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Mitigating Water Crisis by Prioritization Sub -Watershed Areas for Resource Management- A Case Study of Latur, India

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ABSTRACT: Watershed is an ideal unit for management of natural resources like land and water for mitigation of the impact of natural disaster for achieving sustainable development. Watershed management is not so much about managing the natural resources but about enhancing biodiversity and managing the human activities affecting these resources, while watershed development is conservation, regeneration and prudent use of all the resources within the watershed area. The study is carried out in watershed area for Latur, Manjra sub basin. The aim of the study is to prioritized sub-watershed to preserve the land from further erosion and to alleviate natural hazards. The research is includes delineation of watershed area using satellite imagery of SRTM DEM and a comparison of Landsat-7 satellite data and Landsat-8 satellite data to study the changes occurring in built up area, forest, and water bodies of the basin. The morphometric parameters which influence the soil erodibility are considered to prioritize the sub-watershed. The paper finally concludes on the efforts required to conserve, sustain and enhance rainwater to recharge the ground water resources through watershed development, and the suitable models and methods for watershed management of Latur.

Keywords: Watershed Management and Development, Morphometric analysis, SRTM DEM, NDVI change detection, Suitable model for water Conservation.

I. INTRODUCTION

In India day by day water demand is increasing due to growing population, increasing industrialization, rapid urbanization and agriculture irrigation. The demand for water multiplying is leading to scarcity problem. The water scarcity is also increasing problem of water pollution and over exploitation of groundwater in certain areas. Due to rainfall variation and water deficiency at some places water is supplied with the help of tankers. Thus, management of water resources is essential.

Watershed is the area of land where all the water falls in it and drains off of it goes to a common outlet. Also it can be as small as footprint or large enough to encompass all the land that drains water into rivers that drain into ocean. The watersheds are natural hydrological entities that cover a specific aerial expanse of land surface from which the rainfall runoff flows to a defined drain, channel, stream or river at any particular point. The terms region, basin, catchment, watershed etc. are widely used to denote hydrological units. Even though these terms have similar meanings in popular sense, technically they are different A catchment is an area where water is collected by the natural landscape. While the geographical basin is bowl shaped depression or dip in the earth's surface, either oval or circular in shape or the area of land drained by river and its branches. Size of a watershed is governed by the size of the stream occupied by it. Size of the watershed is of practical importance in development programmes. For example, size of irrigation cum hydel project has its watershed size several thousands of square kilometers but for a farm pond the size may be few hectares only.

The entire river systems of the country have been divided into 6 Water Resources Region, which has been further, divided into 35 basins and 112 catchments. These catchments have been further divided into 500 sub- catchments and 3237 watersheds. The suggested hydrological units are: Water resource region, river basins, river sub- basin, watershed, sub watershed, mini-watershed and micro watershed. The recommended size of the watershed is from 250-750 Sq. Km.

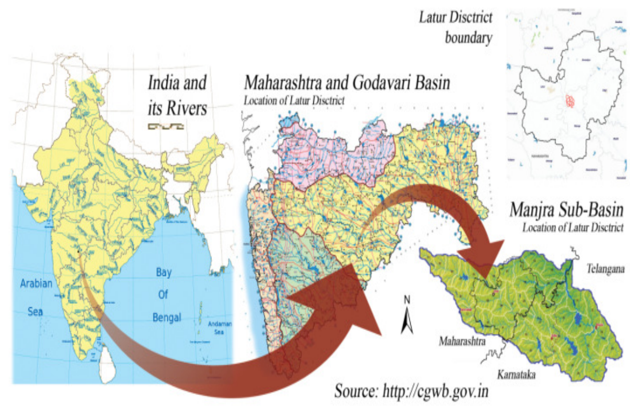
Watershed is an ideal unit for management of natural resources like land and water for mitigation of the impact of natural disaster for achieving sustainable development.

Watershed management is not so much about managing the natural resources but about enhancing biodiversity and managing the human activities affecting these resources.

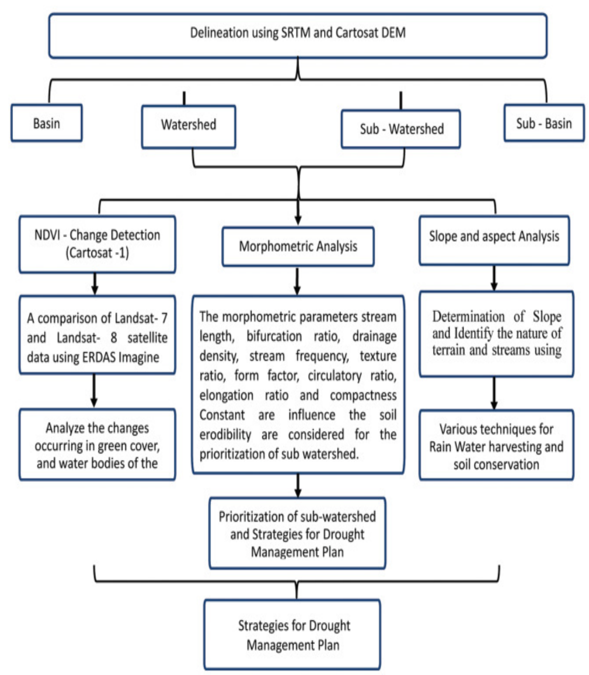
II. DESCRIPTION OF STUDY AREA

Latur is one of the drought districts of Marathwada Region of Maharashtra State. It suddenly became famous after it was worst hit by an earthquake on 30/09/1993 at 0355 hrs. with an intensity of 6.0-6.5 on Rictcher's scale, causing an enormous damage to the area in the loss of human life, livestock standing crops and property. It is situated in the south-eastern part of the State borderring Maharashtra and Karnataka States. It lies between north latitudes 17°55'00'' and 18°50'00'' and east longitude 76°15'00'' and 77°15'00'' and falls in parts of Survey of India degree sheets 56 B, 56 C and 56 F. The district has a geographical area of 7157 sq. km. out of which only 35 sq.km. is covered by forest, whereas cultivable area is 6423 sq. km. and net sown area is 5610 sq. km. The district forms part of Godavari basin. Manjra River is the main river flowing through the district. The district headquarters is located at Latur town. For administrative convenience, the district is divided in 10 talukas viz, Latur, Ahmedpur, Udgir, Nilanga, Ausa, Renapur, Chakur, Shirur-Anantpal, Deoni and Jalkot. It has a population of 24,55,543 as per 2001 census. The district has 5 Nagar Parishads, 10 Panchayat Samitis and 786 Gram Panchayats.

The significant factors for planning and management of watershed- its physiography, geomorphology, soil, land-use/land-cover, availability of water resources and its consumption patterns, runoff coefficient for the areas topography.

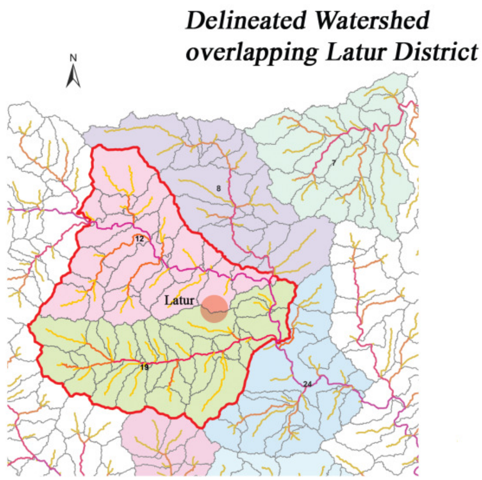


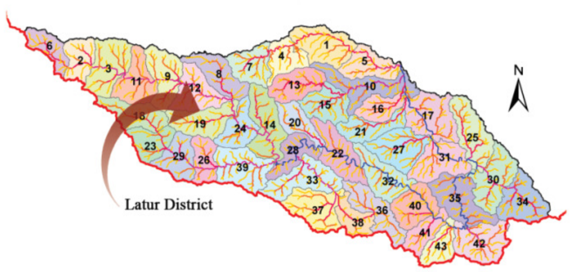
III. METHODOLOGY



IV. DELINEATION OF WATERSHED

To delineate the watershed area SRTM DEM satellite imagery is taken from USGS and spatially analyze in Arc GIS to extract watershed boundary and drainage network of Latur watershed.





V. MORPHOMETRIC ANALYSIS

Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms. Erosion is the greatest destroyer of land resources. For formulation of proper watershed management programs for sustainable development, an inventory on quantitative erosion soil loss and the priority classification of watershed are essential.

Morphometric analysis of a watershed provides a quantitative description of the drainage system which is an important aspect of the characterization of watersheds. Morphometric analysis is a significant tool for prioritization of micro-watersheds by studying different linear and aerial parameters of the watershed even without the availability of soil maps.

In the context of above point of views, the present study aims at the detail morphometric characteristics of Latur district. Objectives are:

- To understand the physiographic characteristic of Latur district;
- To assess the eco-geomorphological characteristic this study can help to understanding the morphology and morphometric characteristic of geomorphic features in hydro geomorphic units of this area;
- It is very much important tool to calculation or identification of land degradation as well as environmental degradation of the study area;
- To help morphometric analysis of all patches (exposed at the surface) and the entire region to be determine degradation severity;
- It's also helped to take decision about geomorphic prioritization with preparation of integrated management.

The various morphometric parameters such as stream length, bifurcation ratio, drainage density, stream frequency, form factor, texture ratio, elongation ratio, circularity ratio and compactness constant were computed. The linear parameters such as drainage density, stream frequency, bifurcation ratio, texture ratio have a direct relationship with erodibility, higher the value, more is the erodibility. Hence for prioritization of mini watersheds, the highest value was rated as rank 1, second 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 constant, circulatory ratio and form factor have an inverse relationship with erodibility*9*, 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 mini 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.

VI. FORMULATION FOR COMPUTATION OF MORPHOMETRIC ANALYSIS

Sr. No	Morphometric Parameters	Formula
1	Stream Order (u)	Hierarchical Rank.
2	Stream Length (Lu)	Length of the stream.
3	Mean Stream Length (Lsm)	Lsm = Lu/Nu , Where Lsm is Mean Stream Length; Lu = Total Stream Length of order u; Nu = Total number of stream segments of order u.
4	Bifurcation Ratio (Rb)	Rb = Nu/ Nu+1, Where Rb = Bifurcation ratio; Nu = Total number of stream segments of order u; Nu+1 = Number of stream of segments of next higher order.
5	Mean Bifurcation Ratio (Rbm)	Rbm = Average of bifurcation ration of all orders.
6	Basic Length (Lb)	Lb = 1.312 * A^0.568,Where Lb= Length of basin (km), A =Area of Basin (km2).
7	Drainage Density (Dd)	Dd = Lu/A, Where Dd = Drainage density, Lu= Total streams length of all order, A =Area of Basin (km^2).

Sr. No	Morphometric Parameters	Formula
8	Stream Frequency (Fs)	Fs = Nu/A, Fs= Stream frequency, Nu =Total number of streams of all order, A =Area of Basin (km2).
9	Texture Ratio (T)	T=Nu/P, Where T= Texture ratio, Nu =Total number of streams of all order, P= Perimeter (Km).
10	Form Factor (Rf)	Rf = A/Lb^2 Where Rf = Form factor; A =Area of Basin (km2); Lb= Length of basin (km).
11	Circularity Ratio (Rc)	Rc = 4 πA/p^2 Rc= Cicularity ratio; A = Area of Basin (km2); P= Perimeter (Km)
12	Elongation Ratio (Re)	Re = (2/Lb)*(A/π)^0.5; Where Re = Elongation ratio; Lb= Basin Length (Km); A = Area of Basin (km2).
13	Compactness Constant (Cc)	Cc = 0.2821(P/A^0.5) Where, Cc=Compactness Constant; P= Perimeter (Km); A = Area of Basin (km2).

The various parameter consider for the study of morphometric analysis are –

VII. LINEAR PARAMETER

(i) Stream order (u) It is a method of assigning a numeric order to links in a stream network. This order is a method for identifying and classifying types of streams based upon their no. of tributaries.

(ii) Mean Stream Length (Lsm) It is the characteristic property related to the drainage network and its associated surfaces. Generally higher the order, longer the length of streams is noticed is nature.

(iii) Bifurcation ratio (Rb) It shows a small range of variation for different regions or for different environments except where the powerful geological control dominates.

(iv) Drainage density (Dd) It shows the landscape dissection, runoff potential, infiltration capacity of the land, climatic conditions and vegetation cover of the basin. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture.

(v) Stream frequency (Fs) It is the total no. of stream segments of all the orders per unit area. Generally, high stream frequency is related to impermeable sub-surface material, sparse vegetation, high relief conditions and low infiltration capacity.

(vi) Texture ratio (T) It is the total no. of stream segments of all order s per perimeter of that area.

MW	A	P	Lb	Rb	Rbm	T	Fs	Dd	Total of L.P
0	76.67	21.60	6.38	8.93	1.00	2.00	6.67	3.11	28.09
1	17.23	29.80	8.53	17.83	7.07	3.66	4.00	18.90	59.99
2	28.17	23.70	7.92	18.35	20.45	4.56	4.55	21.51	77.35
3	16.20	23.60	8.20	1.41	0.50	4.58	4.29	17.76	36.74
4	25.19	28.20	10.82	22.09	7.63	5.74	2.63	12.43	61.34
5	35.08	30.10	9.44	25.68	20.80	3.59	3.35	15.81	78.67
6	47.05	23.70	8.45	18.12	7.79	3.16	4.06	19.20	60.79
7	11.64	23.40	9.38	27.07	22.14	3.83	3.38	15.99	81.79
8	43.60	36.00	11.99	27.05	8.86	3.28	2.20	10.38	63.76
9	32.94	29.80	9.49	21.58	14.21	4.62	3.32	15.68	68.89
10	57.17	32.90	10.83	27.30	9.36	3.38	2.63	12.42	65.91
11	25.68	33.40	8.72	27.14	23.88	3.62	3.85	18.20	85.41
12	32.40	39.00	15.43	1.00	1.00	2.77	1.41	6.66	28.27
13	25.73	29.70	9.90	4.62	0.78	3.64	3.08	14.55	36.56
14	15.09	36.90	11.69	9.26	3.38	2.93	2.30	10.85	40.39
15	42.13	19.80	6.61	4.26	0.32	5.45	6.27	9.61	32.52
16	16.05	27.40	8.74	12.87	0.58	3.94	3.83	6.54	36.50
17	44.89	16.40	5.29	3.65	4.84	6.59	9.28	14.54	44.18
18	27.00	28.50	11.20	9.59	3.39	3.79	2.48	11.70	42.15
19	41.05	26.00	9.55	10.98	4.86	4.15	3.28	15.49	48.31
20	26.58	42.60	13.06	12.96	3.83	2.54	1.89	8.93	43.20
21	49.17	32.00	11.89	24.59	7.89	3.62	2.23	10.53	60.76
22	41.10	28.50	9.25	30.36	27.60	3.79	3.47	16.38	90.85
23	48.45	25.80	8.29	6.01	6.01	4.19	4.21	19.87	48.57
24	16.71	34.00	9.46	3.66	1.16	3.18	3.33	18.00	38.79

25	**4.03**	**27.80**	**8.30**	**1.11**	**1.97**	**4.56**	**4.20**	**17.54**	**37.67**
26	15.09	26.40	8.45	18.56	16.42	4.09	4.07	19.24	70.82
27	11.92	30.20	8.40	20.67	16.78	3.58	4.11	19.43	72.97
28	17.72	32.60	9.70	24.63	18.97	3.31	3.19	15.08	74.88
29	23.72	19.90	6.50	7.45	7.98	5.43	6.46	28.65	62.47
30	32.27	11.50	2.90	4.66	8.03	9.39	26.80	12.49	64.26
31	31.91	19.00	6.13	3.52	9.54	5.68	7.16	33.82	65.85
32	32.55	19.20	6.13	7.79	3.37	3.88	7.16	12.65	40.98
33	28.04	18.60	5.36	8.45	11.07	5.81	9.06	26.87	66.61
34	31.16	22.00	6.72	15.72	28.47	4.91	6.09	28.80	90.70
35	26.53	29.50	10.98	4.33	1.56	5.63	2.56	12.11	37.17
36	26.26	18.80	6.35	12.46	6.95	3.00	6.73	24.87	60.36
37	33.84	34.20	11.39	24.93	6.98	3.23	2.41	11.37	60.30
38	33.05	27.00	9.57	41.57	28.82	4.00	3.27	15.44	102.67
39	26.91	21.30	8.51	31.64	31.64	5.07	4.01	18.96	99.84
40	69.08	38.50	14.54	42.02	42.02	2.81	1.56	7.39	110.34

VIII. SHAPE PARAMETERS

(i) Form factor (Rf) It may be defined as the ratio of the area of the basin and square of basin length. The value of the form factor would always be greater than 0.78 for a perfectly circular basin. Smaller the value of form factor, more elongated will be the basin.
(ii) Circulatory ratio (Rc) It is the ratio of the area of the basins to the area of the circle having the same circumstance as the perimeter of the basin. It is helpful for assessment of flood hazard. Higher the Rc value, higher is the flood hazard at the peak time at the outlet point.
(iii) Elongation ratio (Re) It is defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length.
(iv) Compactness constant (Cc) It is defined as the ratio between the area of the basin and the perimeter of the basin.

MW	A	P	Rc	Rf	Re	Cc	Total	Cv	Priority
0	76.67	21.60	0.44	0.40	0.71	1.51	31.15	3.11	1
1	17.23	29.80	0.38	0.37	0.69	1.62	63.05	6.31	3
2	28.17	23.70	0.53	0.38	0.69	1.37	80.32	8.03	4
3	16.20	23.60	0.57	0.37	0.69	1.33	39.70	3.97	1
4	25.19	28.20	0.65	0.35	0.67	1.24	64.25	6.43	3
5	35.08	30.10	0.45	0.36	0.68	1.49	81.65	8.17	4
6	47.05	23.70	0.59	0.37	0.69	1.30	63.74	6.37	3
7	11.64	23.40	0.73	0.36	0.68	1.17	84.73	8.47	4
8	43.60	36.00	0.48	0.34	0.66	1.45	66.68	6.67	3
9	32.94	29.80	0.46	0.36	0.68	1.47	71.86	7.19	4
10	57.17	32.90	0.48	0.35	0.67	1.45	68.85	6.89	3

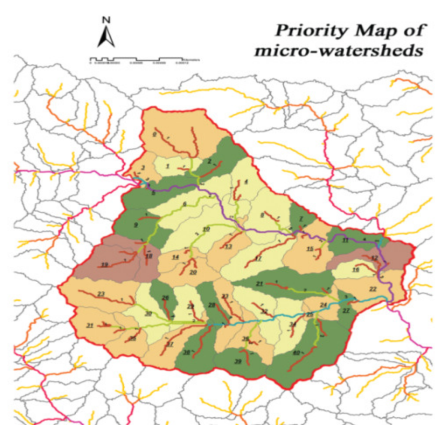
MW	A	P	Rc	Rf	Re	Cc	Total	Cv	Priority
11	25.68	33.40	0.32	0.37	0.69	1.78	88.56	8.86	4
12	32.40	39.00	0.63	0.32	0.64	1.26	31.12	3.11	1
13	25.73	29.70	0.50	0.36	0.68	1.41	39.51	3.95	1
14	15.09	36.90	0.43	0.34	0.66	1.52	43.35	4.34	2
15	42.13	19.80	0.55	0.39	0.71	1.35	35.53	3.55	1
16	16.05	27.40	0.47	0.37	0.69	1.46	39.49	3.95	1
17	44.89	16.40	0.54	0.42	0.73	1.36	47.23	4.72	2
18	27.00	28.50	0.67	0.35	0.67	1.22	45.05	4.51	2
19	41.05	26.00	0.61	0.36	0.68	1.28	51.24	5.12	2
20	26.58	42.60	0.40	0.34	0.65	1.59	46.17	4.62	2
21	49.17	32.00	0.59	0.34	0.66	1.30	63.65	6.37	3
22	41.10	28.50	0.48	0.36	0.68	1.44	93.82	9.38	4
23	48.45	25.80	0.48	0.37	0.69	1.44	51.55	5.16	2
24	16.71	34.00	0.35	0.36	0.68	1.69	41.86	4.19	2
25	4.03	27.80	0.42	0.37	0.69	1.55	40.70	4.07	2
26	15.09	26.40	0.48	0.37	0.69	1.45	73.81	7.38	4
27	11.92	30.20	0.36	0.37	0.69	1.66	76.05	7.61	4
28	17.72	32.60	0.40	0.36	0.68	1.58	77.90	7.79	4
29	23.72	19.90	0.53	0.40	0.71	1.37	65.48	6.55	3
30	32.27	11.50	0.38	0.48	0.78	1.62	67.52	6.75	3
31	31.91	19.00	0.53	0.40	0.72	1.38	68.87	6.89	3
32	32.55	19.20	0.51	0.40	0.72	1.39	44.01	4.40	2
33	28.04	18.60	0.43	0.41	0.73	1.52	69.71	6.97	3
34	31.16	22.00	0.46	0.39	0.71	1.47	93.74	9.37	4
35	26.53	29.50	0.61	0.35	0.67	1.28	40.08	4.01	2
36	26.26	18.80	0.57	0.40	0.71	1.32	63.36	6.34	3
37	33.84	34.20	0.48	0.35	0.66	1.44	63.23	6.32	3
38	33.05	27.00	0.57	0.36	0.68	1.32	105.60	10.56	4
39	26.91	21.30	0.75	0.37	0.69	1.16	102.80	10.28	4
40	69.08	38.50	0.59	0.33	0.64	1.31	113.21	11.32	4

IX. PRIORITY MAP OF MICRO-WATERSHED

Prioritization rating of all the micro watersheds of watershed was carried out by calculating the compound parameter values. The micro watershed with the lowest compound parameter value was given the highest priority. The various indicators which have been used in the prioritization of watershed are described in table.

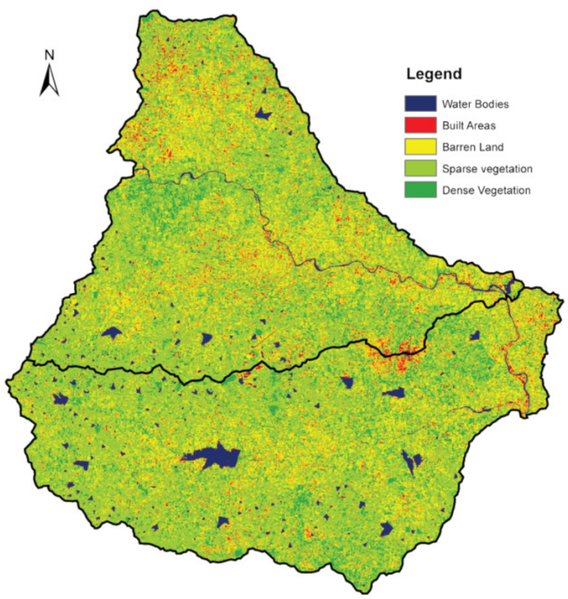
X. NDVI ANALYSIS

Normalized Difference Vegetation Index was analyzed on the basis of Multispectral imagery from LANDSAT 7/8 imagery.



The DN values of the derived analysis can be utilized to derive pixed by the pixel classification of the various land covers; viz water bodies, built-up areas, barren lands, sparse vegetation or forest and dense vegetation or agriculture (healthy plantation). Land-cover change detection for 2006 -2016 was derived to study the spatial deviations for water resource management anomalies.

	2006	2016	Change
Dense vegetation	219.165	531.801	312.636
Sparse vegetation	73.1129	3.40498	-69.708
Barren	539.164	281.726	-257.44
Built Area	131.947	196.818	64.8707
Water	296.613	246.25	-50.363



XI. CONCLUSION

The present study demonstrates the usefulness of remote sensing and GIS for morphometric analysis and prioritization of the sub-watersheds of Manjra watershed of Latur district. The results shows that the morphometric parameters derived from CartoDEM data provide good and satisfactory information about the catchment delineation and its characteristics. The values of drainage density for the present case ranges between 3.11 and 33.82 which are very high confirming that the study area is having a not flat terrain with light vegetative cover and low resistance with impermeable soil. The morphometric parameters which influence the soil erodibility are considered for the prioritization of sub-watershed. There are 41 micro-watersheds out of 6 were given very high priority (15%), as they have very low compound value (Cp), 10 micro-watersheds were given high priority (24%), with low Cp values. 12 micro - watersheds fall under medium (29%), having moderate Cp values and the remaining 13 micro-watersheds were given low priority (32%) which have very high Cp value. Therefore, immediate attention towards soil conservation measures are required in these sub watersheds to preserve the land from further erosion and to alleviate natural hazards. It is to conclude that morphometric analysis can be used for prioritisation of sub-watershed even without the availability of reliable soil maps of the study area.

REFERENCES