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Research Article

USING GEOSPATIAL TECHNIQUES, MORPHOMETRIC INVESTIGATION OF THE NIRGUNA (BHIKUND) RIVER WATERSHED IN THE DISTRICTS OF AKOLA AND WASHIM, MAHARASHTRA, INDIA

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ABSTRACT
The Nirguna (Bhikund) river watershed has been the subject of the current research, which was conducted by utilising the DEM, or Shuttle Radar Topographic Mission. The findings of the morphometric study show that the catchment of the Nirguna (Bhikund) river watershed, which covers an area of 726 sq. km, may be characterised as being of 6th order. The study areas upper and lower portions having dendritic drainage pattern show a lack of structural control and uniformity in texture. The elongated structure of the study area depicted by the values of various ratios like form factor and circulatory ratio. According to the mean bifurcation ratio, geological characteristics have less of an impact on drainage patterns than structural disturbances have on the watershed. A significant gradient may be seen in the longitudinal profile at the beginning, but when the river has eroded its base level, the gradient progressively flattens out. A significant portion of the research area is covered in impermeable rocks, which is the reason for the high runoff, according to the data for the amount of infiltrations, frequency of streams, intensity of drainage, and texture of drainage. Therefore, understanding the effect of catchment characteristics on runoff concerning water harvesting would be helpful.

Keywords: *GIS, Geomorphology, Bhikund, Dendritic Pattern, Catchment Area, DEM.*

INTRODUCTION

The process of developing and carrying out strategies, plans, and projects to improve and protect a watershed which has an impact on the communities of humans, animals, and plants in a watershed catchment area. Without a comprehensive system assessment, watershed management is impossible. The drainage system is mainly, made by the running water that is run-off in the catchment area so it is very important to conserve this water in watershed for its optimumusage in the watershed itself with the help of proper technique and planning. The linear, aerial and relief aspects help to characterize the various morphometric parameters. (Nag and Chakraborty 2003; Nautiyal 1994). The morphometric methodology is a crucial and effective tool for managing watershed, monitoring groundwater, defining groundwater potential zones, evaluating pedological conditions, and assessing environmental and ecological conditions. (Das Sumit and Sudhakar D. Pardeshi, 2018). The evaluation of drainage and their related factors quantitatively provides useful information for designing the development and management plan of water resources (Umrikar, 2016). The information derived from watershed morphometric analysis may be an essential resource for controlling the water availability, controlling soil erosion and mapping the landslip susceptibility, ranking watersheds, and evaluating groundwater investigations (Jena and Dandabat 2019; Salvi *et al.*, 2017; Sujatha *et al.*, 2013; Sreedevi *et al.,* 2009). Various studies can be carried out by morphometric analysis such as hydrological processes within watershed characteristics (Singh *et al.*, 2021**).** Because groundwater being the sole important water source for the Maharashtra state, it plays a crucial role in the state's extensive basaltic topography. Due to the states erratic rainfall and naturally occurring physiographic conditions, the state faces a water shortage every year. It is also important to remember that groundwater is used more than 80% of the time in the state, especially for drinking water. (Bhavana N. Umrikar 2016). Morphometric analysis is seen as a means of analyzing and evaluating comparisons of different features such as Features of sub-watersheds related to erosion and hydrology, landforms, and soil properties. (Amulya *et al.*, 2018; Dar *et al.*, 2013). People and land resources interact in watersheds; what's more, because of their financial exercises, that of hydrology and biophysics and economical units. A watershed is defined as a combination of social and natural systems; it creates landscape hierarchies that are singular and interconnected. (Gadisa Chimdesa Abdeta *et al.*, 2020). A drainage study is necessary to comprehend the flow of water in a hydrological cycle process is important (Alemsha Bogale 2021).

MATERIALS AND METHODS

2.1 Study Area:

Nirguna (Bhikund) river watershed is the tributary of Mun river originating from the hills of Washim and Patur reserve forest area near Bhildurga villege, Washim district Maharashtra. The watershed of Nirguna (Bhikund) River lies in Akola & Washim district and it is encompassed in the Survey of India topo sheet nos.55D/14, 55D/15 and 55D/16 bounded by latitude 20°11’30.24" - 20° 42’44.55"N and longitude 76°52’42.80" - 76°45" 56.92"E on scale of 1:50000 scale with an perimeter of about 187 km and of an area 726 sq.km. (Fig. 1)

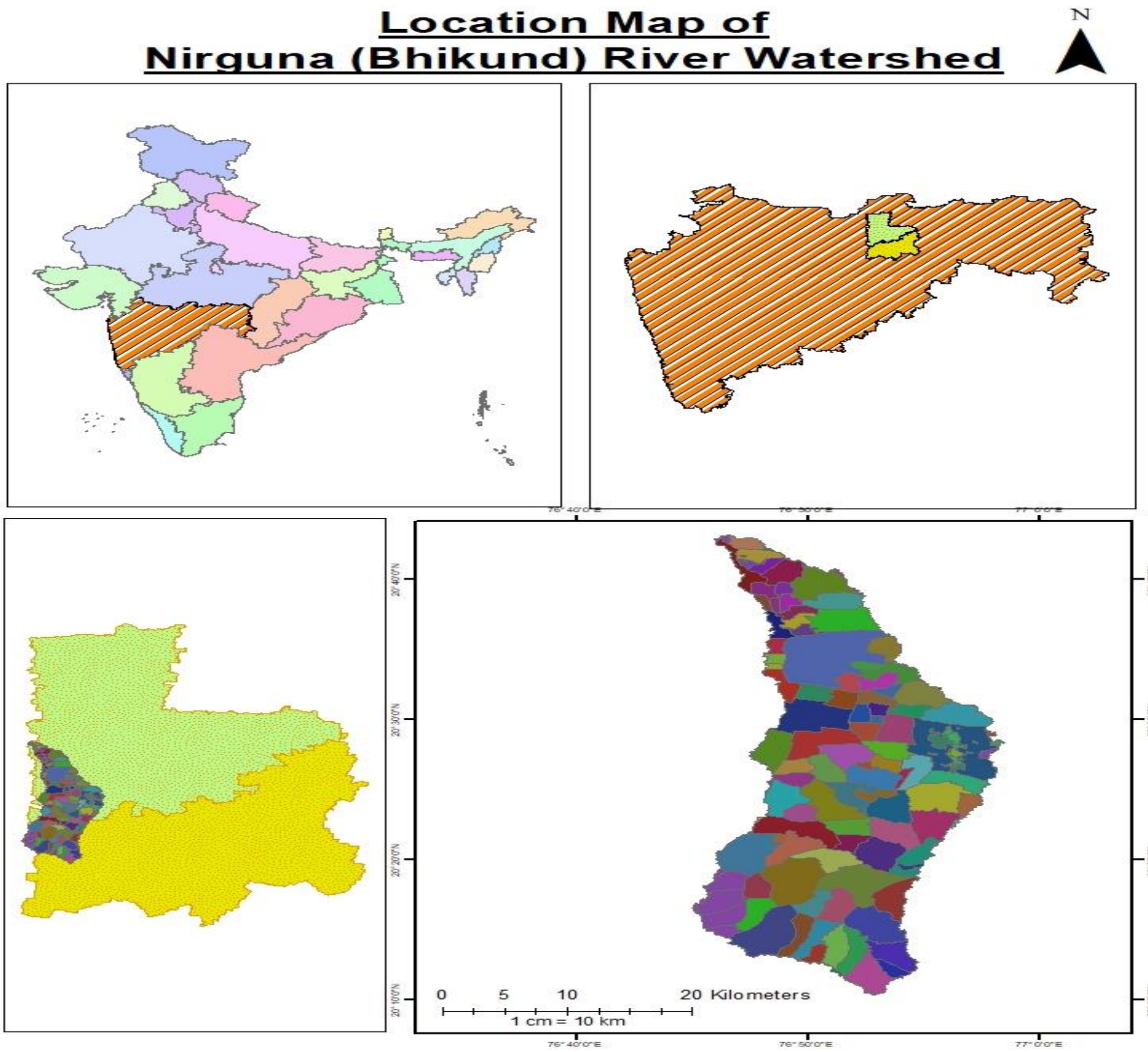

Figure 1: The Nirguna (Bhikund) River Watershed location map.

The majority area of the watershed is covered by Deccan traps dating from the Upper Cretaceous to Lower Eocene, mostly made of black cotton soil and fluvial deposits as an alluvium of recent age. The geological map of the Nirguna (Bhikund) river watershed is prepared. (Fig. 2). A multidisciplinary approach is needed in an integrated watershed development for improvement, conservation and augmentation of land, and water resources for these various studies are needed in different field of studies such as remote sensing, GIS, hydrogeological, geophysical fields etc.

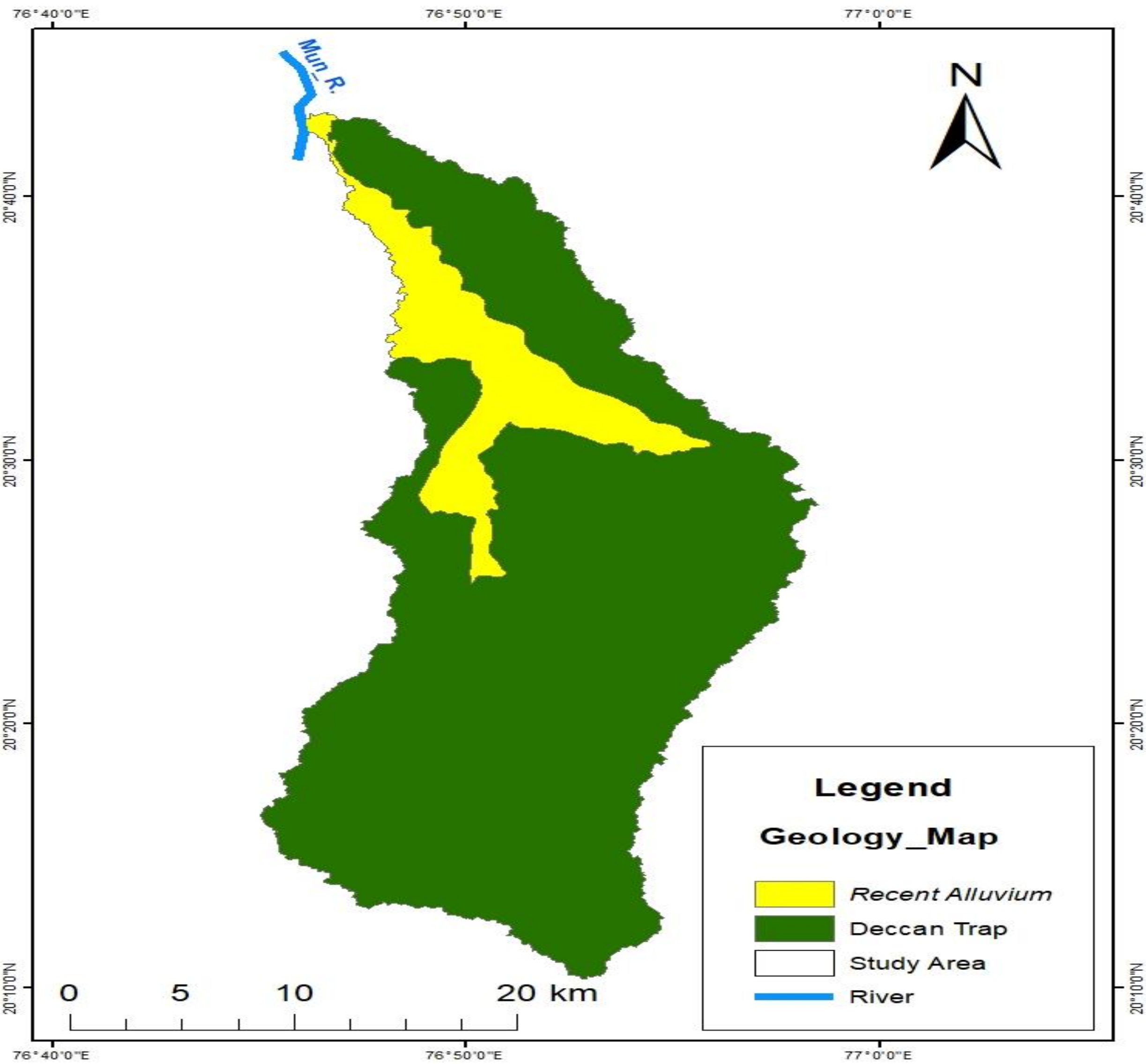

Figure 2: Geological Map of Nirguna (Bhikund) River Watershed

MATERIALS AND METHODS

The first step is three toposheets of the study area are downloaded and that were transformed into TIFF files, and three of them were subsequently independently georeferenced using ArcGIS. The topo sheets are downloaded from the Survey of India portal along with the legend. The downloaded topo sheets might create matching errors after the digitization so three distinct polygon shapefiles that precisely matched the toposheet boundaries were also digitized. To create a single composite toposheet, the georeferenced toposheets were cut and combined using the ArcGIS software, should encompass the whole research area. The merged toposheets were then digitized to produce the watershed and stream network. The missing stream links are then filled in with the DEM data. Stream ordering method as recommended by Strahler has been utilized and the methodology adopted is as follows in Fig.3 below.

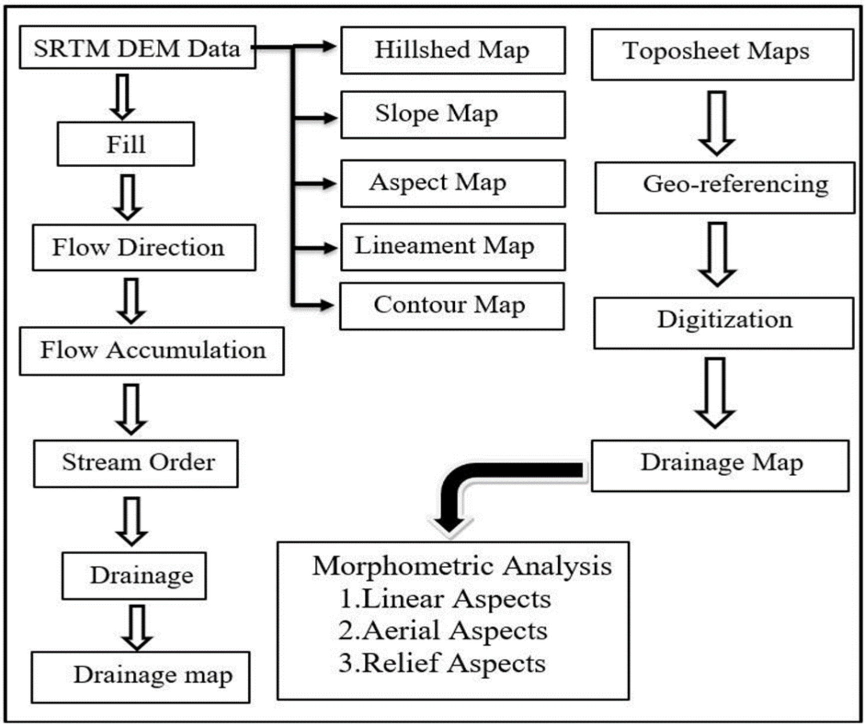

Figure.3 Flowchart illustrating the used methodology.

RESULTS AND DISCUSSION

The formulas suggested by Strahlar, Horton, and Miller were applied in order to determine the different morphometric parameters, as shown in Table 1.

Table: 1 Morphometric parameter formulae for each of the parameters.

Sr, No.	**Parameters**	**Formulae**	**References**
1	Stream order (u)	Hierarchical rank	Strahler (1964)
2	Stream number (Nu)	Number of streams in each order	Horton (1945)
3	Stream length (Lu)	Length of stream	Horton (1945)
4	Mean stream length (Lsm)	Lsm = Lu/Nu	Strahler (1964)
5	Stream length ratio (RL)	RL = Lu/(Lu − 1)	Horton (1945)
6	Bifurcation ratio (Rb)	Rb = Nu/(Nu + 1	Schumm (1956)
7	Mean bifurcation ratio (Rbm)	Rbm = average bifurcation ratio of all order	Strahler (1957)
8	Drainage density (Dd)	Dd = Lu/A	Horton (1945)
9	Stream frequency (Sf)	Sf = Nu/A	Horton (1945)
10	Drainage texture (T)	T = Dd × Sf	Smith (1950)
11	Circularity ratio (Rc)	$Rc = 4\pi A/P^2$	Strahler (1964)
12	Elongation ratio (Re)	Re = D/L = 1.128 A /L	Schumm (1956)
13	Form factor (Ff)	$Ff = A/L^2$	Horton (1945)
14	Relief (R)	R = H – h	Hadley and Schumm(1961)
15	Relief ratio (Rh)	Rh=R/L	Schumm (1963)

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Research Article

The Nirguna (Bhikund) river watershed have been investigated in this paper which is running through a total area of about 726 km area. The different factors which influence the drainage development are climate, geology as well as relief. The Pattern of drainage from dendritic to sub dendritic mainly found in the study area, with an uneven tributary branching pattern that originate in different directions before joining the main stream.

***3.1 Stream Order**:*

The amount of river branches in a river water system is described by the phrase "stream order." The highest order principle stream is known as the trunk stream. Therefore, the streams are classified based on the Strahler's stream ordering technique. Using this technique, it is observed that Nirguna (Bhikund) river watershed have the 6th highest order of stream as shown in the Fig.4 below.

3.2 Mean stream length (Lsm):

It is a representation of the stream network properties within the river watershed system. A stream's mean length (Lsm) can be determined by taking the total length and dividing it by the total number of streams in the specified sequence. The main trunk stream is longer than the other streams, according to the drainage map.

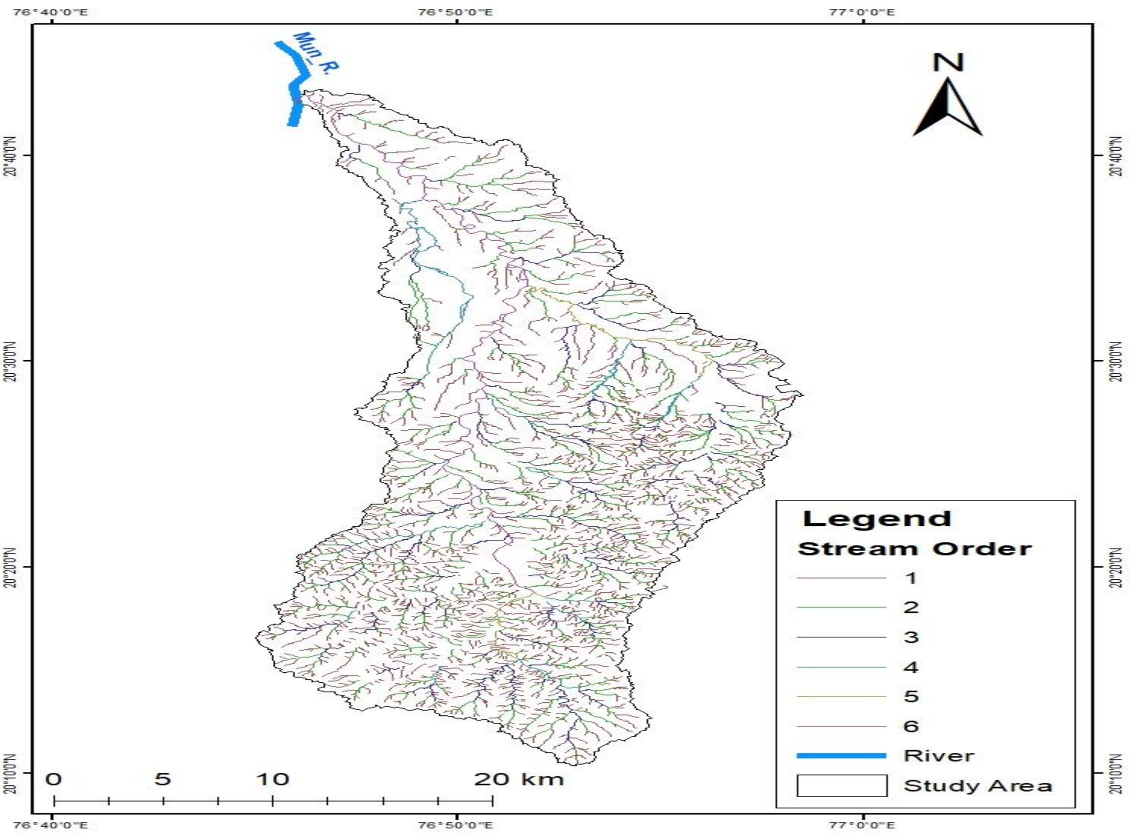

Figure 4: Drainage Map of Nirguna (Bhikund) River Watershed.

3.3 Stream length ratio (RL):

It is an illustration of the characteristics of the stream network found within the river watershed system. The mean stream length (Lsm) is calculated by multiplying the number of streams in an order by the sum of their total lengths. According to the drainage map, the main trunk stream is longer than the other streams.

3.4 Bifurcation ratio (Rb):

A drainage basin's area is used to divide the total number of one-order streams by the total number of higher-order streams to get the bifurcation ratio (Rb). Schumm (1956). Geologic formations have not altered the drainage pattern, as indicated by the bifurcation ratio, (Strahler, 1964). Calculating the bifurcation ratio makes it simple to comprehend the geological and structural controls on the river watershed region. The effect of geological formations on the drainage network and structural disturbances is indicated if the bifurcation ratio exceeds 5. In contrast, a low bifurcation ratio value suggests minor structural disruption and unaltered drainage patterns (Strahler, 1964).

3.5 Mean Bifurcation Ratio (Rbm):

The drainage patterns here are indicated by the mean bifurcation ratio of 4.9, indicating that have not been distorted and that structural control is low to moderate or the structural disturbance is minor. The findings of drainage network properties are displayed in Table 2.

Table 2: The findings of drainage network properties of Nirguna (Bhikund) river watershed.

Sr. No.	Stream order (u)	Number of Stream (Nu)	Total Length of Stream in km (Lu)	Mean Stream Length (Km)	Bifurcation ratio (Rb)	Mean Bifurcation ratio(Rbm)
1	I	1552	946	0.61	4	
2	II	388	363	0.94	3.6	
3	III	108	168	0.64	3.6	
4	IV	30	71	2.37	10	
5	V	3	26	8.67	3	
6	VI	1	65	65	--	
Total		2082	1639			4.9

3.6 Drainage density (Dd):

As stated by Horton (1932), a basin's drainage density (Dd) represents the extent of proximity between the streams. The total length of each and every stream in a drainage area (sq. km.) is known as the drainage density (Dd). A reduced drainage density suggests that the study areas subsoil is highly permeable. While a high drainage density indicates subsurface material that is weak or poorly impermeable. (Fig. 5). The drainage density of 2.3 in the study area suggests that the subsurface has a high permeability and needs a dense vegetative cover.

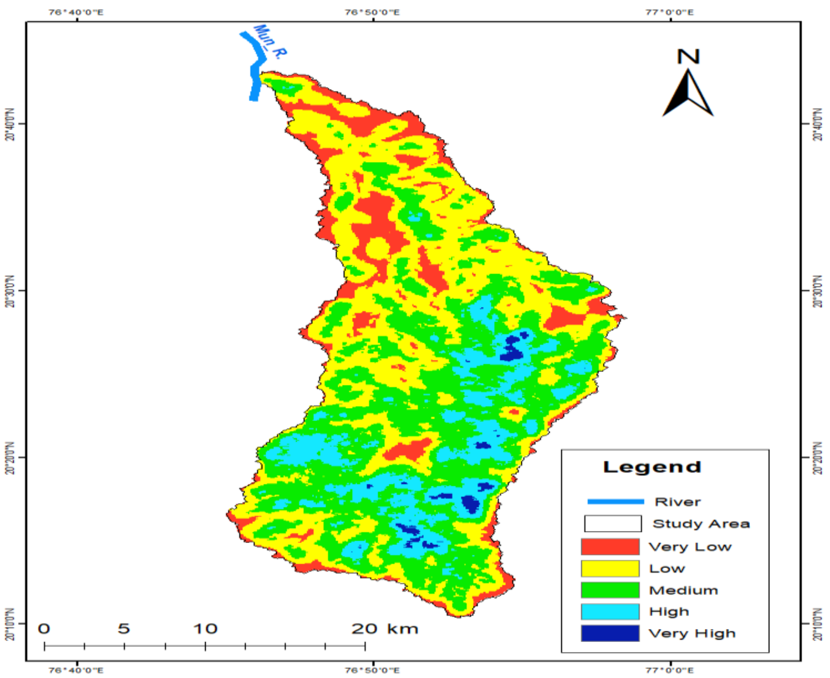

Figure 5: Map showing the watershed of the Nirguna (Bhikund) river's drainage density.

3.7 Stream frequency (Sf):

The proportion of all streams to all land area in basins or watersheds refer to this as the stream frequency. (Horton, 1945). The sort of drainage arrangement is helpfully indicated. The research area's stream frequency (Sf) value is 2.87. The drainage texture is influenced by stream frequency, which rely on study areas lithology. As a result, there is a positive link has been observed between drainage density and stream frequency indicating that drainage density increases with stream frequency. (Sumit Das, Sudhakar D. Pardeshi, 2018). It can be said that the chances of flooding are more depends on the precipitation.

3.8 Drainage texture (T):

Drainage texture (T) is computed as the sum of the lengths of the streams around the watershed's perimeter. (Horton, 1945). While weak or soft rock has a fine drainage texture, hard rock exhibits a coarse texture of drainage. A moderate to fine texture is indicated by the drainage textures score of 6.6.

3.9 Circularity ratio (Rc):

The circulatory ratio can be found by comparing the diameter of a circle with the size of a basin. (1953, Miller). The circularity ratio is impacted by a number of factors like stream frequency, climate, slope, relief, environment, geological structures etc. of the river watershed. Here, the Nirguna (Bhikund) river watershed has an elongated shape, as indicated by its moderate Rc value of 0.26. shape and mature topography.

3.10 Elongation ratio (Re):

Circumference of a circle with the same area in diameter divided by the longest possible drainage basin is called the elongation ratio (Re). (Schumm, 1956). The index of elongation ratios varies in the following categories: less elongated, more elongated, oval, and circular. Runoff drains more effectively into a circular basin than it does into an elongated one. (Singh and Singh, 1997). The study area having Re value of 0.38 depicts that the watershed has an elongated shape.

3.11 Form factor (Ff):

The basin area is the definition of the form factor divided by the basin length square. Horton (1932). There are 0.1 to 0.8 form factors. Diminished form factor indicates the basin's or watershed's elongated shape value as opposed to the higher value indicates the circular type of watershed or basin. If the value of form factor is 0.8 shows a circular shape and due to this there are high chance of flash floods. Because In this research field, the form factor value is 0.1, the watershed has an elongated shape.

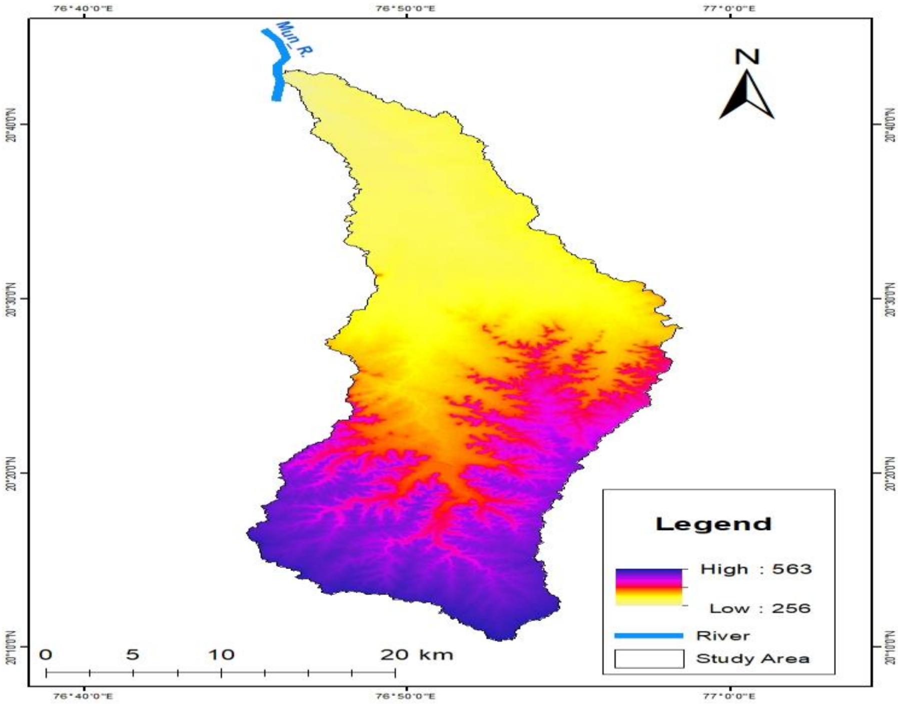

Figure 7: DEM map of Nirguna (Bhikund) river watershed.

3.12 Relief (R):

An essential geomorphic component that aids in understanding processes involved in erosion and mass transport in the study area is basin relief. The difference of Basin relief refers to the highest and lowest elevations found within a basin or watershed. In case of very high relief demonstrates the presence of steep slope, high run-off and high residue transport in the study area, while low relief shows the moderate incline, minimal runoff, and less sediment transport. The relief value ranges from 256 meters at the lowest to 563 meters at the peak. The research area's relief value is displayed in Fig. 7.

3.13 Relief ratio (Rh):

The relief ratio can be computed by ratio of the maximum basin length (Lb) by the basin relief (H). Here the Rh value is 6.63 which indicates the moderate slope and moderate intensity of erosional processes. The results showing morphometric properties of Nirguna (Bhikund) river watershed are shown in Table 3

Table 3. Results showing morphometric properties of Nirguna (bhikund) River watershed.below.

Sr. No.	Parameters	Nirguna (Bhikund) River Watershed
1	Basin area (A) (km^2)	726
2	Basin perimeter (km)	187
3	Basin length (km)	85
4	Drainage density (Dd) (km/ km^2)	2.3
5	Stream frequency (Sf) (No/ km^2)	2.87
6	Drainage texture (T)	6.6
7	Circularity ratio (Rc)	0.26
8	Elongation ratio (Re)	0.38
9	Form factor (Ff)	0.1
10	Relief (R)	563
11	Relief ratio (Rh)	6.63

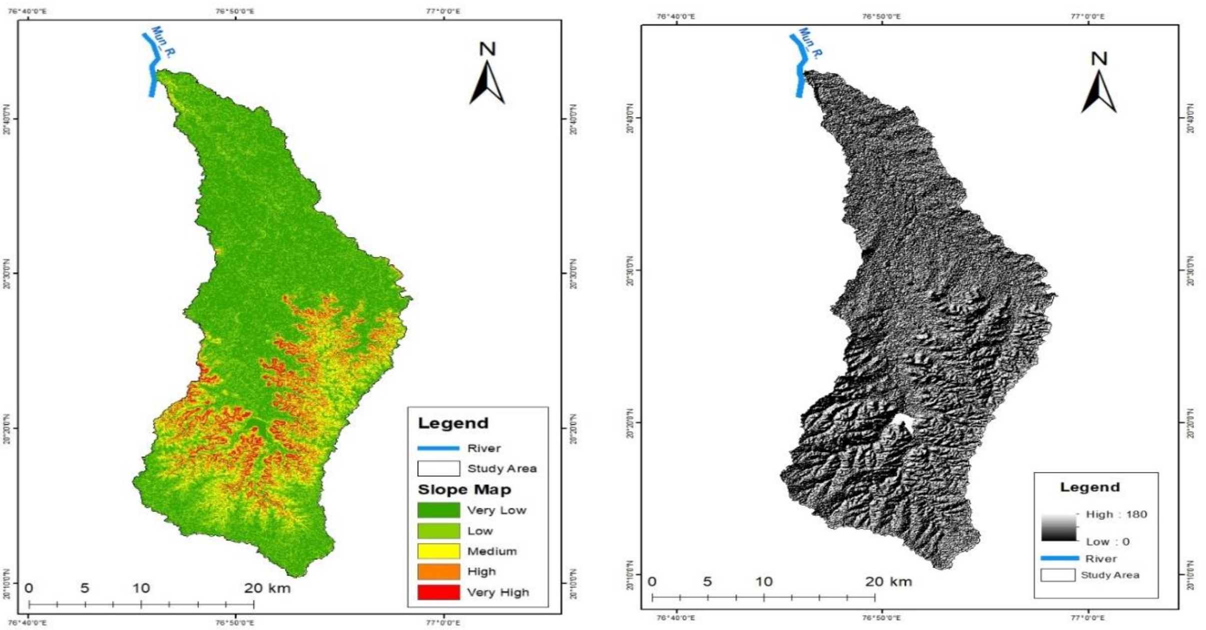

Fig 8 & 9: Slope & Hill shed map of Nirguna (Bhikund) river watershed.

3.14 Slope:

A slope is defined as the degree of inclination relative to the horizontal surface. By utilizing the slope map has been created using ArcGIS software. Studies indicate that there is variation in slope of the Nirguna (Bhikund) river watershed. The values of slopes here in the study area are 0^{o} to 33^{o} and the values of hillshed are 0 to 180. (Fig. 8 & 9). Moderate variation in slopes indicates the steep scarp and rapid runoff.

DISCUSSION

A drainage basins morphometric analysis gives crucial information on the topography, runoff, geological structures, and hydrogeological features of the underlying rock as well as a quantitative approach to define the characteristics of a drainage pattern. It is crucial for comprehending hydrological studies of a river basin or watershed as well (Bhavana N. Umrikar, 2016). All linear, ariel, and relief parameter data have been displayed in attribute form. To characterise and prioritise sub-watersheds, it may be claimed that studying watershed morphometry is insufficient. Instead, an integrated strategy that takes into account changes in both land cover and land use estimates of runoff and sediment output is needed (Abdeta, *et al.*, 2020). Studies using morphometric analysis are considered suitable since they provide a deeper comprehension of the interrelationships between various watershed characteristics. For ex. The watershed having elongated shape, which indicates a steep slope, indicates that it is less susceptible to flash floods but more susceptible to erosion. (G.R. Puno, R.C.C. Puno, 2019). GIS based approach gives information about the connection between the properties of landforms and drainage morphometry, eroded lands, and soils, as well as the analysis of various morphometric parameters (Kuldeep and Upasana, 2012). The current studies have computed morphometric parameters and generated several maps for the extensive analysis of the watershed. However, by including data on watershed prioritization, land use, and land cover studies, it can be made even better.

CONCLUSIONS

To comprehend a watersheds hdrological behaviour, in order to perform morphometric analysis, the advance remote sensing technique have been used. Model of Digital Elevation (DEM) is used for the computational studies which covers the large area of basin with high accuracy. By using standard method various morphometric parameters have been calculated such as the areal parameters and linear parameters and relief parameters. The watershed of the Nirguna (Bhikund) river was morphometrically analysed in the current research. In the research region, which is comprised of an area of approximately 726 sq. km, the maximum 6th order stream was seen. The homogeneous lithology is found because of the study areas drainage network. The studied region is at a mature geomorphic stage, according to the rising trend in the ratio of stream lengths of lower to upper order. The drainage density estimates suggest that there must be a thick vegetative cover in the research region since the subsoil is thick and very permeable. Given that the average bifurcation ratio for a watershed is 4.03, there is either little structural control or little structural disturbance, and no changes have been made to drainage patterns. The impermeable rocks that cover the study area, which is what causes the high surface runoff, as seen by the significant results for stream frequency, infiltration rate, drainage density, and texture. The values of the form factor and the circulation ratio reveals the watershed is elongated. Relief properties of the watershed have shown that the watershed has a less erosional mechanisms. The thorough examination of the watershed morphometric parameters utilising advance technique of RS and GIS enabled us to comprehend the runoff, infiltration capacity, lithology, structural studies, as well as relief that impact the hydrological processes of the Nirguna (Bhikund) river watershed. The result calculated in this paper will also help to establish the watershed development plan for the study area.

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