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GEOMORPHOMETRIC ANALYSIS OF BILDI RIVER SUB BASIN IN BULDHANA DISTRICT OF MAHARASHTRA STATE, INDIA USING GIS AND REMOTE SENSING

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Abstract – Remote sensing and geographical information system (GIS) and global positioning system (GPS) has established to be an efficient tool in delineation of drainage pattern and water resources management and its planning. GIS and image processing techniques have been adopted for the identification of morphological features and analyzing their properties of the Bildi catchment area in Buldhana district of Maharashtra state, India. The basin morphometric parameters such as linear and aerial aspects of the river basin were determined and computed. It is 5 th order drainage basin and drainage pattern mainly in subdendritic to dendritic type. It is observed that the drainage density value is low which indicates the basin is highly permeable subsoil and thick vegetative cover. The circularity ratio value reveals that the basin is strongly elongated and highly permeable homogenous geologic materials. This study would help the local people to utilize the resources for sustainable development of the basin area.

Keywords- Morphometry, Bildi catchment, Remote Sensing, GIS.

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INTRODUCTION

Geomorphology is defined as "The measurement and mathematical analysis of the configuration of the earth's surface and of the shape and dimension of its landforms." The drainage basin and channel morphology are related to the geologic, climatic and hydrologic characteristics of basin. Hence to establish the relationship between them it is necessary to undertake quantitative analysis of the concerned terrain. The drainage basin are formed from complex association of water divides, hill slops, valley heads, River terraces, flood plains, etc. which need to be studied either independently or together and then interpreted. These studies therefore require selection of diagnostic geomorphic variables such as elevation, slope angle, stream length, basin area, stream frequency, bifurcation ratio, drainage density etc. Detailed morphometric analysis of a basin is of great help in understanding the influence of drainage morphometry on landforms and their characteristics [1] - [2]. The morphometric analysis can be carried out through measurement of linear, aerial and relief aspects of basin and slope contributions [3]. The drainage characteristics of Bildi subwatersheds are studied by analyzing topographical map and IRS LIS III satellite data. In

the present study, attempt has been made to evaluate linear, relief and aerial morphometric parameters and analyze soil parameters like porosity, permeability, texture, infiltration, and runoff and land erosion conditions. Drainage morphometric analysis gives overall view of the terrain information, like hydrological, lithological, slope, relief, variations in the watershed, ground water recharge, porosity, soil characteristics, flood peak, rock resistant, permeability and runoff intensity. This information is useful for all geological, hydrological, ground water studies (Manjare et al., 2014)

2. Study Area

Bildi catchment is located in the south eastern part of the Purna alluvium and extends from the ridges and meets to the Mun River. Bildi catchment overlies two districts of the Maharashtra; i.e. Akola and Buldhana. It has an area of approximately 119.91 km 2. The Bildi river basin covers an area of 140 sq.km km2 in the Shegaon Taluka of Buldana District, Maharashtra. It is bounded by longititude 76°33'00" E to 79°46'00" E and latitudes 20°33'00" N to 20°46030" N falling in the Survey of India toposheets No. 55 D/10 and 55 D/14 on 1:50,000 scale The basin is included in Survey of India topographical Maps (Fig. 1.)

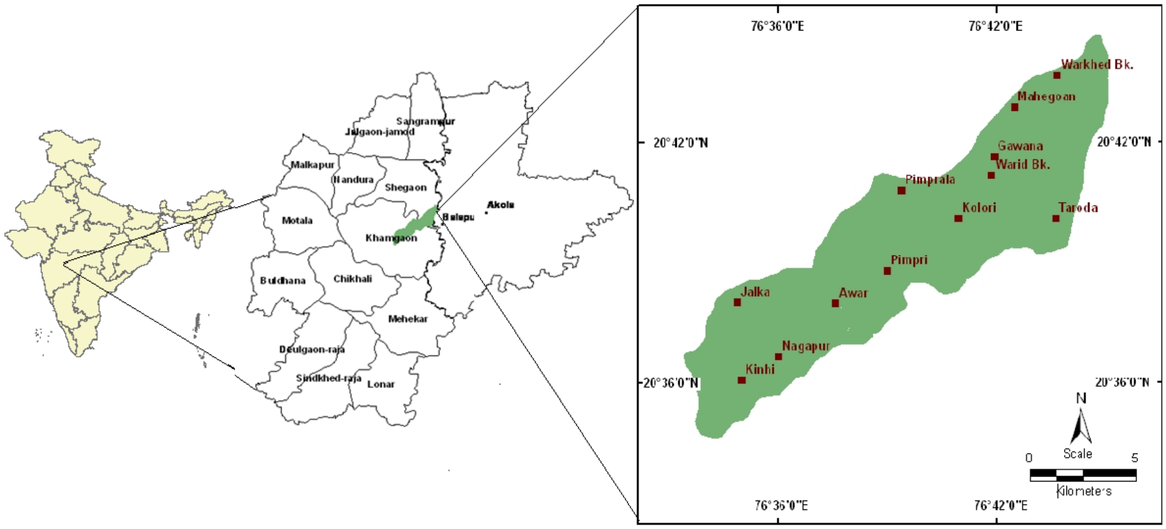


Fig. 1: Location map of Bildi catchment

3. Geomorphology and Geology

The study area is dominated by plains of Deccan trap. Physiographically the district falls under three structural cum physical units. In the north is a hilly strip of the Satpudas, Purna plains in the middle and the Ajanta range comprising Buldhana plateau in the south. The northern region forms a part of Satpura or Gawilgarh hills, which rise to general elevations of 600 to 700 m above mean sea level above MSL (mean sea level) with occasional peaks rising up to 1000 m above MSL or more. Purna plain is the main lowland region of the district, with average elevation ranging between 250 and 270 m above MSL. The Ajanta range carrying on its flat top high level mesa of Buldhana plateau covers the southern part of the district. The edge of this plateau, overlooking the Purna plains to its north, is a hilly ghat with average elevations of 500 to 600 m above MSL. Topographic relief in the Bildi catchment not changes significantly throughout the area. The elevation varies from 256 to 436 mt above MSL. Geology of Akola and Buldhana district is practically the geology of Deccan traps which occur in about- 80 percent of the district. The other geological formation younger than the trap also occurs in the district.

4. Bildi River Sub Basin

The Purna River forms the north eastern boundary of the Akola district, and the eastern portion of the district lies within its watershed. The streams of the Bildi River not comes from a much longer distance and catchment are from the village Kinhi, Nagapur village etc. at its beginning the course of the River towards the north east direction. The course of the Bildi River of the satellite image is quite straight course. The Bildi River sub basin is surrounded by the Purna alluvium and to Mun River near to Warkhed. Downstream of Bildi River the shows NE-SE trending straight reaches which are controlled by weak plain in Deccan trap basalt that floors the River. The River passes through the all Deccan basalt and reaches the south eastern boundary of Mun River. The area of the basin is found to be 119.94 sq.km (Fig. 4).

5. Drainage Pattern of Bildi River Sub Basin

Dendritic to subdendritic drainage pattern is most common pattern is formed in a drainage basin composed of fairly homogeneous rock without control by the underlying geologic structure. The longer the time of formation of a drainage basin is, the more easily the dendritic pattern is formed. The study area has dendritic to sub dendritic drainage type pattern (Fig.3.1). It is characterized by a tree like branching system in which tributaries join the gently curving main stream at acute angles .In the study area at some places the drainage pattern is slightly parallel due to parallel orientation of lineament.

6. Methodology

In order to delineate geomorphological maps the geo-coded IRS-LISS -3 satellite data and SOI toposheet were used. Basic image characteristics like tone, texture, shape, color, associations, etc were used along with field parameters such as topography, relief, slope factor, surface cover, soil and vegetation cover were considered while delineating geomorphic map of the study area. Then suitable logical weights are assigned to each unit of thematic maps and integrated in geographic information systems (GIS) using the spatial overlap method to delineate groundwater potential zones. Depending on the lithological characteristics climatic condition, hydrological condition of the Bildi River sub basin and adjoining region has been divided into different geomorphological units of trifacial origin, namely the structural, fluvial and denudation origin. The descriptions of the various geomorphological units are described below.

7. Geomorphological Units

The study area lithologically comprised by the Deccan trap and Purna alluvium and shows the good exposure of the geomorphic unit illustrated various geomorphic units interpreted from the satellite imagery and using toposheet and district resource map of the study area and each unit is described elaborately in the following sections (Fig. 2 and Table 1).

7.1 Unit's Fluvial Origin

North east trending Bildi River flow in to the lowering depression and negative land form which are surrounded by Purna drainage. These are filled with quaternary sediments of silt gravel and pebbles (Fig. 2 and Table 1).

7.2. Younger Alluvium Flood Plain

This unit mainly differs from the older flood plain in the cycle of deposition and occurs at relatively lower level. The younger alluvium occurs along Purna River, Mun River and Bildi River and lies at south west part of the study area. The younger alluvial plain landform represents a landscape of badland topography resulting from severe soil erosion. The elevation varies from 250 to 320 mt. (Fig. and Table 2).

7.3. Region of Middle Level Plateau on Deccan Trap

Plateau landform is mostly undulating landform occupying the hilly areas and the plains. Moderate to thick soil cover appreciable zone of weathering and less dissection are main characteristics of this landform. This landform found in the North West to south west part of the study area. The Elevation of this **middle level** Plateau is about 360 to 430 mt in the study area. Geologically this unit is covered by Deccan basalt (Fig.2 and Table 1).

7.4. Region of Low Level Plateau on Deccan Trap

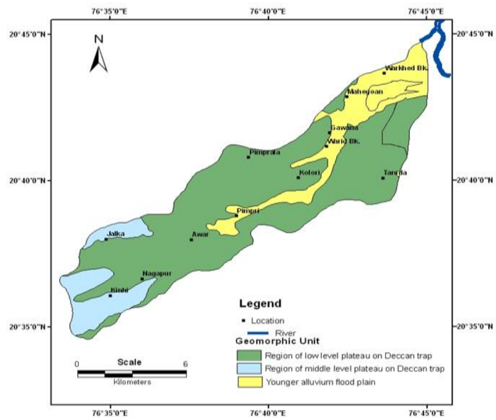
This region found in the study area at central part and having the average elevation is about 320 to 370 mt. These are on the Deccan trap and moderate to thick soil cover with appreciable zone of weathering and less dissection are main characteristics of this landform (Fig. 2 and Table 1).

8. Pimpri Gawli Irrigation Project

In study area the Pimpri Gawli water Dam is a major water body and situated at Pimpri Gawli lies in Survey of India toposheet 55D/10 and 12 Km from Khamgoan and 40 km from Balapur. It is build up on the Bildi River for the irrigation project having the capacity of 0.499-TLC.It is built up on Bildi river the date of 1988. The dam is clearly seen on the IRS-LISS-3 false colour composite satellite image (Fig.3).

Table 1: Area and percentage wise distribution of the geomorphic unit

Sr. No.	Geomorphic unit	Area in Sq. Km	Percentage
1	Region of low level plateau on Deccan trap	85.77	71.47
2	Region of middle level plateau on Deccan trap	13.25	11.02
3	Younger alluvium flood plain	21.16	17.60
4	Total area	120.18	



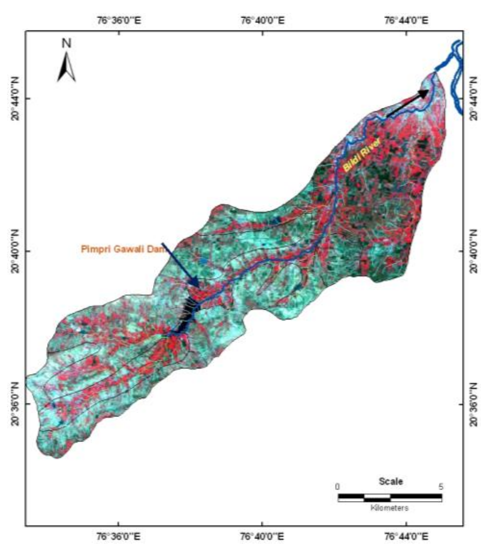


Fig.3. Representation of Pimpri Gawli dam on false colour composite (IRS-LISS-III Satellite image)

9. Geomorphometry

Morphometry is the measurements and mathematical analysis of configuration of the earth's surface, shape and dimension of its landforms [4] [5]. Quantitative measurements on drainages and relief features for morphometric studies have been done using the techniques of remote sensing and GIS in different drainage basins by many workers including [6]-[7]- [3.]

Since then, mathematical analysis of drainage basin has been a subject of considerable analysis, both in temperate region [9]-[10]-[8]-[11]. However, morphometric characteristics of drainage basin exhibit spatial temporal variation, hence the need for detail investigation of basin characteristics, not only from one area to another, but also from time to time. This is because, the form of a basin in terms of its morphometric characteristics determine the processes operating in such a basin. In the present study the remote sensing and GIS techniques have been used to explain the morphometric investigated with a view to understanding the processes operating within them.

10. Methods of Investigation

The drainage map of the study area has been prepared from digital data of IRS LISS-III. These satellite imageries had been geo-referenced and merged using image processing software ERDAS IMAGINE data processing software (Version 8.3) and the thus merged data were used in the present study. The drainage systems have been delineated using merged satellite data of geo-coded FCC of bands 2, 3, 4 on 1:50,000 scales and survey of India toposheets No. 55 G/10 and 55 G/14 as reference.

11. Geomorphometric Analysis

According to [12] morphometry is the measurement and mathematical analysis of the configuration of the earth surface, shape and dimensions of its landforms. The morphometric analysis is carried out through measurement of linear, areal and relief aspects of the basin and slope contribution [3].The measurement of various morphometric parameters namely- stream order, stream length (Lu), mean stream length (Lsm), stream length ratio (RL), bifurcation ratio (Rb),mean bifurcation ratio(Rbm), relief ratio (Rh) drainage density (D), stream frequency (Fs) drainage fexture (Rt), from factor (Rf), circulatory ratio (Rc), elongation ratio (Re) length of overland flow (Lg) has been carried out and the data are presented in Table 2.

12. Linear Aspects

The linear aspects include the stream order, stream length, mean stream length, stream length ratio and bifurcation, which were determined and results have been presented in Table 2.

Table 2: Computed morphometric parameters for linear aspects of the Bildi River sub basin

Sr. No.	Morphometric Parameters	Formula	Reference
1	Stream Order	Heirachial rank	Strahler (1964)
2	Stream Length (Lu)	Length of the Stream	Horton (1945)
3	Mean Stream Length (Lsm)	Lsm = Lu/Nu Where, Lsm= Mean Stream Length Lu = Total Stream Length of order 'u' Nu= Total no. of stream segments of order 'u'	Schumn (1956)
4	Stream Length ratio (RL)	RL=Lu/Lu-1 Where, RL=Stream Length ratio Lu = The total stream length of the order 'u' Lu-1 = The total stream length of its next order	Horton (1945)
5	Bifurcation ratio (Rb)	Rb = Nu/Nu+1 Where, Rb = Bifurcation ratio Nu = Total no. of stream segments of order'u' Nu+1 = Number of segments of the next higher order	Schumn(1956)
6	Mean Bifurcation ratio	Rbm = Average of Bifurcation ratios of all orders	Strahler(1957)

12.1. Stream Order

The first step in the drainage basin analysis is designation of stream orders which is not only the index, the size and scale, but also to afford and approximate index of the amount of stream flow, which can be produced by a particular network, stream order, number. The stream order is a measure of the degree of stream branching within a basin. The study area has dendritic to sub dendritic drainage type pattern. It is characterized by a tree like branching system in which tributaries join the gently curving main stream at acute angles (Fig.3 and Table 3.).

12.2. Stream Number

The count of stream channel in its order is known as stream number. The number of stream segments decreases as the order increases. The higher amount stream order indicates lesser permeability and infiltration. Stream number is directly proportional to size of contributing watershed, to channel dimensions. It is obvious that the number of streams of any given order will be fewer than for the next lower order but more numerous than for the next higher order. The number of streams decreases as the stream order increases (Table 3).

12.3. Bifurcation Ratio

Bifurcation ratio is defined as number of streams of one order to the next higher order. The bifurcation ratio, for a given density of drainage lines, is very much controlled by basin shape and shows a very little variation (ranging between 3 and 5) in homogeneous bedrock from one area to another [13]. The bifurcation ratio will not be precisely the same from one order to the next because of the possibility of variations in basin geometry and the lithology, but tends to be a constant throughout the series. When algorithm of number of streams is plotted against order, most drainage networks show a liner relationship, with small deviation from straight line. Bifurcation ratios characteristically range between 3 and 5 for the basin [14] in which geologic structures do not distort the drainage pattern (Table 4). The hypothetical minimum value of 2 is rarely approached under natural conditions. Abnormally higher bifurcation ratios might be expected in regions of steeply dipping rock strata where narrow strike valleys are confirmed between hogback ridges. Elongated basins with higher Bifurcation ratios yield a low but extended peak flow while rounded basins with low ratios procure sharp peak. Bifurcation ratio is mainly controlled by the basin shape and is not only influences the landscape and morphometry but also controls the surface run off. The bifurcation ratio calculated is 4.14.The direct relationship of bifurcation ratio to stream order is attributed to the semi arid climate characterized by short- duration flash floods (Table 4).

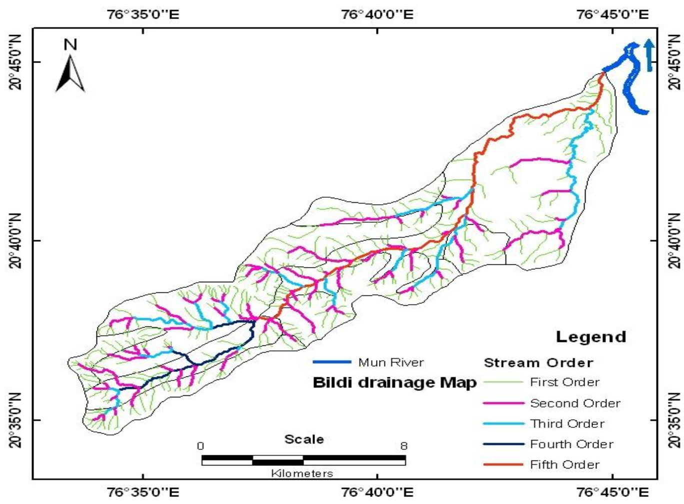


Fig. 3: Stream ordering of the Bildi River sub basin

12.4. Stream Length

The length of a stream is a measure of the hydrological characteristics of the underlying rock surface and the degree of drainage. Wherever the formation is permeable, only a small number of relatively longer streams are formed in a well drained watershed, a large number of streams of smaller length are developed where the formations are less permeable. Generally, the total length of stream segment is the maximum in the first order stream and decreases as the stream order increases. It is inferred from that in most of the miniwatersheds, the stream length decreases as stream order increases (Table 4). However, in case of Bildi river the stream length decreases as stream order increases and the stream segments length for third, fourth and fifth orders are varies at smaller extent. This change may indicate flowing of streams from high altitude, lithological variation and moderately steep slope [7].

12.5. Stream Length Ratio

[4] proposed the factor length ratio, which is the ratio of the mean length of a stream if any given order to the mean length of a stream of the next lower order, based on the fact that mean length of a stream of any given order is always greater than the mean length of a stream of the next lower order (Table 4). The length ratio RL (which is ratio of mean length Lu of segments of order u to mean length of segments of the next lower order LU/(LU- 1) tends to be constant through the successive orders of basin. It indicates that the stream lengths are decreasing with increasing the order of stream texture. The high value of drainage texture and lower value of drainage density indicates the presence of highly resistant permeable material with moderate to high relief. In the study area the stream length ratio is varies from 2.93 to

2.30 (Table 4). It indicates that the stream lengths are decreasing with increasing the order of stream (Fig.3).

12.6. Mean Stream Length

Mean stream length (Lsm) is a characteristic properly related to the drainage network components and its associated basin surfaces [5]. This has been calculated by dividing the total stream length of order (u) by the number of streams of segments in the order. The mean stream length is presented in Table 2. It is seen that Lsm values exhibit variation from 0.62-22.47.It is observed that Lsm values of sub basins indicate that Lsm of the given order is greater than that of the lower order and less than that of its next order. This deviation might be due to change in tophographic elevation and slope of the area (Table 3).

Table 3: Calculation of different morphometric parameter values in study area.

River basin	Basin Area (Km^2)	Stream order(u)	Number of Streams (Nu)	Total length of streams in km
Bildi River sub-basin	119.94	1	275	171.61
		2	69	58.19
		3	14	31.63
		4	3	9.73
		5	1	22.47
			TOTAL=362	TOTAL=293.63

Table 4: Mean stream length and Stream length ratio values in study area.

Sub basin	Mean stream length in km (Lsm)					Stream length ratio (Rl)			
	I	II	III	IV	V	II/I	III/II	IV/III	V/IV
Bildi River	0.62	0.84	2.25	3.24	22.47	2.93	1.83	0.30	2.30

Sub basin	Stream order (u)	Bifurcation ratio				Mean Bifurcation ratio
		I/II	II/III	III/IV	VI/V	
Bildi River	Rb = Nu/ Nu+1	3.98	4.92	4.66	3	4.14

12.6. Relief Aspects

Relief is the elevation difference between the highest and, lowest point on the valley floor of the region. The relief measurements like relief ratio, basin length and total relief have been carried out.

12.7. Relief Ratio

The maximum relief to horizontal distance along the longest dimension of the basin parallel to the principal drainage line is termed as relief ratio [9]. The relief ratio is obtained when basin relief "H" is divided by the maximum basin length (Lb) which results in a dimensionless ratio which is equal to the tangent of the angle formed by two planes intersecting at the mouth of the basin called relief ratio which measures the overall steepness of a drainage basin and is an indicator of the intensity of erosional process operating on slope of the basin [9]. Relief ratio has direct relationship between the relief and channel gradient. The relief ratio normally increases with decreasing drainage area and size of the watersheds of a given drainage basin [15].

Difference in the elevation between the highest point of a basin (on the main divide) and the lowest point on the valley floor is known as the total relief of the river basin. The relief ratio may be defined as the ratio between the total relief of a basin and the longest dimension of the basin parallel to the main drainage line [9]. The possibility of a close correlation between relief ratio and hydrologic characteristics of a basin suggested by scheme who found that sediments loose per unit area is closely correlated with relief ratios .In the study area, the values of relief ratio is 5.26. It is noticed that the high values of Rh indicate steep slope and high relief (250 m), while the lower values may indicate the presence of basement rocks that are exposed in the form of small ridges and mounds with lower degree of slope .

13. Aerial Aspects (Basin Geometry)

Aerial aspects include different morphometric parameters, like drainage density, texture ratio, stream frequency, form factor, circulatory ratio, elongation ratio and length of the overland flow. The values of these parameters are presented in table 5 and discussed and interpreted.

Table 5: Computed morphometric parameters and their respective formulae for aerial aspects of the Bildi River sub basin (Basin geometry)

Sr. No	Morphometric Parameters	Formula	Reference
1	Drainage Density (D)	D= Lu/A Where, D= Drainage Density, Lu=Total stream length of all orders, A= Area of the basin (km2)	Horton (1945)
2	Stream Frequency (Fs)	Fs = Nu/A Where, Fs= Stream Frequency, Nu =Total no. of streams of all orders, A = Area of the basin (km^2)	Horton (1932)
3	Drainage Texture (Rt)	Rt = Nu/P Where, Rt =Drainage Texture, Nu = Total no. of streams of all orders, P = Perimeter (Km)	Horton (1945)
4	Form Factor (Rf)	Rf = A/Lb^2 Where, Rf = Form Factor, A = Area of the basin (km^2), Lb^2 = Square of Basin length	Horton (1932)
5	Circulatory Ratio (Rc)	Rc =$4*Pi*A/P^2$ Where ,Rc=Circulatory ratio, Pi = 3.14,A= Area of the basin (km^2),P^2 = Square of the perimeter (km)	Miller(1953)
6	Elongation ratio (Re)	Re =2√(A/π)/Lb Where. Re = Elongation ratio A=Area of the basin (km^2) Pi= 3.14, Lb = Basin length	Schumn(1956)
7	Length of overland flow (Lg)	Lg =1/D*2, where, Lg = Length of overland flow, D = Drainage Density	Horton (1945)

It is measured as a sum of the channel lengths per unit area and obtained by dividing the total stream length by total area of the basin **(**Table 5).

D d=Σ Lu /Au

Where Σ LU = Mean channel length and Au = Basin area

Drainage density is controlled by the type of formations in the basin areas with impervious formations will have higher drainage density than those with pervious formations [14]. In the Study area drainage density is 2.44. In general low drainage density is favored in regions of high resistant or highly permeable sub soil materials, under dense vegetation cover and where relief is low. High drainage density is favored in regions of weak or impermeable surface materials, sparse vegetation, and mountainous relief. The drainage density is governed by the factors like rock type, run off intensity, soil type, infiltration capacity and percentage of rocky area (Table 6).

13.2. Drainage Frequency

It is a measure of number of stream segments per unit area and is therefore depend on the stream order, where as drainage density is independent of stream order **(**Table 6). It is obtained by dividing the total number of stream to the total drainage basin area.

Fs= Nu/A

Where A = Area of the basin

Nu = Stream number. Drainage frequency of the study area is found to be 3.01 It is also seen that the drainage density values of the sub-basins exhibits +ve correlation with the stream frequency suggesting that there is an increase in stream population with respect to increasing drainage density (Table 6).

13.3. Drainage Pattern

It refers to the orderly spatial arrangement of geologic, topographic or vegetation features. Drainage pattern is an important element in geologic interpretation of aerial photographs. The study area has dendritic to sub dendritic drainage type pattern. It is characterized by a tree like branching system in which tributaries join the gently curving main stream at acute angles. The occurrence of this drainage system indicates homogeneous, uniform soil and rock material (Table 6).

13.4. Drainage Texture

The drainage texture depends upon a number of natural factors such as climate, rainfall, vegetation, rock and soil type, infiltration capacity, relief and stage of development [16]. The soft or weak rocks unprotected by vegetation produce a fine texture, whereas massive and resistant rocks cause coarse texture. Sparse vegetation of arid climate causes finer textures than those developed on similar rocks in a humid climate. The texture of a rock is commonly dependent upon vegetation type and climate [17]. Drainage lines are numerous over impermeable areas than permeable areas. Drainage texture is the total number of stream segments of all orders per perimeter of that area [4]. Horton recognized infiltration capacity as the single important factor which influences drainage texture and considered drainage texture which includes drainage density and stream frequency. Drainage texture is the product of drainage density and stream frequency. It is expressed the same as the drainage and classification is given below. High relief ratio brings high discharge of surface water in a short duration. Small relief ratio indicates the erosional development of the drainage basin .Drainage Texture 1 < 2 Very coarse 2, 2 - 4 Coarse ,3 4 - 6 Moderate ,4 6 - 8 Fine,5 > 8 Very fine in the study area the value is 5.70 shows a very coarse texture (Table 3.6).

13.5. Form Factor

Form factor may be defined as the ratio of the area of the basin and square of basin length (Horton, 1932). It is a less property and is used as a quantitative expression of the shape of basin form. <5 low values- have flattered and flow for longer durations >5 high values – have high peaks and flows shorter duration **(**Table 6).

$R f = A/Lb^2$

Where; A = Area of the basin

$L b^2$ = square of Basin length

The value of form factor would always be greater than 0.71 (Table 6) for a perfectly circular basin. Smaller the value of form factor, more elongated will be the basin. Rf values of in the study area 0.44 and presented in (Table 6). It is noted that the Rf values of the study area suggesting that Bildi River basin elongated in shape (Table 6).

13.6. Circulatory Ratio

The circulatory ratio is mainly concerned with the length and frequency of streams, geological structures, land use/land cover, climate, relief and slope of the basin. It is the ratio of the area of the basins to the area of circle having the same circumference as the perimeter of the basin**.** Circulatory ratio (RC**)** is the ratio of basin area Au, the area of circle having the same perimeter as the basin.

$RC= 4 \pi A/P^2$

Where; Au = Total basin area and P^2 = perimeter

As the basin circulatory ratio reaches unity (one) the basin attains a fan shape and is prone for high floods. Circulatory ratio is the ratio of basin area Au, the area of circle Ac having the same perimeter as the basin. The Bildi River basin sub-basin has value of Re less than 0.5 indicating that it is elongated, while greater value than 0.5 values suggesting that they are more or less circular in shape and are characterised by the high to moderate relief and the drainage system were structurally controlled. The values of circularity ratio and the elongated ratio suggest that the basins are more elongated. Low form factor and high circulatory ratio suggest that the basin is prone for high floods. Higher the ratio lesser will be flood peak (Manjare et al., 2014). The circulatory ratio of the study area is 0.39 (Table 6).

13.7. Elongation Ratio

Elongation ratio is the ratio between the diameter of the circle of the same area as the drainage basin arid the maximum length of the basin . It is expressed by following equation;

Re =2√(A/π)/Lb Where, Rf = Form Factor, A=Area of the basin (km^2) Lb= Square of basin length

Elongation ratio is the ratio of diameter of the circle of the same area in the basin to the maximum basin length. The high values circularity ratio and the elongated ratio suggest that the basins are more elongated. Low form factor and high circulatory ratio suggest that the basin is prone for high floods. Higher the ratio lesser will be flood peak. The values of Re generally vary from 0.6 to 1.0 over a wide variety of climatic and geologic conditions. Values close to 1.0 are typical of regions of very low relief, whereas values in the range 0.6–0.8 are usually associated with high relief. These values can be grouped into three categories namely (a) circular (0.9), (b) oval (0.9–0.8), (c) elongated (0.7). The elongation ratio in the study area is 1.47 which suggests that the basin belongs to the elongated shape basin and moderate relief (Table 6).

13.8. Length and Width of the Basin

Several people defined basin length in different ways, such as [9] defined the basin length as the longest dimension of the basin parallel to the principal drainage line. Gregory and Walling (1973) defined the basin length as the longest in the basin in which are end being the mouth. [11] defined the basin length as the length of the line from a basin mouth to a point on the perimeter equidistant from the basin mouth in either direction around the perimeter. In the study area length of the Bildi River sub basin in accordance with the definition of [9] that is 26.40 Kms, (Table 6).The width of the basin is also important factor to understanding the geometry of the drainage basin. The basin width of Bildi River drainage is 6.59 Km.

13.9. Basin Area

The area of the basin or watershed is another important parameter like the length of the stream drainage. [9] established an interesting relation between the total watershed areas and the total stream lengths, which are supported by the contributing areas. The drainage basin area is one of the important parameters like that of the length of draining the basin. The area of a given order is defined as the total area projected on a horizontal plane contribution overland flow to the channel segments of the given order, which includes all tributaries of the lower order. The author has computed the basin area by using ArcGIS-9.3 software which is 119.94 Sq Kms.

13.10. Basin Perimeter

Basin perimeter is the outer boundary of the watershed that enclosed its area. It is measured along the divides between watersheds and may be used as an indicator of watershed size and shape. The author has computed the basin perimeter by using ArcGIS-9.3 software, which is 63.47 Kms (Table 6).

13.11. Length Overland Flow

It is the length of water over the ground before it gets concentrated in to definite streams channels (Horton, 1945). This factor depends on the rock type, permeability, climatic regime, vegetation cover and relief as well as duration of erosion [9]. The length of overland flow (Lg) approximately equals to half of reciprocal of drainage density [4]. It is the length of water over the ground before it gets concentrated into definite stream channels. This factor basically relates inversely to the average slope of the channel and is quite synonymous with the length of the sheet flow to the large degree. The Lg values of in the study area is 0.20 indicating high relief of the area (Table 6).

Table 6: Aerial aspects values of Bildi River sub basin

Morphometric parameters	Symbol/formula	Result in the study area
Basin Area (sq. km)	A	119.94
Perimeter (km)	P	63.47
Basin Length	Lb	26.40
Drainage density (km/sq. km)	Dd = Lu/A	2.44
Stream frequency	Fs = Nu/A	3.01
Texture ratio	T = Nu/P	5.70
Elongation ratio	$Re=2\sqrt{(A/\pi)}/Lb$	1.47
Circularity ratio	$Rc=4\pi A/P^2$	0.21
Form factor ratio	$Rf=A/(Lb)^2$	0.71
Length of Overland Flow	Lg=1/D*2	0.20

Where;

Lu = Total stream length of all orders

Nu = Total no. of streams of all orders

N1= Total no. of 1st order streams

Π = 3.14

14. Conclusion

The drainage density less than 2 indicates very coarse, between 2.4 is related to coarse, between 4 and 6 is moderate, between 6 and 8 is fine and greater than 8 is very fine drainage texture. The observed, drainage texture is 5.7 indicates the very coarse drainage texture. The high value of drainage texture and lower value of drainage density indicates that the basin has porous nature and coarse grained texture and the region has highly permeable subsoil materials, homogenous rock type, low runoff zone, loose soil with high infiltration capacity. The entire basin elongation ratio (0.60) indicates that the basin is elongated shape and less prone to overflowing. The values of circularity ratio and the elongated ratio suggest that the basins are more elongated. Low form factor and high circulatory ratio suggest that the basin is prone for high floods. Higher the ratio lesser will be flood peak. The basin Bifurcation ratio is 4.14 which indicate dendritic to sub dendretic drainage type. Kolar Sub basin drainage basin is having good ground water prospects. Drainage morphometric analysis gives overall view of the terrain information, like hydrological, lithological, slope, relief, variations in the watershed, ground water recharge, porosity, soil characteristics, flood peak, rock resistant, permeability and runoff intensity. This information is useful for all geological, hydrological, ground water studies. The Lg values of in the study area is 0.20 indicating high relief of the area. It is noted that the Rf values of the study area suggesting that Bildi River basin elongated in shape. Arc GIS 10.1 software tools like Hydrology, Data management, Geo statistical, Analysis tools etc. are very useful for mapping, analysis and representation for fast and accurate results in less time.

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