MORPHOMETRIC ANALYSIS OF BARA TEHSIL OF ALLAHABAD DISTRICT THROUGH CARTOSAT-1 DEM DATA

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Abstract: **Morphometric analysis of Bara tehsil of Allahabad district is carried out to understand the hydrological behavior for assessing ground water potential, water resource management, hazard reduction, flood control etc. CARTOSAT-1 DEM data is major data source for extracting drainage network and for delineating Yamuna basin, Tons basin & all the 8 watershed belongs to both basin. Arc-hydro tool of ArcGIS software version 10.2.2 has been used for generating different thematic layers & attribute tables. Raster calculator and excel sheet is used for calculating linear, areal and relief parameters of drainage basin. The obtained result indicates that Yamuna and Tons river basin have 6th and 5th order stream respectively, both have dendritc drainage pattern with moderate to good infiltration due to low sloppy terrain**

IndexTerms **- CARTOSAT-1 DEM, Arc-hydro tool, Morphometric analysis.**

1. INTRODUCTION

Morphometric analysis is the measurement and mathematical analysis of the configuration, shape, form and structure of the drainage basins along with their associated networks described by their morphometric parameters (Clark, 1966). Morphometric parameters comprises linear, areal and relief parameter which incorporates quantitative measurement of stream segment like; stream length, stream order, bifurcation ratio, drainage density, stream frequency, texture ratio, elongation ratio etc. (Horton, 1945). These morphometric parameters are not only indicators of structural influence on drainage development but also used to assess surface & ground water potentiality of the basins through surface runoff and infiltration ratio of the basins and to locate suitable sites for construction of artificial recharge structures (Avinash et al., 2011). Morphometric parameters are very useful for identification of deficit and surplus groundwater zones (Yadav et al.,2014). Geospatial technology is increasingly being used for deriving morphometric parameters of drainage basins throughout the world (Lyew-Ayee et al., 2007). Hence in the present study all important morphometric parameters are derived from thematic layers and calculated accurately to infer the hydrological behavior of study area in arc-gis environment.

2. STUDY AREA

Bara tehsil comprises of Jasra and Shankargarh development block, which represents transition zone between the plain of Yamuna and uplands of the Vindhyan region. It is situated in the south western part of Allahabad district, Uttar Pradesh, India (fig. 1). It lies between $25^0 2'30''$- $25^0 22'30''$ N latitude and $81^0 31'$- $81^0 50'$ E longitude with total extent of 729.45 km^2. The plains of Yamuna and Tons river has low elevation (-7 to 33 m) than the North-western part of Bara tahsil. The above said plain is occupied by rocks of Kaimur group and have highest elevation ranges from 46 m to 129 m. The study area has tropical monsoon type of climate which is characterized by cool, dry, invigorating winter and scorching & dusty summer. Annual temperature range of the study area is 8.93^0 C to 41.48^0 C and maximum rainfall occurs during monsoon period i.e. 240.82 mm. It is a backward region endowed by low agricultural productivity, stone quarrying and ceramic industry due to presence of red sand stone, glass sand and quartz minerals which belongs to the Vindhyan super group (GSI, 2001). Population statistics of study area discloses that 51.22 % population is supported by Jasra block with only 34.05 % area of Bara tehsil whereas 48.72 % population is supported by Shankargarh block with 65.95 % area of Bara tehsil. Both blocks of study area facing water scarcity problem hence study of morphometric analysis is important for water resource management.

3. RESEARCH METHODOLOGY

Drainage network of study area is extracted from the CARTOSAT-1 DEM data having 2.5 m spatial resolution acquired in 2013. It is downloaded from the website of USGS earthexplorer (https://earthexplorer.usgs.gov) . The delineation of Yamuna and Tons river basin, with its 8 watershed along with drainage network, is based on thematic layers such as fill, flow direction, flow accumulation, stream to feature etc. (fig. 2). These thematic layers are generated from CARTOSAT-1 DEM data and processed through ArcHydro tool of ArcGis software v 10.2.2. Further, attribute table, containing stream length, basin area, basin perimeter, basin relief etc. has been generated and other morphometric parameters has been computed at watershed level through raster calculator & excel-sheet using the morphometric formulas listed in table 1.

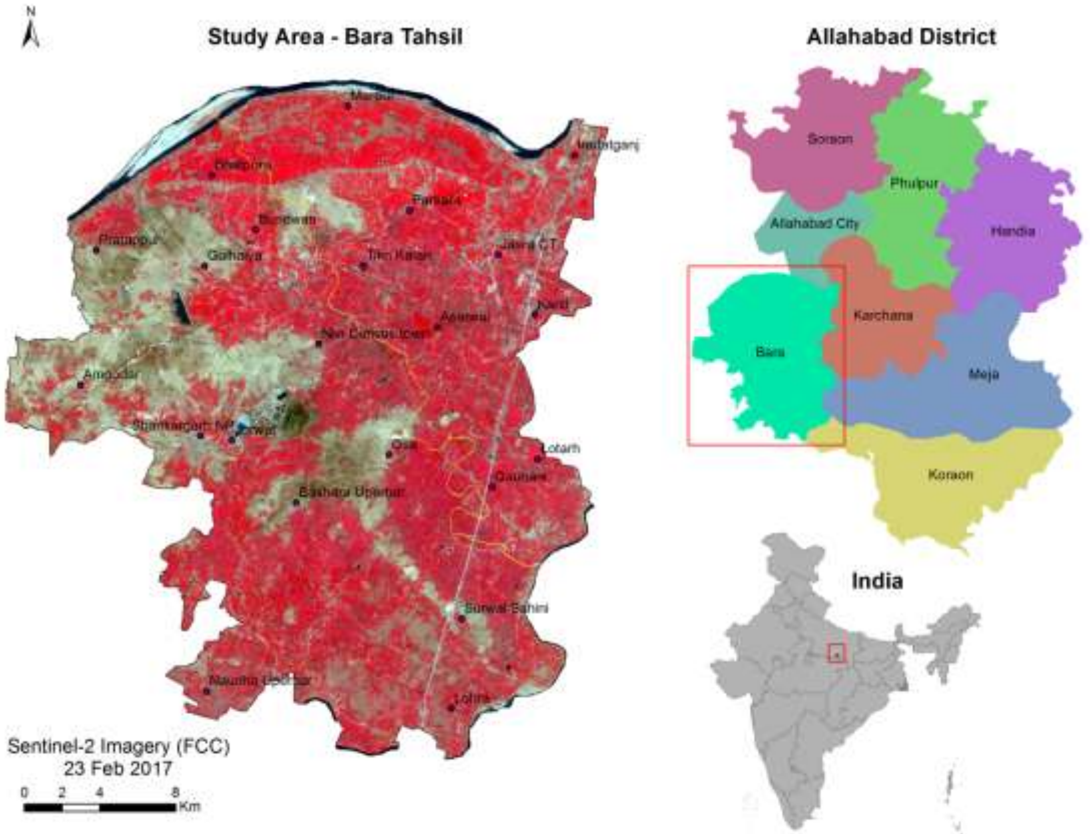

Figure 1. Location Map of Study Area

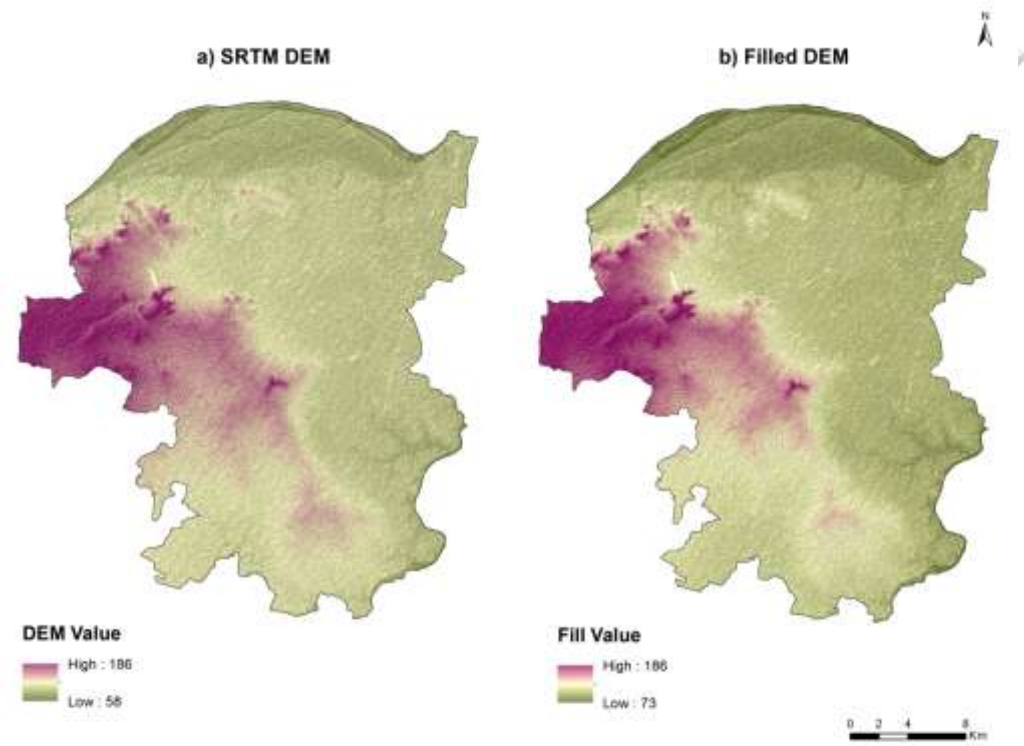

Figure 2.1. Methodology of Extraction of Drainage Network from CARTOSAT-1 DEM

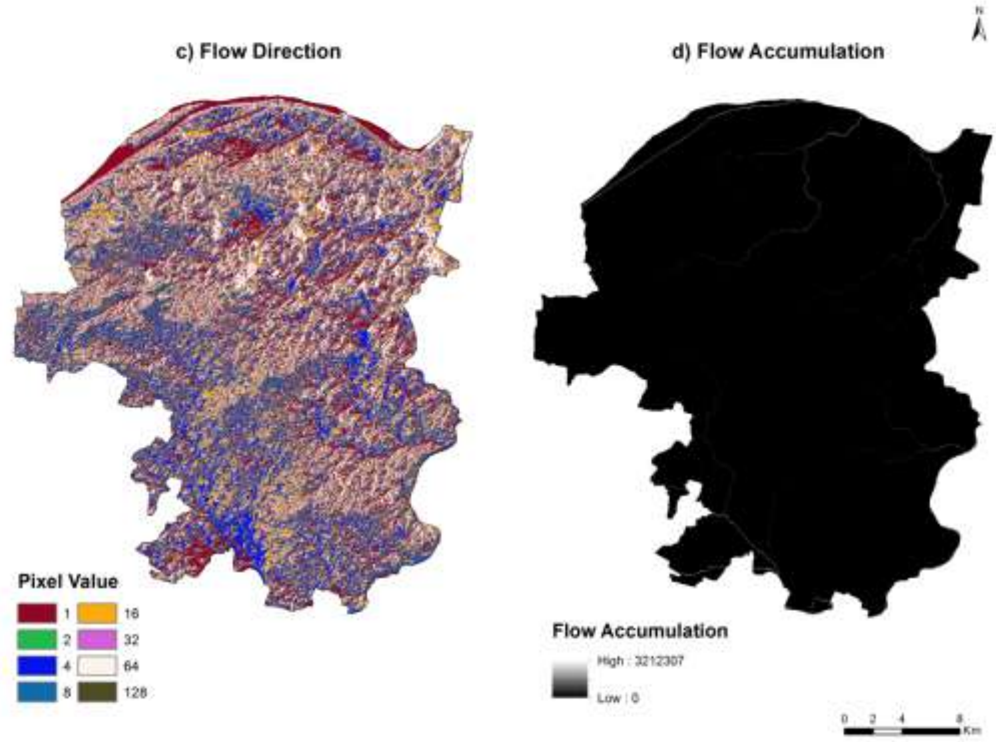

Figure 2.2. Methodology of Extraction of Drainage Network from CARTOSAT-1 DEM

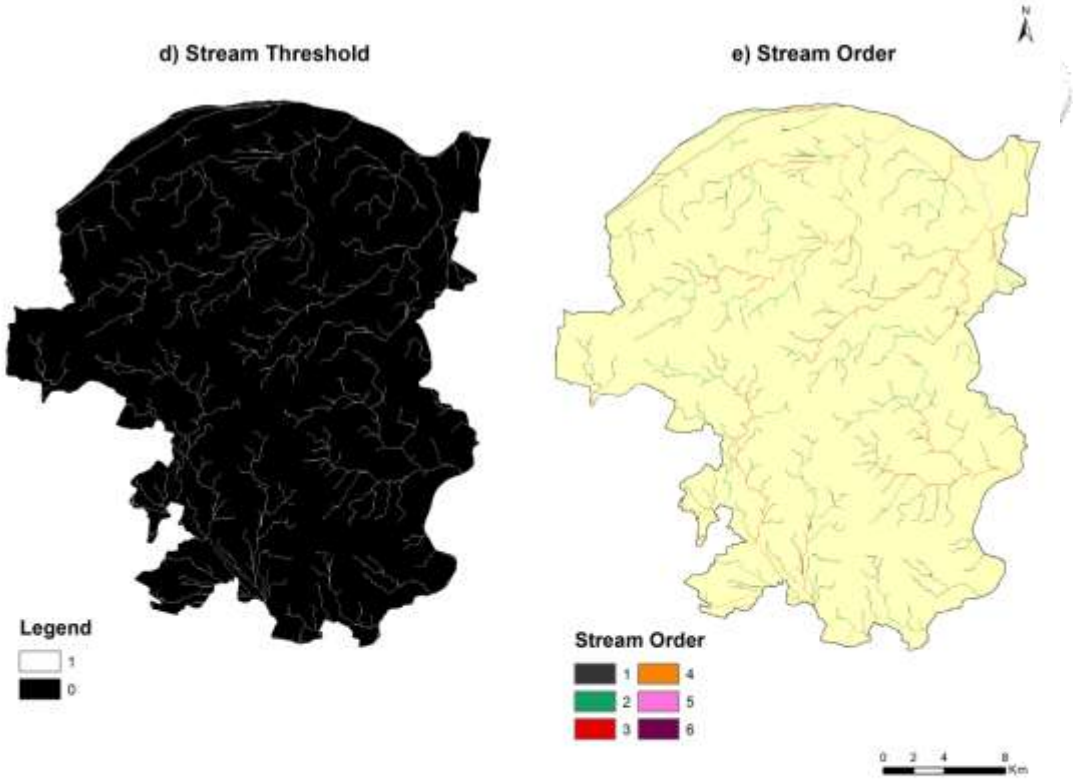

Figure 2.3. Methodology of Extraction of Drainage Network from CARTOSAT-1 DEM

4. RESULT & DISCUSSION

Yamuna and Tons river delineating north and south east border of study area with length of 31.50 km and 29.62 km respectively. These rivers are main outlet for all major tributaries of study area. In the study area, total 8 watershed (WS) having minimum 3 order streams are identified from CARTOSAT-1 DEM data (in which WS 1, WS 2, WS 3 and WS 4 belongs to Yamuna basin whereas WS 5, WS 6, WS 7 and WS 8 belongs to Tons basin). Both Yamuna and Tons river basin are separated by moderately dissected plateau having elevation of 114-180 m. It is endowed by rocks enriched with sandstone & quartzite belongs to Kaimur group of rocks of Vindyhan super-group and this plateau is extended in NW to SE direction with broader to narrower

Table 1. Morphometric Parameters and their Formulas computed for Yamuna and Tons Basin

SI. No.	Morphometric Parameters	Formulae	Reference
	Drainage Network		
1	Stream Order (S_u)	Hierarchical Rank	Strahler, 1952
2	Stream Number (N_u)	$N_u = N_1 + N_2 + ...+ N_n$	Hortorn, 1945
3	Stream Length (L_u)	$L_u = L_1 + L_2 + ...+ L_n$	Strahler, 1964
4	Stream Length Ratio (L_{ur})	$L_{ur} = L_u / L_{u-1}$	Strahler, 1964
5	Mean Stream Length Ratio (L_{urm})	$\sum L_{ur}$	Hortorn, 1945
6	Bifurcation Ratio (R_b)	$R_b = N_u / N_{u+1}$	Strahler, 1964
	Basin Geometry		
7	Basin Length (L_b)	-	Schumn, 1956
8	Basin Area (A)	-	Schumn, 1956
9	Basin Perimeter (P)	-	Schumn, 1956
10	Form Ratio (F_f)	$F_f = A / L_b^2$	Hortorn, 1932
11	Elongation Ratio (R_e)	$R_e = 2 / L_b * (A/\pi)^{0.5}$	Schumn, 1956
12	Circularity Ratio (R_c)	$R_c = 4 \pi A / P^2$	Miller, 1953
	Drainage Texture Analysis		
13	Stream Frequency(F_s)	$F_s = N_u / A$	Hortorn, 1932
14	Drainage Density (D_d)	$D_d = L_u / A$	Hortorn, 1932
15	Drainage Texture(D_t)	$D_t = N_u / P$	Hortorn, 1945
16	Constant of Channel Maintenance(C)	$C = 1 / D_d$	Schumn, 1956
17	Length of Overland Flow (L_g)	$L_g = 1/2*A / \sum L_u$	Hortorn, 1945
18	Infiltration Number (I_f)	$I_f = F_s * D_d$	Faniran, 1968
	Relief Parameter		
19	Height of Basin Mouth (z)	-	-
20	Maximum Height of the Basin (Z)	-	-
21	Total Basin Relief (H) (Relative Relief)	H = Z-z	Strahler, 1954
22	Relief Ratio (R_h)	$R_h = H / L_b$	Schumn, 1956
23	Absolute Relief (R_a)	-	-
24	Ruggedness Number (R_n)	$R_N = D_d * (H/1000)$	Strahler, 1964
25	Dissection Index (D_{is})	$D_{is} = H/R_a$	-

shape respectively. Linear, areal and relief parameters are discussed in detail with regard to 8 WS of study area in the following sections;

4.1. Drainage Network

Drainage Network is analyzed in reference with stream order, stream length, stream length ratio and bifurcation ratio which is as follows:

4.1.1 Stream Order (S_u)

Stream Order shows the hierarchy of streams within an area. Strahler method (1952) is used for assigning order to stream, where order 1st is assigned to all those streams having no tributaries, convergence of 1st order stream makes 2nd order stream. Thus same order stream makes higher order when they intersect. Study area has 6th order drainage basins. In study area, total 415 no. of streams are identified by providing 1000 pixels as threshold limit for making a stream using arc-hydro tool. Out of 415 no. of streams, 204 no of streams delineated in Yamuna basin (139 are of 1st order, 42 are of 2nd order, 15 are of 3rd order, 5 are of 4th order, 2 are of 5th order and 1 is 6th order), whereas 211 no. of streams belongs to Tons basin (147 are of 1st order, 46 are of 2nd order, 10 are of 3rd order and 7 are of 4th order) (table 2). Yamuna and Tons river belongs to the 6th & 5th order stream respectively. All the streams of the study area are making dendritic drainage pattern which indicate geological structural control over drainage system in form of inhomogenity of drainage pattern.

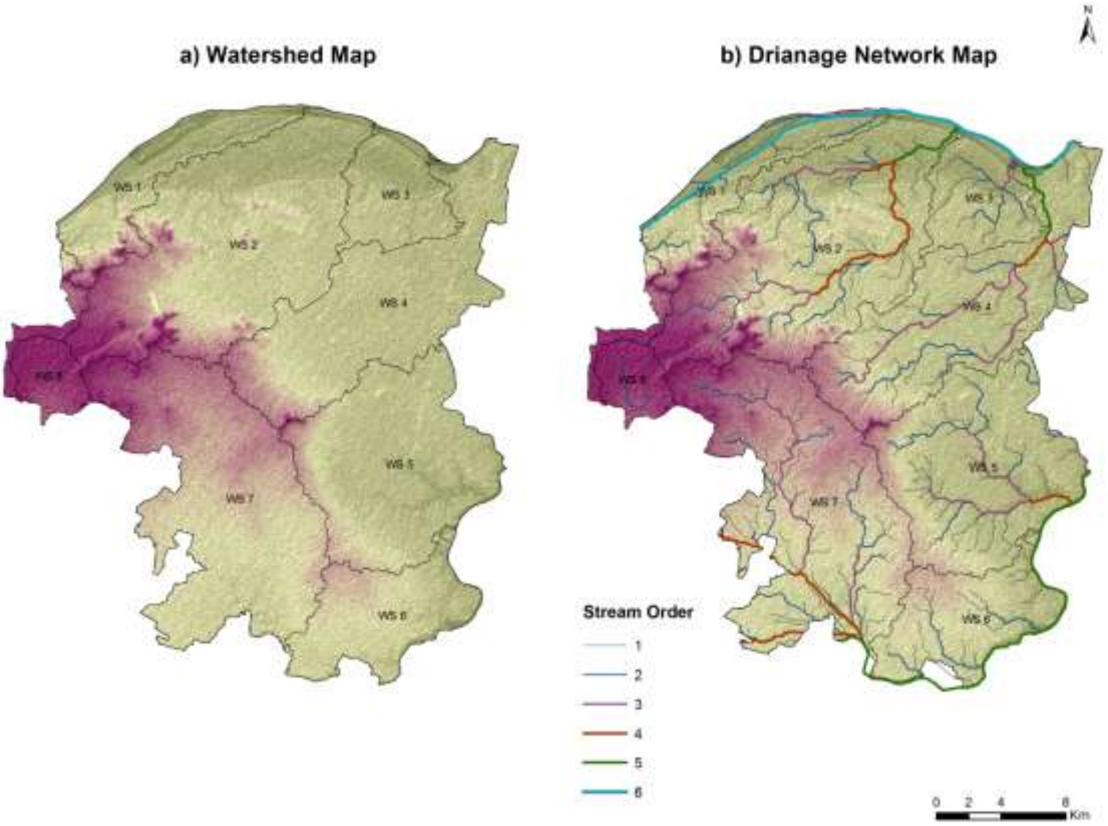

Figure 3. Drainage Network Map of Study Area at Watershed Level

4.1.2 Bifurcation Ratio (R_b)

Bifurcation ratio denotes the ratio of number of streams of lower order to number of streams of next higher order which ranges between 3 to 5 in plain region. The mean bifurcation ratio calculated as arithmetic mean of bifurcation ratio which is close to 3 and 5 for all 8 WS (table 3 & 4). The value of mean bifurcation ratio is low for Yamuna basin than Tons basin since Yamuna basin have alluvial origin. The bifurcation ratio of 2nd, 5th and 2nd order of WS 6, WS 7 and WS 8 respectively shows higher values which reflects high dissection in the moderately dissected plateau near Shankargarh region. The other lower order stream segments have low bifurcation value showing conformity with alluvial region and slope.

4.1.3 Stream Length (L_u)

Total stream length of study area is 715.76 km, in which Yamuna basin constitutes 366.95 km (table 2). In general successive stream order have direct relationship with mean stream length but it has inverse relationship with total stream length. This is also seen in study area for Yamuna and Tons basin. However higher order stream have more stream length in comparison to lower order in both basin because of the following two reasons-(i) elongated shape of the basin and (ii) Yamuna & Tons rivers are flowing along with the periphery of the basin. So, in study area, only right and left dendritic branches of Yamuna and Tons rivers distributed respectively.

4.1.4 Stream Length Ratio (L_{ur}) & Mean Stream Length (L_{urm})

The stream length ratio is the ratio of mean length of a given stream order to mean length of next lower stream order. Which is calculated for each pair of orders for both basins. Stream length ratio for 4th-5th order of Yamuna and Tons basin are higher than 1st-2nd order of the same basin. This variation in the length ratio is attributed to variation in slope of topography (Singh and Singh, 1997, Vittala et al., 2004). It also indicates youth and mature stage of geomorphic development of 1st-2nd order and 4th-5th order stream respectively.

4.2. Basin Geometry

The geological structure, lithology, relief and precipitation pattern of study area controls shape of the basin which varies from narrower elongated form to circular form (A. Biswas et al, 2014). Three parameters viz; form factor ratio, elongation ratio and circulatory ratio are used for the quantitative expression of shape of the basin:

Table 2. Result of Drainage Network Analysis in Yamuna and Tons Basin

Yamuna Basin					
Stream Order	**No. of Stream (N_u)**	**Stream Length (km)(L_u)**	**Mean Stream Length (L_{um})**	**Stream Length Ratio (L_{ur})**	**Bifurcation Ratio (R_b)**
1	139	159.090	1.145	-	-
2	42	95.334	2.270	0.599	3.310
3	14	49.374	3.292	0.518	2.800
4	5	19.615	3.923	0.397	3.000
5	2	12.031	6.015	0.613	2.500
6	1	31.505	31.505	2.619	2.000
Total	**204**	**366.949**	**48.149**	**4.746**	**13.610**
Average	**-**	**-**	**3.329**	**0.949**	**2.722**
Tons Basin					
Stream Order	**No. of Stream (N_u)**	**No. of Stream (N_u)**	**Mean Stream Length (L_{um})**	**Stream Length Ratio (L_{ur})**	**Bifurcation Ratio (R_b)**
1	147	177.365	1.207	-	-
2	46	83.722	1.820	0.472	3.196
3	10	39.053	3.905	0.466	4.600
4	7	19.045	2.721	0.488	1.429
5	1	29.622	29.622	1.555	7.000
Total	**210**	**348.807**	**39.275**	**2.982**	**16.224**
Average	**-**	**-**	**7.855**	**0.745**	**4.056**

4.2.1. Form Factor Ratio (F_f)

Form factor ratio is the numerical index used for representation of shape of a basin through ratio of basin area to the square of the basin length (Horton 1932). It ranges from 0.1 to 0.8 which indicates elongated to circular shape of a basin. Circular shape of basin characterized with high peak flow in short duration can be inferred from high value of form factor ratio of WS 3 and WS 6, whereas WS 1 and WS 4 have low value of form factor which indicate elongated shape of basin with low surface runoff in long duration. Tons basin have high form factor ratio (0.655) compared to Yamuna basin (0.421). High value of F_f is due to hard and consolidated rocky structure coincides along with the upper part of Tilghana, Patpari, Biharia, Gahera tributaries of Tons basin.

4.2.2. Elongation Ratio (R_e)

Elongation ratio is the ratio between diameter of the circle having the same area as the basin and maximum length of the basin (Schumn, 1956). It ranges from 0 to 1 representing three different shape of basin; Circular (> 0.9), Oval (0.9 – 0.8), less elongated (0.8 – 0.7) and elongated (< 0.7). In study area, WS 3, WS 5 and WS 8 are having circular shape whereas others have elongated shape. Yamuna basin is characterized with more elongated shape whereas Tons basin have more circular shape (table 5).

4.2.3. Circulatory Ratio (R_c)

Shape of watershed is validated through circulatory Ratio, which is the ratio of area of the basin to the area of the circle having same circumference as the basin perimeter (Miller, 1953). Its ranges between 0 to 1 representing elongated to circular shape of the basin. In study area value of R_c for all WS is varies from 0.18 to 0.50 and the R_c value for Yamuna and Tons basin are 0.367 and 0.159 respectively.

4.3. Drainage Texture Analysis

Drainage texture indicates the amount of dissection in the geomorphic structure and also gives idea about surface runoff and infiltration capacity of the region. It includes calculation of stream frequency, drainage density, texture ratio, constant of channel maintenance, length of overland flow and infiltration number:

Table 3. Result of Drainage Network Analysis at watershed level of Yamuna Basin

	Stream Order	No. of Stream (N_u)	Stream Length (km)(L_u)	Mean Stream Length (L_{um})	Stream Length Ratio (L_{ur})	Bifurcation Ratio (R_b)
Watershed 1	1	14	13.663	0.976	-	-
	2	8	18.207	2.276	1.333	1.750
	3	1	2.436	2.436	0.134	8.000
	4	1	19.001	19.001	7.801	1.000
	Total	**24**	**53.307**	**24.688**	**9.267**	**10.750**
	Average	**-**	**-**	**6.172**	**3.089**	**3.583**
Watershed 2	1	66	79.448	1.204	-	-
	2	19	40.899	2.153	0.515	3.474
	3	5	16.133	3.227	0.394	3.800
	4	3	15.455	5.152	0.958	1.667
	5	1	5.243	5.243	0.339	3.000
	6	1	4.243	4.243	0.809	1.000
	Total	**94**	**64.777**	**21.221**	**3.016**	**12.940**
	Average	**-**	**-**	**3.537**	**0.603**	**2.588**
Watershed 3	1	11	15.815	1.438	-	-
	2	4	10.136	2.534	0.641	2.750
	3	3	3.759	1.253	0.371	1.333
	4	1	4.500	4.500	1.197	3.000
	Total	**19**	**34.209**	**9.724**	**2.209**	**7.083**
	Average	**-**	**-**	**4.862**	**1.104**	**2.361**
Watershed 4	1	48	50.164	1.045	-	-
	2	11	26.093	2.372	0.520	4.364
	3	6	27.725	4.621	1.063	1.833
	4	2	3.482	1.741	0.126	3.000
	5	1	6.788	6.788	1.949	2.000
	6	1	3.764	3.764	0.554	1.000
	Total	**69**	**118.015**	**20.330**	**4.212**	**12.197**
	Average	**-**	**-**	**3.388**	**0.842**	**2.439**

4.3.1 Stream Frequency (F_s)

Stream frequency is the total number of stream segments of all orders in per unit area (Horton, 1932). Stream frequency has proportional relationship with increasing elevation. Stream frequency of entire watershed ranges from 0.49 km^{-2} to 0.78 km^{-2}. Low stream frequency in study area is attributed to the development of WS in low elevation area & its large extension found in the alluvial and pediplain zone whereas WS 8 have higher stream frequency due to its alignment and development in the plateau region having elevation range 72-128 m.

4.3.2 Drainage Density (D_d)

Drainage density is a numerical index used to express closeness of spacing between streams and is a measure of the total length of stream segment of all orders in per unit area. It is affected by weathering resistance capacity of rocks, rocks permeability, climatic conditions, vegetative cover, relief etc. (Javed Akram et al, 2009). The D_d value for all the watershed ranges from 0.74 km^{-2} to 1.10 km^{-2}. It is higher for WS 6 and WS 7 which indicates that this region underlain by weak & impermeable rock, sparse vegetation and upland sloppy area, whereas D_d value is low for WS 2 and WS 3 which shows region having more permeable rock with low relief and vegetative cover compared to WS 8.

Table 4. Result of Drainage Network Analysis showing at watershed level of Tons Basin

	Stream Order	No. of Stream (N_u)	Stream Length (km)(L_u)	Mean Stream Length (L_{um})	Stream Length Ratio (L_{ur})	Bifurcation Ratio (R_b)
Watershed 5	1	44	55.542	1.262	-	-
	2	16	22.492	1.406	0.405	2.750
	3	4	16.710	4.177	0.743	4.000
	4	1	3.219	3.219	0.193	4.000
	5	1	6.835	6.835	2.123	1.000
	Total	**66**	**104.798**	**16.900**	**3.464**	**11.750**
	Average	-	-	**3.380**	**0.866**	**2.938**
Watershed 6	1	22	31.021	1.410	-	-
	2	6	13.937	2.323	0.449	3.667
	3	1	19.819	19.819	1.422	6.000
	Total	**29**	**64.777**	**23.552**	**1.871**	**9.667**
	Average	-	-	**7.851**	**0.936**	**4.833**
Watershed 7	1	69	84.286	1.222	-	-
	2	22	42.279	1.922	0.502	3.136
	3	6	20.852	3.475	0.493	3.667
	4	5	15.825	3.165	0.759	1.200
	5	1	2.969	2.969	0.188	5.000
	Total	**103**	**166.211**	**12.752**	**1.941**	**13.003**
	Average	-	-	**2.550**	**0.485**	**3.251**
Watershed 8	1	11	6.686	0.608	-	-
	2	2	5.014	2.507	0.750	5.500
	3	1	1.492	1.492	0.297	2.000
	Total	**14**	**13.192**	**4.607**	**1.047**	**7.500**
	Average	-	-	**1.536**	**0.524**	**3.750**

4.3.3 Drainage Texture (D_t)

Drainage texture is the total number of streams segments of all orders in a river basin to the perimeter of the basin (Horton, 1945). Smith (1950) classified D_t into five classes i.e., very coarse (< 2), coarse (2-4), moderate (4-6), fine (6-8) and very fine (>8). In study area, all the watershed are categorized in very coarse texture. In general alluvial basin has very coarse to coarse texture whereas sloppy area has fine texture.

4.3.4 Constant of Channel Maintenance (C)

This parameter is inverse of drainage density having dimension of length as a property which indicates the requirement of unit of channel length (Schumn, 1956). WS 2 has high value of C and low D_d compared to WS 7. Higher value of C indicates high permeability of the area if the WS belongs to alluvial deposit.

4.3.5 Length of Overland flow (L_g)

Length of overland flow is an independent variable used to show length of water over the ground before it gets concentrated into definite stream channels (Horton, 1945). Its value ranges from 0.452 to 0.674. It determines sheet erosion if its quantity exceed to certain threshold of erosion.

4.3.6 Infiltration Number (I_f)

Infiltration number is the product of drainage density and stream frequency. High value of I_f shows low infiltration & more surface runoff i.e. higher D_d. WS 7 developed in the moderately dissected plateau and pediplain zone have high I_f compared to others.

Table 5. Basin Geometry of Study Area

Basin	Watershed	Basin Length (km)	Area (km^2)	Perimeter (km)	Form Factor Ratio	Elongation Ratio	Circularity Ratio
Yamuna Basin	WS 1	16.246	48.733	58.242	0.185	0.485	0.181
	WS 2	20.906	170.987	83.049	0.391	0.706	0.312
	WS 3	6.193	38.649	36.500	1.007	1.132	0.365
	WS 4	20.159	122.610	86.217	0.302	0.619	0.207
Tons Basin	WS 5	12.962	118.073	61.795	0.703	0.946	0.389
	WS 6	7.335	58.530	50.728	1.088	1.177	0.286
	WS 7	20.724	158.117	103.273	0.368	0.684	0.186
	WS 8	5.100	17.790	21.0233	0.684	0.933	0.506
Total	Yamuna Basin	30.075	380.979	114.228	0.421	0.785	0.367
	Tons Basin	23.204	352.510	166.495	0.655	0.909	0.159

Table 6. Areal Parameters showing Drainage Texture of Study Area

Basin	Watershed	Stream Frequency (F_s)	Drainage Density (D_d)	Drainage Texture (D_t)	Constant of Channel Maintenance (C)	Length of Overland Flow (L_g)	Infiltration Number (I_f)
Yamuna Ba.	WS 1	0.492	1.094	0.412	0.914	0.457	0.539
	WS 2	0.549	0.944	1.132	1.059	0.529	0.519
	WS 3	0.492	0.885	0.521	1.129	0.565	0.435
	WS 4	0.563	0.963	0.800	1.039	0.519	0.542
Tons Basin	WS 5	0.559	0.887	1.068	1.127	0.563	0.496
	WS 6	0.495	1.107	0.572	0.904	0.452	0.548
	WS 7	0.651	1.051	0.997	0.951	0.476	0.685
	WS 8	0.788	0.742	0.666	1.349	0.674	0.584
Total	Yamuna Bas.	0.535	0.963	1.786	1.042	0.519	0.516
	Tons Basin	0.599	0.989	1.267	1.011	0.505	0.592

4.4. Relief Parameter

Relief parameter includes measurement of relief ratio, ruggedness number & dissection index. These relief parameters reveals the erosion potential of the fluvial processes operating within a drainage basin (A. Biswas et al, 2014).

4.4.1. Relief Ratio (R_h)

Relief ratio is the ratio between the total relief of a basin i.e. elevation differences of a lowest and highest points of a basin, and the longest dimension of the basin parallel to the principal drainage line (Schumn, 1956). Thus relief ratio measures steepness of drainage basin and indicates intensity of erosion operating on the slope of the basin. The relief ratio of study area lies between 3.02 to 8.62 (Table 7). WS 8 has more R_h compared to WS 4 because of following two reasons- (i) WS 8 has less basin area compared to WS 4 and (ii) presence of hard quartzite and sand stone rocks in WS 8 facilitates more surface runoff in steeper basin compared to flat topography and gentle sloppy surface of WS 4.

Table 7. Relief Parameters showing Relief Characteristics of Study Area

Basin	Watershed	Height of Basin Mouth(z)	Maximum Height of the Basin (Z)	Total Basin Relief (H)	Relief Ratio (R_h)	Ruggedness Number (R_n)	Dissection Index (D_{is})
Yamuna Ba.	WS 1	128	75	53	3.262	0.024	0.414
	WS 2	178	74	104	4.974	0.061	0.584
	WS 3	100	80	20	3.229	0.011	0.200
	WS 4	134	73	61	3.026	0.036	0.455
Tons Basin	WS 5	154	77	77	5.940	0.048	0.500
	WS 6	120	90	30	4.090	0.013	0.250
	WS 7	179	95	84	4.053	0.052	0.469
	WS 8	179	135	44	8.627	0.066	0.246
Total	Yamuna Bas.	162	73	89	2.959	0.049	0.549
	Tons Basin	179	77	102	4.396	0.063	0.569

4.4.2. Ruggedness Number (R_n)

Ruggedness number is derived by multiplying basin relief (H) to drainage density (D_d) (Strahler, 1968). Its value will be higher if slopes of the basin have high steepness with more length. Value of R_n is low in the region which implies that the area is less or moderately prone to soil erosion (Pareta and Pareta, 2011). In study area, Rn value ranges between 0.011 for WS 3 with low sloppy area to 0.066 for WS 8 with higher basin relief.

4.4.3. Dissection Index (D_{is})

Dissection index is a ratio calculated by dividing the basin relief (H) by absolute relief of the basin. D_{is} shows vertical dissection in the region and it reveals the stage of landscape development of the basin (Singh and Dubey 1994). D_{is} for study area ranges from 0.20 to 0.58 which shows moderate dissection. High value of D_{is} indicates high dissection in the region and vice versa. WS 2, WS 5 and WS 7 have more dissection than WS 3, WS 6 & WS 8.

5. Conclusion

The significance of analyzing the morphometric properties of study area lies in the fact that it will helpful in watershed development, water resource management, hazard reduction, flood control etc. The extended area of Vindhyan ranges in form of plateau surface is not a very hilly and sloppy nature excepts inselberge, mesa, butte, isolated hill tops etc. Thus morphometric parameters have little differences in both Yamuna and Tons river basin in spite of having different origin and sedimentation. So it can be concluded that plateau area of Tons and Yamuna basin is not severely affected by flash flood as having low topographic surface which facilitates good to moderate infiltration thus having good ground water potential. Morphometric analysis is significant for surface and ground water resource management when a large area (i.e. Bara tehsil) requires water for irrigation (i.e. Jasra & Shankargarh) and settlement expansion (i.e. Shankargarh).

REFERENCES

[1] A. Biswas, D. D. Majumdar, S. Banerjee. 2014. Morphometry Governs the Dynamics of a Drainage Basin: Analysis and Implication.Geography Journal, vol.2014.

[2] A. Faniran. 1968. The index of drainage intensity - a provisional new drainage factor. Australian Journal of Science, vol. 31, pp. 328–330.

[3] A. Javed, M. Y. Khanday, and S. Rais. 2011.Watershed prioritization using morphometric and land use/land cover parameters: a remote sensing and GIS based approach. Journal of the Geological Society of India, vol. 78, no. 1, pp. 63–75.

[4] A. N. Strahler. 1964. Quantitative geomorphology of drainage basin and channel network in Handbook of Applied Hydrology, V. T.Chow, Ed., McGrawHill, NewYork, NY,USA.

[5] A.N. Strahler.1952. Hypsometric analysis of erosional topography. Bulletin of the Geological Society of America, vol. 63, pp. 1117– 1142.

[6] A.N. Strahler. 1957. Quantitative analysis of watershed geomorphology. Transactions of American Geophysics Union, vol. 38, pp. 913–920.

[7] J. E.Miller. 1968. An introduction to the hydraulic and topographic sinuosity indexes. Annals of the Association of American Geographers, vol. 58, no. 2, pp. 371–385.

[8] J. I. Clarke. 1966. Morphometry from maps in Essays in Geomorphology ,G. H. Dury, Ed., pp. 235–274, Elsevier, New York, NY,USA.

[9] K.Avinash, K. S. Jayappa, and B.Deepika. 2011. Prioritization of sub basins based on geomorphology and morphometric analysis using remote sensing and geographic information system (GIS) techniques. Geocarto International, vol. 26, no. 7, pp. 569–592.

[10] Mamatha, R.M. Janardhana, A.C. Dinesh, 2016. Quantitative Morphometric Analysis to Infer the Hydrological Behaviour of the East Suvarnamukhi basin in Tumkur district, Karnataka using Remote Sensing, GIS and bAd (bearing, Azimuth and drainage Calculator). International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), Vol. 5, Issue 9, September 2016.

[11] P. Lyew-Ayee, H. A. Viles, and G. E. Tucker. 2007. The use of GIS based digital morphometric techniques in the study of cockpit karst. Earth Surface Processes and Landforms, vol. 32, no. 2, pp.165–179.

[12] Pareta, K., and Pareta, U. 2011. Quantitative morphometric analysis of a watershed of Yamuna basin, India using ASTER (DEM) data and GIS. International Journal of Geomatics and Geosciences, 2(1).

[13] R. E. Horton. 1945. Erosional development of streams and their drainage basins: hydro physical approach to quantitative morphology. Geological Society of America Bulletin, vol. 56,pp. 275–370.

[14] S. A. Schumm. 1956. Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey. Bulletin of the Geological Society of America, vol. 67, pp. 597–646.

[15] Schumaker, N.H. 2004. Alternative futures for the Willamette River basin, Oregon. Ecological Applications.4(2): 313–324.

[16] Singh, S., Dubey, A. 1994. Geo environmental planning of watersheds in India. Chugh Publications, Allahabad, 28–69.

[17] Vittala S. S., Govindaih, S. and Gowda, H. 2004. Morphometric analysis of sub-watershed in the Pavada area of Tumkur district, South India using remote sensing and GIS techniques, Journal of Indian Remote Sensing, 32, 351–362.

[18] Yadav, S.K., Singh S.K., Gupta, M., Srivastava, P.K. 2014. Morphometric analysis of Upper Tons basin from Northern Foreland of Peninsular India using CARTOSAT satellite and GIS. Geocarto International, 29:8, 895-914.

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