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WATERSHED CHARACHTERIZATION AND PRIORITIZATION IN MAN RIVER BASIN: A GEOSPATIAL APPROACH

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ABSTRACT

The word Morphometry is applied for the drainage basin refers to the measurement of the linear, areal and relief aspects of the drainage basins and treating as a fundamental geomorphic unit. These quantitative approaches to the drainage basins are initiated by Horton (1945). It is proficiently important to conserve the limited and precarious natural resources vis land, water and soil which should be categorically studied at watershed level. Due to improper land, soil and water management practices, land and water resources getting degraded and eroded, water getting In this regard present study is profoundly concerned to characterization and prioritization of Man river basin .which is tributary of Bhima River in satara sangali and solapur district, Maharashtra. The prioritization of this sub basin has been carried out on the basis of Morphometric analysis for land reclamation and water conservation. Database has been prepared in ArcGIS 9.3 desktop application, ARCSWAT extension tool for sub basin demarcation and other analysis carried out for certain significant Morphometric parameters vis stream length, stream frequency, bifurcation ratio, Length of overland flow, perimeter of basin, drainage density etc. have been assesseds.

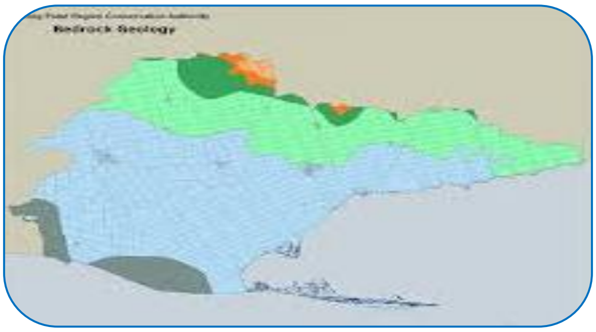
KEYWORDS: *Morphometric Analysis, Prioritization, water harvesting, water conservation.*

1. INTRODUCTION:

Geospatial technology has been used in the morphometric study of basin characteristic for assessment of precise accuracy and better results to decide soil erosion prevention, water conservation and sustainable development of agriculture.

Morphometric is a perfect unit for management of water resources and mitigation of the impact of natural disasters on attaining sustainable development. The Morphometric characteristics at the basin scale may contain important information regarding its formation and development because all hydrologic and geomorphic processes happen within the basin.

River basin prioritization is the ranking of different sub-basin of a watershed according to the order for water conservation measures. Morphometric analysis could be utilized for prioritization of sub-basin by concentrate distinctive linear and aerial parameters of the basin.



2. STUDY REGION

Man basin stretches from 16°59’56” North to 17°51’48’North latitudes and 74°22’30’’ East to 75°30’30’’ East longitudes. It is a part of Southern Maharashtra, lies in the district of Satara, Sangli and Solapur tahsils of Maharashtra State. The river Man originates at Kalasakarwadi (Kulakjai) nearby Shitamai hill. 25 km away from western side of Shikhar

Shingnapur, at the height of 917m from mean sea level. The Study region covers the total area of 4753 sq km.

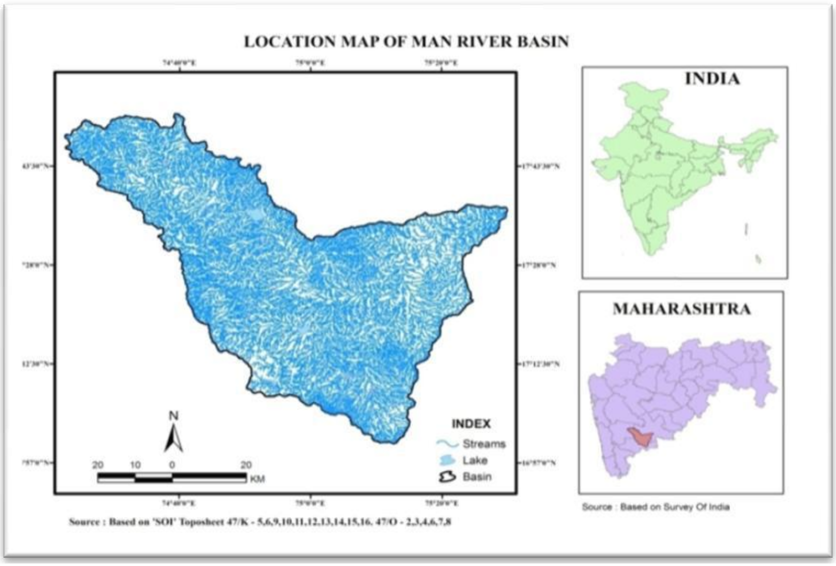


Fig:- 1

3. DATABASE & METHODOLOGY

The success of any applied research depends on the methodology which was adopted for systematic data collection, compilation and various type of analysis on scientific lines. This work was basically based on Morphometric analysis of man basin to the watershed development. At first, Man basin was delineated with the help of ARCSWAT extension tool in in ArcGIS 9.3 software. Inlet and outlet are defined to demarcate Man watershed. Sub-basins are also demarcated by using the same software to carry out the sub-basin thoughtful morphometric analysis. As reference and base map preparation, four SOI toposheets on 1:50000 scale in paper format were used. The digital data format of SRTM DEM with 90 m was used to meet the requirement of the area under study. The SOI toposheets (47K-5,6,9,10,11,12,13,14,15,16 and 47/O-2,3,4,6,7,8) and digital satellite data were geometrically rectified and georeferenced to world space coordinate system using digital image processing software (ERDAS IMAGINE ver: 9.3). Digitization work has been carried out for entire analysis of basin morphometry using GIS software (ArcGIS 9.3). The order was given to each stream by following Strahler (1964) stream ordering technique. Geoinformatics techniques and Topography Mission Digital Elevation Model (SRTM DEM) data were used for evaluation of morphometric parameters. The prioritization was carried out by assigning ranks to the individual indicators, and a compound value was calculated. River basins with highest compound value were of low priority while those with lowest compound value were of high priority.

4. MORPHOMETRIC PARAMETERS

Basic and Main Parameters are the kind of Morphometric parameters.

I) Basic Parameter: Basin area, Basin Perimeter, Length of the Basin, and Number of Streams are the basic Morphometric parameters used for the study.

a) Basin Area (A):

The drainage area has the great importance for the hydrologic design that generates the water of rainfall. The present study shows that the Man river basin has an area of 4753.25q km. Computed the eight subbasin area by using the ArcGIS-9.3 software.

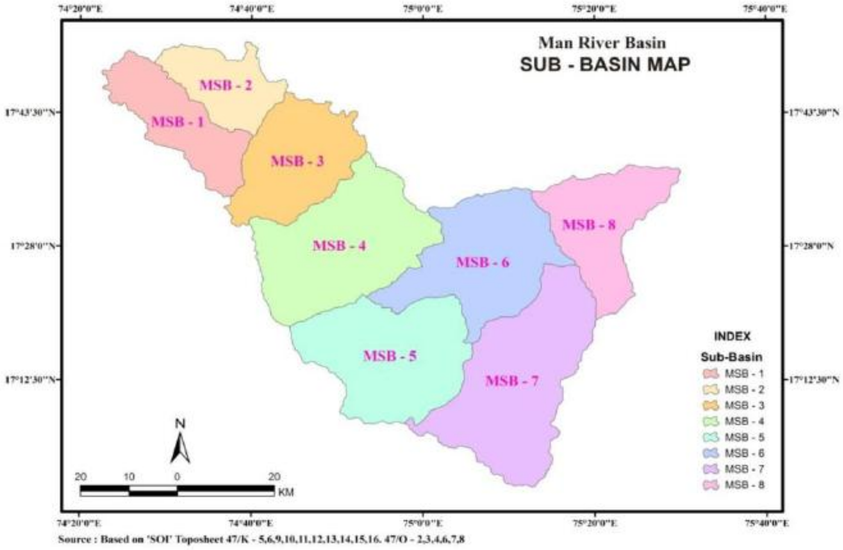

Man River Basin
SUB - BASIN MAP
MSB - 1
MSB - 2
MSB - 3
MSB - 4
MSB - 5
MSB - 6
MSB - 7
MSB - 8
INDEX
Sub-Basin
MSB - 1
MSB - 2
MSB - 3
MSB - 4
MSB - 5
MSB - 6
MSB - 7
MSB - 8
N
20 10 0 20
KM
74°20'0"E
74°40'0"E
75°0'0"E
75°20'0"E
75°40'0"E
17°43'30"N
17°28'0"N
17°12'30"N
Source : Based on 'SOI' Toposheet 47/K - 5,6,9,10,11,12,13,14,15,16. 47/O - 2,3,4,6,7,8

Fig.:- 2

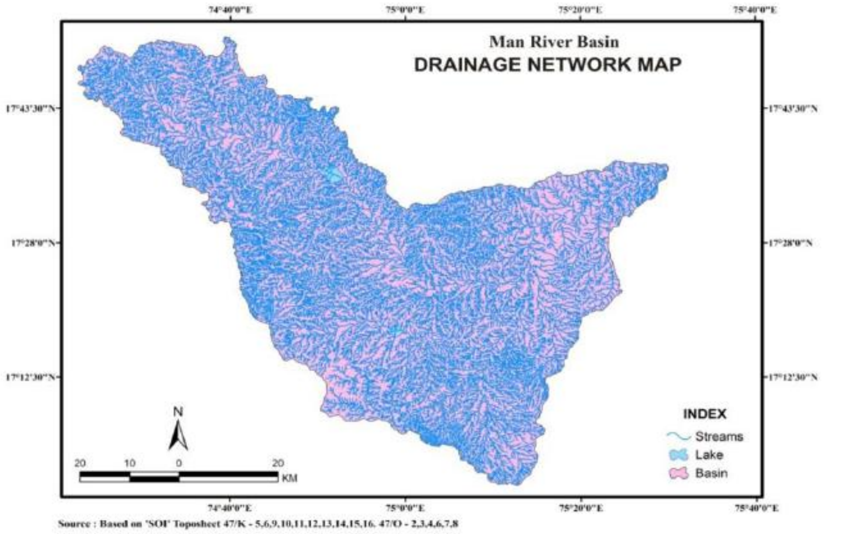

Man River Basin
DRAINAGE NETWORK MAP
INDEX
Streams
Lake
Basin
N
20 10 0 20
KM
74°40'0"E
75°0'0"E
75°20'0"E
75°40'0"E
17°43'30"N
17°28'0"N
17°12'30"N
Source : Based on 'SOI' Toposheet 47/K - 5,6,9,10,11,12,13,14,15,16. 47/O - 2,3,4,6,7,8

Fig:- 3

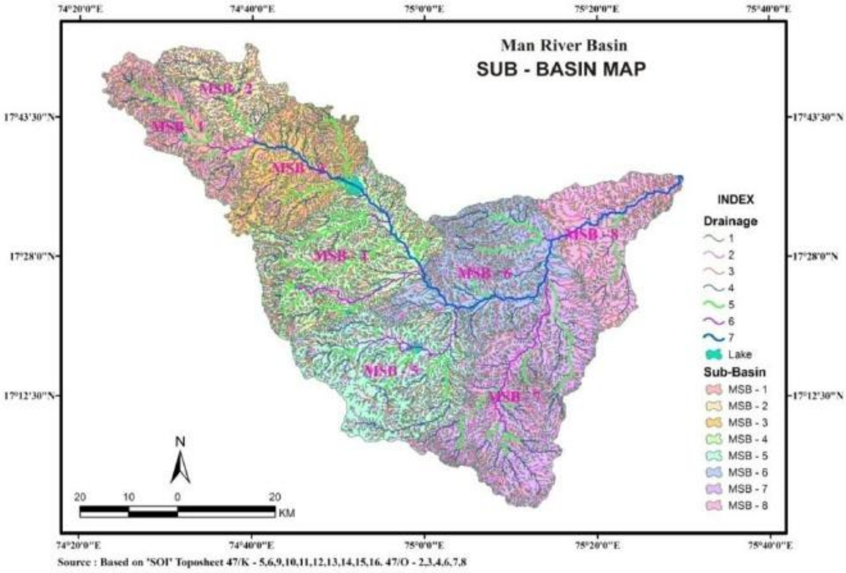


Fig:- 4

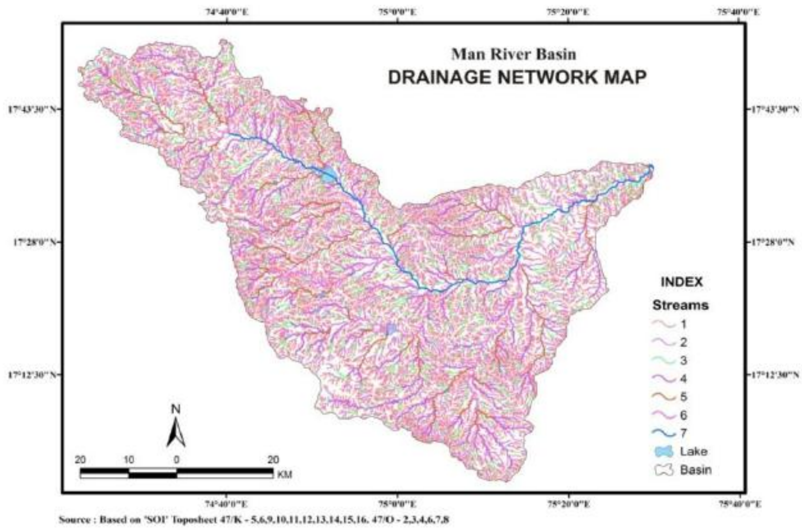


Fig:- 5

b) Basin Perimeter (P):

The area is totally enclosed with the outer boundary of the area is subdivided between the sub-basin that can be used size and shape of the basin. The basin area is 984.37 Km.in perimeter of man river basin.

c) Length of the Basin (Lb):

The length of the basin is measured from the main channel from the basin outlet up to its divide. The major shape parameters are generally counted with the help of Basin length as the main input parameter. It results in 121 Km of a length of man river basin.

d) Number of Streams (Ns):

The orderly stream segments are also considered as stream number(Horton 1945) it is the statement of Harton that the inverse geometric sequence with on order number is formed by the number of stream segment. In the study area, the total streams segments present are 18218 of which first order streams are having 14163 segments, a second order having 3145, the 3rd order having 695, the 4th order having 164, and 5th, 6th, the 7th order having 38, 10, three segments respectively.

Table:- 1. Man River Basin Is Basic Parameters.

Sr. No	Parameters	Area (Km^2)	Perimeter	Number of streams	Length of Basin (Km)
1	**MSB – 1**	389.13	110.21	1511	32.79
2	**MSB - 2**	297.39	87.82	1138	26.1
3	**MSB - 3**	510.19	110.86	1815	22.27
4	**MSB - 4**	805.91	137.47	3578	21.94
5	**MSB - 5**	724.96	122.89	2441	34.95
6	**MSB - 6**	670.91	146.03	2891	39
7	**MSB - 7**	885.16	155.75	3621	47.33
8	**MSB - 8**	469.61	113.35	1223	29.82
	full river	**4753.25**	**984.37**	**18218**	**121**

Source: Collected And Computed By The Researcher.

II) The Main Parameter:

Linear, Aerial and Relief aspects are the main parameters of Morphometric analysis

i) Bifurcation Ratio (Rb)

The bifurcation ratio denotes the ratio of stream segments. The index of relief and dissection comes under the area of bifurcation. Bifurcation ratio of different sub-basin have been calculated by Strahlar method by using the following formula

$$\mathbf{R_b = \frac{N_u}{N_u} + 1}$$

Where,

N_u = Total No. of Stream Segments of Order ‘u’
N_u + 1 = No. of segments of the next higher order

Bifurcation ratio of MSB-1 is varies from 3.5 to 4.42, MSB -2 is 1 to 5, MSB-3 is 3.2 to 5, MSB-4 is 2 to 4.58, MSB-5 is 3.25 to 8, MSB-6 is 1 to 11.5, MSB-7 is 3.94 to 7 and MSB-8 is 1 to 8. It is clearly noted that region wise variation of the small range is shown by bifurcation ratio except the area where the geological dominance has control. (Strahler, 1952).

Table:- 2. Man River Basin Bifurcation Ratio.

Stream order	MSB-1		MSB-2		MSB-3		MSB-4		MSB-5		MSB-6		MSB-7		MSB-8	
	Ns	Rb	Ns	Rb	Ns	Rb	Ns	Rb	Ns	Rb	Ns	Rb	Ns	Rb	Ns	Rb
1	1168	4.42	898	4.76	1433	4.84	2762	4.37	1866	4.3	2275	4.82	2795	4.33	966	4.51
2	264	4.4	188	4.7	296	4.63	632	4.58	434	4.09	472	4.07	645	4.67	214	6.48
3	60	4.29	40	5	64	4	138	4.06	106	4.08	116	5.04	138	3.94	33	4.12
4	14	3.5	8	4	16	3.2	34	3.78	26	3.25	23	11.5	35	5	8	8

5	4	4	2	2	5	5	9	4.5	8	8	2	1	7	7	1	1
6	1		1	1	1		2	2	1		2	2	1		1	
7							1				1					
Rbm		4.12		3.58		4.33		3.88		4.74		4.74		4.99		4.82

Source: Compiled and computed by the researcher.

ii) Mean bifurcation ratio (Rbm) –

The mean bifurcation ratio of all orders with respectively sub-basin varies from 3.58 to 4.99. In MSB-7, We find the greater value of mean bifurcation (4.99) suggesting the structural control and low permeability shows large variation in geological structure. Moreover, lower mean bifurcation ratio shows basins are geologically homogenous.

iii) Form Factor (Ff)

The ratio of the river basin area to the square of basin length is called the form factor. It is a dimensionless property and it is used as a quantitative expression of the shape of basin form. By using the following formula of Schumm (1956),

$$F_f = \frac{A}{Lb^2}$$

Where,

Ff = Farm Factor

A = Area of Basin in Sq. Km

Lb = Basin Length in Meter

The difference between form factor sub-basins is 0.36 to 053. The analyses reveal that the sub-basins are more or less elongated. The MBN-7 sub-basin is having the low value of Form factor, the analysis entire river basin value 0.32 form factor. It clearly marks that the basin will get flatter peak flow for a long time as elongated flood flows are easy to manage than that of the circular basin.

iv) Elongation Ratio (Re)

Schumm (1956) defined elongated ratio as the ratio of the diameter of the circle of the same area in the basin to the maximum basin length. Elongation ratio is calculated by using Miller (1953) formula. The Values of elongation ratio is grouped into three categories namely (a) circle (> 0.9), (b) Oval (0.9 to 0.8), (c) Less elongated (<0.7).

$$\mathrm{Re} = \frac{\left(\frac{4*A}{\Pi^{0.5}}\right)}{Lb}$$

Where,

R_e = Elongation Ratio

A = Area of the Basin (Sq.Km)

Π = Π Value i.e. 3.141

L_b = Basin Length in Meter

The elongation ratio of sub-watershed of Man river basin varies from 0.68 to 1.46. Subbasin of man MSB3 and MSB4 indicate circle elongation ratio, MSB2, MSB5, MSB6, MSB7 and MSB8 shows oval shape and MSB1indicate less elongated shape.

v) Circulatory Ratio (Rc)

Circularity ratio is the ratio of the basin area to the area of a circle having the same circumference perimeter as the basin, which is dimensionless and expresses the degree of circularity of the basin (Miller, 1953).

$$Rc = \frac{\left(\frac{4*A}{\Pi^{0.5}}\right)}{P^2}$$

Where,

R_c = Circulatory Ratio

Π = Π Value i.e. 3.141

A = Area of the Basin (Sq. km)

P^2 = Square of the perimeter, km

The length and the streams frequency are influenced a lot. The flow of the water, the use of land the surrounding atmosphere is the great influence on this structure. That the sub-area has long.The late mature stage of the topographical area is indicated by the MSB-5 circulatory region. The sub-basin area is filled with slope diversity, its relief and the structure of the land.

vi) Stream Frequency (Fs)

The total number of stream element according to the order of per unit area is called stream frequency. The formula used by Horton has been applied for the calculation of Stream Frequency.

$$F_s = \frac{N_u}{A}$$

Where,

F_s = Stream Frequency

N_u = Total No. of streams of all orders

A = Area of the Basin (Sq. Km)

Different types of stream frequencies observed in basin and sub-basin area. If the number of stream remains high, it is the mark of high stream frequency. The maximum stream frequency indicates a large number of streams availability. MSB-4 sub-basin has maximum stream frequency that is 4.44 Km/km2. The minimum stream density is 2.6 km/km^2 which are in MSB-8 sub-basin.

vii) Drainage Density (Dd)

Horton coined the idea of drainage density. The close area between the channels is called drainage density. To measures, the drainage density following formula has been used.

$$D_d = \frac{L_u}{A}$$

Where,

D_d = Drainage Density

L_u = Total Stream Length of all Orders

A = Area of the Basin (Sq.Km)

The time travel that needs the permanent element to have its existence has a significant role in drainage density. In the study region, drainage density varies from 2.21 to 2.97 (table no 3.4). It is observed that MSB-1, MSB-3 MSB-4, MSB-6 and MSB-7 sub-basins have high drainage density while MSB-5 and MSB-2 are observed in medium density category. MSB-8 is observed in low drainage density category.

viii) Compactness coefficient:

The compactness coefficient of a sub-basin is the ratio of the perimeter of sub-basin to the circumference of circular area (Gravelius, 1914), which equals the area of the sub-basin. Using the following formula,

$$C_c = 0.284 * P * A * 0.5(6.21)$$

Where,

Cc = Compactness Ratio

A = Area of Basin in Sq.Km

P = Basin Perimeter in Km

Though Cc is independent of the size of sub-basin and dependent only on the slope. If the basin was a perfect circle, then Cc would be equal to 1 (Gravelius, 1914). The computed compactness coefficient of the Man river -basin is 1.44.

5. Sub-Basin Prioritization for Water Conversation and Management

Sub-basin wise river basin prioritization is nothing but a plan of action for the conservation of natural resources viz. water and soil for their optimal utilization and socio-economic development of the people in the basin area. The water resource and land management are controlled by the drainage system and the catchment and sub-catchment area (Moore et.al., 1994) Catchments and watersheds are considered in the purpose of administration for the conservation of these resources. Micro-level prioritization requires knowledge of the basin and intensity of the problem. Advanced techniques viz. GIS provide the reliable, accurate and spatiotemporal information of the area. Degraded sub-basin should be given first priority for conservation and reclamation process and vice versa. Present topic is being focused on prioritization of sub-basins of Man river basin for water conservation and management.

sub-basin prioritization has assessed the conservation of water in accordance with areal, linear and relief aspects. The linear aspects one correlated with water conversation and management. Hence, the parameter of the higher value indicates the possibility of water conversation. The water conservation and management are the tools in which the ratio of bifurcation frequency of stream and the value of drainage density found susceptible in general for water conversation and management.

Table: - 3. Man River Basin Morphometric Final Prioritization

Final prioritization of Man river basin									
Sub-basin	**Mean Rb**	**Dd**	**Fs**	**Ff**	**Rc**	**Cc**	**Re**	**Compound parameter**	**Final priority**
MSB-1	4.12	2.84	3.88	0.36	0.4	1.57	0.68	1.98	1
MSB-2	3.58	2.75	3.83	0.44	0.48	1.43	0.75	1.9	1
MSB-3	4.33	2.86	3.56	1.03	0.52	1.38	1.14	2.11	2
MSB-4	3.88	2.97	4.44	1.67	0.54	1.36	1.46	2.34	3
MSB-5	4.74	2.52	3.37	0.59	0.6	1.28	0.87	2	1
MSB-6	4.74	2.84	4.31	0.44	0.4	1.59	0.75	2.15	2
MSB-7	4.99	2.79	4.09	0.4	0.46	1.47	0.71	2.13	2
MSB-8	4.82	2.21	2.6	0.53	0.46	1.47	0.82	1.85	1

Source: GIS Analysis Completed By the Researcher

Table: - 4. Final Prioritization Classes Of Man River Basin.

Sr. No	Priority value	Priority	Name Of Sub- Basin	Remark
1	< 2.00	High Priority	MSB-8, MSB-2, MSB-1	Better water conservation region
2	2.1-2.15	Medium Priority	MSB-5, MSB-3, MSB-7, MSB-6	Medium water conservation region
3	> 2.15	Low Priority	MSB-4	Low water conservation region

Source: GIS Analysis Completed By the Researcher

Man River Basin Morphometric Final Prioritization

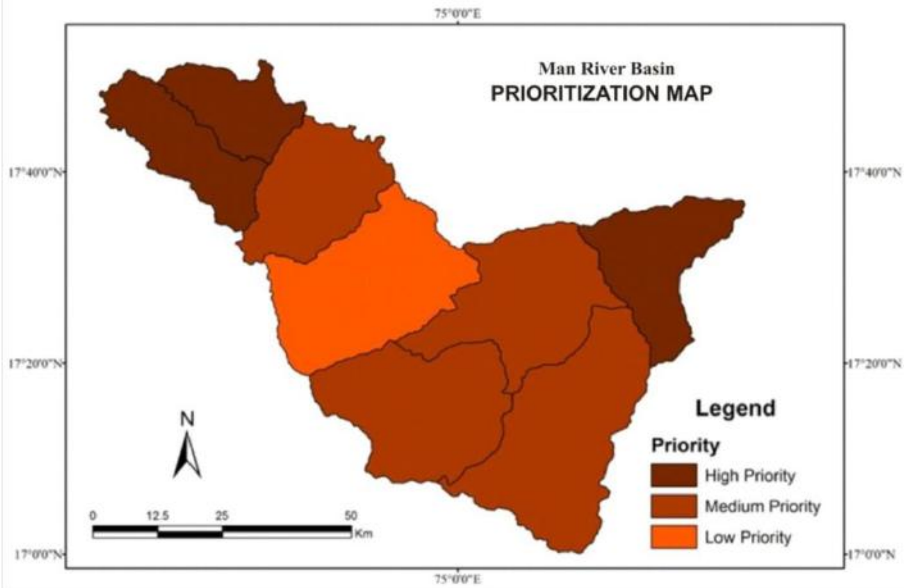


Fig: - 6

6. RESULT AND DISCUSSION

The Morphometric parameters i.e., bifurcation ratio (Rb), basin shape (Bs) drainage density (D), stream frequency (Fs), form factor (Rf), circularity ratio (Rc), drainage texture (Rt), and elongation ratio are called as erosion risk assessment parameters. It is generally used in order of sub-basin. There is the direct attainment of linear aspect with soil erosion and Water conservation hence, the parameter of the higher value indicates the possibility of soil erosion and water conservation sites. The sub-basins of the higher value of drainage density, stream frequency and bifurcation ratio are much more susceptible for soil erosion. Therefore, the higher value is rated as rank first; the second highest value is rated as rank second and so on. Shape parameters like elongation ratio, form factor and basin shape have the inverse relationship with soil erosion and water conservation. The sub-basin having the least rating values was assigned second priority and so on. The sub-basin which got the highest Compound parameter values sub basin were then categorized into three classes as high (< **2.00**), medium (**2.1 – 2.15**), and low (> **2.15**), priority on the basis of the range of Compound parameter values. MSB -1, MSB -2, and MSB -8 got Better water conservation region, MSB -3, MSB -5, MSB -6, MSB -7 falls in medium priority Medium water conservation region and MSB -4 in the low priority category were Low water conservation region.

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