Morphometry Analysis of the *Khori* River Basin: A Simple Approach and Methods

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ABSTRACT:

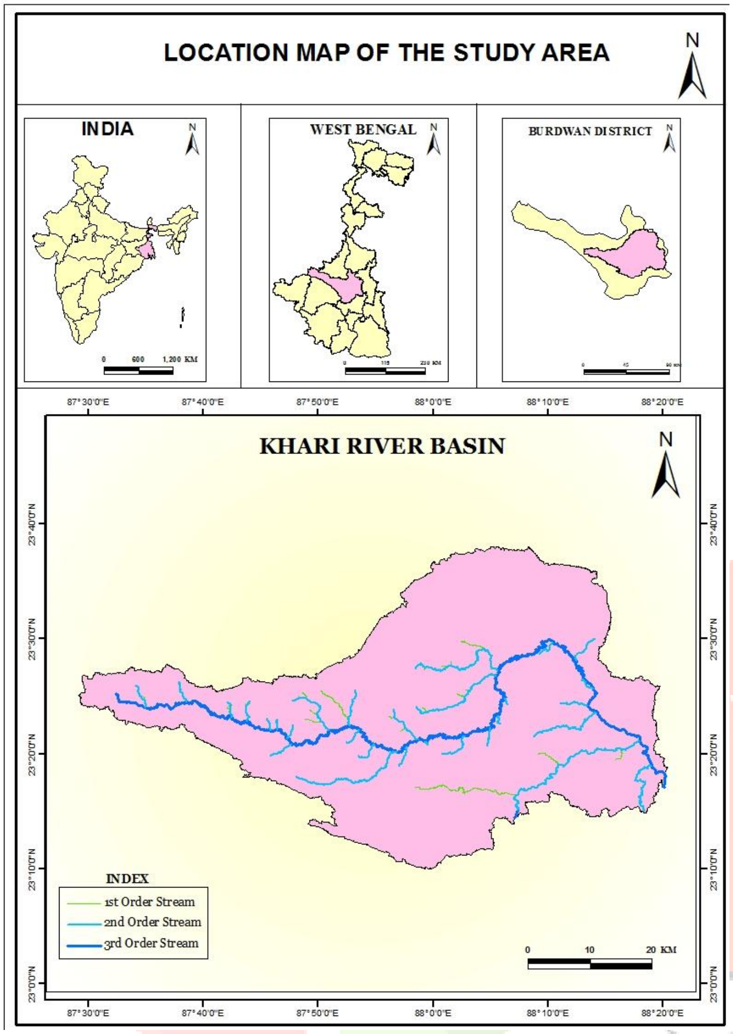
All the research methodology tries to explain the geographic events both physical as well as socio-economic which exist over the earth surface. Nobody can ignore that the dynamic earth surface and spatial behavior is the source of any research orientation and it should be analyzed by using the principal of spatial analysis. The spatial analysis tries to focus on dualistic nature like systematic and regional account for better representation of dynamicity of earth's events. In this connection, river Khari is an essential embodied and a natural system on the basis of methodological principle of the spatial analysis. The river Khari is very interesting from both the outlooks like river mechanism and impact analysis. It is clearly detect the inland source point of this river at Maro village (near Mankar station) and develop a long profile and wider basin and ultimately transfer its energy into Bhagirathi at meeting point. From source to river confluence, it is also found the different types of morphometric features both areal and linear. This paper is try to highlighted on the characteristics of morphological dimensions of the river Khori in systematic way

Key Words: Natural System, River Mechanism, Morphological Dimension etc.

1. STUDY AREA

The area under study constitutes the Khari river basin. River Khari is a left bank tributary of Bhagirathi River and a Palaeochannel of river Damodar. The river Khari passing through a vast area from western Burdwan to eastern Burdwan. The total area of the basin is 2252.86 sq km. It falls between the latitudes $23^{0}10^{/}$ N to $23^{0}40^{/}$ N and longitudes $87^{0}30^{/}$ E to $88^{0}20^{/}$ E. Khari river flows through nine Community Development Blocks viz. Galsi-I, Galsi-II, Ausgram-II, Bardhhaman-I, Bhatar, Manteswar, Purbasthali-I, Purbasthali-II and Kalna-I. The study area covers the portions of the 1: 50,000 Survey of India topographical maps numbering 73 M/11, 73

M/15, 79 A/3 and 79 A/7. The elevation of the study area ranges from less than 10 meters to 60 meters above mean sea level and consists mainly of flood plain.



2. OBJECTIVES:

The main objectives of this research work are to understand the nature of morphological dimension of River Khari as well as changes of linear and areal features of the basin area by appropriate methods.

3. DATA BASE

River morphology should be analyzed by different morphometric techniques. Field measurement is very much important for analyzing morphometric and fluvio-hydraulic characteristics of any river. The secondary source of data is collected from Literature report, Maps, Topographical sheet no. 73 M/11, 73 M/15, 79 A/3 and 79 A/7 of Survey of India, GSI, Satellite imagery, Google Earth etc. The different data sources and their tabular data format are given below, which have been used to analysis the research work.

Data sources

Sources of data and maps	Types of data and maps
Survey of India Toposheet map(73 M/11, 73 M/15, 79 A/3 and 79 A/7)	R.F = 1:50,000
www.bhuvan.com(National Remote Sensing Centre)	LISS-III data with 30 meter resolution
Global Land Cover Facility (GLCF)	Shuttle Radar Thematic Mapper
Geological Survey Of India	District Resource map of hydrology, geology and geomorphology
Google Earth	Digital data(Google image)
India Meteorological Department (IMD)	Climatic data

4. RESULT AND DISCUSSION:

Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms (Agarwal,1998.,and Ahmad, H.R., 2013). A major emphasis in geomorphology over the past several decades has been on the development of quantitative physiographic methods to describe the evolution and behavior of surface drainage networks (Horton, 1945). Evaluation of the morphometric parameters necessitates preparation of drainage map, ordering of the various streams, measurement of the catchment area and perimeter, length of drainage channels, drainage density and frequency, bifurcation ratio, circulatory ratio and constant channel maintenance, which helps to understand the nature of drainage basins (Krishnamurthy et al., 1996; Kumar et al., 2000; Obi Reddy et al., 2002).GIS techniques are now a day used for assessing various terrain and morphometric parameters of the drainage basins and watersheds, as they provide a flexible environment and a powerful tool for the manipulation and analysis of spatial information. The study area covers the portions of the 1: 50,000 Survey of India topographical maps numbering 73 M/11, 73 M/15, 79 A/3 and 79 A/7. For the analysis of morphometry of River Khari topographical maps were rectified/ referenced geographically and mosaiced and entire study area was delineated in GIS environment with the help of Arc-GIS 10.2.1 software. Since, morphometric analysis of a drainage basin requires the delineation of all the existing streams, digitization of the drainage basin was carried out for morphometric analysis in GIS environment using Arc-GIS 10.2.1 software. The attributes were assigned to create the digital data base for drainage layer of the basin. Various morphometric parameters such as linear, aerial and relief aspects(stream order, stream length,bifurcation ratio, stream length ratio, basin length, drainage density, stream frequency, elongation ratio, circularity ratio, form factor, basin relief, relief ratio) of the basin were computed. The different morphometric parameters were determined by using the standard methodologies as shown table in below.

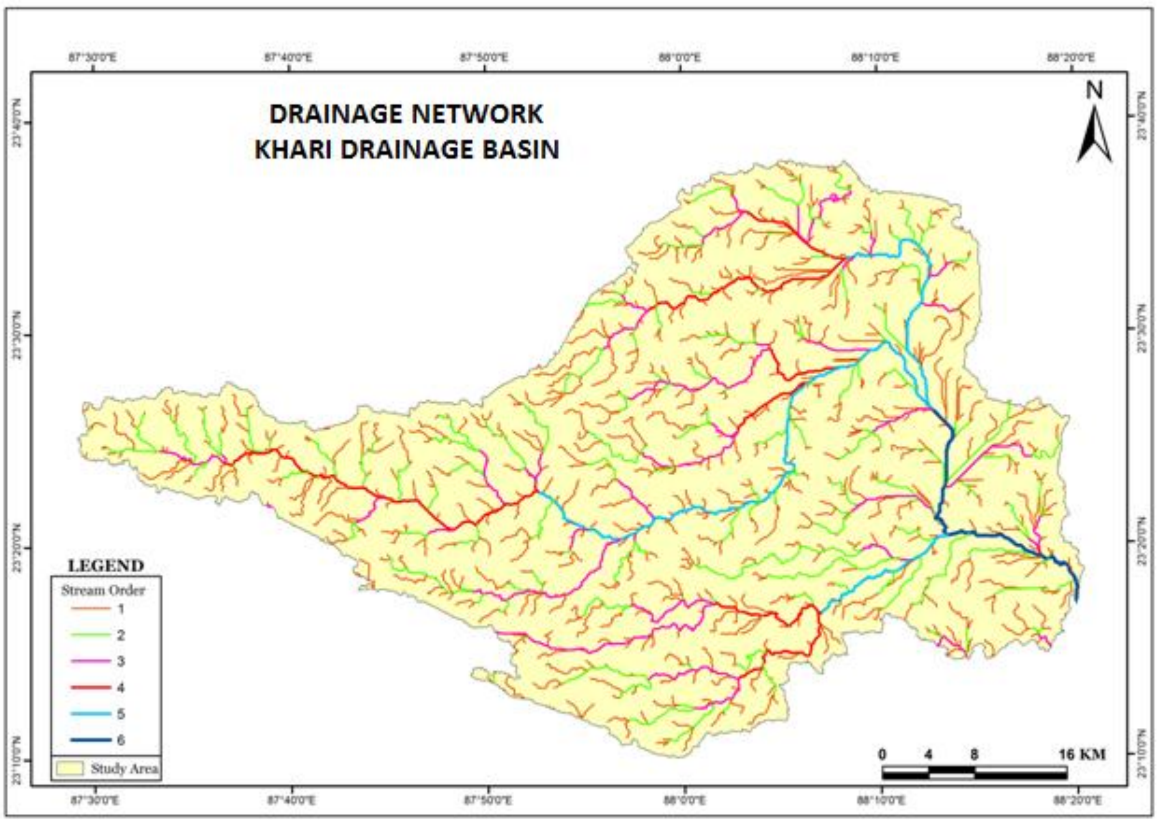
4.1 Linear Aspects of the Basin

Linear aspects of the basins are related to the channel pattern of the drainage network wherein the topographical characteristics of the stream segments in terms of open links of the network system(streams) are analysed. The drainage network, which consists of all of the segments of streams of a particular river, is reduced to the level of graphs, where stream junction act as points and streams, which connect the points, become links or lines wherein the numbers of all segments are counted, their hierarchical orders are determined, the lengths of all stream segments are measured and their different interrelationships are studied. The nature of flow paths in terms of sinuosity is equally important in the study of linear aspects of the drainage basins (S.Singh, 1998: p-358). Thus, the morphometric investigation of the linear parameters of the basins includes stream order (Sμ), bifurcation ratio (R_b), stream length (Lμ), mean stream length (Lsm), stream length ratio (R_L), length of overland flow (Lg), basin perimeter (P), basin length (Lb), sinuosity indices etc.

4.1.1 Stream order (Sμ)

Stream ordering refers to the determination of the hierarchical position of a stream within a drainage basin. A river basin consists of its several branches having different positions in the basin area and they have their own morphometric characteristics and, therefore, it becomes necessary to locate the relative position of a segment in the basin, so that the hierarchical organization of stream segments is visualized (S.Singh, 1998). 'Stream order is defined as a measure of the position of a stream in the hierarchy of tributaries' (L.B.Leopold, M.G. Wolman and J.P. Miller, 1969).

There are four different system of ordering streams that are available [Gravelius(1914), Horton (1945), Strahler (1952) and Schideggar (1970)]. Strahler's system, which is a slightly modified of Hortons system, has been followed because of its simplicity, where the smallest, un-branched fingertip streams are designated as 1st order, the confluence of two 1st order channels give a channels segments of 2nd order, two 2nd order streams join to form a segment of 3rd order and so on. When two channel of different order join then the higher order is maintained. The trunk stream is the stream segment of highest order. Stream order analysis shows that the main basin is ranked sixth in order in the drainage network. In all 1500 streams were identified of which 758 are first order, 346 are second order, 181 are third order, 102 in fourth order, 89 in fifth order and 24 are sixth order. Stream frequency decreases as the stream order increases. Drainage patterns of stream network from the basin have been observed as mainly of dendritic type which indicates the homogeneity in texture and lack of structural control. Number of streams in each order varied because of the physiographic conditions of particular area.



Drainage network map of Khari drainage basin

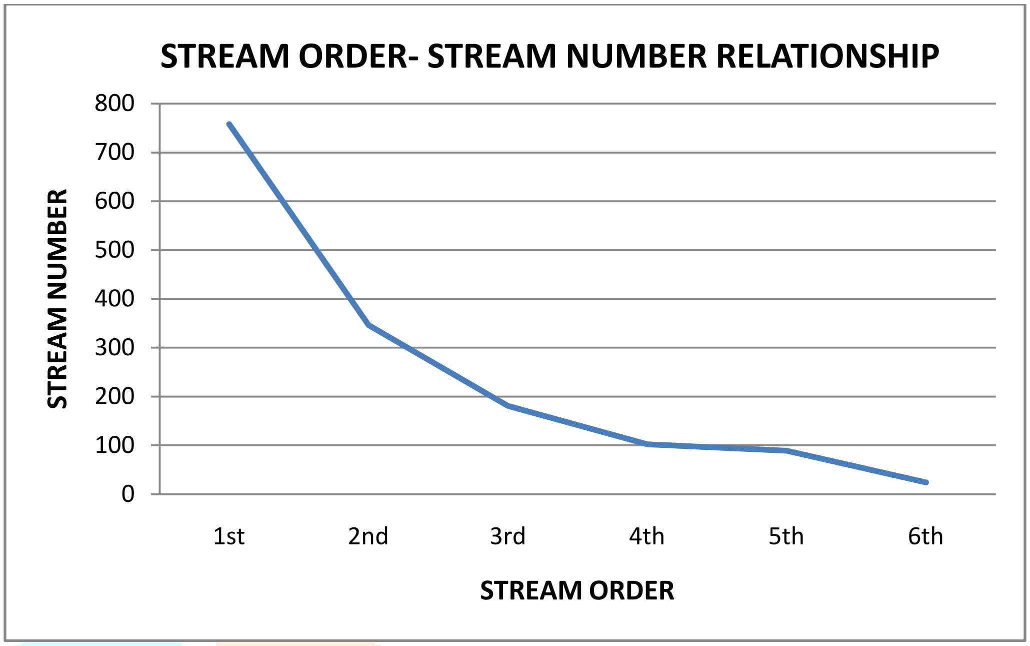


Figure 3.2: Stream Order-Stream Number relationship

4.1.2 Stream Length (Lµ)

The stream length (Lµ) has been computed based on the law proposed by Horton. Stream length is one of the most significant hydrological features of the basin as it reveals surface runoff characteristics. The stream of relatively smaller length is characteristics of areas with larger slopes and finer textures. Longer lengths of streams are generally indicative of flatter gradient. Generally, the total length of stream segments is higher in first order stream and decreases as stream order increases. The numbers of streams are of various orders in Khari basin has counted and their lengths from mouth to drainage divide have measured with the help of GIS software. The length of first order stream is 1057.12Km, second order stream is 475.26Km, third order stream is 226.23 Km, fourth order stream is 110.02 Km, fifth order stream is 94.89Km and the sixth order stream is 29.02 Km. The observation of stream length shows that the length of stream segment of each order forms an inverse geometric relation with order number i.e. stream length decreases with increase of stream order.

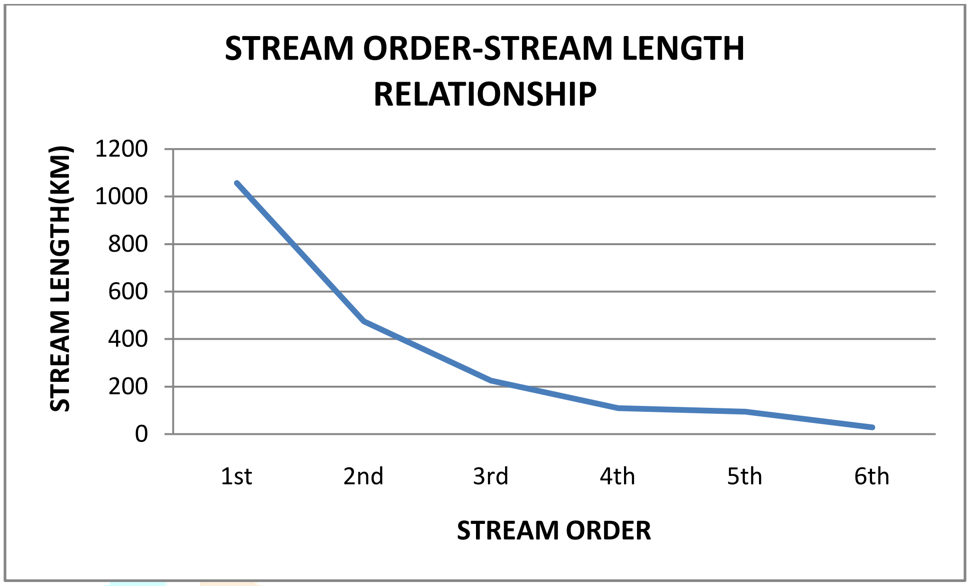


Figure 3.3: Stream Order-Stream Length relationship

4.1.3 Mean Stream Length (Lsm)

The mean stream length is a characteristic property related to the drainage network and its associated surfaces (Strahler,1964).The mean stream length (Lsm) has been calculated by dividing the total stream length of order by the number of stream. The mean stream length of study area is 1.39 for first order, 1.37 for second order, 1.25 for third order, 1.07 for fourth order, 1.06 for fifth order and 1.21 for sixth order. The mean stream length of stream decreases with increase of the order.

4.1.4 Stream Length Ratio (R_L)

The stream length ratio can be 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). The R_L values between streams of first order and second order is 2.22, between second order and third order is 2.10, between third order and fourth order is 2.05, between fourth order and fifth order is 1.16 and between fifth order and sixth order is 3.27. The R_L values between streams of different order in the basin reveal that there are variations in slope and topography.

4.1.5 Bifurcation Ratio (R_b)

Bifurcation ratio (R_b) may be defined as the ratio of the number of stream segments of given order to the number of segments of the next higher order (Schumn 1956). Horton (1945) considered the bifurcation ratio as an index of relief and dissections. Strahler (1957) demonstrated that the bifurcation ratio shows a small range of variation for different regions or different environmental conditions, except where the geology dominates. 'Mean bifurcation ratios vary from about 2.0 for flat or rolling basins to 3.0-4.0 for mountainous, hilly dissected basins' (Horton, 1945). But Savindra Sing denied Horton's statement and stated that 'this hypothesis does not hold good as none of the basins draining over flat and rolling surface of the studied regions (125 drainage basins of 6 physiographic regions in India) show mean bifurcation ratios of 2.0, rather the values range between 3.0 and 5.0 in the same way as they range in the basins developed over hilly and highly dissected regions but it becomes clear that mean bifurcation ratios of the basins of mountainous and dissected regions are slightly more than the mean bifurcation ratios of the basins of the flat and rolling surfaces'(S.Singh, et.al, 1984). It is observed from the R_b is not same from one order to its next order these irregularities are dependent upon the geological and lithological development of the drainage basin (Strahler, 1964). The lower values of R_b are characteristics of the watersheds, which have suffered less structural disturbances (Strahler, 1964). In the study area R_b varies from 1.15 to 3.70; the mean R_b of the entire basin is 2.14. Usually these values are common in the areas where geologic structures do not exercise a dominant influence on the drainage pattern. In the present study the mean R_b values indicative of drainage basin that are not affected by structural disturbances.

Linear morphometric parameters of the drainage network of Khari drainage basin

Stream order (Sµ)	Stream Number (Nu)	Bifurcation Ratio (R_b)	Stream Length (Lµ) (in km)	Mean Stream Length (Lsm) (in km)	Stream Length Ratio (R_L)	Mean Bifurcation Ratio (R_{bm})
1^{st}	758		1057.12	1.39		2.14
		2.19			2.22	
2^{nd}	346		475.26	1.37		
		1.91			2.10	
3^{rd}	181		226.23	1.25		
		1.77			2.05	
4^{th}	102		110.02	1.07		
		1.15			1.16	

5th	89		94.89	1.06		
		3.70			3.27	
6th	24		29.02	1.21		
Total	1500		1992.54			

4.1.6 Length of overland flow (Lg)

Length of overland flow is one of the most important independent variables affecting both hydrologic and physiographic development of drainage basins (Horton,1932., Nag,S.K.1998) Overland flow is significantly affected by infiltration/percolation through the soil that vary in time and space (Schmid, 1997; Kanth,2012). Length of overland flow is defined as the length of flow path, projected to the horizontal, non channel flow from point on the drainage divide to a point on the adjacent stream channel (Horton, 1945). Horton, for the sake of convenience, had taken it to be roughly equal to half the reciprocal of the drainage density. The length of overland flow of the Khari basin is 0.57 kilometers, which shows gentler slopes in the valleys and hence low surface runoff and longer flow paths.

Method of Calculating Morphometric Parameters of Drainage basin			
	Morphometric Parameters	**Formula/ Definition**	**References**
	Stream order (Sμ)	Hierarchical order	Strahler,1964
	Stream Length (Lμ)	Length of the stream	Hortan, 1945
	Mean stream length (Lsm)	Lsm=Lu/Nu; Where, Lu=Mean stream length of a given order (km), Nu=Number of stream segment.	Hortan, 1945
LINEAR	Stream length ratio (R_L)	RL= Lu / Lu-1 Where, Lu= Total stream length of order (u), Lu-1=The total stream length of its next lower order.	Hortan, 1945
	Bifurcation Ratio (R_b)	Rb = Nu / Nu+1 Where, Nu=Number of stream segments present in the given order Nu+1= Number of segments of the next higher order	Schumn,1956

	Length of overland flow (Lg)	Lg=1/2Dd Where, Dd = Drainage density	Hortan, 1945
	Basin Perimeter (P)	GIS Software Analysis	Schumm(1956)
	Sinuosity Indices (SI)	SI= L_C/ Lv where, L_C= Channel thalweg length, L_V= Channel valley length	Leopold and Wolman (1957)

Method of Calculating Morphometric Parameters of Drainage basin			
	Morphometric Parameters	**Formula/ Definition**	**References**
	Basin Area (A)	GIS Software analysis	Schumm(1956)
	Drainage density (Dd)	Dd=L/A Where, L=Total length of stream, A= Area of basin.	Hortan, 1945
	Stream frequency (Fs)	Fs=N/A Where, L=Total number of stream, A=Area of basin	Hortan, 1945
AERIAL	Drainage texture (Dt)	Dt=N/P Where, N=Total number of stream segments of all order, P=Perimeter of basin.	Hortan, 1945
	Form Factor (Ff)	Ff=A/(Lb)2 Where, A=Area of basin, Lb=Basin length	Hortan, 1945
	Elongation Ratio (Re)	Re=√(Au/π)/ Lb Where, A=Area of basin, π=3.14, Lb=Basin length	Schumn 1956

	Circulatory Ratio (Rc)	$Rc=4\pi A/P^2$ Where A= Area of basin, π=3.14, P= Perimeter of basin.	Miller,1953

Method of Calculating Morphometric Parameters of Drainage basin			
	Morphometric Parameters	**Formula/ Definition**	**References**
AERIAL	Relative relief	Vertical distance between the lowest and highest points of basin.	Schumn,1956
	Relief Ratio (Rh)	Rh = Bh / Lb Where, Bh=Basin relief, Lb=Basin length	Schumn,1956
	Ruggedness Number (Rn)	Rn=Bh×Dd Where,Bh= Basin relief, Dd=Drainage density	Strahler(1968)
	Dissection index (DI)	$DI = R_R / A_R$ Where, R_R = Relative relief (m) and A_R = Absolute relief (m)	Dov Nir(1957)
	Channel gradient (C_g)	$Cg = H / \{(\pi/2) \times Clp\}$ Where, H = basin relief (m) and Clp= Longest Dimension Parallel to the Principal Drainage Line (Kms) =Lb	Broscoe (1959)

4.1.7 Basin Perimeter (P)

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 Arc-GIS-10.2.1 software, which is 340.41 km.

4.1.8 Sinuosity Indices (SI)

Sinuosity of a stream denotes the degree of deviation of its actual path from expected theoretical straight path (course). The analysis of deviation of the course of drainage line from the straight path, say sinuosity, may help considerably in studying the effect of terrain characteristics on the river course and vice versa (Singh,1998). In the present study to know the type of channel pattern of River Khari Sinuosity index has been calculated by using Leopold and Wolman formula i.e. sinuosity index is the ratio of channel Thalweg length (L_C) and Valley length(L_V). The sinuosity index value of River Khari is 1.99 that means it is a meandering channel.

4.2 Aerial aspects of the basin

The areal aspects of drainage basin include different morphometric parameters, like basin area (A), drainage density (Dd), stream frequency (Fs), form factor (Rf), circulatory ratio (Rc), elongation ratio (Re) . The values of these parameters were calculated and results are presented here.

4.2.1 Basin Area (A)

The area of the watershed is another important parameter like the length of the stream drainage. Schumm (1956) established an interesting relation between the total watershed and the total stream lengths, which are supported by the contributing areas. The basin area of River Khari has computed by using Arc-GIS 10.2.1 software, which is 2252.86 Sq Km.

4.2.2 Drainage density (Dd)

By definition drainage density of a basin is the total length of the streams of all orders per drainage area. Dd is expressed as the ratio of the total sum of all channel segments within a basin to the basin area i.e., the length of streams per unit of drainage density. It is a dimension inverse of length(Horton, 1932). Drainage densities can range from less than 5 km/km^2 when slopes are gentle, rainfall low and bedrock permeable (e.g. sandstones), to much larger values of more than500 km/km2 in mountainous areas where rocks are impermeable, slopes are steep and rainfall totals are high(Hugget,2003). It has been observed from drainage density measurement made over a wide range of geologic and climatic type that a low drainage density is more likely to occur in region and highly resistant of highly permeable subsoil material under dense vegetative cover and where relief is low. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture (Strahaler, 1964).The drainage density (Dd) of study area is 0.88 Km/Km^2 indicating low drainage densities. The low drainage density indicates the basin is highly permeable subsoil and vegetative cover and the slopes are gentle.

4.2.3 Stream frequency (Fs)

The stream frequency (Fs) or channel frequency or drainage frequency of a basin may be defined as the total number of stream segments within the basin per unit area (Horton,1945). The stream frequency value of the study area is $0.66/Km^2$ indicating low stream frequency (Fs) which can be attributed to the low relief and high infiltration capacity. The low stream frequency of the basin is indicating low relief and permeable sub surface material. The existence of less number of streams in a basin indicates matured topography, while the presence of large number of streams indicates that the stream is youthful and still undergoing erosion. It is an index of the various stages of landscape evolution. Both values of stream frequency and drainage density show that Khari basin has a low relief and by implication has a low response to surface runoff.

4.2.4 Drainage texture (Dt)

Drainage texture is defined as the total number of stream segments of all order in a basin per perimeter of the basin (Horton, 1945). The drainage texture is considered as one of the important concept of geomorphology which shows the relative spacing of the drainage lines (Chorley, 1957). The drainage texture of the basin area is 4.40. This shows that the basin has a moderate texture. Smith have classified five different drainage textures related to various drainage densities as very coarse (below 2), coarse (2 - 4), moderate (4 - 6), fine (6 - 8) and very fine (8 and above). Drainage texture depends on a number of natural factors such as climate, rainfall, vegetation, rock and soil types, infiltration capacity, relief and stage of development. The moderate drainage texture indicates the moderate dissection in the Khari drainage basin.

4.2.5 Form Factor (Ff)

Form factor (Ff) is defined as the ratio of the basin area to the square of the basin length. This factor indicates the flow intensity of a basin of a defined area (Horton, 1945). The form factor value should be always less than 0.7854 (the value corresponding to a perfectly circular basin). The smaller the value of the form factor, the more elongated will be the basin. Basins with high form factors experience larger peak flows of shorter duration, whereas elongated watersheds with low form factors experience lower peak flows of longer duration (Horton,1945). The Ff value for Khari basin area is 0.29, indicating elongated basin with lower peak flows of longer duration than the average.

4.2.6 Elongation Ratio (Re)

Elongation ratio (Re) is a significant index in the analysis of basin shape which helps to give an idea about the hydrological character of a drainage basin (Strahler,1964). Schumm (1956) defined elongation ratio as the ratio of diameter of a circle of the same area as the drainage basin and the maximum length of the basin. Values of Re generally vary from 0 to 1.0(in the circular shape) over a wide variety of climatic and geologic types. Re values close to unity correspond typically to regions of low relief, whereas values in the range 0.6–0.8 are usually associated with high relief and steep ground slope (Strahler 1964). These values can be grouped into three categories namely (a) circular (>0.9), (b) oval (0.9-0.8), (c) less elongated (<0.7) (Waikar, 2014). The Re values in the study area is 0.30 (Table 3.5) indicating gentle to moderate ground slope and area when collaborated with Strahler's range seem to suggest an elongated shape.

4.2.7 Circulatory Ratio (Rc)

Circularity Ratio is the ratio of the area of a basin to the area of circle having the same circumference as the perimeter of the basin (Miller, 1953). It is influenced by the length and frequency of streams, geological structures, land use/ land cover, climate and slope of the basin. The value of Re varies from 0 (in highly elongated shape) to unity i.e. 1.0 (in the circular shape). Schumm(1956) described the basin of the circularity ratios of the range 0.4 to 0.5 as indicative of strongly elongated and highly permeable homogenous geologic materials. The calculated Rc value, 0.24 (Table 3.5) indicates that the Khari drainage basin is elongated in shape.

4.3 Relief Aspects of the Basin

The relief aspects of the drainage basins are related to the study of three dimensional features of the basins involving area, volume and altitude of vertical dimension of landforms to analyze different geo-hydrological characteristics. Some of the important relief parameters that are related to the study have been analyzed.

4.3.1 Relative relief

Relative relief is defined as the differences in height between the highest and the lowest points (height) in a unit area. It is an important morphometric parameter used in the overall assessment of morphological characteristics of terrain and degree of dissection (Singh,1998). The Relative relief of Khari basin is 51.7 m. The lowest basin relief of 8.3 m is observed near confluence point of River Khari and highest of 60 m in the extreme western portion of the basin. In the present study area the elevation varies from less than 10 m to 60 m which represent the land has gentle to moderate slope.

4.3.2 Relief Ratio (Rh)

The relief ratio, (Rh) is ratio of maximum relief to horizontal distance along the longest dimension of the basin parallel to the principal drainage line (Schumm, 1956). The Rh normally increases with decreasing drainage area and size of watersheds of a given drainage basin (Gottschalk, 1964). Relief ratio measures the overall steepness of a drainage basin and is an indicator of the intensity of erosion process operating on slope of the basin (Schumm, 1956). The relief ratio of Khari river basin is 0.6. The relief ratio of the basin is low, which is characteristics features of less resistant rocks. The low relief ratio is due to low relief and gentle slope (Fig. 3.4). This implies low erosive energy of the stream and less sediment loss from this basin (Schumm, 1956).

4.3.3 Ruggedness Number (Rn)

Strahler's (1968) ruggedness number is the product of the basin relief and the drainage Density. Calculated accordingly, the Khari drainage basin has a ruggedness number of 45.49 . An extreme high value of ruggedness number occurs when both variables are large and slope is steep (Strahler, 1956). The low ruggedness value of watershed implies that area is less prone to soil erosion and have intrinsic structural complexity in association with relief and drainage density (Schumm,1956).

4.3.4 Dissection index (DI)

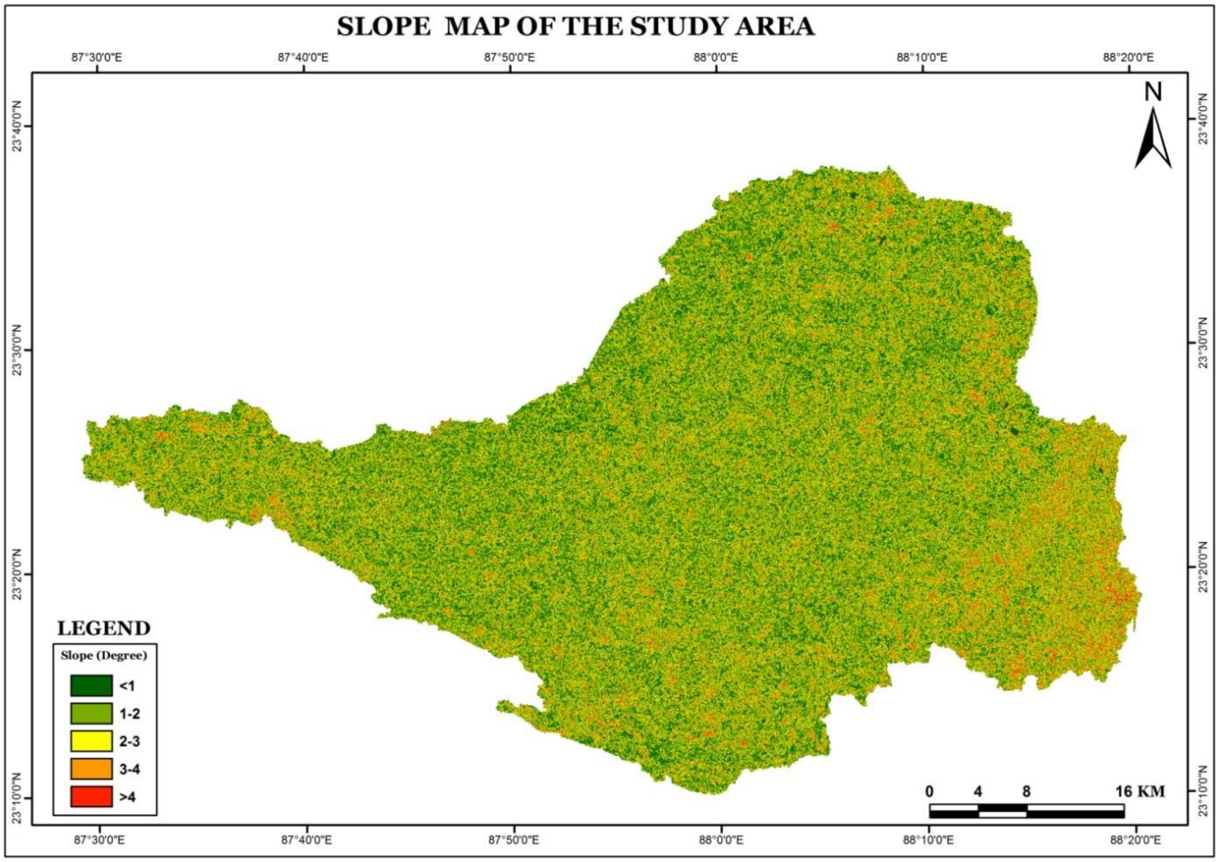
Dissection index (DI) is a parameter implies the degree of dissection or vertical erosion and expounds the stages of terrain or landscape development in any given physiographic region or basin (Thornbury,1969). On an average, the values of DI vary between'0' (complete absence of vertical dissection/erosion and hence dominance of flat surface) and '1' (in exceptional cases, vertical cliffs, it may be at vertical escarpment of hill slope or at seashore). Dissection value of Khari basin is 0. 86 which indicate the watershed is a moderately dissected.

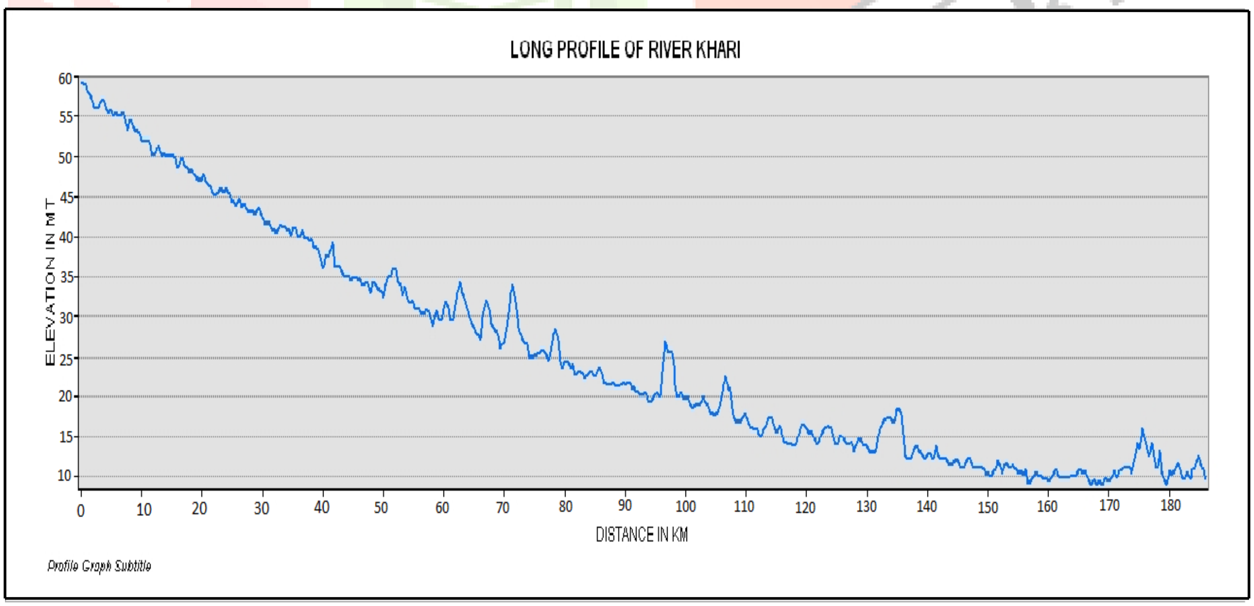
4.3.5 Slope Analysis (Sa)

Slopes, defined as angular inclinations of terrain between hill-tops and valley bottoms, resulting from the combination of many causative factors like geological structure, absolute and relative reliefs, climate, vegetation cover, drainage texture and frequency, dissection index etc. (Singh, 1998).There are many contributions to slope-geomorphology and various methods of representing the slope, but the contributions made by Rich (1916), Wentworth (1930), Raisz and Henry (1937), Smith (1938-39), Robinson (1948), Calef (1950), Calef and Newcomb (1953), Strahler (1956), Miller (1960), Eyles (1965) and Pity (1969), are very important. Slope can evaluated as quantitatively parameter. Slope map has created by using Surface Analysis Tool in ArcGIS-10.2.1. The slope in the study area varies from less than 1^0 to more than 4^0.

4.3.6 Longitudinal Profiles (Lp)

Longitudinal profile or Long profile gives a vivid picture of breaks in longitudinal profile or longitudinal course of the river and numerous pronounced breaks may indicate nick points or heads of rejuvenation, and these breaks help in examining the polycyclic nature of landform development (Singh,1998). The longitudinal profile is an erosional curve, which can interpret the surface history and different stage of valley development from source to mouth. In fact, long profile of a river represents channel gradient of the river from its source to the mouth(Singh, 1998). With the help of Arc-GIS 10.2.1 software a longitudinal profile of River Khari has drawn which shows a smooth concave curve developed by this river. The channel gradient has computed from this profile, which is 0.19 m/Km indicate low channel gradient.





Longitudinal Profile of River Khari

Result of Morphometric analysis

Sl. No.	Perimeter	Value
1	Mean Bifurcation Ratio (R_b)	2.14
2	Length of Overland flow (L_g)	0.57Km
3	Basin Perimeter (P)	340.41Km
4	Sinuosity Index (SI)	1.99
5	Basin Area (A)	2252.8646 Sq Km
6	Drainage Density (D_d)	0.88 Km/Km^2
7	Stream Frequency (F_s)	0.66/Km^2
8	Drainage texture (D_t)	4.40
9	Form Factor (Ff)	0.29
10	Elongation Ratio (R_e)	0.30
11	Circulatory Ratio (R_c)	0.24
12	Relative Relief	51.7m
13	Relief Ratio (R_h)	0.60
14	Ruggedness Number (R_n)	45.49
15	Dissection Index(DI)	0.86
16	Channel gradient (C_g)	0.19m/Km

Conclusion:

Geologically the study area belongs to the Bengal Basin, and covered by newer alluvium of middle Pleistocene age to recent age. Original basement complex of the study area is usually of igneous and metamorphic rocks of Archean formation. Morphologically the study area is a riverine depositional plain. On the basis of physiographic division of Bengal it comes under the Ganga-Damodar depositional plain. Hence it is not possible to chalk out the true morphological dimensions of river Khori and its broader effects on channel behavior on the area. It can be analysis that the morphometric parameters are the main strength for the study of behavior of this river. But it is needed to highlighting on fluvio-metric character of the study. The issue of the river Khori is emerged out due to decaying condition of river, excessive rainfall in monsoon season, changes of channel geometry and encroachment of people in the meander belt.

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