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Morphomatric based Sub-watershed Prioritization using Spatial Information Technology: A case study of Upper part of Dwarakeswar

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Introduction:

A watershed is a hydrological unit which generates runoff by itself as a result of precipitation. Watershed degradation is the global problem, which is more serious in developing countries like India. West Bengal, India, being a part of the northern great Plains, a large number of watersheds can be delineated with different aerial coverage and most of them are in degraded condition that need to be managed properly. Watershed management implies prudent use of all the natural resources to ensure optimum and sustained productivity.

Geoinformatics technology has been successfully employed for identify scarcity and potential zone and also management (Bera et al. 2011).

The resource consideration for implementation of watershed management programs or various other reasons pertaining to administration or even political consideration may limit implementation to a few watersheds. Morphometric analysis of a watershed provides quantitative description of the drainage system which is an important aspect of the characterization of the watershed (Strahler, 1964). Even otherwise it is always better to start management measures from the highest priority watershed available. Watershed prioritization is the ranking of watershed according to the order in which they have to be taken up treatment. In this paper we have prioritized the watershed based on its morphometric parameter. Geo-morphological analysis of a watershed is usually used for evolving the regional hydrological models for resolving different hydrological difficulties of the ungauged watersheds in the absence of data accessibility conditions (Gajbhiye et. al.2014).

Objective:

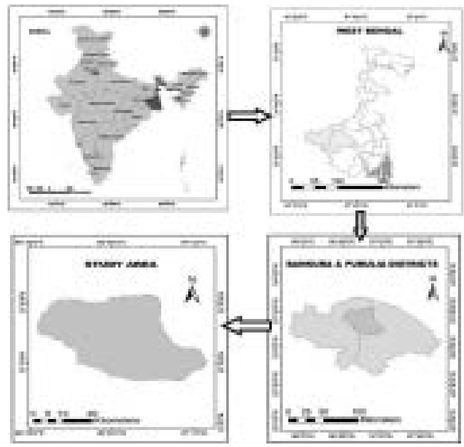
In the purpose of better water resource management in the sub-watershed level the study aims to achieve the following objectives:

1. Identification of Dwarakeswar upper catchment area.
2. Delineation of sub watersheds of the area.
3. To study the physical parameter of the area like relief, drainage, climate, geology etc.
4. To classify the streams according to drainage order as suggested by Strahler.
5. To study the linear morphometric aspects.
6. To study the relief morphometric aspects of the study area
7. To study the areal morphometric aspects of the study area.

8. To analyse the land use land cover of the study area and analyse its relationship with the drainage pattern.
9. And finally to prepare sub-watershed prioritization map based on the above parameter.

About the Study Area

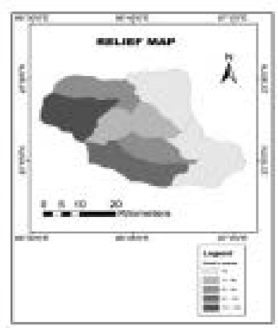
Dwarakeswar River, also known as (dhalkisor) is a major river in the western part of West Bengal. The Dwarakeswar basin is one of the 26 river sub basins of the state and is under the Ganges-Bhagirathi system. The basin located between the latitudinal extension of 22º37'00"N and 23º33'0"N and longitudinal extension of 86º 31'0"E and 87º51'0"E. It occupies a total area of 4673sqkm. The river is about 220 km in length. It originates from Tilbani hill in Purulia district and



Passes through the three districts namely, Purulia, Bankura and Hoogly and releases ultimately into the Rupnarayan, a right bank tributary of the Bhagirathi- Hoogly in its lower reaches. The Gandheswari, Beko, Dudhbhariya, dangra ,futiyari, arkasa, Birai are some of the prominent tributaries of Dwarakeswar in the upper basin**.**

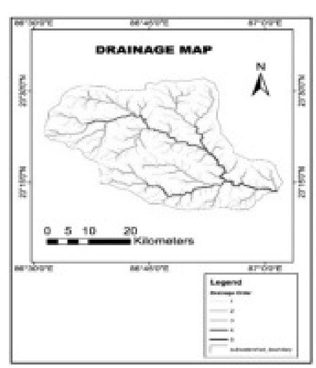
Relief

The relief map shows the relative relief of an area. It can be seen from the map below that sub watershed 1 and 7 that is the eastern part of the area shows a very low(below 70 m) relative relief while the western part shows mainly high elevated area where relative relief is very high(above 110 m). The middle area shows comparatively medium relative relief. However analysis of the map shows an undulated topography of the area.



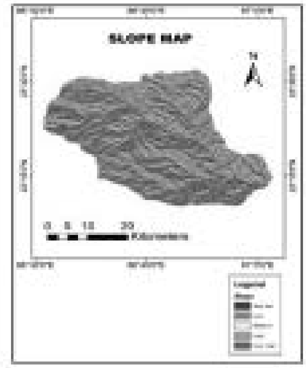
]**Drainage**

Dwarakeswar River is a major river in the western part of West Bengal. It originates from Tilbani hill in Purulia district and passes through the three districts namely, Purulia, Bankura and Hoogly and releases ultimately into the Rupnarayan. It flows from the northeast to southeast of the study area. In the study area it has formed a dendritic drainage pattern. We can see five stream orders prominently in the below drainage map below and 7 subwatersheds has been delineated based on these stream orders. The river in the study area is 80.250 km in length. Beko, Dudhbhariya, Dangra, Futiyari, Arkasa are some prominent tributaries of the river flowing through the study ar



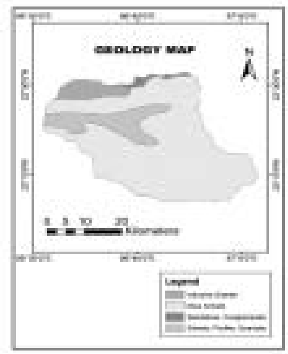
Slope

Slope is defined as the ratio between the difference between the elevation of two ground points and the distance between these two points. The slopes are varying in the area. Mainly the steep slopes are situated at the western part of the area and their direction is to the north and northwest. Mainly the medium slope covers the entire area. Very gentle slope or basically flat areas are very rare expressing that it is an undulated area.



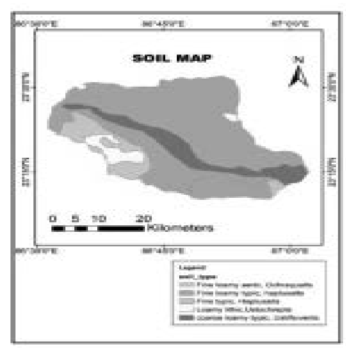
Geology

The geology of the study area is mainly comprises Archean and Dhawarian Rocks and is an extended portion of Chhotonagpur plateau. There are two shear zones; A – South Purulia shear zone that is WNW to ESE distributed tectonically. B – North Purulia shear zones. Apart from the whole districts, our study area mainly comprises of Granite, Gneiss, Migmatite, Mica schist, Amphibolites and Hornblende etc. And Intrusive Granites are also present.



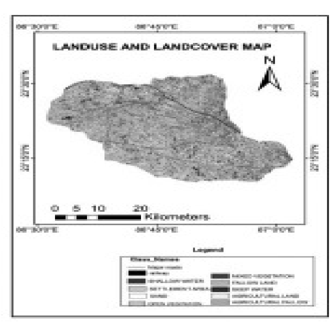
SOIL

Soil mapping helps to determine the rate of runoff, infiltration etc and thus helps in identifying the agricultural behavior of an area. The soil map of the study area reveals that the area is generally comprised of Sandy and loamy type of soil with very high to moderate draining capability. However cultivation is a prominent feature in this area depending on these soil types. After prolonged rainfall in the monsoon, when the soils have much moisture for cultivation “the shole” areas are cultivated once in the year. In the summer monsoon Gully erosion in these soil types are common.



Land use /Land cover

A land use land cover map has been prepared to show the relation between natural resources and anthropogenic activity of Dwarakeswar, upper catchment area using Remote sensing and GIS technology. The map shows that the land’s natural resources include the river, water bodies, mixed vegetation, open vegetation etc and depending upon this land cover a number of anthropogenic activities have been built up like the agricultural lands, settlement zone, roads, railway etc.



Climate

The climate of the district is tropical sub-humid with normal annual rainfall ranging from 110cm in the west to 140 cm in the east. The mean daily temperature ranges from minimum 12º c in the winter to 45º c in the summer. The variation in the number of rainydays and soil moisture limitations are common. Severe drought periods lasting for weeks affect the crop growth and yields during the Kharif season the main cropping season in the area.

Data and Methodology:

LANDSAT 5 TM satellite data and CARTOSAT DEM are collected from USGS, U.S.A and ISRO, INDIA official websites. The complete list of data and specification of the data are given below.

Table 1

Data Used

DATA	SOURCE	USED FOR
LANDSAT TM	USGS	Land use and land cover
CARTOSAT DEM	BHUBAN	DEM, Drainage, Contour, Slope
GEOLOGY MAP	GSI, KOLKATA	Geology
SOIL MAP	NBSS & LUP, KOLKATA	Soil

Morphometric Analysis

Watershed is a unit of particular runoff region; and runoff is the amount of total precipitation (Bera et al. 2013).The morphometric analysis is one of the significant geographical information system tools for prioritization of micro-watershed even without soil map and land use/land cover map. This is the most common approach which is used for basin analysis, morphometric associated with interpretation and analysis of ûuvially originated landforms. The drainage pattern refers to spatial relationship among streams or rivers, which may be influenced in their erosion by inequalities of slope; soils rock resistance, structure and geologic history of a region. The arrangement of the stream system of a drainage basin has been expressed quantitatively with some very crucial linear and aerial morphometric parameters such as Drainage density (Dd), Texture ratio(T), Stream frequency (Fu), Length of overland flow (Lo), Bifurcation ratio (Rb) ,Circularity Ratio (Rc) , Elongated ratio (Re), Form factor (Rf), Shape factor (Bs), Compactness coefficient (Cc). The relief parameters are relief ratio (Rh) and ruggedness number (Rn).

Table 2

Methods of Calculating Morphometric Parameter

	Morphometric parameter	Methods	Refferences
LINEAR	Stream order(u)	Hirerchial order Length	strahler,1964
	Stream length(Lu)	of the stream = Lu/	Horton, 1945
	Mean Stream length(Lsm)	Nu where, Lu= Stream length of order 'u' Nu= Total number of stream segments Of order 'u'	Horton, 1945

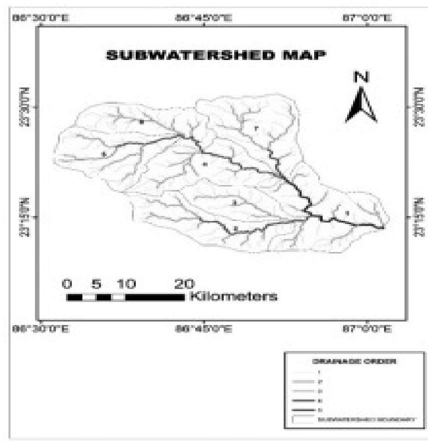
	Stream length ratio(Rl)	Rl=Lu/Lu-1; where Lu=Total stream length of order 'U', Lu1=Stream length of next lower order	Horton, 1945
	Bifurcation ratio(Rb)	Rb = Nu/ Nu+1; where, Nu=Total number of stream segment of order'u'; Nu+1= Number of segment of next higher order	Schumn, 1956
RELIEF	Basin relief(Bh)	Vertical distance between the lowest and highest points of watershed	Schumn, 1956
	Relief ratio(Rh)	Rh=Bh/Lb; Where, Bh= Basin relief;Lb=Basin length	Schumn, 1956
	Ruggedness no(Rn)	Rn = Bh × Dd Where, Bh =Basin relief; Dd= Drainage density	Schumn, 1956
AREAL	Drainage Density(Dd)	Dd = L/A where, L=Total length of streams;A=Area of watershed	Horton, 1945
	Stream frequency(N)	Df = N/A where, N=Total number of streams; A=Area of watershed	Horton, 1945
	Texture ratio(T)	T = N1/P where, N1= Total number of first order streams; P=Perimeter of watershed	Horton, 1945
	Form factor(Rf)	Rf=A/(Lb)2 ;where, A=Area of watershed, Lb=Basin length	Horton, 1932
	Circulatory ratio(Rc)	Rc=4ðA/P2 ;where, A= Area of watershed, ð=3.14, P=Perimeter of watershed	Miller,1953
	Elongation ratio(Re)	Re=2ˆ(A/ð)/Lb ;where, A= Area of watershed, ð=3.14, Lb=Basin length	Schumn, 1956
	Length of overland flow (Lof)	Lof = 1/2Dd where, Dd= Drainage density	Horton,1945
	Constant channel maintaenance©	C= 1/Dd, where Dd= Drainage density	Horton,1945

Prioritization Of Subwatershed

The drainage network of Dwarakeswar upper Beko watershed has been extracted from the CARTOSAT DEM. Then the drainage network has been divided upto subwatershed level. The various morphometric parameter namely linear, aerial and relief has been calculated in the Microsoft office excel based on the formulas in table 3. The prioritization was carried out by assigning ranks to the individual indicators and a compound value (Cp) was calculated.

Result And Discussion

Sub Water shed Delineation



Water sheds are those are as from which run off resulting from precipitation, flows past a single point into a large stream river, lake or an ocean. These are natural hydrologic entities that cover a specific a erialexten to fland from which rainwater flows to a defined gully, stream or river of a particular point. The drainage network helps in delineation of wate rshed for a particular river system. Water shed Atlas of India published All India Soil & Land Use Survey, Ministry of Agriculture and Co-operation, Govt. of India (1990) has been referred for delineation up to watershed level. Here the details of watershed have been measured up to sub watershed level over the drainage network as prepared from the CARTOSAT1 DEM measured. The sub watershed map and the table showing the area of each watershed are given.

Linear Morphometric Parameters

Linear parameters analysis includes:

Stream orders (Nu), stream length (Lu),

mean stream length (Lsm) and bifurcation ratio (Rb). The PARAMETERs have been discussed below in the table5.

Stream order (u): In any watershed study, the behavior of the ûow ûnding is very difficult; therefore, it is necessary to subdivide the watershed into sub-watersheds. It will be done according to stream order and area of the sub-watersheds. There are a number of methods of indicating stream orders for a stream network (Horton, 1945; Strahler, 1964).

Table 3: Area of sub watersheds

SUB-WATERSHED	AREA(sq km)
1	254.394
2	188.213
3	116.39
4	197.502
5	188.988
6	154.101
7	214.035

According to Strahler (1964), the smallest fingertip tributaries are designated as order 1. Where two first-order tributaries join, a tributary segment of order 2 is formed; where two of order 2 join, a segment of order 3 is formed; and so forth. The trunk stream through which all discharge of water and sediment passes is therefore the stream segment with highest order.

Stream number (Nu): Number of streams is also described as total counts of stream segments of different order separately and is inversely proportional to the stream order. Stream number is denoted by Nu. 330 stream segments were recognized in the upper Beko watershed, out of which 76.36% is a 1st order, 16.06% is a 2nd order, 4.85% is a 3rd order, 2.12% (6) is a 4th order, and 0.30% is a 5th order.

Total stream length (Lu): Total stream length is calculated as measuring the length of all ordered seasonal streams within the catchment area of the watershed and is denoted by Lu. According to Horton's second law (1945), the stream length characteristics of the sub-basins validate the ''laws of stream length'', which states that the average length of streams of each of the different orders in a drainage basin tends closely to approximate a direct geometric ratio (Horton 1945). Generally, the total length of stream segments decreases with stream order.

Mean stream length (Lsm): Mean stream length is the ratio of total stream length of particular order to the total number of same ordered stream and is denoted by Lsm.

Bifurcation ratio (Rb): The term bifurcation ratio (Rb) is used to express the ratio of the number of streams of any given order to the number of streams in the next higher order (Schumn, 1956). Bifurcation ratios characteristically range between 3.0 and 5.0 for basins in which the geologic structures do not distort the drainage pattern (Strahler, 1964). The lower bifurcation ratio values are characteristics of the watershed, which has suffered less structural disturbances and the drainage pattern has not been distorted by the structural disturbances. High value of Rb indicates the severe over land ûow and low recharge for the sub-watershed. In this study, the value of mean bifurcation ratio varies between 2.27 and 3.37 that indicate the area's drainage pattern is less affected by the structural disturbances. The bifurcation ratio is also indicative of shape of the basin also. An elongated basin is likely to have a high Rb, whereas a circular basin is likely to have low Rb.

Stream length ratio (RL): The stream length ratio (RL) is the ratio of the mean length of the stream of a given order (Lu) to the mean length of the streams of the next smaller order (Lu-1).

Table 4:
Linear Parameters

SWS	PARAMETRE	I Order	II Order	III order	IV Order	V order	Mean Rb
1	NUMBER OF SEGMENTS(Nu)	51	10	2	1	1	
	STREAM LENGTH(Lu)	88.704	45.92	9.389	1.669	27.577	
	BIFURCATION RATIO(Rb)		5.1	5	2	1	3.275
	MEAN STREAM LENGTH(Lsm)	1.739294	4.592	4.6945	1.669	27.577	
	STREAM LENGTH RATIO(RL)		0.517677	0.204464	0.177761	16.52307	
2	NUMBER OF SEGMENTS(Nu)	42	8	2	1	0	
	STREAM LENGTH(Lu)	61.569	14.598	25.915	21.843	0	
	BIFURCATION RATIO(Rb)		5.25	4	2	0	3.75
	MEAN STREAM LENGTH(Lsm)	1.465929	1.82475	12.9575	21.843	0	

	STREAM LENGTH RATIO(RL)		0.2371	1.775243	0.842871	0	
3	NUMBER OF SEGMENTS(Nu)	20	3	1	1	0	
	STREAM LENGTH(Lu)	40.677	18.226	11.125	3.693	0	
	BIFURCATION RATIO(Rb)		6.666667	3	1	0	3.555556
	MEAN STREAM LENGTH(Lsm)	2.03385	6.075333	11.125	3.693	0	
	STREAM LENGTH RATIO(RL)		0.448066	0.610392	0.331955	0	
4	NUMBER OF SEGMENTS(Nu)	40	8	2	1	0	
	STREAM LENGTH(Lu)	73.77	25.72	14.85	17.69	0	
	BIFURCATION RATIO(Rb)		5	4	2	0	3.666667
	MEAN STREAM LENGTH(Lsm)	1.84425	3.215	7.425	17.69	0	
	STREAM LENGTH RATIO(RL)		0.348651	0.577372	1.191246	0	
5	NUMBER OF SEGMENTS(Nu)	36	7	4	1	0	
	STREAM LENGTH(Lu)	63.551	28.538	20.988	12.979	0	
	BIFURCATION RATIO(Rb)		5.142857	1.75	4	0	3.630952
	MEAN STREAM LENGTH(Lsm)	1.765306	4.076857	5.247	12.979	0	
	STREAM LENGTH RATIO(RL)		0.449057	0.73544	0.618401	0	
6	NUMBER OF SEGMENTS(Nu)	28	9	3	1	0	
	STREAM LENGTH(Lu)	54.683	19.44	16.49	7.739	0	
	BIFURCATION RATIO(Rb)		3.111111	3	3	0	3.037037
	MEAN STREAM LENGTH(Lsm)	1.952964	2.16	5.496667	7.739	0	
	STREAM LENGTH RATIO(RL)		0.355504	0.848251	0.469315	0	
7	NUMBER OF SEGMENTS(Nu)	35	8	2	1	1	
	STREAM LENGTH(Lu)	73.15	32.03	17.49	10.17	0.09	
	BIFURCATION RATIO(Rb)		4.375	4	2	1	2.8438
	MEAN STREAM LENGTH(Lsm)	2.09	4.00375	8.745	10.17	0.09	
	STREAM LENGTH RATIO(RL)		0.437867	0.546051	0.581475	0.00885	

Relief Parameters

Relief parameters analysis includes the relief ratio and the ruggedness number. The following parameters have been discussed quantitatively for each sub watershed in the table no 6.

Drainage density (Dd): Drainage density is inûuenced by various factors, among which resistance to erosion of rocks, inûltration capacity of the land and climatic conditions rank high (Verstappen 1983). According to Langbein (1947), the signiûcance of drainage density is a low drainage density is more likely represent the regions with resistant like area with permeable subsoil under dense vegetative cover, and where relief is low. In contrast, high drainage density is favoured in regions of weak or impermeable subsurface materials, sparse vegetation and mountainous relief. In the watershed, drainage density of seven sub-watersheds varies from 0.62 to 0.68 and is shown in Table 6.

Basin relief (Bh): The basin relief is nothing but the difference between highest and lowest elevation for a particular river basin. It is mainly representative of the underlying rock types and the slope present in the area. Here the relief ranges from 0.07 to 0.18, indicating a medium relief that is medium to gentle slope over the whole river basin**.**

Relief ratio (Rh): It is the basin relief divided by the length of the basin. The values of relief ratio are given in Table 4 which ranges from 0.0029 to 0.0084. It is noticed that the high values of Rh indicate steepness of the basin and is an indicator of intensity of erosion process operating on the slopes of the watershed**.**

Ruggedness number (Rn): It is the product of the basin relief and the drainage density where both the parameters are in same unit. An extreme high value of ruggedness number occurs when both variables are large and slope is steep (Strahler, 1956). The value of ruggedness number in the present basins varies from 0.04 to 0.12 indicating less run off in most of the sub watersheds.

Table 5

Relief aspects

SWS	SWS1	SWS2	SWS3	SWS4	SWS5	SWS6	SWS7
TOTAL STREAM OF ALL ORDER	65	53	25	51	48	41	47
TOTAL STREAM ALL LENGTH OF ORDER(Km)	173.259	123.925	73.721	132.03	126.056	98.352	132.93
AREA OF BASIN (SQ KM)	254.394	188.213	116.39	197.502	188.988	154.101	214.035
CONTOUR(M)	30	50	40	60	90	170	60
	100	200	130	140	270	90	140
DRAINAGE DENSITY(Dd)	0.6810656	0.65843	0.633396	0.6685	0.667005	0.638231	0.621067
BASIN LENGTH(Lb)	24	28.88	25.82	25.5	21.38	23.32	24.21
BASIN RELIEF(Bh)	0.07	0.15	0.09	0.08	0.18	0.08	0.08
RELIEF RATIO(Rh)	0.0029167	0.005194	0.003486	0.003137	0.008419	0.003431	0.003304
RUGGEDNESS NUMBER (Rn)	0.0476746	0.098764	0.057006	0.05348	0.120061	0.051058	0.049685

Aerial Aspects

In morphometric analysis of a river system, the maximum numbers of parameters are analysed for the areal parameters. The parameters include stream frequency (Fs), texture ratio (T), form factor (Rf), length of overland flow (Lof), constant channel maintenance(C) (aerial parameters). The result is discussed in the table 7.

Stream frequency (Fs)*:* Stream frequency or channel frequency (Fs) is the total number of stream segments of all orders per unit area (Horton, 1932). Drainage frequency or channel frequency is directly related to stream population per unit area of the watershed (Horton 1932). It indicates the close correlation with drainage density value of the sub-watershed. The calculated value of stream frequency (Fs) ranges from 0.21 to 0.29 in upper Beko watershed, which can be attributed to moderate relief and high infiltration capacity.

Texture ratio (T): Horton (1945) defined drainage texture is the total number of stream segments of all order in a basin per perimeter of the basin. It is important to geomorphology which means that the relative spacing of drainage lines. Drainage texture is on the underlying lithology, infiltration capacity and relief aspect of the terrain. Smith (1950) has classified drainage texture into 5 different textures i.e., very coarse (<2), coarse (2 to 4), moderate (4 to 6), fine (6 to 8) and very fine (>8).In the present basin texture ratio varies from 0.22 to 0.75 indicating an undulated topography throughout the basin.

Form factor (Rf): Horton (1932) outlined form factor as a dimensionless ratio of the area of the basin to the square of the length of the basin. Basin shape can be indexed by simple dimensionless ratios of the basic measurements of area, perimeter and length (Singh, 1998).The form factor calculated for all 7 sub watersheds are given in Table 7. Most of the researchers have suggested that the value of form factor is less than 0.7854 for perfectly circular basin (Rekha et al. 2011; Gajbhiye et al. 2014). In watershed, the smaller value of the form factor shows maximum elongation of the basin. The high value of form factor shows high peak in short duration and vice versa. In this study, it was found that the value of form factor varies 0.17(sw 3) to 0.44(sw 1), which indicates that the sub watersheds are basically elongated or nearly oval in the basin.

Circulatory ratio (Rc): Miller (1953) defined a dimensionless circulatory ratio (Rc) as the ratio between the area of the basin and the area of the circle having the same perimeter as that of the basin. The more the value of the Rc , the more the shape will be circular. The circulatory ratio calculated for the sub watersheds show that the value ranges from 0.38 to 0.61 indicating that the entire sub watershed is nearly elongated.

Elongation ratio (RE): Generally, the values of elongation ratio (Re) generally lie between 0.6 and 1.0 which is associated with a wide variety of climate and geological properties. The values close to 1.0 are typical of regions of very low relief, whereas that of 0.6 to 0.8 are followed with high relief and steep ground slope (Strahler, 1964). In this watershed, elongation ratio varies between 0.47 (SWS-3) and 0.75 (SWS-1), whereas the feature of watershed lies oval cum elongated in nature. However, sub-watersheds are elongated with moderate slope with relatively high to moderate relief

Length of overland ûow (LOF): The length of overland ûow (Lg) approximately equals half the reciprocal of the drainage density (Horton, 1945). This factor relates inversely to the average slope of the channel and is quite synonymous with the length of sheet ûow. The values of length of overland ûow in sub-watersheds vary from 0.73 (SWS-1) to 0.81 (SWS-7). More the value represents long time of flow in the basin.

Constant of channel maintenance (C): This parameter indicates the requirement of units of watershed surface to bear one unit of channel length. Schumn (1956) has used the inverse of the drainage density having the dimension of length as a property termed constant of channel maintenance. The drainage basins having higher values of this parameter, there will be lower value of drainage density. The constant(C) is expressed in km2/km and depends not only upon the rock type, climatic region, relief, vegetation cover but also upon duration of erosion and climatic history. Higher value of constant channel Maintenance reveals strong control of lithology with a surface of high permeability. Alluvial basin of plain and piedmont zone shows highest value, as the permeability in this zone is high. In the present basin the value ranges from 1.46 to 1.61.

Table 6

Areal aspects

SWS	SWS1	SWS2	SWS3	SWS4	SWS5	SWS6	SWS7
AREA OF WATERSHED (sqkm)	254.394	188.213	116.39	197.502	188.988	154.101	214.035
PERIMETRE OF WATERSHED(m)	84.76	73.4	52.68	70.59	62.56	70.97	66.53
BASIN LENGTH(Lb)	24	28.88	25.82	25.5	21.38	23.32	24.21
DRAINAGE DENSITY(Dd)	0.6810656	0.65843	0.633396	0.6685	0.667005	0.638231	0.621067
STREAM FREQUENCY(Fs)	0.2555	0.2815	0.2148	0.2582	0.254	0.2661	0.2195
TEXTURE RATIO(T)	0.6016989	0.223151	0.379651	0.566653	0.575448	0.394533	0.766571
FORM FACTOR(Rf)	0.4416563	0.22566	0.174583	0.303732	0.413446	0.283366	0.36517
CIRCULATORY RATIO(Rc)	0.4447486	0.43878	0.526761	0.497823	0.606499	0.384278	0.60735
ELONGATION RATIO(Re)	0.7500796	0.536158	0.471592	0.622029	0.725729	0.600813	0.682045
LENGTH OF OVERLAND FLOW(Lof)	0.7341437	0.759383	0.789395	0.747944	0.749619	0.783416	0.805067
CONSTANT CHANNEL MAINTAINANCE(c)	1.4682874	1.518765	1.57879	1.495887	1.499238	1.566831	1.610133

Prioritization Of Subwatershed

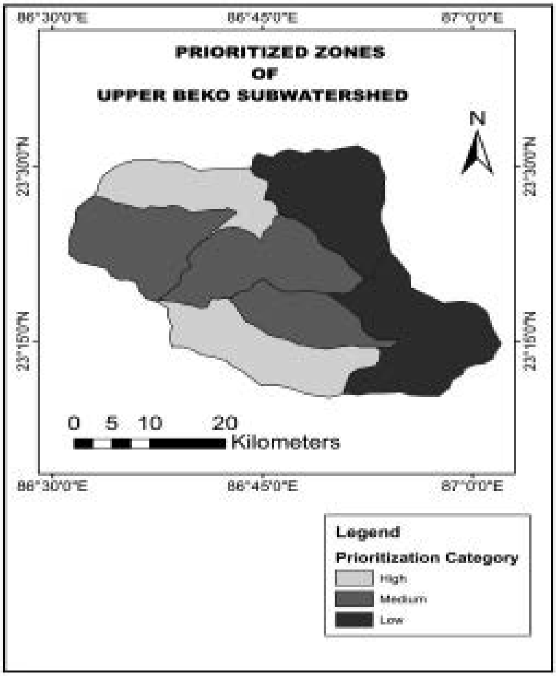
Drainage pattern of watershed refers to geospatial relationship among the streams or rivers and is associated with slope, soil type and rock resistance, structural and geological status of the basin. The study emphasizes the prioritization of the sub-watersheds on the basis of morphometric analysis. The parameters were calculated from area, perimeter, basin length, drainage density, and stream length but bifurcation ratio was calculated from the number of streams in particular micro-watershed. Bifurcation ratio being the one of the very important parameter plays significant role in prioritization of micro-watershed. All these parameters were computed using ARC/INFO and MS Excel Software. In this study, linear parameters are bifurcation ratio, drainage density, stream frequency, and the aerial parameters are circularity ratio, form factor, elongation ratio texture ratio, length of overland ûow, constant channel maintenance and the relief parameters are mainly the relief ratio and the ruggedness number. Hence, the linear and relief parameters have a direct relationship with erodibility and the aerial parameters have inverse relationship with erodibility, The highest value of the linear and relief parameters was ranked as 1 and next highest value was ranked 2 and so on, as well as the lowest value of aerial or shape factor was ranked 1 and next lowest value was ranked 2 and so on (Table: 8). Thus after ranking each parameter from rank 1 to 7, a compound value has been assigned to rank each of the sub watersheds by simply averaging the values of all the parameters for each watershed. . However, the ûnal priority has been assigned as the least rating value was assigned as highest priority; next higher value was assigned second priority and so on. The maximum and minimum prioritized score of sub-watersheds is 2.72 (sw2) and 5.18 (sw 7) respectively. The sub-watersheds have been categorized into three classes as high (2.72-3.18), medium (3.19-4.36) and low (4.37-5.18) priority on the basis of span of Cp value.

Table 7

Ranking of parameters

SWS	Rb	Dd	Fs	Rh	Rn	T	Rc	Rf	Re	Lof	C	Compound parametre	Final priority
1	3	1	4	7	7	2	3	7	7	7	6	4.909090909	VI
2	1	4	1	2	2	7	2	2	2	4	3	2.727272727	I
3	4	6	7	3	3	6	5	1	1	2	4	3.818181818	III
4	6	2	3	6	4	4	4	4	4	6	5	4.363636364	V
5	5	3	5	1	1	3	6	6	6	5	1	3.818181818	IV
6	2	5	2	4	5	5	1	3	3	3	2	3.181818182	II
7	7	7	6	5	6	1	7	5	5	1	7	5.181818182	VII

Figure 9: Prioritized zones map of the study area



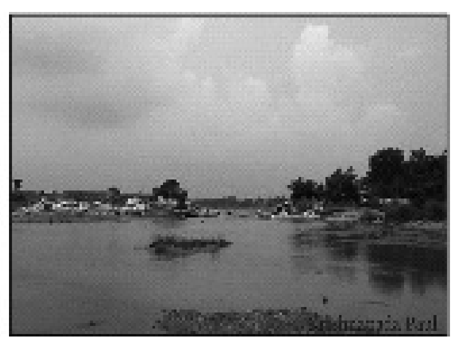
Conclusion

Drainage morphometry of a sub-watershed reflects hydro-geologic maturity of that river. Satellite remote sensing has an ability of obtaining the synoptic view of a large area at one time, which is very useful in analyzing the drainage morphometry. GIS has proved to be an efficient tool in drainage delineation and this drainage has been used in the present study. The morphometric analysis of different sub-watersheds shows their relative characteristics with respect to hydrologic response of the catchment. The morphometric analysis of seven sub-watersheds exhibits the dendritic drainage pattern and the variation in stream ratio might be due to changes in slope as well as topographic features of the study region. Higher runoff may also affect the sediment yield. The variation in bifurcation ratio among the sub-watersheds is described to the difference in topography and geometric development. The stream frequencies for all sub-watersheds of the study exhibit positive correlation with the drainage density values indicating the increase in stream population with respect to increase in drainage density. Drainage density is very coarse to coarse texture. Elongation ratio shows that speciûc sub-watershed possesses nearly circular shape, while the remaining marks elongated pattern. Thus by analysing the morphometry of the drainage system the present study becomes valuable for erosion control, watershed management, land and water resources planning and future prospective related to runoff study. In our study the SWS 2 and 6 are of very high priority and 1 and 7 are of low priority. This priority class may be taken for conservation measures by engineers and the decision makers who planned for developments and management of natural resources.

GCP COLLECTION

SOIL DEGRADATION

GULLY EROSION AFTER RAINFALL



DWARAKESWAR RIVER

Referrences:

Bera K and Bandyopadhyay J, (2011). Management of Ground Water Using Geoinformatics in Dwarkeswar Watershed of Puruliya District, *Indian Cartographer, 31*, pp 265-270.

Bera K and Bandyopadhyay J, (2013) Prioritization of Watershed using Morphometric Analysis through Geoinformatics technology: A case study of Dungra subwatershed, West Bengal, India, Int. *Journal of Advances in Remote Sensing and GIS, Vol. 2, No. 1*.

Gajbhiye S, Mishra SK, Pandey A (2014) Prioritizing erosion-prone area through morphometric analysis: an RS and GIS perspective. *Appl Water Sci 4(1):*51–61.

Rekha, 2011. Morphometric Analysis and Micro-watershed Prioritization of Peruvanthanam Subwatershed, the Manimala River Basin, Kerala, South India *Environmental Research, Engineering and Management, 3(57),* pp 6–14. 12.

Strahler, A. N. 1964. Quantitative geomorphology of drainage basins and channel networks, section 4II, In: *Handbook of Applied Hydrology*, edited by V.T. Chow, McGraw Hill, p. 439.