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MORPHOMETRIC STUDY AND PRIORITIZATION OF SUB-WATERSHED OF KULSI RIVER BASIN USING GIS

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Abstract: For planning, designing and management of any water resources system, the study of the properties of river basin plays a significant role. Actually the life of any reservoir depends on sediment load of the river on which the basin is located. So to extend the life of the reservoir it is essential to study the drainage characteristics of the basin and the areas which contribute maximum sediments to the reservoir. Morphometric analysis gives the basic information about the drainage conditions, size and shape of the basin. In this study morphometric analysis has been carried out on Kulsi river basin using remote sensing and GIS. The study has been carried out for the area up to the dam site, as the sediment contribution to the reservoir is dominated by this area. From the analysis, it has been found that the basin is of 6^{th} order and dendritic drainage pattern having elongated shape with less runoff and less prone to soil erosion. The whole watershed is divided into seven sub-watersheds (SWS 1-SWS 7) for prioritization, to determine the most erosion prone areas in the basin. Compound parameters have been estimated from areal, relief and shape parameters for prioritization of the sub-watersheds. The compound parameter value showed SWS 1 as the highest priority for land management and SWS 2 as the lowest priority. The priorities of watershed managements for the sub-basins are in the order of SWS 1, SWS 6, SWS 3, SWS 4, SWS 5, SWS 7 and SWS 2.

Keywords: **Morphometric analysis, prioritization, GIS and remote sensing, drainage density, bifurcation ratio.**

1. INTRODUCTION

For the development of any river basin, the study of the hydrologic characteristics of the watershed is very essential. There is a very significant relationship between morphology of a river basin and its hydrologic characteristics. The hydrologic characteristics of a river basin depends on the morphometric parameters such as stream order, stream numbers, stream lengths, drainage density, bifurcation ratio, stream length ratio etc. In this paper the hydrological characteristics of Kulsi River basin is undertaken for the study. The Kulsi multipurpose project is proposed by the Brahmaputra Board, Central Water Commission and Government of Assam jointly. The Kulsi river basin is located between $25^0 32^/$ N & $26^0\,07^/$ N and $90^0\,45^/$ E & $91^0\,48^/$ E and on the southern part of the mighty river Brahmaputra. The basin occupies the area in Kamrup and Golapara district of Assam as well as West Khasi hills and East Garo hills district of Meghalaya. The Kulsi river is a tributary of the Brahmaputra river. The total catchment area of the watershed is 1628 km^2 upto the dam site. Fig.1shows the location of Kulsi basin.

Fig.1: Location map of Kulsi watershed

2. LITERATURE REVIEW

The reservoirs are the most essential elements of complex water resources system (Biswas, 2004). Hence management and development of reservoirs are very important for sustainable planning of any water resources system. Morphometric analysis gives an idea about the hydrologic characteristics of the watershed and the area which is more erosion vulnerable and may contribute more sediment to the reservoir. Horton (1945) and Strahler (1964) contributed a plenty of literatures for management and development of river basins. They established various relationships of morphometric parameters. (Mishra et al. 2010) explained the importance of GIS in investigation of morphological characteristics and prioritization of the sub-watershed on Hati watershed of Odisha and suggested urgent surveillance regarding vulnerability of soil erosion and action for protection of land from future erosion. (Vanlalchhuanga et al. 2021) assessed the soil erosion potential of north-eastern frontier Himalayan ranges of north-east India and analysed various morphometric parameters using GIS tool. Choudhari et al. (2018) evaluated the morphometric parameters of Mula river basin of Pune, Maharashtra and prioritized the sub-watershed for land and water management. Nagaraju et al. (2015) carried out morphometric analysis of Byramangala watershed, Bangalore urban district, Karnataka, India. GIS was used in evaluation of linear, areal and relief aspects of morphometric parameters and prioritization of sub-watershed. A comparative geomorphic study using GIS and remote sensing on the Subansiri river basin of Eastern Himalaya and the Alaknanda river basin of Western Himalaya was carried out by Devi and Goswami (2015). It was observed from the study that both the two basins viz. the Subansiri and the Alaknanda have contrasting features in regard to their relief, slope and aspects conditions. The results of the study proved useful in understanding the regional physiography and structure of the great Himalayan arc and the dominant geographic processes operating on them. The morphometric analysis of Imphal river basin was studied using GIS by Sharma (2014). The analysis of the morphometric features of the catchment using GIS indicated size, shape, slope of the catchment and distribution of stream network within the catchment. Bifurcation ratio, stream length and stream order of basin indicated that the basin was sixth order basin with geological structures less disturbing the drainage pattern and the terrain characterized by variation in lithology and topography. Study of geomorphology and drainage basin characteristics of Kaphni glacier, Uttarakhand, India, was carried out by Jayal (2015). The main aim of the study was to analyse morphometric parameters of river basin area. The geometric properties of drainage basin were estimated on topographical sheet, satellite imagery and GIS techniques. The drainage characteristic of the basin has been carried out with the help of different morphometric attributes; stream order, drainage frequency, drainage density, stream number, stream length and stream length ratio. Similar works were done by Manjare (2015), Meshram and Sharma (2017), Debelo et al.(2017), Gumma et.al (2016), Biswas and Chakraborty (2016), Vittala et.al (2008), Pandita et.al (2014) , Suji et. al (2015) and many more researchers.

3. METHODOLOGY

Since the ultimate fate of a reservoir is to be filled up by sediment, so by reducing the sediment deposition, the date of expiry of the reservoir can be postponed. Hence, identification of the areas which contribute maximum sediment to the reservoir is necessary. For preparation of Digital Elevation Model (DEM) to analyze the characteristics of the watershed, Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) (from http://www.gdem.ASTER.ersdac.or.jp) data is used. The delineation of watershed is done using ArcMap 10.1 software. For the analysis, the basin is sub-divided into seven sub-watersheds and morphometric analysis is done for each sub-watershed separately. The computations of the basic parameters such as area, perimeter, stream order, stream length, stream number and elevation of each sub-watershed are analyzed using the remote sensing and GIS approach. Finally bifurcation ratio, drainage density, drainage frequency, drainage texture, form factor, circulatory ratio, elongation ratio and compactness coefficient are calculated with the help of standard formulae presented in table-1.

Table-1: Formulae adopted for computation of morphometric parameters

Morphometric parameter	Formulae/Relationship	Reference
Stream order	Hierarchical rank	Strahler,1964
Stream length (L_u)	Length of stream	Horton,1945
Basin length (L_b)	$1.312A^{0.568}$	Nookaratnam et.al.2005
Mean Stream length (L_{um})	$L_{um} = L_u/N_u$, where Lu is the total stream length of order 'u', Nu is the total number of stream segments of order 'u'	Strahler,1964
Stream length ratio (R)	$R = L_u/L_u$-1, where Lu is the total stream length of order 'u', Lu-1 is the total stream length of its next lower order	Horton,1945
Bifurcation ratio (R_b)	$R_b = N_u/N_u+1$, where Nu is the total number of stream segment of order 'u', N_u+1 is the number of stream segments of the next higher order	Schumn, 1956
Mean bifurcation ratio (R_{bm})	R_{bm} = average of the bifurcation ratio of all the order	Strahler,1957
Elongation ratio (R_e)	$(2/L_b)(A/\pi)^{0.5}$	Schumn, 1965
Relief ratio (R_h)	$R_h = H/L_b$, where H is the total relief (relative relief) of the basin, Lb is the basin length	Schumn, 1956
Relative relief (R_r)	$R_r = H/P$, where H is the total relief (relative relief) of the basin, P is the perimeter (km) of the basin	Melton, 1957
Drainage density (D_d)	$D_d = L_u/A$, where Lu is the total stream length of order 'u' and A is the basin area in km2	Horton,1932
Constant of channel maintenance (C_m)	$C_m = 1/ D_d$, where D_d is the drainage density	Schumn, 1956
Length of overland flow (L_g)	$L_g =1/(2 \text{ x } D_d)$, where D_d is the drainage density	Horton,1945
Ruggedness number (R_n)	$R_n = D_d$x H, where D_d is the drainage density and H is the total relief (relative relief) of the basin	Strahler,1958
Stream/Drainage frequency (D_f)	$D_f = N_u/A$, where Nu is the total number of stream segment of order 'u' and A is the basin area in km^2	Horton,1932
Drainage texture (T)	$T = N_u/P$, where Nu is the total number of stream segment of order 'u' and P is the perimeter (km) of the basin	Horton,1945
Form factor (R_f)	$R_f = A/L_b^2$, where A is the basin area in km^2 and Lb is the basin length (km)	Horton,1932
Circulatory ratio (R_c)	$R_c = (12.57 \text{ x } A)/P^2$, where A is the area (km^2) and P is the perimeter (km) of the watershed	Miller,1953
Shape factor (Bs)	L_b^2/A; where, A=Area of basin, L_b=Basin length	(Horton,1945)

4. MORPHOMETRIC ANALYSIS AND RESULTS

To extract the information in respect of drainage basin and its characteristics, the various morphometric parameters are computed using GIS technique are discusses below. The main watershed of Kulsi basin is divided into seven sub-watersheds named as SWS 1 to SWS 7 using Arc GIS tool. The various morphometric analysis is carried out for each of the basin to calculate different morphometric parameters. Based on the values of the parameters obtained in GIS, prioritazion and other analysis is performed. Fig-2 below shows the map of sub-watershed of Kulsi basin.

The basin area and perimeter are the most important morphometric parameters. The basin area is the total area that is projected on a horizontal plane and contributing the surface runoff to the channel. The larger is the area, smaller is the runoff and vice versa. The total area and perimeter of Kulsi watershed are computed as 1628 Km^2 and328.80 Km respectively. The ordering of stream is done as suggested by Strahler. The first order channel is that which originates at a source. The first order channel is un-branched and at the starting point. These are the finger tip channels. When two channels of first order are joined together, then a second order channel is originated. The second order channels receive water from first order channels; the third order channel receives water from second order channels and so on. When two different order channels joined together then resulting channel will retain the higher order of the two channels. Order of streams always increases from upstream to downwards according to watershed geomorphology. From the drainage map of Kulsi basin, it is found that Kulsi basin has a highest 6th order stream and drainage pattern is dendritic. For the sub-watersheds, the SWS 1 and SWS 4 have 5th order stream. The SWS 2, SWS 3, SWS 5, SWS 6 and SWS 7 have 4th order streams.

Number of streams (N_u) is expressed the total number of stream segments under different order separately. With the increasing order of streams, the numbers of streams decreases. Hence it is inversely proportional to the stream order. For any watershed, the stream length (L_u) is also an important element to understand about the characteristics of the basin. The stream length in a river basin gives significant idea about the surface runoff.

Fig.2: Map showing sub-watersheds of Kulsi basin

Generally in hilly areas the lengths of streams are shorter and in flat areas the lengths of streams are longer. Total stream length is calculated as measuring the length of all ordered streams within the catchment area of the watershed. Usually, the total length of stream segments is highest in first order stream and decreases as the stream order increases. The physical parameters of sub-watersheds are represented below in table-2.

Table-2: Physical parameters of sub-watersheds of Kulsi basin

S. No	Sub-watershed	Area (A)Km^2	Perimeter (P)Km	Max^m elevation (m)	Min^m elevation (m)	Total relief (H) m	No. of streams (N_u)	Total stream length (L_u) Km
1	SWS 1	630.5	362.4	1683	65	1618	161	464.59
2	SWS 2	108.7	85.44	1646	292	1354	23	85.56
3	SWS 3	139.4	131.6	1773	278	1495	43	109.14
4	SWS 4	175.3	124.6	1913	202	1711	43	134.46
5	SWS 5	209.5	133.0	1923	945	978	49	168.073
6	SWS 6	205.5	147.8	1782	634	1148	56	163.599
7	SWS 7	158.9	98.83	1861	893	968	42	121.36

The morphometric parameters for each sub-watershed are also calculated and presented in table-3 below. The stream length ratio (R) between various orders of streams indicates the variations in slopes. It has a direct relation with surface runoff of the basin. The stream length ratio of main watershed is 0.4928 and sub-watershed varies from 0.430 to 0.740 from SWS 2 to SWS 4. Bifurcation ratio (R_b) describes the arrangement of branch in a drainage network. It is a useful factor for determination of shape of the basin. The bifurcation ratio is high for an elongated basin. On the other hand it is low for a circular basin. Its value generally lies in between 3.0 to 5.0. Lower value indicates alluvial region, on the other hand higher value indicates a hilly terrain. The bifurcation ratio of Kulsi basin is 4.44, which indicate significantly hilly terrain, elongated basin and the rivers are prone to flooding during rainy season. For sub-watersheds the values ranges from 2.88 to 5.300 from SWS 4 to SWS 6.

The basin length (L_b) is defined as the length of most remote point to the outlet of the basin. It is inversely proportional to the peak discharge. If length of basin increases, the peak discharge decreases. The basin length of main watershed is 87.53 Km and sub-watersheds values varies from 18.815 Km to 51.069 Km for SWS 2 to SWS 1. Length of overland flow (L_o) of main watershed is 0.66 km/km^2 and the values ranges from 0.623 to 0.679 km/km^2 for the sub-watersheds which indicates the longer flow path with more infiltration and less surface runoff.

The Form factor (R_f) of Kulsi river basin is 0.21, which represents an elongated basin and flow for longer duration. In an elongated basin the management of flood is easier in comparison to a circular basin. The values of sub watersheds ranges from 0.242 to 0.307 for watersheds SWS 1 to SWS 2 respectively.

Table-3: Morphometric parameters of the sub-watersheds of Kulsi basin

Sl No	Morphometric parameters	SWS 1	SWS 2	SWS 3	SWS 4	SWS 5	SWS 6	SWS 7
1	Area (A) Sq.km	630.500	108.700	139.400	175.300	209.500	205.500	158.900
2	Basin perimeter (P) Km	362.400	85.440	131.600	124.600	133.000	147.800	98.830
3	Basin length (L_b) Km	51.069	18.815	21.671	24.683	27.313	27.015	23.344
4	Total no of streams (N_u) Nos.	161.000	23.000	43.000	43.000	49.000	56.000	42.000
5	Total stream length (L_u) Km	464.590	85.560	109.140	134.460	168.073	163.600	121.360
6	Drainage density (D_d) Km/ km^2	0.737	0.787	0.783	0.767	0.802	0.796	0.764
7	Constant of channel maintenance (C_m) km^2/km	1.357	1.270	1.277	1.304	1.246	1.256	1.309
8	Total relief (H) Km	1.618	1.354	1.495	1.711	0.978	1.148	0.968
9	Length of overland flow (L_o) Km	0.679	0.635	0.639	0.652	0.623	0.628	0.655
10	Drainage texture (T) Unit/ km	0.444	0.269	0.327	0.345	0.368	0.379	0.425
11	Drainage frequency (D_f)	0.255	0.212	0.308	0.245	0.234	0.273	0.264
12	Form factor (R_f)	0.242	0.307	0.297	0.288	0.281	0.282	0.292
13	Bifurcation ratio (R_b)	4.030	3.170	4.380	2.880	3.430	5.300	3.140
14	Stream length ratio (R)	0.577	0.430	0.723	0.740	0.579	0.485	0.725
15	Elongation ratio (R_e)	0.313	0.353	0.347	0.342	0.337	0.338	0.344
16	Circulatory ratio (R_c)	0.060	0.187	0.101	0.142	0.149	0.118	0.204
17	Relief ratio (R_h)	0.032	0.072	0.069	0.069	0.036	0.042	0.041
18	Relative relief (R_r)	0.004	0.016	0.011	0.014	0.007	0.008	0.010
19	Ruggedness number (R_n)	1.192	1.066	1.170	1.312	0.785	0.914	0.739
20	Shape factor (B_s)	4.14	3.26	3.37	3.48	3.56	3.55	3.43
21	Compactness coefficient (C_c)	0.009	0.024	0.023	0.018	0.016	0.017	0.018

The elongation ratio (R_e) is an index to classify the shape of a basin. It is useful to recognize the drainage characteristics of basin. Its value is generally lies in between 0.6 to 1.0. The elongation ratio of Kulsi river basin is 0.294, which indicate basin is highly elongated, less surface runoff and less prone to erosion. Its values ranges from 0.313 to 0.353 for sub-watersheds SWS 1 and SWS 2. Circulatory ratio (R_c) is also an important factor for understanding the shape of a basin. It is dependent on the length, frequency and slope of streams. The value of circulatory ratio generally varies from 0 to 1. Lower value indicates an elongated basin, where as higher value indicates a circular basin. Circulatory ratio of Kulsi basin is 0.189, which is below 0.5 and hence strongly elongated basin, with low peak flow indicating less prone to soil erosion. The values of sub-watersheds SWS 1 and SWS 7 ranges from 0.06 to 0.204 respectively.

The drainage density (D_d) of the study area is 0.76 km/km^2 and the values ranges from 0.737 to 0.802 for the sub-watersheds. This indicates that the study area has less drainage density having gentle slope, highly permeable sub-soil with dense vegetation cover. The Drainage frequency (D_f) generally depends on the topography and drainage system of the area. The area with impermeable surface, scanty vegetation, high relief and low infiltration have high drainage frequency. Lower values indicate less surface runoff. The drainage frequency of the study area is 0.62 stream segments per square kilometer. The value of drainage frequency ranges from 0.212 to 0.308 for sub-watersheds SWS 2 and SWS 3 respectively. Low drainage density and low stream frequency in Kulsi river basin indicate lower runoff from the basin.

In the present study drainage texture of the Kulsi river basin is found 3.08, which indicate coarse texture. The values for the sub-watersheds ranges from 0.629 to 0.444 for sub-watersheds SWS 2 and SWS 1 respectively indicates very coarse texture. The value of constant of channel mainenance (C_m) in the present study area is 1.31 and for the sub-watersheds, it ranges from 1.246 to 1.357 for SWS 5 and SWS 1 respectively. Hence the sub basin is less erodable. It is the inverse of drainage density. Its higher value reveals the lower drainage density. Higher value indicates high permeability.

The total relief is the difference in elevation of the highest and lowest points on the watershed. The relief ratio is the maximum relief to the longest dimension of the drainage basin length parallel to the predominant drainage line. It indicates steepness of the drainage basin and intensity of erosion. Its value is generally higher in case of decreasing area and shape of the drainage basin. High value indicates steep slope results in quick depletion of surface runoff with higher soil loss. The relief ratio of Kulsi basin is 0.019. The lower value indicates the basin having gentle slope with low relief. The value of R_h for the study area ranges from 0.032 to 0.072 for sub-watersheds.

Relative relief (R_r) is defined as the maximum basin relief to the boundary length of the basin. Its high value indicates steep slopes. Steeper the slope, lower will be the permeability and higher runoff. The relative relief of the basin is 0.010. The relative relief of sub-watersheds varies from 0.004 to 0.016. The lower value indicates the predominantly gentle slope.

Ruggedness number (R_n) is the multiplication of total relief and drainage density. It is a dimensionless parameter. The value of ruggedness number will be higher if both relief and drainage density values are higher. It is an indicator of surface unevenness. Its value directly depends upon basin relief and drainage density. The ruggedness number (R_n) of the watershed is 1.30. The value of R_n ranges from 0.739 to 1.192 for sub-watersheds SWS 7 and SWS 1 respectively, which is quite low in the study area indicates less prone to soil erosion.

5. PRIORITIZATION OF SUB-WATERSHEDS

Prioritization is defined as the process of evaluation of a group of parameters and ranking them in a systematic order of importance. Here prioritization is done to find the degree of erodibility of sub-watershed. In this study, for prioritization of sub watershed the entire Kulsi basin is sub-divided into seven sub-watersheds. To extract the morphometric parameters of each sub-watersheds GIS tools are used.

For analysis of prioritization the parameters like; aerial aspects, linear aspects, relief aspects are calculated. Stream order, stream frequency, length of overland flow, drainage density, elongation ratio, form factor etc are the parameters which have direct relationship with the erodibility possibilities for a basin. Since the erodibility is related to the linear and relief parameters, the highest value of linear and relief parameters are assigned as first rank, the next higher value is assigned as second rank and so on. The higher is the value of linear and relief parameters, more is the susceptibility of soil erosion. On the other hand, lower is the value of areal aspects such as form factor, elongation ratio and circulatory ratio value more will be the erodibility and vice versa. In this case the lowest value of aerial parameters has been assigned as 1st rank, next lower value as 2nd rank and so on. The compound parameter (C_p) for each sub-watershed is obtained by taking the average of sum of values of ranking of all the linear, relief and aerial parameters of all the sub-watershed.

Table- 4: Compound parameter of sub-watersheds of Kulsi basin

Sub-watershed	Linear parameters					Shape parameters					Relief parameters		
	Drainage density (D_d)	Drainage frequency (D_f)	Bifurcation ratio (R_b)	Drainage Texture (T)	Length of overland flow (L_o)	Form factor (R_f)	Shape factor (B_s)	Compactness coefficient (C_c)	Elongation ratio (R_e)	Circulatory ratio (R_c)	Ruggedness Number (rn)	Relief Ratio (Rh)	Compound parameter (C_p)
SWS 1	7	4	3	1	1	1	7	1	1	1	2	6	2.9
SWS 2	3	7	5	7	5	7	1	6	7	6	4	1	4.9
SWS 3	4	1	2	6	4	6	2	5	6	2	3	2	3.6
SWS 4	5	5	7	5	3	4	4	4	4	4	1	2	4.0
SWS 5	1	6	4	4	7	2	6	2	2	5	6	5	4.2
SWS 6	2	2	1	3	6	3	5	2	3	3	5	3	3.2
SWS 7	6	3	6	2	2	5	3	4	5	7	7	4	4.5

Based on the compound parameter values for each sub-watershed , the sub-watersheds are again assigned final priority rank. For assigning ranks, the sub watershed having lowest value of compound parameter is ranked as 1, second lowest value is ranked as 2 and so on. The sub-watershed having highest value of compound parameter is rated as last in rank. The sub-watershed having lowest compound value is given the highest priority, the next lower value is given second priority and so on. The highest compound parameter value is given the lowest priority.

The criteria for priority have been decided as high, medium and low priority based on the compound parameter value. The sub-watersheds has been categorized into three classes as high (< 3.5), medium (3.5-4.5), Low (> 4.5) priority. Thus an index of high, medium and low priority is developed. The high priority region are generally dominated by steep slopes, high drainage density, stream frequency and drainage texture with moderate to low values of form factor, shape factor and elongation ratio. Medium priority sub-watersheds are characterized by moderate slopes, high to moderate values of drainage density, stream frequency, drainage texture, form factor, circulatory ratio and compactness coefficient. The low priority area mainly consists of moderate to low values of drainage

Table-5: Final priority of sub-watersheds

Sl.No.	Sub-watershed	Compound parameter (C_p)	Final priority	Erodibility
1	SWS 1	2.9	I	High
2	SWS 2	4.9	VII	Low
3	SWS 3	3.6	III	Medium
4	SWS 4	4.0	IV	Medium
5	SWS 5	4.2	V	Medium
6	SWS 6	3.2	II	High
7	SWS 7	4.5	VI	Medium

density, stream frequency, texture ratio whereas values of shape factor, circulatory ratio, elongation ratio show moderate to high with moderate slope. Hence, the sub-watersheds having higher priority are potential sector for watershed development and management.

Compound parameter of sub-watersheds of Kulsi basin is shown in table-4 and the final priority chart of sub-watersheds based on morphometric parameters are represented in table-5. Low priority sub-watersheds have a low risk of land degradation. Out of seven sub-watersheds of Kulsi basin, the watershed SWS 1 and SWS 6 falls in high priority; SWS 3, SWS 4, SWS 5 and SWS 7 are in medium priority; SWS 2 falls under low priority. The SWS 1 belongs to lowest C_p value, so it is considered as highest erosion prone sub-watershed. The SWS 6 belongs to second lowest C_p value, so it is considered as second highest erosion prone sub-watershed.

Highest priority stipulates the substantial degree of soil erosion in that sub-watershed and it is very much essential to take action for soil conservative measures. Since the sub-watershed SWS 1 of the present study area is considered as the highest erosion prone area, so soil conservation measures should be undertaken first in SWS 1 and then to the other sub-watersheds based on the priority. Final priority map of sub-watersheds showing erodibilty classes is shown in fig-3.

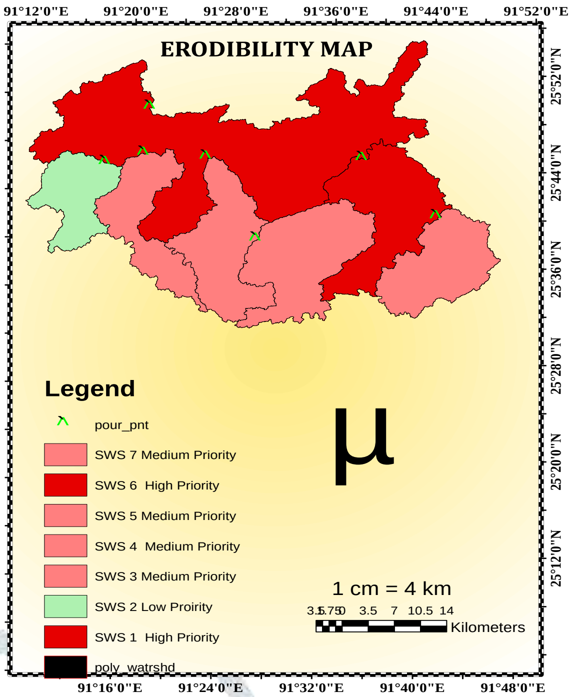

Fig -3: Final priority map of sub-watersheds showing erodibilty classes

6. CONCLUSION

In the present study, the morphometric analysis and prioritization of sub-watershed is done for the catchment area up to the dam site. The contribution of sediment to the reservoir is dominated by this area. So, to reduce the sediment deposition and to postpone the date of expiry of the reservoir, it is necessary to identify the most vulnerable area in the basin for management and conservation of soil.

The morphometric analysis of the basin is carried out from ASTER DEM of 30 m resolution. The whole watershed is divided into seven sub-watersheds and morphometric analysis is done for each sub-watershed. From the present morphometric analysis of Kulsi basin following points can be highlighted.

The area and perimeter of the basin are 1628 Km^2 and 328.80 Km respectively. The basin has an elevation ranging from 65m to 1921 m. The slope ranges from 0 to 41%, indicates nearly level surface to very steep slope. The highest order of drainage is 6^{th} order and dendritic pattern. There are total 1014 numbers of streams in the basin. The numbers of 1^{st} order streams are 683, 2^{nd} order streams are 155, 3^{rd} order streams are 136, 4^{th} order are 35, 5^{th} order are 4 and 6^{th} order is 1. Total stream length is 1242.544 Km. Out of which, 1^{st} order stream length is 593.663 Km, 2^{nd} order is 267.899 Km, 3^{rd} order is 224.168 Km, 4^{th} order is 108.742 Km, 5^{th} order is 35.148 Km and 6^{th} order is 12.921 Km.

The bifurcation ratio of Kulsi basin is 4.44. This high value indicates that the basin is elongated, significantly hilly terrain and the rivers are prone to flooding during rainy season. The elongation ratio is 0.294. The lower value indicates a highly elongated basin, less surface runoff and less prone to erosion. The form factor of the basin is 0.21. Lower value indicates an elongated basin, flow for longer duration and management of flood is easier. Lower value of circulatory ratio also indicates an elongated basin with low peak flow indicating less prone to soil erosion.

Low drainage density (0.76 Km/km^2) and low stream frequency (0.62) in the basin indicate gentle slope, lower runoff from the basin, highly permeable sub-soil with dense vegetation cover. Length of overland flow is 0.66 Km/km^2 (> 0.3 Km/km^2) which indicates longer flow path with more infiltration and less surface runoff. Drainage texture of the Kulsi river basin is 3.08, which indicates coarse texture, more infiltration and less runoff. The relief ratio and relative relief of the basin are 0.019 and 0.010 respectively. The lower value indicates the basin having gentle slope with low relief. The value of constant of channel mainenance in the present study area is 1.31 (> 0.5) indicates least erodable. Ruggedness number 1.30 is quite low in the study area indicates less prone to soil erosion.

To find the degree of erodibility, the prioritization of sub-watershed is also done for taking action on priority basis for management and conservation of soil. For analysis of prioritization, the parameters like; aerial aspects, linear aspects, relief aspects are calculated for each sub-watershed. Since the erodibility is directly related to the linear and relief parameters, the highest value of linear and relief parameters are assigned as first rank, the next higher value is assigned as second rank and so on. The higher is the value of linear and relief parameters, more is the susceptibility of soil erosion. On the other hand, lower is the value of areal aspects more will be the erodibility and vice versa. Hence lowest value of aerial parameters has been assigned as 1^{st} rank, next lower value as 2^{nd} rank and so on. The compound parameter for each sub-watershed is obtained by taking the average of sum of values of ranking of all the linear , relief and aerial parameters of all the sub-watershed.

Based on the compound parameter values the final priority ranks are assigned. The sub watershed having lowest value of compound parameter is ranked as 1, second lowest value is ranked as 2 and so on. The sub watershed having lowest compound value is given the highest priority, the next lower value is given second priority and so on. Based on the compound parameter value, the criteria for priority have been decided as high , medium and low priority.

The sub-watersheds are categorized into three classes as high (< 3.5), medium (3.5-4.5), low (>4.5) priority. Out of seven sub-watersheds of Kulsi basin, the watershed SWS 1 (C_p=2.9) and SWS 6 (C_p=3.2) falls in high priority; SWS 3 (C_p=3.6), SWS 4 (C_p=4.0) SWS 5 (C_p=4.2) and SWS 7 (C_p=4.5) are in medium priority; SWS 2 (C_p=4.9) falls under low priority. The SWS 1 belongs to lowest C_p value, so it is considered as highest erosion prone sub watershed. So, soil conservation measures should be undertaken first in SWS 1 and then to the other sub-watersheds based on the priority.

7. REFERENCES

[1] Biswas Asit K. 2004. "Integrated Water Resources Management: A Reassessment" Water International, Volume 29, - Issue Pages 248-256.

[2] Biswas Rekha and Dr. Chakraborty Sandipan, 2016 " Watershed Prioritization Based On Geo-Morphometry And Land Use Parameters – An Approach To Watershed Development Using Remote Sensing And GIS, Neora Watershed, Darjeeling And Jalpaiguri Districts, West Bengal, India", Journal of Applied Geology and Geophysics (IOSR-JAGG) e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 4, Issue 3 Ver., PP 36-49

[3] Choudhari P. P. Nigam Gaurav K. , Singh Sudhir Kumar and Thakur Sapana,2018. "Morphometric based prioritization of watershed for groundwater potential of Mula river basin, Maharashtra, India", Journal Geology, Ecology, and Landscapes, doi.org/10.1080/24749508.2018.1452482.

[4] Debelo Gutema, Tadele Kassa and Koriche Sifan A. 2017. " Morphometric analysis to identify erosion prone areas on the Upper Blue Nile using GIS (case study of Didessa and Jema sub-basin, Ethiopia)",International Research Journal of Engineering and Technology (IRJET): 04 Issue:

[5] Devi Sangita and Goswami Dulal C. 2015. "The Subansiri River Basin Of Eastern Himalaya And The Alaknanda River Basin Of Western Himalaya: A Comparative Geomorphic Study Using GIS And Remote Sensing", The International Journal Of Engineering And Science (IJES), Volume- 4, Issue- 2, Pages- PP.33-39.

[6] Gumma Murali Krishna, Birhanu Birhanu Zemadim, Mohammed Irshad A., Tabo Ramadjita and Whitbread Anthony M. 2016. "Prioritization of Watersheds across Mali Using Remote Sensing Data and GIS Techniques for Agricultural Development Planning", Water 2016, 8, 260; doi:10.3390/w8060260.

[7] Horton R. E. 1945. "Erosional development of streams and their drainage basins: Hydrophysical approach to quantitative morphology", Geol. Soc.Amer. Bull. 56, pp 275-370.

[8] Jayal Tripti, 2015. "Study of geomorphology and drainage basin characteristic of Kaphni Glacier, Uttarakhand, India", International Journal of Interdisciplinary and Multidisciplinary Studies (IJIMS), Vol 2, No.7, 35- 48

[9] Manjare B. S. 2015. "Prioritization of sub-watersheds for sustainable development and management of natural resources: An integrated approach using remote sensing, GIS techniques."16th Esri India User Conference

[10] Meshram Sarita Gajbhiye and Sharma S. K. 2017. "Prioritization of watershed through morphometric parameters: a PCA-based approach", Applied Water Science, Springer, 7, 1505-1519

[11] Mishra Sangita, Nagarajan S. R. 2010. "Morphometric analysis and prioritization of sub watersheds using GIS and Remote Sensing techniques: a case study of Odisha, India", International Journal of Geomatics and Geosciences, Volume 1, No 3.

[12] Nagaraju D., Siddalingamurthy S., Balasubramanian A., Lakshmamma and Sumithra S. 2015. "Morphometric analysis of Byramangala Watershed, Bangalore Urban District, Karnataka, India", International Journal of Current Engineering and Technology, Vol.5, No.3.

[13] Pandita Sundeep, Thakur Kuldeep K., Goyal Vikas and Singh Yudhbir,2014. "Characterisation of drainage basin morphometric parameters of Balawal Watershed, Jammu province, Jammu and Kashmir", Himalayan Geology, Vol. 35 (2), , pp. 124-134

[14] Shamurailatpam, Sharma Ashalata 2014. "Morphometrical Analysis of Imphal River Basin using GIS", International Journal of Geology, Earth & Environmental Sciences, Vol. 4 (2) May-August, pp. 138-144.

[15] Strahler A. N. 1952 "Dynamic Basis of Geomorphology", Geological Society of America Bulletin, 63, 923-938.

[16] Strahler A. N. 1964. "Quantitative geomorphology of drainage basin and channel networks. In: Chow VT (ed) Handbook of applied hydrology." McGraw Hill Book, New York, pp 4–76.

[17] Suji V R, Sheeja R V and Karuppasamy S. 2015. "Prioritization using Morphometric Analysis and Land Use/Land Cover Parameters for Vazhichal Watershed using Remote Sensing and GIS Techniques", International Journal for Innovative Research in Science &Technology| Volume 2 Issue 1 ISSN (online): 2349-6010

[18] Vanlalchhuanga, Jena Roomesh Kumar, Moharana Pravash Chandra, Kumar Nirmal, Sharma R.P. and Ray Sanjay Kumar,2021 "Morphometric analysis for prioritizing sub-watersheds and management planning and practices in the north-eastern frontier Himalayan ranges of India" October 2021,Journal of Soil and Water Conservation 20(3):279-289

[19] Vittala S. Srinivasa , Rudraiah M. and Govindaiah S. 2008. "Morphometry using remote sensing and GIS techniques in the sub-basins of Kagna river basin, Gulburga district, Karnataka, India", Journal of the Indian Society of Remote Sensing 36(4):351-360 · December 2008.