Geoinformatics for Prioritization of Dal Lake Watershed at Micro scale based on Morphometric and Land Use Analysis

Arif H Shah[1], Zahoor A Nengroo[2], M Sultan Bhat[3]

[1] *Department of Geography & Regional Development, University of Kashmir (India).*

[2] *Department of Geography & Regional Development, University of Kashmir (India).*

[3] *Department of Geography & Regional Development, University of Kashmir (India).*

ABSTRACT

Drainage morphometry and land use planning has gained importance in natural resource management, especially in the context of Watershed management. The present study makes an attempt to prioritize micro-watersheds based on Morphometric and land use characteristics using remote sensing and GIS techniques in Dal Lake watershed of J&K. Dal Lake Watershed has an area of 331 km^2 and lies between 34° 02'-34°13' N latitude & 74° 48'-75° 08' E longitude. Dal Lake Watershed has been divided into thirty eight micro-watersheds designated as Z1a1 to Z1b13 for prioritization purpose. Topographic maps of 1961 on 1:50000 scale were utilized to delineate the drainage system, thus to identify precisely water divides using Geographic Information System (GIS).Various Morphometric parameters, linear and shape, have been determined for each micro-watersheds and assigned ranks on the basis of value/relationship so as to arrive at a computed value for a final ranking of the micro-watersheds. Four land use/land cover classes, Built up, Wasteland, Forests and Agriculture were used to prioritize the micro-watersheds. Based on Morphometric and land use/land cover analysis, the micro-watersheds have been classified into four categories as Very High, High, Medium and Low.

Keywords: Morphometric Analysis, Land use/land cover, Watershed, Remote Sensing and GIS, Prioritization.

I INTRODUCTION

A watershed is an area from which runoff resulting from precipitation flows past a single point into large streams, rivers, lakes or oceans. The Morphometric characteristics at the watershed scale may contain important information regarding its formation and development because all hydrologic and geomorphic processes occur within the watershed **[1]**. Morphometric analysis of a watershed provides a quantitative description of the drainage system which is an important aspect of the characterization of watersheds **[2]**. Morphometric analysis requires measurement of linear features, areal aspects, gradient of channel network and contributing ground slopes of the drainage basin **[3]**. Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms **[4], [5]**. In fact, they are the fundamental units of the fluvial landscape and a great amount of research has focused on their geometric characteristics, including the topology of the stream networks and quantitative description of drainage texture, pattern and shape **[6]**. Land use denotes the human employment of the land and is a synthesis of physical, chemical and biological systems and processes on the one hand and human/social processes and behavior on the other **[7]**. The resource development programmes are applied generally on watershed basis and thus prioritization is essential for proper planning and management of natural resources for sustainable development **[8]**. Drainage basins, catchments and the sub-catchments are the fundamental units of the management of the land and water, identified as planning units for administrative purposes to conserve natural resources **[9]**. The watershed management concept recognizes the interrelationship among the linkages between upland and lowlands, land use, geomorphology, slope and soil **[10]**. Thus the integrated approach plays an important role for sustainable development and management of natural resources **[11]**. Prioritization of sub-watersheds based on Morphometric analysis of drainage basins using remote sensing and GIS techniques, was attempted by **[12]**. **[13]** carried out check dam positioning by prioritization of micro-watersheds using Silt Yield Index (SYI) model and Morphometric analysis using remote sensing and GIS in Midnapur district of West Bengal. **[14]** attempted a rule-based physiographic characterization of a drought-prone watershed applying remote sensing and GIS techniques in Gandeshwari watershed in Bankura district of West Bengal.

II STUDY AREA

Dal Lake Watershed is situated between 34˚ 5′ 20′′ to 34˚13′40′′ N latitude and 74˚ 48′ 35′′ to 74˚ 08′ 32′′ E longitude, at an altitude of 1583 m to the north-east of Srinagar city. One of the significant features of Dal Lake is its vast and diverse watershed, which spreads over an area of about 331 sq. km. The Lake is surrounded by high mountains on one side and by an urban area on the other side. The Dal lake watershed is fan shaped and broadens in the westward direction. Topographically, the watershed has evolved out of outwash apron of the Dachigam creek and has assumed the shape of a triangle. The main source is the Dachigam Creek (Nallah) that enters into the lake on the northern side after originating from the Marsar Lake, high up in the mountains and draining the Dachigam Reserve Forest. The average annual rainfall is 650 mm at Srinagar and 870 mm at Dachigam. It is in this season that the snow thaw in the higher reaches of the watershed results in the maximum discharge in Dachigam and Dara Nallah.

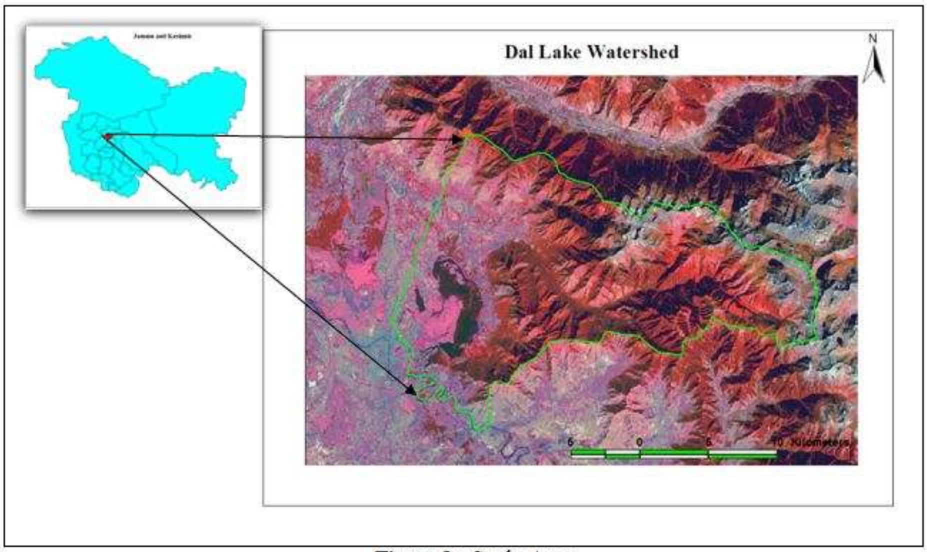


Figure 1: Study Area

III MATERIALS AND METHODS

The drainage was initially derived from SOI Toposheets, 1961. The micro-watershed boundaries were demarcated on the basis of contour value, slope, relief, and drainage flow directions and Dal Lake watershed was divided into thirty eight micro-watersheds designated as Z1a1 to Z2b13. The Morphometric parameters such as stream length, bifurcation ratio, drainage density, stream frequency, drainage texture, form factor, circularity ratio, elongation ratio and length of overland flow were computed using standard methods and formulae **[15]**. Standard visual image interpretation method based on photographic and geotechnical elements such as tone, texture, size, shape, association and field knowledge was followed to delineate various land use/land cover categories using the IRS P6 LISS III data of 2010. Limited ground truth verification was carried out before the finalization of maps. Land use/land cover categories such as Built-up, Wasteland, Agriculture and Forests were considered for prioritization apart from shape and linear parameters of morphometry.

IV RESULTS AND DISCUSSIONS

4.1 Morphometric Analysis

Area of a basin (A) and perimeter (P) are the important parameters in quantitative morphology. It is interesting that the maximum flood discharge per unit area is inversely related to size. In the present study Stream Number, Stream Order, Bifurcation Ratio, Drainage Density, Stream Frequency, Drainage Texture, Length of Overland, Basin Shape, Form Factor, Circulatory Ratio, Elongation Ratio and Compactness Coefficient are derived and tabulated on the basis of linear and Shape drainage channels using GIS based on drainage lines as represented over the topographical maps (scale 1:50,000).

4.1.1 Linear Parameters

Drainage parameters such as bifurcation ratio, drainage density, stream frequency, drainage texture and length of overland flow are grouped under linear parameters and are discussed below:

Stream order (Nu): In the drainage basin analysis the first step is to determine the stream orders. In the present Study, the channel segment of the drainage basin has been ranked according to Strahler's stream ordering system. According to **[16]**, the smallest fingertip tributaries are designated as order 1. Where two first order channels join, a channel segment of order 2 is formed and where two of order 2 joins, a segment of order 3 is formed, so on and so forth. The study area is a 5th order drainage basin. The total number of 848 streams were identified of which 677 are 1st order streams, 137 are 2^{nd} order, 30 are 3rd order, 3 in 4th order and one is indicating 5^{th} order streams.

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 next higher order **[17]**. Bifurcation ratios characteristically range between 3.0 and 5.0 for basins in which the geologic structures do not distort the drainage pattern **[18]**. If the bifurcation ratio is not same from one order to its next order, then these irregularities are dependent upon the geological and lithological development of the drainage basin **[19]**. In the study area mean bifurcation ratio (Rbm) varies from 2.39 to 9, lower values in Z1b4 suggest less structural disturbance, whereas higher value in Z1a4 indicates that it has structurally controlled drainage pattern. The mean bifurcation ratio value is 5.63 for the study area (Table 4) which indicates that the geological structures are less disturbing the drainage pattern.

Drainage Density (D): [20] introduced the drainage density (D), an important indicator of the linear scale of landform elements in stream eroded topography. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture **[21]**. **[22]** recognized the significance of drainage density as a factor determining the time of travel by water and suggested that drainage density values between 0.55 and 2.09 km/km2 correspond to humid regions. In the present study the drainage density ranges from 0.28 to 3.68 km/ km2, which suggests that the Dal Lake watershed is underlain by highly permeable material. The highest value of drainage density is recorded in Z2a7, whereas lowest drainage density is found in Z1a7. The study area has a drainage density of 2.12 km/sq.km.

Stream Length (Lu): Stream length is one of the most significant hydrological features of the basin as it reveals surface runoff characteristics streams of relatively smaller lengths and are characteristics of areas with larger slopes and finer textures. Longer lengths of streams are generally indicative of flatter gradients. Generally, the total length of stream segments is maximum in first order streams and decreases as the stream order increases. The number of streams of various orders in the basin is counted and their lengths from mouth to drainage divide are measured with the help of GIS software. The order wise mean stream length in the study area for the first order is 0.73 kms, 0.84 kms for second order, 1.62 kms for third order, 6.96 kms for fourth order and 20.52 kms for the trunk stream (5^{th} order).

Stream Frequency (Fs): Stream frequency or channel frequency (Fs) is the total number of stream segments of all orders per unit area **[23]**. **[24]** stated that low values of stream frequency Fs indicate presence of a permeable subsurface material and low relief. Stream frequency values of the micro-watersheds vary from 0.1 (Z1a7) to 5.77 (Z1b6), suggests micro-watersheds having lower Fs values represents low relief and permeable sub surface material whereas, micro-watersheds with higher Fs values show resistant/low conducting subsurface material, sparse vegetation and high relief. In general Fs values indicate positive correlation with the drainage density in all micro-watersheds suggesting an increase in stream population with respect to increase in drainage density. The stream frequency value of the watershed is 2.56.

Drainage Texture (Rt): Drainage Texture (Rt) is an important factor in the drainage morphometric analysis which is depending on the underlying lithology, infiltration capacity and relief aspect of the terrain. **[25]** defined drainage texture as the total number of stream segments of all orders divided by the perimeter of the watershed. Smith (1954) classified drainage density into five different classes of drainage texture, i.e. < 2 indicates very coarse, between 2 and 4 is coarse, between 4 and 6 is moderate, between 6 and 8 is fine and greater than 8 is very fine drainage texture. Drainage texture values of the micro-watersheds lie between 0.43 (Z2b5) and 2.29 (Z1b5). In the present study the texture ratio of the watershed is 6.78.

Length of Overland Flow (Lo): Length of overland flow is referred to as the distance of flow of the precipitated water, over the land surface to reach the stream. The results obtained for the study area was 0.23 km. The value of overland flow is higher in the semi arid regions than in the humid and humid temperate regions, in addition to absence of vegetation cover in the semi arid regions is primarily responsible for lower infiltration rates and for the generation of higher surface **[26]**. Length of overland flow is one of the most important independent variables affecting hydrologic and physiographic development of drainage basin. The average length of overland flow is approximately half the average distance between stream channels and is therefore approximately equals to half of reciprocal of drainage density **[27]**. The Lo values of micro-watersheds are varying from 0.14 for Z2b12 and Z2b13 to 1.76 for Z1a7. The low overland flow of 0.23 for Dal Lake Watershed clearly indicates that the Watershed has a well developed stream network and receives heavy rainfall as well.

4.1.2 Shape Parameters

Drainage parameters such as basin shape, form factor, circularity ratio, elongation ratio and compactness coefficient are grouped under shape parameters and are discussed below:

Basin Shape (Bs): Basin shape (Bs) is the ratio of square of basin length (Lb) to the area of the basin (A). Basin shape may be indexed by simple dimensionless ratios of the basic measurements of area, perimeter and length **[28]**. The values of Bs range from 1.99 (Z1a8) to 2.58 (Z1a1) which indicate low flood discharge periods, whereas rest of the micro-watersheds may have sharp peaked flood discharge. Dal lake watershed as a whole has a basin shape of 3.79.

Form Factor Ratio (Rf): Horton (1932) defined form factor (Rf) as a dimensionless ratio of basin area (A) to the square of basin length (Lb). The value of form factor would always be less than 0.7854 (for a perfectly circular basin). The basins with higher form factor are normally circular and have high peak flows for shorter duration, whereas elongated basins with lower values of form factor have low peak flows for longer duration. Quantitative expression of drainage basin outline form was made by **[29]** through a form factor ratio (Rf), which is the dimensionless ratio of basin area to the square of basin length. The form factor value of the watershed is

0.26 which indicate lower value of form factor and thus represents elongated in shape. The elongated basin with low form factor indicates that the basin will have a flatter peak of flow for longer duration. Flood flows of such elongated basins are easier to manage than of the circular basin. In the study area Rf values have been found varying from 0.39 (Z1a1) to 0.5 (Z1a8), suggesting that most of the micro-watersheds represent elongated shape with lower peak flows for longer duration.

Circularity Ratio (Rc): Circularity Ratio is the ratio of the area of a basin to the area of circle having the same circumference as the perimeter of the basin **[30].** He described the basin of the circularity ratios range 0.4 to 0.5 which indicates strongly elongated and highly permeable homogenous geologic materials. It is influenced by the length and frequency of streams, geological structures, land use/land cover, climate and slope of the watershed. The circularity ratio value (0.4) of the basin corroborates the Miller's range which indicating that the basin is elongated in shape, low discharge of runoff and highly permeability of the subsoil condition. The circularity ratios of micro-watersheds vary from 0.28 (Z1a4) to 0.73 (Z1b5).

Elongation Ratio (Re): [31] used an elongation ratio (Re) defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length and is found generally varying from 0.6 to 1.0 depending upon vagaries of climate and geology. It is a very significant index in the analysis of basin shape which helps to give an idea about the hydrological character of a drainage basin. The Elongation Ratio (Re) of the watershed is 0.1. Re values of micro-watersheds vary from 0.79 (Z1a8) to 1.11 (Z2b13), higher values of Z2b12 and Z2b13 show high infiltration capacity and low runoff, whereas rest of the micro-watersheds show lower Re values which are characterized by high susceptibility to erosion and sediment load **[32].**

Compactness Coefficient (Cc): Compactness Coefficient (Cc) is used to express the relationship of a hydrologic basin to that of a circular basin having the same area as the hydrologic basin. A circular basin is the most susceptible from a drainage point of view because it will yield shortest time of concentration before peak flow occurs in the basin **[33]**. The values of Cc in the study area vary from 1.17 (Z1b5) to 1.9 (Z2a4) showing wide variations across micro-watersheds (Table 2).

4.2 Land Use Land Cover Analysis of 2010:

The land use/land cover categories which were taken for prioritization of micro-watersheds includes Built up, Agriculture, Wasteland and Forests.

Built up: The increase in built-up area not only reduces the area under agriculture but it also affects the hydrology of the watersheds by reducing percolation of rain water. More the area under built-up category, greater the impact on the environment. The watershed with maximum percentage of watershed area under built-up category was given rank one as high priority and vice versa. The uninhabited watersheds share a common rank. The watershed under Built up covers an area of 24.80 km^2 (7.46 Percent). The micro-watershed which has highest percentage of Built up includes Z1a1 (34.84 Percent) followed by Z1a9 (34.68 Percent) and Z2b12 (22.28 Percent).

Agriculture: The micro-watershed with lowest area under agriculture was assigned rank one as high priority while the area under highest percentage area under agriculture was given lowest priority. The micro-watersheds without any agricultural area were given a common rank. Dal Lake watershed had an area of 12.36 km^2 (3.72 percent) under agriculture. The highest percentage was found in Z2b11 (29.11 percent) followed by Z2b8 (18.78 Percent) and Z2b7 (18.44 percent).

Wasteland: Wasteland may be described as degraded land which is currently under or unutilized. The land may be deteriorating due to lack of appropriate water and soil management or due to natural causes. The watershed has 12.59 percent area under wastelands with maximum area found in Z1b8 (69.41 percent) followed by Z2a1 (60.96 Percent) and Z2a5 (47.34 percent). Micro-watersheds having higher percentage of wasteland were given higher priority and vice versa.

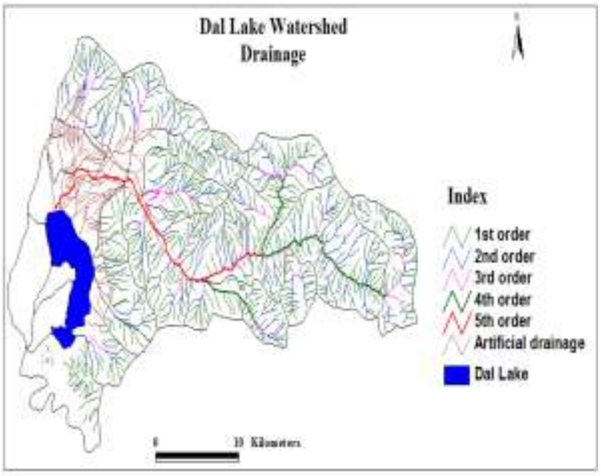
Table 1: Micro-watershed wise Morphometric and Land use/land cover Analysis of Dal Lake Watershed

			Linear parameters					Shape Parameters					Land use/land cover category			
Serial No.	Micro-watersheds	Area (Sq.km)	Mean Bifurcation	Drainage Density	Stream Frequency	Drainage Texture	Length of overland Flow	Basin Shape	Form Factor	Circulatory Ratio	Elongation Ratio	Compactness Coefficient	Built-Up (%)	Agriculture (%)	Wasteland (%)	Forest (%)
1	Z1a1	19.96	6.00	1.27	2.05	1.33	0.39	2.58	0.39	0.36	1.08	1.67	36.84	4.24	3.31	22.56
2	Z1a2	8.95	3.75	1.98	2.12	0.95	0.25	2.32	0.43	0.51	1.02	1.39	8.12	0.32	0.97	72.54
3	Z1a3	5.28	_	1.21	1.89	0.76	0.41	2.16	0.46	0.38	0.86	1.62	9.18	1.71	0.32	72.86
4	Z1a4	10.1	9.00	2.47	2.97	1.81	0.20	2.36	0.42	0.57	1.07	1.32	3.39	4.84	0.76	84.5
5	Z1a5	7.09	4.34	2.79	3.10	1.32	0.18	2.25	0.45	0.54	0.99	1.36	_	1.45	0.03	95.79
6	Z1a6	7.48	8.50	2.31	2.54	1.38	0.22	2.26	0.44	0.62	1.04	1.27	1.53	11.07	3.31	66.29
7	Z1a7	9.83	_	0.28	0.10	_	1.76	2.35	0.43	0.47	1.01	1.46	20.72	10.11	2.81	4
8	Z1a8	2.99	_	_	_	_	_	1.99	0.50	0.42	0.79	1.55	24.75	0.65	_	_
9	Z1a9	5.63	_	_	_	_	_	2.18	0.46	0.44	0.90	1.50	34.68	0.12	_	_
10	Z1b1	11.66	3.75	2.72	3.09	1.65	0.18	2.40	0.42	0.55	1.09	1.35	_	_	_	99.47
11	Z1b2	7.27	2.58	2.37	3.03	1.23	0.21	2.26	0.44	0.54	0.99	1.37	_	_	0.38	99.56
12	Z1b3	9.63	2.91	3.32	5.09	2.13	0.15	2.34	0.43	0.40	0.97	1.58	_	_	_	97.81
13	Z1b4	6.96	2.38	2.80	4.60	1.32	0.18	2.24	0.45	0.34	0.88	1.71	_	_	_	98.9
14	Z1b5	7.5	4.22	2.79	4.13	2.29	0.18	2.26	0.44	0.73	1.08	1.17	_	_	2.12	72.2

International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.04, March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

15	**Z1b6**	5.72	4.33	1.04	5.77	1.82	0.48	2.18	0.46	0.41	0.89	1.56	_	_	6.34	67.05
16	**Z1b7**	5.77	3.42	2.87	4.68	2.01	0.17	2.18	0.46	0.66	1.00	1.23	_	_	29.76	30.32
17	**Z1b8**	7.25	2.94	2.57	4.55	1.69	0.19	2.25	0.44	0.49	0.97	1.43	_	_	69.41	16.94
18	**Z2a1**	9.54	4.33	2.75	4.61	2.18	0.18	2.34	0.43	0.44	0.99	1.51	_	_	60.96	25.74
19	**Z2a2**	13.58	3.73	2.86	3.90	2.01	0.17	2.45	0.41	0.41	1.04	1.56	_	_	30.13	24.42
20	**Z2a3**	10.92	4.21	2.71	3.57	1.74	0.18	2.38	0.42	0.49	1.05	1.42	_	_	20.38	43.05
21	**Z2a4**	6.72	2.69	2.66	5.36	1.43	0.19	2.23	0.45	0.28	0.83	1.90	_	_	33.3	64.41
22	**Z2a5**	10.94	4.00	2.82	3.47	1.81	0.18	2.39	0.42	0.50	1.05	1.41	_	_	47.34	52.66
23	**Z2a6**	9.06	3.83	2.93	4.08	2.12	0.17	2.33	0.43	0.53	1.03	1.37	_	_	17.04	82.85
24	**Z2a7**	4.88	2.85	3.68	4.92	1.63	0.14	2.14	0.47	0.64	0.97	1.25	_	_	8.17	91.59
25	**Z2a8**	7.53	7.00	1.03	2.26	1.17	0.48	2.27	0.44	0.66	1.05	1.23	_	_	4.34	95.65
26	**Z2b1**	7.14	4.42	3.03	3.92	1.66	0.17	2.25	0.44	0.51	0.98	1.40	_	_	0.44	98.67
27	**Z2b2**	10.5	3.25	3.62	3.90	1.86	0.14	2.37	0.42	0.51	1.05	1.40	_	_	8.57	87.66
28	**Z2b3**	10.91	3.78	2.74	3.94	1.63	0.18	2.38	0.42	0.32	0.94	1.78	1.38	2.8	17.63	71.69
29	**Z2b4**	7.9	6.30	3.09	4.68	1.60	0.16	2.28	0.44	0.38	0.92	1.63	_	_	21	79.07
30	**Z2b5**	5.43	6.00	0.81	1.47	0.43	0.62	2.17	0.46	0.36	0.85	1.67	5.31	13.57	7.1	54.87
31	**Z2b6**	10.1	2.74	2.51	3.17	1.55	0.20	2.36	0.42	0.63	1.10	1.26	1.44	2.63	9.34	79.15
32	**Z2b7**	7.56	3.00	1.32	1.59	0.55	0.38	2.27	0.44	0.45	0.96	1.49	2.24	18.44	20.48	22.29
33	**Z2b8**	5.58	3.33	2.19	2.33	0.86	0.23	2.17	0.46	0.51	0.94	1.39	4.54	18.78	20.35	28.81
34	**Z2b9**	8.35	2.75	2.53	2.75	0.87	0.20	2.30	0.44	0.40	0.95	1.58	3.06	14.03	8.92	49.11
35	**Z2b10**	6.02	4.10	2.56	3.65	1.37	0.19	2.20	0.46	0.56	0.97	1.34	_	17.23	23.87	38.56
36	**Z2b11**	7.85	_	_	_	_	_	2.28	0.44	0.58	1.03	1.31	14.68	29.11	2.98	_
37	**Z2b12**	6.43	_	_	_	_	_	2.22	0.45	0.46	0.94	1.47	22.28	4.07	2.54	_
38	**Z2b13**	12.42	_	_	_	_	_	2.43	0.41	0.57	1.11	1.32	54.8	_	0.76	_
	Dal Lake Watershed	**331**	**5.63**	**2.12**	**2.56**	**6.78**	**0.23**	**3.79**	**0.26**	**0.41**	**0.1**	**1.54**	**7.46**	**3.72**	**12.59**	**52.56**

Source: Computed from Survey of India Toposheets 1:50000



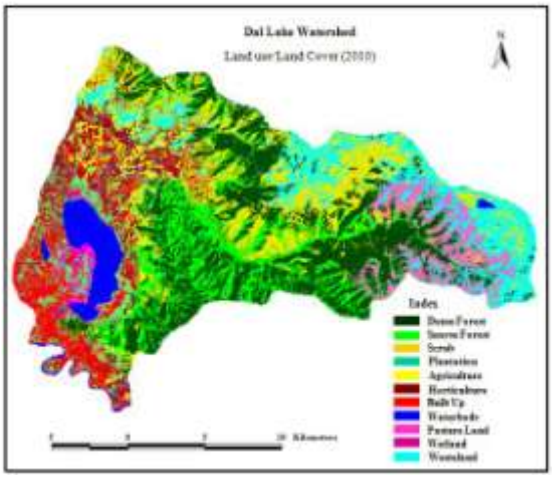


Figure 2: Drainage of Dal Lake Watershed

Figure 3: Land use/land cover of Dal Lake Watershed-2010

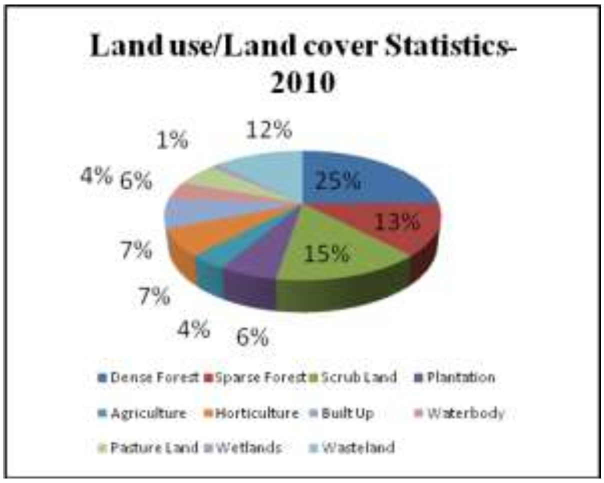


Figure 4: Land use/land cover statistics of Dal Lake Watershed-2010

Forests:

The dominance of forests is an indication of ecosystem stability and strength. The forest covers the highest percentage under land cover category in Dal lake watershed (53 percent). The lowest area under forests was occupied by Z2a1 (0.53 percent), Z1a7 (1.12 percent) and Z2a5 (2.29 percent). The watershed with lowest percentage of forest cover was assigned rank one as high priority and vice-versa. Dense forests covering 82.78 sq.kms (25 Percent) and Sparse forests covering 43.07 sq.kms (Percent) Figure 3. Scrub land was the next dominant land cover category covering an area of 48.77 sq.kms (14.68 percent) followed by Wastelands as 41.84 sq.kms (12.59 percent) and Built-up by 24.80 sq.kms (7.46 percent). Horticulture accounts for 21.07 sq.kms (6.72 percent) while Plantation constituted an area of 19.12 sq.kms (5.75 percent) and Pasture land covered an area of 18.61 sq.kms (5.6 percent). Water body had an area of 14.88 sq.kms (4.48 percent) followed by Agriculture and Wetlands as 12.36 sq.kms (3.72 percent) and 3.71 sq.kms (1.12 percent) respectively (fig.4).

V PRIORITIZATION OF MICRO-WATERSHEDS

The prioritization not only helps in the identification of watersheds which have been severely degraded and need immediate attention but also explains its causes and is thus helpful in reducing degradation of watersheds. The resource development programmes are applied generally on watershed basis and thus prioritization is essential for proper planning and management of natural resources for sustainable development **[34]**. Drainage basins, catchments and the sub-catchments are the fundamental units of the management of the land and water, identified as planning units for administrative purposes to conserve natural resources **[35], [36]**. The watershed management concept recognizes the interrelationship among the linkages between upland and lowlands, land use, geomorphology, slope and soil **[37]**. Thus the integrated approach plays an important role for sustainable development and management of natural resources **[38], [39]**.

5.1 Based on Morphometric Analysis

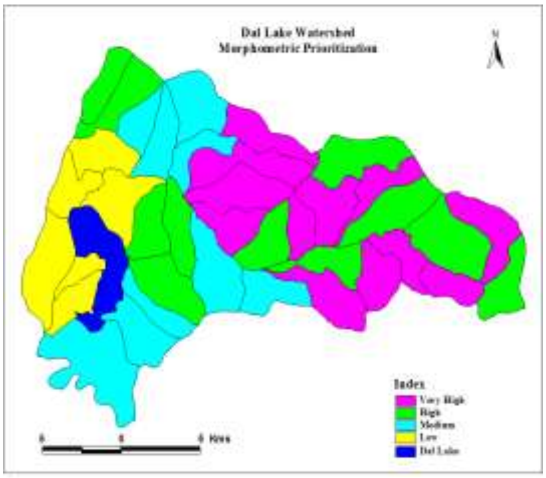
The morphometric parameters i.e., bifurcation ratio (Rb), basin shape (Bs), compactness coefficient (Cc), drainage density (D), stream frequency (Fs), drainage texture (Rt), length of overland flow (Lo), form factor (Rf), circularity ratio (Rc), and elongation ratio (Re) are also termed as erosion risk assessment parameters and have been used for prioritizing sub-watersheds **[40]**. The linear parameters such as drainage density, stream frequency, bifurcation ratio, drainage texture, length of overland flow have a direct relationship with erodibility, higher the value, more is the erodibility. Hence for prioritization of micro-watersheds, the highest value of linear parameters was rated as rank 1, second highest value was rated as rank 2 and so on, and the least value was rated last in rank. Shape parameters such as elongation ratio, compactness coefficient, circularity ratio, basin shape and form factor have an inverse relationship with erodibility **[41]**, lower the value, more is the erodibility. Thus the lowest value of shape parameters was rated as rank 1, next lower value was rated as rank 2 and so on and the highest value was rated last in rank. Hence, the ranking of the micro-watersheds has been determined by assigning the highest priority/rank based on highest value in case of linear parameters and lowest value in case of shape parameters (Table 2).

	Linear Parameters					Shape Parameters							Land use/land cover Analysis-2010						
Micro-Watersheds	Mean Bifurcation Ratio	Drainage Density	Stream Frequency	Drainage Texture	Length of overland Flow	Basin Shape	Form Factor	Circulatory Ratio	Elongation Ratio	Compactness Coefficient	Cp Value	Priority	Built-Up	Agriculture	Wasteland	Forests	Cp Value	Priority	Common Priority
Z1a1	5	27	27	19	5	26	1	4	22	26	16.2	Medium	2	11	17	15	11.25	Very High	
Z1a2	15	25	26	23	7	15	4	15	17	12	15.9	Medium	8	3	26	21	14.5	High	
Z1a3	29	28	28	26	4	3	7	5	4	24	15.8	Medium	9	4	29	11	13.25	Very High	
Z1a4	1	21	21	8	11	19	3	20	21	7	13.2	High	10	8	27	30	18.75	Medium	
Z1a5	7	11	18	20	13	10	6	17	14	10	12.6	High	18	5	30	22	18.75	Medium	
Z1a6	2	23	23	17	9	11	5	22	19	5	13.6	High	17	10	23	17	16.75	High	High
Z1a7	29	32	31	28	1	18	4	12	16	16	18.7	Low	3	12	22	1	9.5	Very High	
Z1a8	29	33	32	28	18	1	9	8	1	21	18	Low	7	2	30	34	18.25	Medium	
Z1a9	29	33	32	28	18	5	7	9	7	19	18.7	Low	4	1	30	34	17.25	Medium	
Z1b1	15	14	19	12	13	23	3	18	23	9	14.9	Medium	18	18	30	33	24.75	Low	
Z1b2	27	22	20	21	10	11	5	17	14	11	15.8	Medium	18	18	28	26	22.5	Low	
Z1b3	22	3	3	3	16	17	4	6	12	23	10.9	Very High	18	18	30	32	24.5	Low	
Z1b4	28	10	7	28	13	9	6	3	5	27	13.6	High	18	18	30	23	22.25	Low	
Z1b5	9	11	9	1	13	11	5	26	22	1	10.8	Very High	18	18	25	18	19.75	Medium	
Z1b6	8	29	1	7	3	5	7	7	6	22	9.5	Very High	18	18	20	10	16.5	High	
Z1b7	17	7	5	5	14	5	7	25	15	2	10.2	Very High	18	18	8	5	12.25	Very High	Very High
Z1b8	21	17	8	10	12	10	5	13	12	16	12.4	High	18	18	3	2	10.25	Very High	
Z2a1	8	12	6	2	13	17	4	9	14	20	10.5	Very High	18	18	1	7	11	Very High	Very High
Z2a2	16	8	13	5	14	25	2	7	19	22	13.1	High	18	18	4	9	12.25	Very High	
Z2a3	10	15	15	9	13	21	3	13	20	15	13.4	High	18	18	6	16	14.5	High	High
Z2a4	26	16	2	16	12	8	6	1	2	29	11.8	Very High	18	18	5	13	13.5	High	
Z2a5	12	9	16	8	13	22	3	14	20	14	13.1	High	18	18	2	19	14.25	High	High
Z2a6	13	6	10	4	14	16	4	16	18	11	11.2	Very High	18	18	11	27	18.5	Medium	
Z2a7	23	1	4	13	17	2	8	24	12	3	10.7	Very High	18	18	18	14	17	High	
Z2a8	3	30	25	22	3	12	5	25	20	2	14.7	High	18	18	21	25	20.5	Medium	
Z2b1	6	5	12	11	14	10	5	15	13	13	10.4	Very High	18	18	28	24	22	Low	
Z2b2	19	2	13	6	17	6	3	15	20	13	11.4	Very High	18	18	15	31	20.5	Medium	
Z2b3	14	13	11	13	13	13	3	2	9	28	11.9	Very High	15	7	7	28	14.25	High	
Z2b4	4	4	5	14	15	7	5	5	8	25	9.2	Very High	18	18	9	20	16.25	High	
Z2b5	5	31	30	28	2	24	7	4	3	26	16	Medium	11	9	19	8	11.75	Very High	
Z2b6	25	20	17	15	11	20	3	23	25	4	16.3	Medium	16	6	14	29	16.25	High	
Z2b7	20	26	29	27	6	21	5	10	11	18	17.3	Medium	14	16	10	4	11	Very High	
Z2b8	18	24	24	25	8	13	7	15	9	12	15.5	Medium	13	14	13	3	10.75	Very High	
Z2b9	24	19	22	24	11	4	5	6	10	23	14.8	High	12	15	16	12	13.75	High	High
Z2b10	11	18	14	18	12	19	7	19	12	8	13.8	High	18	13	12	6	12.25	Very High	
Z2b11	29	33	32	28	18	12	5	21	18	6	20.2	Low	6	17	24	34	20.25	Medium	
Z2b12	29	33	32	28	18	4	6	11	9	17	18.7	Low	5	6	25	34	17.5	Medium	
Z2b13	29	33	32	28	18	14	2	20	24	7	20.7	Low	1	18	26	34	19.75	Medium	

Table 2: Ranking of Micro-Watersheds in Dal Lake Watershed on the basis of Morphometric and Land use/land cover Parameters.

Source: Computed from Survey of India Toposheets 1:50000 and Landsat IRS P6 LISS-III 2010.

IJARSE
ISSN: 2319-8354



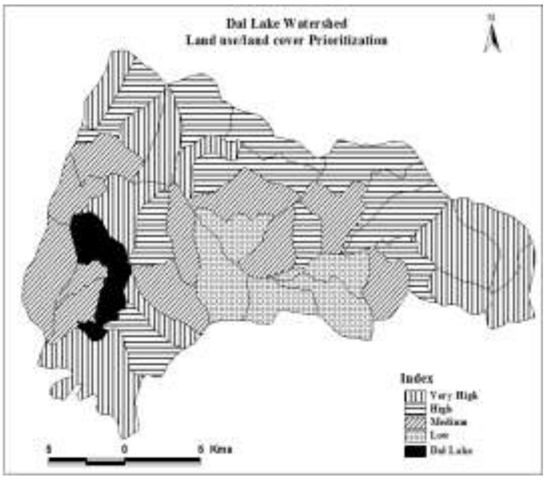


Figure 5: Morphometric Prioritization of Dal Lake Watershed

Figure 6: Land use/land cover Prioritization of Dal Lake Watershed

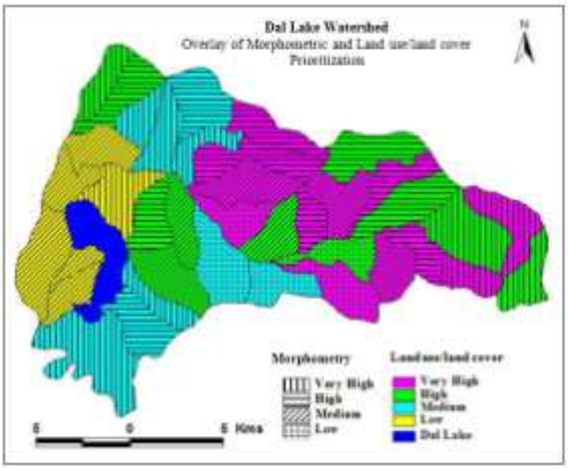


Figure 7: Overlay Analysis of Morphometric and Land use/land cover for Dal Lake Watershed

After the ranking has been done based on every single parameter, the ranking values for all the linear and shape parameters of each micro-watershed were added up for each of the thirty eight micro-watersheds to arrive at Cp value (compound value). Based on the value of these parameters, the micro-watersheds having the least rating value was assigned highest priority, next higher value was assigned second priority and so on. The micro-watershed which got the highest Cp value was assigned last priority. The micro-watersheds were then categorized into four classes as very high (9.20-12.02), high (12.03-14.85), medium (14.86-17.68) and low (17.69-20.70) priority on the basis of the range of Cp value. Hence, on the basis of morphometric analysis, Z1b3, Z1b5, Z1b6, Z1b7, Z1b8, Z2a1, Z2a2, Z2a4, Z2a6, Z2a7, Z2b1, Z2b2, Z2b3 and Z2b4 fall in very high priority zone, Z1a4, Z1a5, Z1b1, Z1b4, Z2a3, Z2a5 and Z2b10 in high priority zone, Z1a1, Z1a2, Z1a3, Z1a6, Z1a7, Z1b2, Z2a8, Z2b5, Z2b6, Z2b7,Z2b8 and Z2b9 in Medium priority zone and Z1a8, Z1a9, Z2b11, Z2b12 and Z2b13 fall in low priority zone (Fig5).

5.2 Based on land use/land cover analysis

Land use categories i.e., Built up, wasteland, Agricultural land and Forests in all the thirty eight micro-watersheds were considered for prioritization of micro-watersheds based on land use/land cover analysis. The existing percentage area under each category of land use was considered and ranking was assigned on the basis of area under each land use category (Table 2). For Built up and Wasteland categories higher the percentage area in a particular micro-watershed higher the rank i.e. rank 1, second highest value as rank 2 and so on was assigned while for Agriculture and Forest land cover class lowest the area highest the rank was assigned.

Table 3: Prioritization Values and Category in Dal Lake Watershed

Morphometry		Land use/land cover		Common Priority
Very High (9.20-12.02)	**12**	**Very High** (9.50-13.31)	**11**	**2**
High (12.03-14.85)	**11**	**High** (13.32-17.13)	**11**	**4**
Medium (14.86-17.68)	**9**	**Medium** (17.14-20.95)	**11**	
Low (17.69-20.70)	**6**	**Low** (20.96-24.77)	**5**	
Total	**38**	**Total**	**38**	**6**

Source: Computed from Survey of India Toposheets,1961, IRS P6 LISS III 2010.

Finally, the ranking under each land use category was added up to arrive at Cp value, lower the composite score, higher is the ranking/ priority. The final priority/ranking was given by classifying the highest and lowest range of Cp value into four classes as very high (9.50-13.31), high (13.32-17.13), medium (17.14-20.95) and low (20.96-24.77) priority (Table 2).

Hence, on the basis of land use Z1a1, Z1a3, Z1a7, Z1b8, Z2a1, Z2a2, Z2b5,Z2b7, Z2b8 and Z2b10 fall in very high priority while Z1a2, Z1a6, Z1b6, Z2a3, Z2a4, Z2a5, Z2a7, Z2b3, Z2b4,Z2b6 and Z2b9 fall in high Priority and Z1a4, Z1a5, Z1a8, Z1a9, Z1b5, Z2a6, Z2a8, Z2b2, Z2b11, Z2b12 and Z2b13 in medium priority while Z1b1, Z1b2, Z1b3, Z1b4 and Z2b1 fall in the low priority category (Fig.6). The results obtained from Morphometric and land use/land cover analysis were correlated to find out the common micro-watersheds falling under each priority. The correlation shows that Z1b7 and Z2a1 fall under very high priority, Z1a6, Z1a3, Z1a5 while Z2b9 in high priority, (Fig 7) based on Morphometric as well as land use/cover analysis. However, the rest of the micro-watersheds exhibit little correlation and differ in their priority under Morphometric and land use/cover change analysis (Table 3).

VI CONCLUSION

Watershed prioritization is one of the most important aspects of planning for implementation of its development and management programmes. The present study demonstrates the utility of remote sensing and GIS techniques in prioritizing micro-watersheds based on Morphometric and land use/land cover analysis as well as with the integration of these two. The study has found that Z1b7 and Z2a1 fall under very high priority, Z1a6, Z1a3, Z1a5 while Z2b9 falls in high priority based on Morphometric as well as land use/cover analysis. These micro-watersheds may be taken up with detailed survey for soil and water conservation measures, water resources development, scientific land-use planning for preservation of eco-diversity, integrated study for development of natural as well as social resources, moisture conservation, sustainable farming system, etc. to accelerate the rehabilitation of the micro-environment and to generate a detailed database in each natural resources theme, which is a pre-requisite for formulation of watershed plan for its sustainable development and management. Hence these micro-watersheds may be taken for conservation measures by planners and decision makers for locale-specific planning and development.

REFERENCES

[1] Singh, S. and Singh, M.C. (1997), "Morphometric analysis of Kanhar river basin." National Geographical journal of India, 43**,** 1: 31-43

[2] Strahler, A.N. (1964), "Quantitative geomorphology of drainage basins and channel networks". In: Chow, V.T. (eds.), *"Handbook of Applied Hydrology."* McGraw Hill Book Company, New York, Section, pp. 4-11 Strahler A.N. (1957), "Quantitative slope analysis" *Bulletin of the Geological Society of America,* 67: 571-596.

[3] Nag, S.K. (1998), "Morphometric analysis using remote sensing techniques in the Chaka sub-basin, Purulia district, West Bengal" *Journal of Indian Society of Remote Sensing,* 26, 2: 69-76

[4] Agarwal, C.S. (1998), "Study of drainage pattern through aerial data in Naugarh area of Varanasi district, U.P." *Journal of Indian Society of Remote Sensing,* 26: 169-175

[5] Obi Reddy, G.E., Maji, A.K. and Gajbhiye, K.S. (2002). "GIS for morphometric analysis of drainage basins." GIS lndia, 11, 4: 9-14

[6] Abrahams, A.D. (1984), "Channel networks: a geomorphological perspective" *Water Resource Research,* 20:161–168

[7] Meyer, W.B. and Turner II, B.L. (1991), "Human population growth and global land use/cover change." *Ann. Rev. Ecol. Systematics,* 23: 39-62

[8] Vittala, S.S., Govindiah, S. and Gowda, H.H. (2008), "Prioritization of sub-watersheds for sustainable development and management of natural resources: An integrated approach using remote sensing, GIS and Socio-economic data" *Current Science,* 95, 3: 345-354

[9] Moore, I.D., Grayson, R.B. and Ladson, A.R. (1977), "Digital terrain modeling." In: Bewan, et al. (eds.), *"A review of hydrological, geomorphological and biological applications".* John Villey, Chichester, pp. 7-13

[10] Tideman, E.M. (1996), *"Watershed management, guidelines for Indian conditions."* New Delhi: Omega scientific publishers

[11] Khan, M.A., Gupta, V.P. and Moharana, P.C. (2001), "Watershed prioritization using remote sensing and Geographical Information System, A case study of Guhiya, India" *Arid Environment*, 49: 465-475

[12] Biswas S, Sudhakar S and Desai VR (1999) Prioritization of sub-watersheds based on Morphometric Analysis of Drainage Basin, District Midnapore, West Bengal. *J. Indian Soc. Remote Sensing* 27(3):155–166

[13] Nooka Ratnam, K., Srivastava, Y.K., Venkateswara Rao, V., Amminedu, E. and Murthy, K.S.R (2005). Check dam Positioning by Prioritization of Microwatersheds using SYI model and Morphometric Analysis - Remote sensing and GIS Perspective. J. Indian Soc. Rem. Sens., 33(1): 25-38.

[14] Arun PS, Jana R and Nathawat MS (2005) A rule based physiographic characterization of a drought prone watershed applying remote sensing and GIS. *J. Indian Soc. Remote Sensing* 33(2): 189–201

[15] Horton, R.E. (1932), "Drainage basin characteristics." *Am. Geophys. Union, Trans.* 13: 348–352

[16], Strahler, A.N. (1964), "Quantitative geomorphology of drainage basins and channel networks". In: Chow, V.T. (eds.), *"Handbook of Applied Hydrology."* McGraw Hill Book Company, New York, Section, pp. 4-11 Strahler A.N. (1957), "Quantitative slope analysis" *Bulletin of the Geological Society of America*, 67: 571-596.

[17] Schumm, S. A. (1956): Evolution of Drainage System And Slope in Badlands at Perth Amboy,New Jersey, *Bulletin, Geological Society of America*, 67: 597-646 Sekliziotis, S. (1980): *A Survey of Urban Open Space Using Colour-infrared Aerial Photographs.* Ph.D Thesis, University of Aston, Aston.

[18] Strahler, A.N. (1964), "Quantitative geomorphology of drainage basins and channel networks". In: Chow, V.T. (eds.), *"Handbook of Applied Hydrology."* McGraw Hill Book Company, New York, Section, pp. 4-11 Strahler A.N. (1957), "Quantitative slope analysis" *Bulletin of the Geological Society of America*, 67: 571-596.

[19] Strahler, A.N. (1964), "Quantitative geomorphology of drainage basins and channel networks". In: Chow, V.T. (eds.), *"Handbook of Applied Hydrology."* McGraw Hill Book Company, New York, Section, pp. 4-11 Strahler A.N. (1957), "Quantitative slope analysis" *Bulletin of the Geological Society of America*, 67: 571-596.

[20] Horton, R.E. (1932), "Drainage basin characteristics." *Am. Geophys. Union, Trans.* 13: 348–352

[21] Strahler, A.N. (1964), "Quantitative geomorphology of drainage basins and channel networks". In: Chow, V.T. (eds.), *"Handbook of Applied Hydrology."* McGraw Hill Book Company, New York, Section, pp. 4-

11 Strahler A.N. (1957), "Quantitative slope analysis" *Bulletin of the Geological Society of America,* 67: 571-596.

[22] Langbein, W.B. (1947) Topographic Characteristics of Drainage Basins. U.S. Geol. Surv. Water-Supply Paper, 986(C), pp.157-159.

[23] Horton, R.E. (1932), "Drainage basin characteristics." *Am. Geophys. Union, Trans.* 13: 348–352

[24] Reddy, O.G.P., Maji, A.K., Chary, G.R., Srinivas, C.V., Tiwary, P. and Gajbhiye, S.K. (2004a) GIS and Remote Sensing applications in prioritization of river sub-basins using morphometric and USLE parameters-A case study. Asian Jour. Geoinformatics, v.4(4), pp.35-48.

[25] Horton, R.E. (1945), "Erosion development of streams and their drainage basins: Hydrological approach to quantitative geomorphology" *Bulletin of the Geological Society of America*, 56: 275-370.

[26] Kale, V. S. and Gupta, A. (2001): *Introduction to Geomorphology*. pp. 84-86.

[27] Horton, R.E. (1945), "Erosion development of streams and their drainage basins: Hydrological approach to quantitative geomorphology" *Bulletin of the Geological Society of America*, 56: 275-370.

[28] Singh, S. (1998): *Physical Geography*, Prayag Pustak Bhawan, Allahabad, India.

[29] Horton, R.E. (1932), "Drainage basin characteristics." *Am. Geophys. Union, Trans.* 13: 348–352

[30] Miller, V. C. (1953): *A Quantitative Geomorphic Study of Drainage Basin Characteristics in the Clinch Mountain Area, Virginia And Tennessee*", Project NR 389042, Tech. Rept. ,Columbia University, Department of Geology, ONR, Geography Branch, New York.

[31] Schumm, S. A. (1956): Evolution of Drainage System And Slope in Badlands at Perth Amboy,New Jersey, *Bulletin, Geological Society of America*, 67: 597-646 Sekliziotis, S. (1980): *A Survey of Urban Open Space Using Colour-infrared Aerial Photographs.* Ph.D Thesis, University of Aston, Aston.

[32] Reddy, O.G.P., Maji, A.K. and Gajbhiye, S.K. (2004b) Drainage morphometry and its influence on landform characteristics in a basaltic terrain, Central India – A remote sensing and GIS approach. Internat. Jour. Applied Earth Observation and Geoinformatics, v.6, pp.1-16.

[33] Nooka Ratnam, K., Srivastava, Y.K., Venkateswara Rao, V., Amminedu, E. and Murthy, K.S.R (2005). Check dam Positioning by Prioritization of Microwatersheds using SYI model and Morphometric Analysis - Remote sensing and GIS Perspective. J. Indian Soc. Rem. Sens., 33(1): 25-38.

[34] Vittala, S.S., Govindiah, S. and Gowda, H.H. (2008), "Prioritization of sub-watersheds for sustainable development and management of natural resources: An integrated approach using remote sensing, GIS and Socio-economic data" *Current Science*, 95, 3: 345-354

[35] Moore, I.D., Grayson, R.B. and Ladson, A.R. (1977), "Digital terrain modeling." In: Bewan, et al. (eds.), *"A review of hydrological, geomorphological and biological applications".* John Villey, Chichester, pp. 7-13

[36] Honore, G. (1999), *"Our land, ourselves- a guide to watershed management in India"* Government of India, New Delhi

[37] Tideman, E.M. (1996), *"Watershed management, guidelines for Indian conditions."* New Delhi: Omega scientific publishers

[38] Khan, M.A., Gupta, V.P. and Moharana, P.C. (2001), "Watershed prioritization using remote sensing and Geographical Information System, A case study of Guhiya, India" *Arid Environment,* 49: 465-475

[39] Gosain, A.K. and Rao, S. (2004), "GIS based technologies for watershed management." *Current Science,* 87: 948-953

[40] Biswas S, Sudhakar S and Desai VR (1999) Prioritization of sub-watersheds based on Morphometric Analysis of Drainage Basin, District Midnapore, West Bengal. *J. Indian Soc. Remote Sensing* 27(3):155–166

[41] Nooka Ratnam, K., Srivastava, Y.K., Venkateswara Rao, V., Amminedu, E. and Murthy, K.S.R (2005). Check dam Positioning by Prioritization of Microwatersheds using SYI model and Morphometric Analysis - Remote sensing and GIS Perspective. J. Indian Soc. Rem. Sens., 33(1): 25-38.