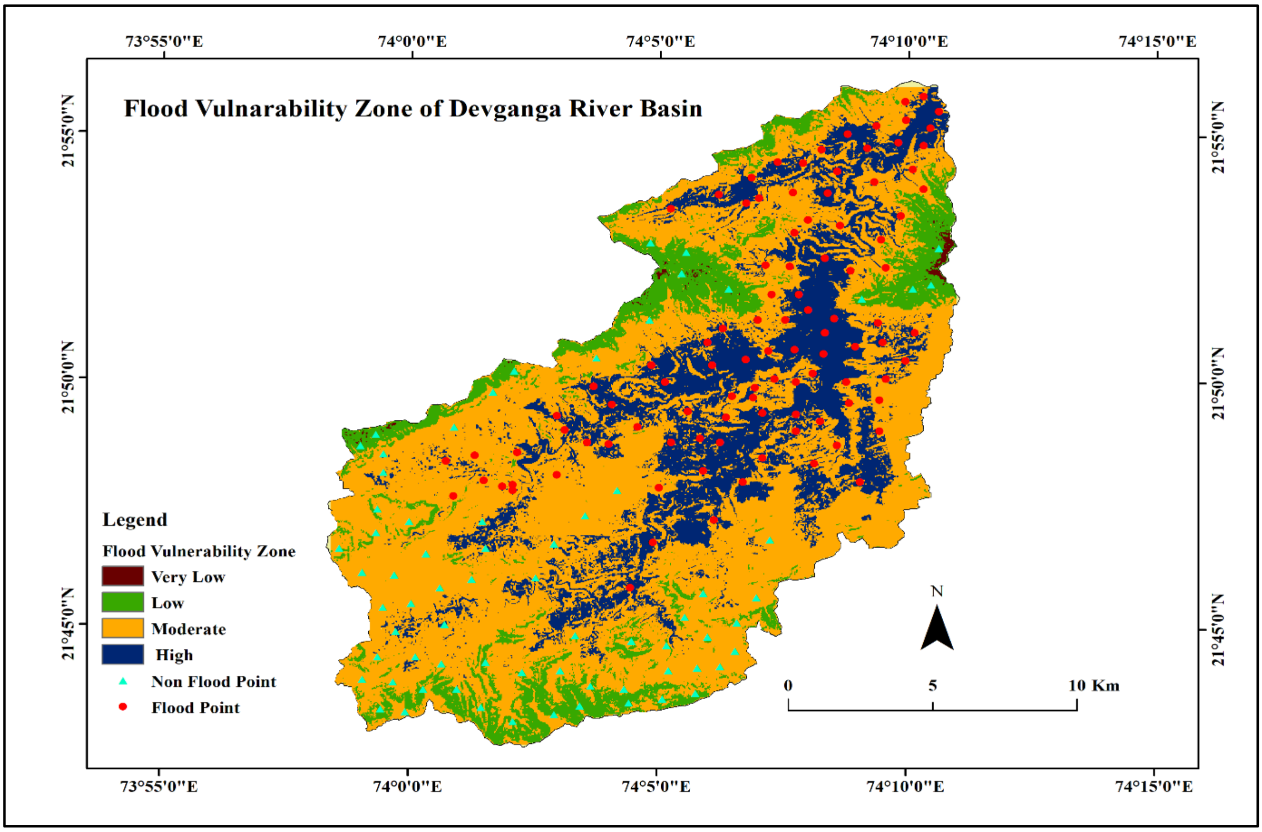

Figure 4. Flood vulnerability zone (FVZ) of Devganga river basin in Satpura mountain ranges.

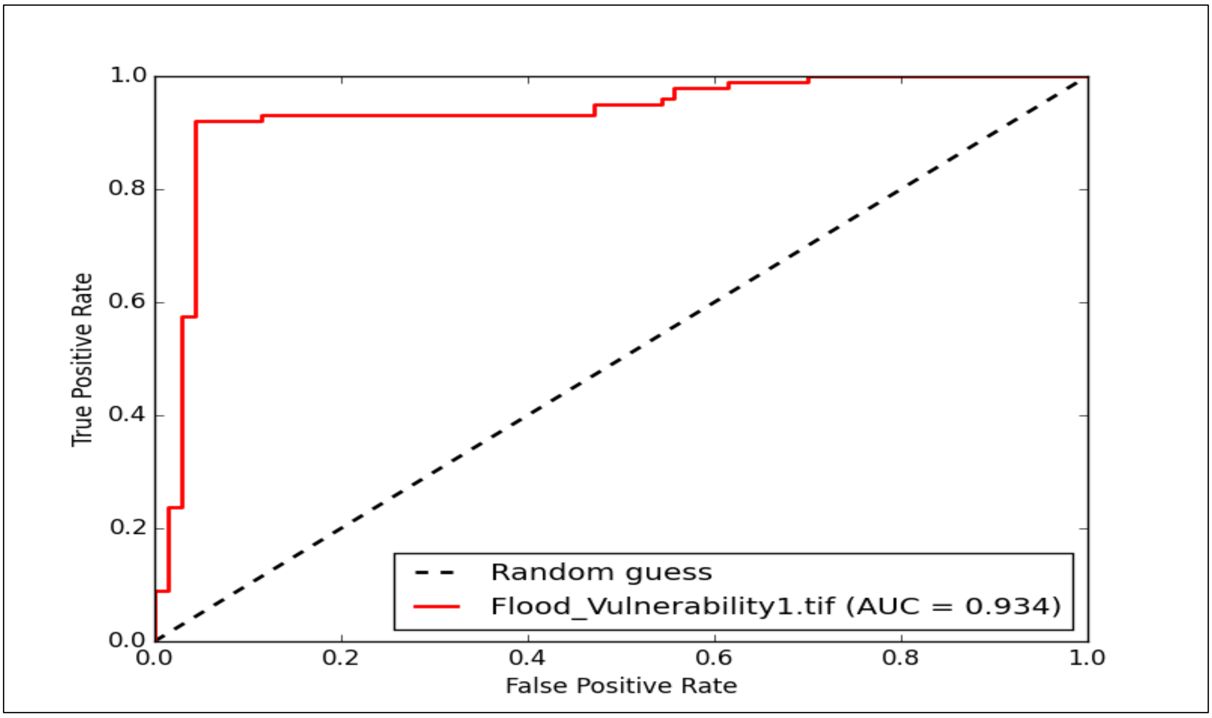

Figure 5. ROC- AUC curve of Flood vulnerability zone (FVZ) in Devganga river basin.

The river basin's extremely steep and level topography also contributes to this mechanism. By the use of satellite images that are high resolution, along with ground truth point data collected using a Garmin GPS survey, the Devganga River Basin's erosional stage, landform structure, and other features may now be better understood. The presence of several 1st and 2nd order streams in this research region makes surface runoff a major contributor to soil erosion.

Field-based observation will benefit from the morphometric analysis of this work, and measurement techniques must be implemented for administrative reasons. Drainage density, height, and slope are important morphometric variables that impact the magnitude of floods of Devganga stream or watershed. Deepest part of Devganga stream in Satpura mountainous area is particularly at risk of flooding due to its low elevation and high drainage density, which are providing favorable conditions.

Author Statement

MV: Conceptualization, data analysis, mapping in Arc GIS 10.5 software, Methodolohy, model validation , editing and supervision. SG: writing original draft review, statistical data analysis, editing and supervision.

Acknowledment:

The contributes acknowledge Dr. Jayanta Das, Department of Geography Rampurhat College, Rampurhat, Birbhum, West Bengal for providing invaluable guidance and support in conducting the present study.

References:

Adnan M. S. G., A. Dewan,, K. E. Zannat and A. Y. M. Abdullah (2019). The use of watershed geomorphic data in flash flood susceptibility zoning: a case study of the Karnaphuli and Sangu River basins of Bangladesh. Natural Hazards, 99 (1), 425-448. https://doi.org/10.1007/s11069-019-03749-3.

Clark C. (1966). Morphometry from maps. Essay in geomorphology (pp. 235–274). New York: Elsevier Publication Company. review. Journal of Hydrology, 375 (3), 613-626.

Horton.R.(1932). Drainage basin characteristics, Transcation, Anerican Geographical Union, 13 (1), 350. https://doi.org/10.1029/tr013i001p00350.

Horton R. E. (1945). Erosional development of streams and their drainage basins; Hydrophysical approach to quantitative morphology. Bulletin of the Geological Society of America, 56 (3), 275-370. https://doi.org/10.1130/0016 7606 (1945), 56 .

Melton M. (1966). The geomorphic and paleoclimatic significance of alluvial deposits in Southern Arizona: A reply. The Journal of Geology, 74 (1),102-106. https://doi.org/10.1086/627147.

Miller V. C. (1953). A quantitative geomorphic study on drainage basin characteristics in the Clinch Mountain area, Virginia and Tennessee, Project NR 389-042. Technical report 3. Columbia University, New York.

Rai P. K., K. Mohan, S. Mishra, A. Ahmad and V. N. Mishra (2017). A GIS-based approach in drainage morphometric analysis of Kanhar River Basin, India. Applied water science, 7 (1), 217-232. https://doi.org/10.1007/s13201-014-0238-y.

Samal D. R., S. S. Gedam and R. Nagarajan (2015). GIS based drainage morphometry and its influence on hydrology in parts of Western Ghats region, Maharashtra, India. Geo carto International, 30 (7), 755-778.

Schumm S. A. (1956). Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey. Bulletin of the Geological Society of America, 67(5), 597–646. https://doi.org/10.1130/0016 7606(1956)67.

Soni S. (2016). Assessment of morphometric characteristics of Chakrar watershed in Madhya Pradesh India using geospatial technique. Applied Water Science, 7(5),2089–2102. https://doi.org/10.1007/s13201-016-0395-2.

Strahler A. (1953). Hypsometric (area-altitude) analysis of erosional topography. Geological Society of America Bulletin, 63 (11), 1117. https://doi.org/10.1130/0016-7606.

Strahler A. (1957). Quantitative analysis of watershed geomorphology Transactions, American Geographical Union, 38 (6), 913. https://doi.org/10.1029/tr03i006p00913.

Strahler A. N. (1964). Quantitative geomorphology of drainage basins and channel networks, section 4II. In V. T. Chow (Ed.), Handbook of applied hydrology. New York: McGraw Hill.