Morphometric Analysis of Jam Watershed, Parbhani District, Maharashtra

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***Abstract*—Morphometric analysis of a watershed is essential for understanding hydrological behavior, groundwater potential and planning of soil and water conservation measures. The present study was undertaken to delineate *Jam (Jamb) watershed in Parbhani district* (19° N, 76° E, 350 m MSL, Godavari-Purna sub-basin) covering 2198 ha (4.95 km²) and to determine its morphometric parameters using geospatial techniques. The watershed is under IWMP Parbhani-IWMP-16/2010-11 (PIA: DRDA & GSDA), semi-arid climate with 760-1200 mm rainfall, vertisols, 0-3% slope, under soybean-cotton based cropping system. Methodology involved SRTM/Cartosat DEM processing in ArcGIS using Fill, Flow Direction, Flow Accumulation and Strahler ordering. Linear, Areal and Relief parameters were computed as per Horton (1945), Strahler (1964), Schumm (1956). Results revealed 2nd order dendritic basin with total stream length 25.5 km, mean Rb 9, indicating less structural control. Drainage density is 1.185 km/km² (coarse), stream frequency 2.10 indicating permeable sub-surface, low relief and moderate infiltration. Form factor, circulatory ratio and elongation ratio suggest elongated shape with moderate runoff and good recharge potential.**

The study demonstrates RS & GIS as rapid, accurate tools for watershed prioritization, erosion-prone area identification and site suitability for check dams, CCTs and farm ponds for sustainable dryland agriculture.

***Index Terms*—Morphometric analysis, SRTM DEM, Watershed**

I. INTRODUCTION:

A drainage basin is a part of land where water from rainfall is contributing to a common point. It is useful element of the catchment, and all flow of water is governed by its properties (Christopher et al. 2010). GIS and remote sensing techniques are efficient tools used to analyze the hydrological process of the drainage basin (Waikar and Nilawar 2014). Drainage basin analysis is an essential used to assess and manage both ground and surface water resource. Important characteristics of the drainage basin such as shape, length of tributaries, size, and slope are highly correlated with drainage basin hydrological process (Rastogi and Sharma 1976). Drainage basin networks exhibit temporal and spatial variations. Such runoff patterns change hydrological systems and significantly change both catchment inputs and output such as stream discharge, suspended sediment, solutes and litters, and watershed characters. Hydrological behaviour of the drainage basin is used to design appropriate type of soil and water management system, prior work, erosion prone area, food analysis, and selection of appropriate site for different water infrastructures. The drainage basins are also appropriate to consider the onsite and offsite ecology. As hydrology, water that flows in and out of the basin will deposit and pick up various elements such as sediment, nutrients, and pollutants (Oyegoke and Ifeadi 2008). They can affect both onsite and offsite ecology of the basin. Therefore, investigating the drainage basin process is the potential to understand the movement of water within the hydrologic cycle.

Geographic Information System (GIS) technology can be a useful tool in the analysis of watershed morphometry. A thorough evaluation of the features of watersheds is made possible by the integration of RS

and GIS in morphometric analysis. With the use of these technologies, which offer numerous types of spatial data, scientists may analyze and understand the complex relationships that exist between hydrological processes, environmental variables, and landforms. Researchers can obtain important insights into the morphology and behavior of watersheds by utilizing the capabilities of GIS and RS. This can help with informed decision-making in a variety of fields connected to water resources, land management, and environmental planning (Raja Shekar and Mathew 2024). Remote sensing has the ability of obtaining synoptic view of large area and very useful in analyzing the drainage morphometric parameter. Many works have been carried out on morphometric analyzing using RS and GIS. Sarita et al. (2013) presented their work prioritizing erosion-prone area through morphometric analysis (Sayeed et al. 2017). The proven effective methods for drainage basin delineation, updating, and morphometric analysis are remote sensing and GIS techniques.

Any hydrological investigation, such as determining the potential and management of groundwater, must consider the drainage basin analysis. The physiographic properties of drainage basins, such as stream length and size, drainage density, area and slope of the drainage area, and the shape and size of the drainage area, can be connected with a number important hydrologic phenomenon. For example, ridgeline delineation, characterization, priority evaluation, problem identification, evaluation of potentials and management needs, identification of erosion-prone areas, evolving water conservation strategies, and reservoir and check dam site selection can all benefit from the use of remote sensing data in conjunction with conventional data (Waikar and Nilawar, 2017.) The study was conducted with objective to delineate Jam watershed and to determine morphometric parameters of watersheds using geospatial techniques.

II. REVIEW OF LITERATURE:

Literature pertaining to research topic has been reviewed. Horton (1945) explained the concept of formation of streams and basins quantitively. Using the mathematical description to the modern quantitative geomorphology. He described the morphometric properties such as linear, areal and relief characteristics of watershed. Each of the properties provide the useful for understanding the nature and behaviour of stream orders. Strahler (1964) studied the morphometric analysis of a watershed provides the quantitative aspects of the characterization of watersheds. Various scholars have carried out morphometric analysis of river basins by using remote sensing and geographical information system techniques.

Bhatt and Ahmed (2014) evaluated basin features based on infiltration rates morphometric parameters aids in understanding the catchments' physical response to flooding. Modern technologies like Geographic Information Systems and Remote Sensing (GIS) were utilized to assess the morphometric study by collecting drainage networks for the Upper Krishna basin using the Cartosat Digital Elevation Model (DEM). To evaluate the primary influencing catchments that contribute to flooding in the main Krishna River, basin morphometric parameters were used. The morphometric examination of the basin's ten principal flood-prone river catchments shows that, due to their high relief ratios (Rh), river catchments like the Krishna, Koyna, and Yerla have a stronger tendency to peak discharge to the main Krishna River quickly. The results indicate that there may be more runoff in the higher streams of the higher Krishna River basin, including Krishna, Koyna, Yerla, Panchaganga, and Dhudhganga, during the rainy season. allows the basin's lowest portion to flood. There is a structure like for controlling floods. Final map showing the order of catchments, from higher to lower, that affect floods in the Upper Krishna basin's major Krishna River.

Salvi et al. (2017) carried out the morphometric analysis of the Vashishthi Watershed in the Ratnagiri district of Maharashtra, India, focused on its four sub-catchments. Remote sensing and geographic information system (GIS) techniques, employing satellite imagery and topographic maps at a scale of 1:50000, were utilized for this study. The Vashishthi watershed has fifth order basin and dendritic drainage pattern. The investigation concentrated on the linear, aerial, and relief aspects concerning morphometric parameters. The drainage density in the study area ranged from 0.730 to 0.742 Km/km2, indicating excellent permeability of the subsurface. No structural disturbances or significant geological variations were observed, as evidenced by the bifurcation ratio ranging

from 1.9 to 2.6. Through morphometric analysis, sub-catchment 1 displayed lower form factor, texture ratio, and elongation ratio values. Conversely, sub-catchment 3 exhibited lower drainage density and stream frequency values. The compound parameter values derived from the study were arranged in ascending order, starting from the lowest value. These findings contribute distribution ofstreams in relation to sub-watersheds, as well as the impact of catchment evaluation of characteristics (e.g., size, shape, slope) on these distributions.

Kudnar (2020) studied GIS-based assessment of morphological and hydrological parameters of Wainganga River Basin, Central India. Various morphological and hydrological parameters of the Wainganga River are evaluated in this study using remote sensing, geographic information system and Global Positioning System techniques. The information can be used for basin management, hydrological studies, and restoration and preservation of ecological studies in the future. The design of river basins involves a systematic approach to the specific issues related to the availability and use of water for diverse purposes, as well as safeguarding the ecological integrity of a river system. The Wainganga River originates from a spring in the plains of Madhya Pradesh and winds its way through the landscape. This region has a shallow and wide river. The river's depth grows in the tributaries of the Sanjay Sarovar Dam. The number of streams in 27 sub-basins is 9472, implying geological heterogeneity at the river basin scale.

Salunke and Wayal (2023) concluded Morphometric Analysis of Panjhara River Basin with Use of GIS for Development of Watershed Plan. The Panjhara River basin, tributary of Tapi River was selected for this study. The study shows that GIS and RS data may be used to analyze and roughly assess the length and rate of erosional activities in a Panjhara River basin, which can lead to better planning and maintenance. Using a 30-meter shuttle radar topography mission digital elevation model (SRTMDEM) and Survey of India toposheet, the method extracts morphometric data and performs hypsometric analysis rapidly and effectively. A mature stage of landform development with low relief, no structural control, minimal vegetation, and a low infiltration rate is indicated by morphometric and hypsometric investigations. The Panjhara River is a component of the west flowing river system and flows in an elongated basin in a dendritic drainage pattern. This study will help set the required measures in place to protect soil and water resources for the watershed's long-term development.

III. METHODOLOGY

3.1 Description of Jamb Watershed:

The Jam Watershed in Parbhani District, Maharashtra, features a reservoir with favourable conditions and holds water quality suitable for agricultural and local use. Located in a region with major rivers like the Purna and Dudhana. The area is a part of watershed project, typically managed under integrated watershed management programs (IWMP) to enhance agricultural productivity.

3.2 Project implementing agency (PIA)

The Jam watershed development programme was implemented by District Rural Development Agency (DRDA), Parbhani and Ground Water Survey and Development Agency (GSDA). It is listed in the IWMP project locations under Parbhani-IWMP-16/2010-11.

3.3 General Features of Jam Watershed

3.3.1 Location

The Jamb watershed is situated in Parbhani district of Marathwada region, which is 10 Km away from the Parbhani city. It is located at 19^0 N latitude and 76^0 E longitudes. Jamb watershed is situated at an altitude of 350 m above mean sea level (MSL). The Region is part of the Godavari- Purna Sub basin.

3.3.2 Soil and Topography

The total geographical area of Jamb Village is 2,198 ha out of that is upto 1,900 ha area is under cultivation. The topography of watershed is flat, fertile and plain. The watershed comes under semi- arid area. The general slope of cultivable land ranges from 0 to 1 percent while slope of non-cultivable area ranges from 1 to 3 percent. The Jamb watershed area consists of two types of soils which are dark brown to black and vertisols. Population of Jamb village is 4,835out of which 2,485 are male and 2,350 females. The land capability classification and soil characteristics of Jamb watershed are given in following table.

3.3.3 Climate

The watershed area falls within the tropical wet and dry climate zone of central Maharashtra. The average annual rainfall is ranges from 760-1200 mm, which is uneven, erratic and varies from year to year. South-West monsoon is the major source of rainfall and about 89 percent rainfall receives during monsoon season i.e., from the month of June and September.

The average maximum temperature of 40^0C is normally record during the month of April to May, while the lowest temperature is 30.5^0C recorded during December to January.

The average temperature during rainy season varies from 32.1^0C. The average maximum relative humidity during recorded as 80 percent, while lowest 60 pe rcent.

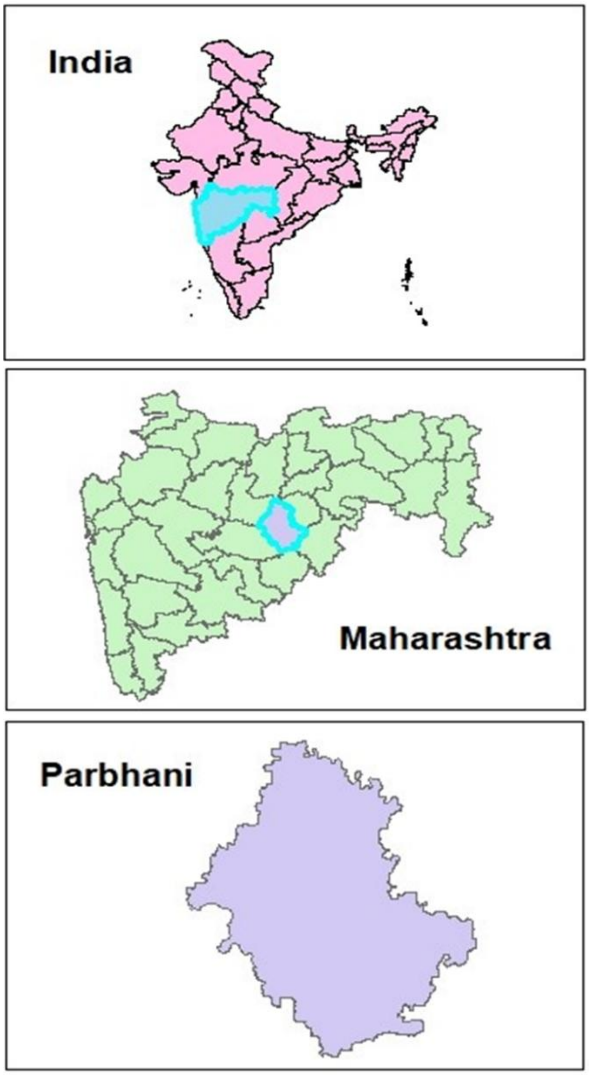


Fig 3.1: Location of study area

Table 3.1: Physical properties of soil of Jamb watershed

Sr. No	Particulars	Range
1	PH	7.0 to 8.2
2	Organic carbon (%)	0.05 to 1.05
3	Available Phosphorus kg/ha	5.35 to 22.11
4	Available Potash(kg/ha)	316 to 800
5	Available nitrogen(kg/ha)	121 to 356
6	Soluble salt (ds/m)	0.12 to 0.45
7	Fertility level	1.67 to 2.33

Table 3.2: Land capability classification of Jamb watershed

Sr. no.	Land Capability Class	Area (ha)
1	Class-II	1650 - 1750
2	Class-III	220 - 330
3	Class-IV	110 - 150
4	Class-VI	50-110
	Total	2198.16

3.3.4 Hydrology

The watershed sits on the Deccan Traps, specifically weathered, vesicular, and fractured basalt. Groundwater exists in both phreatic (unconfined) and confined conditions. The area includes the Jamb percolation tank, which covers approximately 118.54 hectares and serves as a critical structure for augmenting groundwater recharge.

3.3.5 Vegetation

The vegetation of the Jamb watershed in Parbhani is primarily defined by intensive agricultural land use, with natural vegetation being sparse and largely confined to non-cultivable areas. The watershed is highly agrarian, with over 85% of theland typically used for crop production.

3.3.6 Cropping pattern

The cropping pattern in the Jamb watershed, as in most of Parbhani, is dominated by soybean and cotton, pigeon pea, during the kharif, gram (Chickpea), wheat, rabi and sorghum, groundnut, onion, watermelon in summer season.

3.4 Collection and Data:

The Jamb watershed was determined using SRTM - DEM with a which was downloaded from the USGS.

3.5 Software and System:

The data was collected, analysed, and produced using the software programme ArcGIS. The boundary of the watershed was determined using the ArcGIS software.

3.6 Delineation of watershed:

Watershed delineation is a process for creating a boundary that represents the contributing for a specific control point or water outlet, with the intent of characterization and analysis of portions of a study area. The study watershed and stream networks are automatically generated from DEM using ArcGIS. The overall methodology used to delineate and generate stream networks is as follows.

Using the ArcGIS software, acquire and reproject the DEM data to the UTM zone 43 N coordinate system.

The DEM filled out the pits using fill Sinks tool under Spatial Analyst tools of Hydrology option.

Then generate the flow direction tool to Creates a raster of flow direction from each cell to its downslope neighbour, or neighbours, using D8, Multiple Flow Direction (MFD) or D-Infinity (DINF) methods.

Then flow accumulation tool is used to Creates a raster of accumulated flow into each cell. A weight factor can optionally be applied.

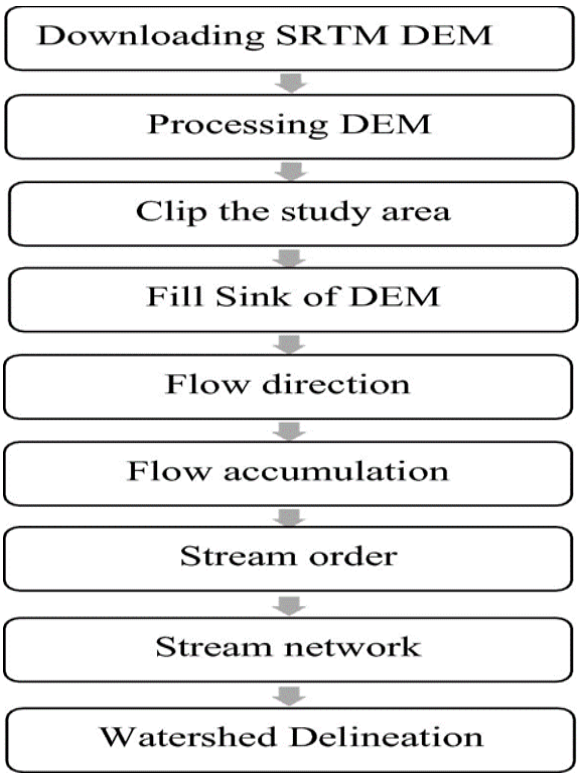


Fig. 3.2 Process of watershed delineation

Generate the Stream Network using 'Strahler Stream Order' tool based on Strahler order. It is used to Assigns a numeric order to segments of a raster representing branches of a linear network. And to Converts a raster representing a linear network to features representing the linear network.

Place the desired location of watershed outlet, use the 'Upslope Area' tool to delineate the watershed based on outlet point

Then use the snap pour point tool to Snaps pour points to the cell of highest flow accumulation within a specified distance.

The watershed boundary was plotted, and the area of the watershed, length and order of the streams were calculated.

3.7 Determination of Morphometric Parameters of Watershed:

In order to accomplish the objective of this study, the morphometric characteristics of the watershed were analysed by combining GIS and remote sensing techniques. We studied the morphologic characteristics of the watershed using ArcGIS software.

Using ArcGIS tools, the study watershed and stream networks are automatically generated using DEM. The morphometric parameters are determined using an Excel spreadsheet. The following is the general process that was followed to delineate watershed and generate stream networks:

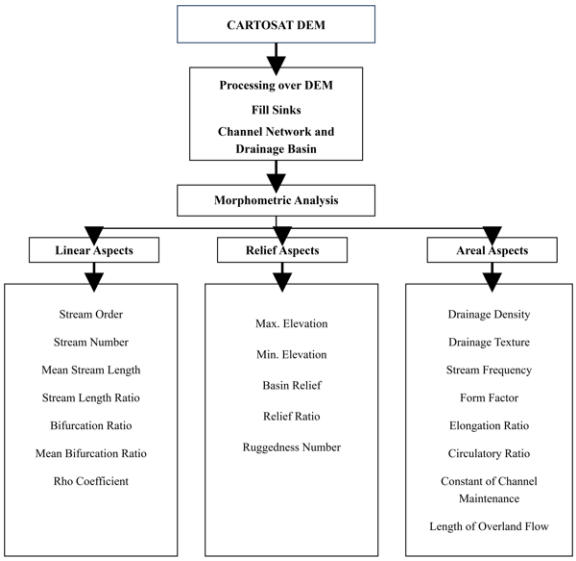


Fig 3. Determination of Morphometric Parameters of Watershed

Table 3.3: Formulae for Determination of Linear Parameters

Sr. No.	Morphometric Parameters	Formula	References
1.	Stream Order (Nu)	Hierarchical rank	Strahler, 1964
2.	Stream Length (Lu)	Length of the Stream in km	Horton, 1945
3.	Mean Stream Length (Lsm)	Lsm = Lu/Nu Where, Lu = Total stream length of order 'u'; Nu = Total no. of stream segments of order 'u'	Horton, 1945
4.	Stream Length Ratio (RL)	RL= Lu / Lu-1 Where, Lu= stream length of a given order; Lu-1= stream length of next lower order	Horton, 1945
5.	Bifurcation Ratio (Rb)	Rb = Nu / Nu +1 Where, Rb = Bifurcation Ratio; Nu = No. of stream segments of a given order; Nu +1= No. of stream segments of next higher order	Schumn, 1956
6.	Mean bifurcation ratio (Rbm)	Rbm = Average of bifurcation ratios of all orders.	Strahler, 1957

Table 3.4: Formulae for Determination of Areal Parameters

Sr. No.	Morphometric Parameters	Formula	References
1.	Drainage Density (Dd)	Dd = Lu/A Where, Dd = Drainage Density (1/km); Lu = Total stream length of all orders; A = Basin Area (km2)	Horton, 1945
2.	Stream Frequency (Fs)	Fs = Nu/A Where, Fs = Stream Frequency; Nu = Total no. of streams of all orders and; A = Area of the basin (km2)	Horton, 1945
3.	Drainage Texture Ratio (Dt)	Dt = Nu /P Where, Nu = No. of streams in a given order; P = Perimeter of basin (km)	Horton, 1945
4.	Form Factor (Ff)	Ff = A/Lb2 Where, A = Basin Area; Lb = Basin length	Horton, 1945
5.	Constant Channel Maintenance (C)	C = 1/ Dd Where, Dd = Drainage Density	Horton, 1945
6.	Circulatory Ratio (Rc)	$Rc = 4\pi A / P^2$ Where, A = Basin area (km2); P= Perimeter of the basin (km)	Miller, 1953
7.	Elongation Ratio (Re)	$Re = \sqrt{A} / \pi / Lb$ here, A= Basin area (km2); Lb= Basin length (km)	Schumn, 1956
8.	Length of Overland Flow (Lg)	Lg = 1/ 2 * Dd Where, Dd = Drainage Density	Horton, 1945

Table 3.5: Formulae for Determination of Relief Parameters

Sr. No.	Morphometric Parameters	Formula	References
1.	Basin Relief (R)	R = H-h Vertical distance between the lowest and highest points of watershed	Schumn, 1956
2.	Relief Ratio (Rr)	Rr = H / Lb Where, H = Basin Relief (km); Lb = Basin length (km)	Schumn, 1956
3.	Ruggedness Number (Rn)	Rn = H x Dd Where, H = Basin Relief (km); Dd = Drainage Density	Schumn, 1956

IV. RESULTS AND DISCUSSION:

The morphometric parameters of Jam watershed have been studied in detail and found that the Jamb watershed covers an area about 4.95 km^2. (Table 4.1)

Table 4.1 Basin parameters of Jam watershed

Basin Area (A)	Basin Perimeter(P)	Basin length (L)
4.95 km^2	8.68 km	3.25 km

4.1 Linear parameters

4.1.1 Stream Order (Nu):

The drainage basin analysis starts with the classification of stream order. Identifying stream orders is the first stage in the drainage basin study process Horton (1945) was the first to demonstrate a stream ordering system; however, Strahler (1952) introduced this ordering system after minor modifications.

Table 4.2 No. of streams and Stream Order

Sr. No.	Number of stream Order	Total no. of streams
1	1st Order stream	9
2	2nd Order stream	1

4.1.2 Stream Length (Lu)

The stream length is good indicator of the morphological characteristics of the watershed. Higher stream length indicates well drained area. It is the most important hydrological characteristics of the basin as it affects the surface runoff. Smaller stream length indicates steep slope. The stream length decreases as the stream order increases. The total length of stream in the study watershed is 25,500 m. The length of first and second order streams is 18,500 m and 7,000 m respectively.

4.1.3 Mean Stream Length (Lsm)

The mean stream length is the characteristics of a drainage network and its associated surface (Strahler 1964). It is calculated by dividing the total length of all streams under a stream order by the number of the same order. Generally, it is calculated for each order of streams separately.

The mean stream length for 1st order is 2,060 m and for 2nd order it is 700 m. It is quite obvious that the mean length of the stream keeps on increasing with increasing of the stream order. The overall, mean stream length for the watershed is 25,500 m.

4.1.4 Stream Length Ratio:

The stream length ratio is defined as the ratio of the mean stream length of a given order to the mean stream length of next lower order and has an important relationship with surface flow and discharge (Horton, 1945).

4.1.5 Bifurcation Ratio (Rb):

Bifurcation ratio is the ratio of a number of the stream segments of specified order and a number of streams in the next higher order. The Rb is dimensionless property. Basically, there are two classes of Rb value; low and high.

Low class means the drainage pattern is not affected by the geologic structures, whereas the high class means the drainage pattern is controlled by the geologic structures. In the present study the value of the mean of the all Rb is 9.

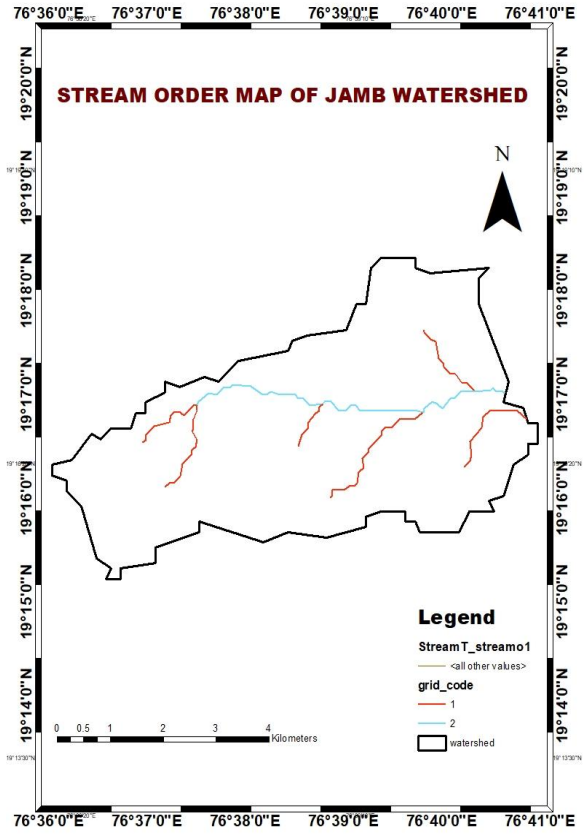


Fig 4.1: Stream order map of Jam Watershed

Table 4.3 Linear Parameters of Jamb watershed

Stream order (u)	Stream count (Nu)	Stream Length (Lu)	Mean Stream Length (Lsm)	Stream length ratio (Rl)	Bifurcation ratio (Rb)
1	9	18,500	2,060	3.40	9
2	1	7000	700	-	-
Total	10	25,500	2,760		Mean RB=9

4.2 Areal Parameters:

4.2.1 Drainage density (Dd):

Drainage density is the ratio of total length of streams to the total area of watershed. The lower density is associated with the region where the length of the stream is less while the area coverage is large. It is important parameter which indicates dissection of landscape and peak run off potential of watershed. The drainage density pattern is: coarse if Dd is less than 5 km per sq. km, medium if Dd is between 5-10 km per square kilometre and fine if Dd is more than 10 km per square km. In the present study the value of the Dd is 1.185 km/km^2 which indicates coarse pattern of drainage network.

4.2.2 Drainage Texture (Dt):

The variation in the value of drainage texture depends upon in the number of natural factors such as climate, rainfall, vegetation, rock, soil type and their infiltration capacity and relief of the basin. High drainage density is a resultant of weak impermeable sub surface material. The drainage density less than 2 indicate very coarse, 2-4 is related to coarse, between 4-6 is moderate, and 6-8 is fine and greater than 8 is very fine drainage texture. It is observed if the drainage texture is 8 it indicates the impermeable material with high relief.

4.3.3 Stream frequency (Fs):

Stream frequency (Fs) is the total number of channel segments of all stream orders per unit area (km2). A total number of channel segments are dimension-less. Commonly, there are the low and the high classes of stream frequency which are relative among the investigated watersheds in a research area. In the present study the value of the Fs is 2.10 which is indicate that stream frequency indicates permeable sub-surface material and moderate to low relief.

4.2.4 Form factor (Ff):

Form factor is a ratio of watershed area to the square of the length of the watershed. Flood hydrograph always affects the basin form. There are some different value ranges of form factor. The range values for form factor are 0.78 (circular). There are also other range values for Rf classification, i.e., elongated (0 or low value) and circular. In the present study the value of the form factor is 0.34 which is indicate that the watershed is elongated in nature.

4.2.5 Elongation Ratio (Re):

Elongation ratio is the ratio of the diameter of a circle of the same area as the basin to the maximum basin length. Therefore, Re is a dimension-less property. Generally, elongation ratio value is classified into two classes, i.e., the low value which means elongated watershed, and high value which means circular watershed. There are many classifications used in some papers. Four classes of Re are elongated (0.9). Three classes of Re are less elongated (< 0.7), oval (0.8 – 0.9), and circular (>0.9). Last but not least, two classes of Re are the low class and the high class. In the present study the value of Re is 0.67 which indicate that the Basin has the more elongated in shape.

4.2.6 Circulatory ratio (Rc):

Circularity ratio is the ratio between the areas of a watershed to the area of the circle having the same circumference as the perimeter of the watershed. Rc is also a dimension-less property. In the present study the value of circulatory ratio is 0.22 which indicate that Circulatory ratio is low, basin is elongated in nature. The Constant of channel Maintenance is the inverse of the drainage density (Schumm, 1956). Therefore, higher the drainage density lowers the constant of channel maintenance and vice versa. Higher value indicates least erodible and vice versa. Regarding the Jamb watershed the average constant of channel maintenance(C) is 0.53. This high value indicates low structural disturbances, high permeability, low to moderate slopes and low surface run off.

4.2.7 Constant of channel Maintenance (C):

The Constant of channel Maintenance is the inverse of the drainage density (Schumm, 1956). Therefore, higher the drainage density lowers the constant of

channel maintenance and vice versa. Higher value indicates least erodible and vice versa. Regarding the Jamb watershed the average constant of channel maintenance(C) is 0.53. This high value indicates low structural disturbances, high permeability, low to moderate slopes and low surface run off.

Table 4.4: Areal Parameters of Jam Watershed

Sr. no.	Parameter	Value
1.	Drainage density	1.18
2.	Drainage texture (Dt)	8.00
3.	Stream frequency (Fs)	2.10
4.	Form factor (Ff)	0.34
5.	Elongation ratio (Re)	0.67
6.	Circularity ratio (Rc)	0.22
7.	Constant of channel maintenance (C)	0.53
8.	Length of overland flow (Lg)	0.26

4.3 Relief Parameters

4.3.1 Basin Relief (R):

Basin relief is the difference in elevation between the highest and the lowest point of the basin. The maximum elevation of the Jamb watershed is 458 m and minimum elevation is 393 m. The value of basin relief (R) 65 m indicates moderate relief, higher infiltration and low runoff conditions of watershed.

4.3.2 Relief ratio (Rr):

Relief Ratio (Rh) is the difference in the elevation of the highest and lowest points in a watershed. To classify it, researchers did it based on the values of relief ratio in their study area relatively. Generally, the low value of relief ratio means low relief and the high value means steep slope and high relief. In the present study the value of relief ratio is 0.004 indicating that the terrain consists primarily of gentle slopes and low relief.

4.3.2 Ruggedness Number (Rn):

Ruggedness number is the product relief of basin (R) and drainage density (Dd). Ruggedness number (Rn) gives an idea of overall roughness of watershed. It can describe the slope steepness and length of the basin. The watershed's low ruggedness value suggests that the area is less prone to soil erosion. In the Jamb watershed the value of Rn is 0.134, which reflects a less rugged terrain with low relief and low stream density.

Table 4.5: Relief Parameters of Jam Watershed

Sr. No.	Parameter	Value
1.	Basin relief (R)	65 m
2.	Relief ratio (Rr)	0.004
3.	Ruggedness Number (Rn)	0.134

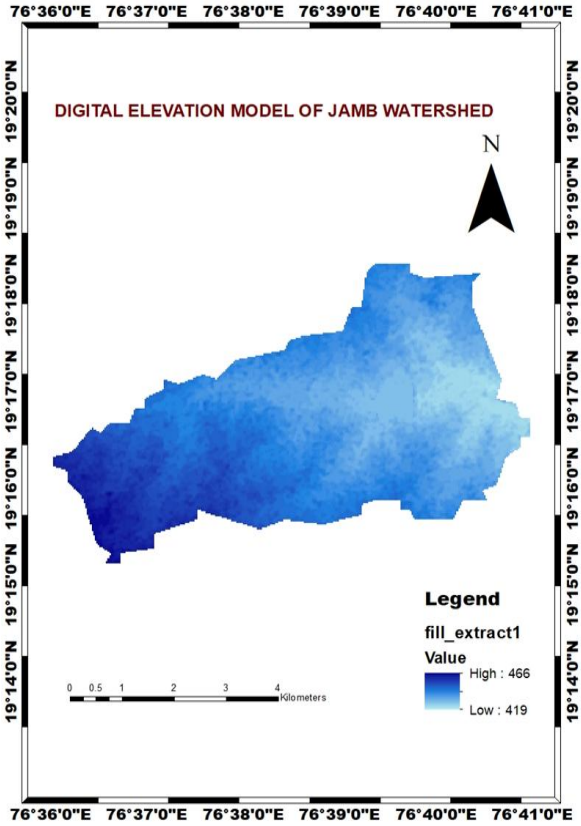


Fig 4 .5 Digital elevation model (DEM) of Jamb watershed

This is a map showing the DEM of Jamb watershed. The Jamb village is located in Maharashtra's Parbhani district Marathwada region, which is 10 Km away from the Parbhani city. It is located at 19^0 N latitude and 76^0E longitude. Jamb watershed is situated at an attitude of 350 m above mean sea level (MSL). Low elevation (401) is shown in sky blue on the map near the mouth, and high elevation (458) is shown in dark blue at the upstream end.

The Hillshade Map provides a 3D-like visualization of the terrain by simulating how the terrain would appear under illumination from a light source. The virtual 3D visualization of watershed depending on sun's azimuthal angle.

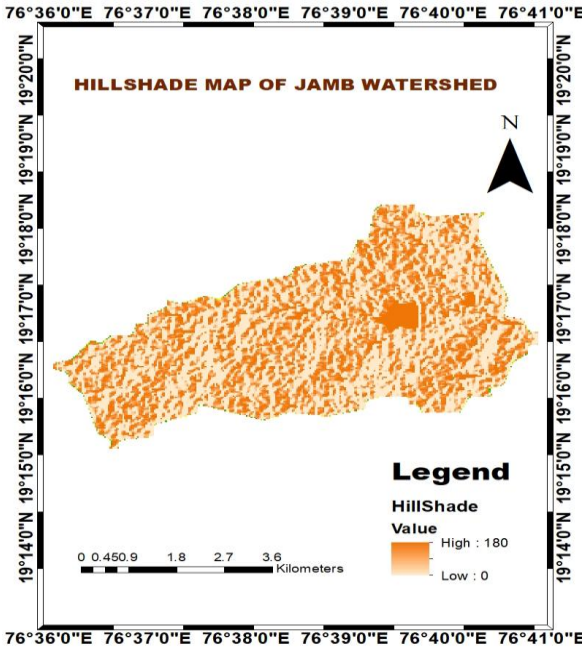


Fig 4.6: Hillshade Map of Jam watershed

The sun's position in the sky is the primary consideration when making a terrain map. Shadow and light are, by default, gray hues associated with numbers ranging from 0 to 180. This map highlights elevation changes and landform features such as ridges and valleys. It enhances interpretation of slope, aspect, and helps in understanding landform structure and hydrological behaviour in a visually intuitive way.

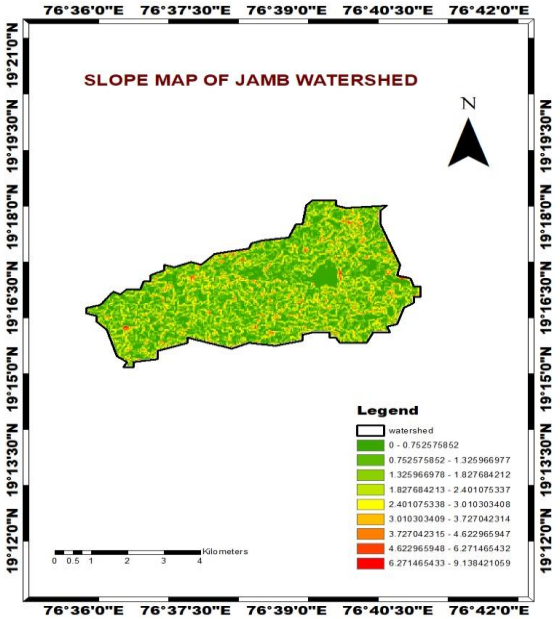


Fig 4.7: Slope map of Jamb watershed

This is the Slope Map of Jamb Watershed, prepared using DEM data in GIS. The slope map helps us understand the variation in terrain steepness within the watershed. It is a key factor in identifying erosion-prone areas, land use planning, and soil conservation. Most of the area falls under the terrain which is relatively flat or has a very gentle slope. However, the southern and eastern parts, shown in dark green and light green, are exceptionally flat and need soil and water conservation practices. Slope analysis contributes to relief aspects of morphometric parameters and helps in planning for sustainable watershed management.

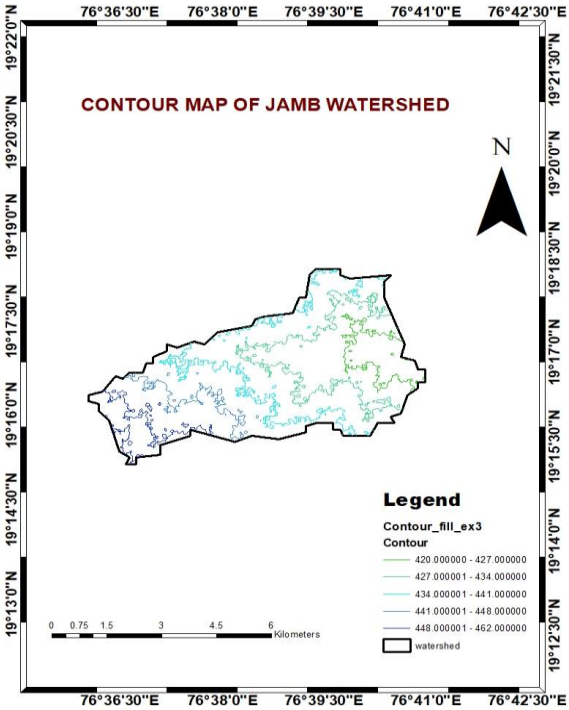


Fig 4.8: Contour map of Jamb watershed

The Contour Map shows the elevation variation in the Jamb Watershed area. Contour lines were generated from the DEM and clipped to the watershed boundary. Contours help in visualizing the topography of the area and are important for understanding surface runoff, drainage direction, and designing structures like check dams and bunds.

V. CONCLUSION:

Geospatial technique is a powerful tool to assess the morphometric parameters of watershed. The value of

elongation ratio, circularity ratio and form factor suggest that the watershed is elongated in shape. Morphometric analysis helps to understand the basin hydrology and planning of soil and water conservation work as well as to identify suitable sites for soil and water conservation works as well as to identify ground water potential zones.

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