RESEARCH ARTICLE OPEN ACCESS

Prioritization of Catchments Area of MPKV Central Campus (West) For Soil and Water Conservation Measures Using Morphological Characteristics

N. R. Kanawade* and S. N. Umare**
** Ex M. Tech (SWCE) student, Dr. ASCAE, MPKV, Rahuri.*
*** Ex M. Tech, (SWE) student UAS, Raichur, Karnataka*

ABSTRACT: A study has been conducted to identify priority catchment for water conservation measures in MPKV Central Campus (west), Rahuri using Remote Sensing and Geographical Information System (RS-GIS). The Cartosat-2 DEM of the area were used. The thematic maps such as Drainage map and Catchment map were prepared. Six catchments were identified as per their outlet location. Morphological characteristics such as drainage density, stream frequency, bifurcation ratio, drainage texture, length of overland flow, elongation ratio, compactness coefficient, circularity ratio, and basin shape and form factor were determined in ArcGIS 10.2 environment. Marks were assigned as per their relation with erosive potential and compound values were computed. As per morphometric analysis compound value shows high to low priority for catchments A, D, E, B, C and F with compound value (C_p) as 3.88, 3.33, 2.88, 2.11, 2.11 and 2.00 respectively.

I. INTRODUCTION

India is an agrarian country, water and soil resources are limited but increasing demand. Continuous failure of monsoon, increasing demand and over exploitation of these resources leads to water and soil degradation. This problem could be sorted out to certain extent by constructing water and soil conservation structures. Water and soil conservation structures are highly location specific. Delineation of potential sites for conservation structures is governed by several factors such as, morphology, village location, permeability, drainage, slope and terrain etc. Construction of water and soil conservation structures at appropriate location is most important. In the present study, priority catchment for soil and water conservation measures have been analysed by using Remote sensing and GIS techniques. A study has been conducted to identify priority catchment for water conservation measures in MPKV Central Campus (west), Rahuri Taluka of Ahmednagar district of Maharashtra state.

II. METHODOLOGY

2.1 Bifurcation ratio (R_b)

It is related to the branching pattern of the drainage network. It is expressed in terms of the following equation.

$$R_b = \frac{N_u}{N_{u+1}}$$

Where,

N_u = Number of streams of the given order
N_{u+1} = Number of streams of the next higher order

The lower bifurcation ratio values are characteristic of the watersheds, which have suffered less structural disturbances and the drainage pattern has not been distorted. In such areas because of the structural disturbances the R_b values range between 3.0 and 5.0 (Sujata, 2012). The bifurcation ratio is indicative of shape of the basin also. An elongated basin is likely to have a high R_b, whereas a circular is likely to have a low R_b values.

2.2 Drainage density (D_d)

The drainage density is considered as an important measure of the total length of the streams available to dispose runoff per unit area, indicating the degree of abstraction. Watersheds which are having high values of drainage density indicates well developed network and torrential runoff resulting intense floods, while low values of drainage density indicates moderate and high permeability of the terrain (Strahler, 1964). The watersheds can be grouped into four categories on the basis of drainage density (Malik et al., 2011) as, low (below 2.0 km/km^2), moderate (2.0-2.5 km /km^2), high (2.5-3.0 km /km^2) and very high (Above 3.0 km km^{-2}). Drainage density is derived as the ratio of total stream segment length cumulated for all orders to the drainage area (A) expressed in km/ km^2.

$$D_d = \frac{\sum_{i=1}^{u} L_u \times N_u}{A}$$

Where,

D_d= Drainage density (km km^{-2})
L_u = Length of stream order (km)
N_u = Number of streams
A = Area of watershed (km^2)

2.3 Stream frequency (F)

It is another measure to describe the capacity of stream network to carry the discharge and is derived as number of stream segments per unit area. It can be expressed in number per square kilometre. High value of stream frequency for the catchment indicates greater erosion hazard in the area and vice versa.

$$F = \sum_{i=1}^{u} \frac{N_u}{A}$$

2.4 Circularity ratio (R_c)

It is measured as dimensionless ratio of basin area (A) to the area of a circle (A_c) whose circumference is the same as that of the basin perimeter (P_b)

$$R_c = A / A_c$$

The value of circulatory ratio varies from zero (in a line) to one (in a circle). Higher the Values of circulatory ratio, more circular will be the shape of the basin and vice-versa.

2.5 Elongation ratio (R_e)

Elongation ratio is the ratio of the diameter of a circle which has same area as the basin to the maximum length of the basin.

$R_e = D / L_b$

Where,

D = Diameter of circle equivalent to area of the watershed

L_b = Length of the basin (km)

The value of elongation ratio varies from zero (in highly elongated shape) to unity (in circular shape). Thus, higher the values of elongation ratio, more circular will be the shape of the basin.

2.6 Drainage texture (D_t)

Drainage texture is one of the important concept of geomorphology which means that the relative spacing of drainage lines. Drainage texture is on the underlying lithology, infiltration capacity and relief aspect of the terrain. Drainage texture is total number of stream segments of all orders per perimeter of that area (Horton, 1945). Drainage texture has classified into five different textures i.e. very coarse (<2), coarse (2 to 4), moderate (4 to 6), fine (6 to 8) and very fine (>8) (Smith, 1950).

$D_t = Nu / P$

Where,

D_t = Drainage texture, km^{-1}

Nu = Total number of stream segments of all orders

P = Perimeter of the watershed, km

2.7 Compactness coefficient (C_c)

It is measured as the ratio of the perimeter of watershed (P_b) to the circumference (P'_b) of a circle equivalent to the area of the watershed.

$$C_c = \frac{P_b}{P'_b} \quad \text{Hence} \quad C_c = \frac{P_b}{2\sqrt{\pi A}}$$

Where

A = Area of watershed (km^2)

P_b= Perimeter of the basin (km)

2.8 Length of overland flow (L_g)

Length of overland flow is defined as the length of flow path, projected to the horizontal, non-channel flow from point on the drainage divide to a point on the adjacent stream channel.

$L_g = 1/ 2D_d$

Where

D_d= Drainage density (km / km^2)

The morphometric parameters i.e., bifurcation ratio, basin shape, compactness coefficient, drainage density, stream frequency, drainage texture, length of overland flow, form factor, circularity ratio, and elongation ratio are also termed as erosion risk assessment parameters and have been used for prioritizing sub-watersheds (Biswas et al., 1999). The linear parameters such as drainage density, stream frequency, bifurcation ratio, drainage texture, length of overland flow have a direct relationship with erosive potential, higher the value, more is the erosive potential. Hence for prioritization of catchments, the highest value of linear parameters should assigned weightage as 5, second highest value should rate as 4 and so on, and the least value should assigned minimum weightage. Shape parameters such as elongation ratio, compactness coefficient, circularity ratio, basin shape and form factor have an inverse relationship with erosive potential (Nookaratnam et al., 2005), lower the value, more is the erosive potential. Thus the lowest value of shape parameters should assigned weightage as 5, next lower value should assigned weightage as 4 and so on Hence, the weightage of the catchments has been determined by assigning the highest priority/ weightage based on highest value in case of linear parameters and lowest value in case of shape parameters. After the ranking has been done based on every single parameter, ranking values for all the linear and shape parameters of each catchment were added up for each of the six catchments to arrive at compound value (Cp). Based on average value of these parameters, the catchments having the highest point value was assigned highest priority, next lower value was assigned second priority and so on. The sub-watershed which got the lowest C_p value was assigned last priority

III. RESULTS

3.1 Generation of thematic maps

Using ArcGIS 10.2 version, various thematic maps were generated such as base map, drainage map, contour map, digital elevation model, slope map, flow accumulation map, as a spatial database.

3.1.1 Base map

The base map is represented by villages, roads, streets, canal, Places, etc. The base map was prepared using SoI top sheet and ground truth data in ArcGIS10.2 software.

3.1.2 Digital Elevation Model (DEM)

The digital elevation model downloaded from website bhuvan.nrsc.gov.in. The DEM was reclassified into two classes namely high (570 m) and low (510 m) and used to precisely delineate the physiographic features.

3.1.3 Contour map

Contour map was prepared from Digital Elevation Model of study area with 5 m contour interval. The corresponding contour intervals were recorded in the attribute table. The total length of contours was 184.74 km.

3.1.4 Slope map

The slope map was derived using the DEM for the study area. The slope map was classified into six classes according to IMSD guidelines. About 10.47 % of the total study area fell into slope class 1 (< 1 %) while 30.03 % of the study area having a slope class-2 fell in the range of (1 – 3 %). In similar way slope class-3 (3-5 %), class-4 (5-10%), class-5 (10-15%) and class-6(15-29.92

Table No. 1 Aerial aspects of catchment area.

Sr. No	Aerial aspects	Catchments					
		A	B	C	D	E	F
	Parameters having direct relationship with erosive potential						
1.	Drainage density (Dd), km km-2	3.15	1.69	2.00	2.41	2.51	2.49
2.	Stream frequency (F), Nos km-2	7.36	5.98	4.92	7.58	5.93	4.28
3.	Length of overland flow (Lg), km	0.15	0.29	0.25	0.20	0.20	0.20
4.	Drainage texture (Dt)	4.37	1.09	1.48	1.99	1.78	0.93
5.	Bifurcation Ratio	2.77	3.00	2.15	2.28	1.91	3.00
	Parameters having inverse relationship with erosive potential						
1.	Circularity ratio (Rc)	0.53	0.63	0.70	0.47	0.76	0.64
2.	Elongation ratio (Re)	0.74	0.88	0.83	0.82	0.84	0.86
3.	Compactness coefficient (Cc)	1.37	1.26	1.19	1.46	1.14	1.25
4.	Form factor (Rf)	0.43	0.61	0.54	0.53	0.54	0.58

Table No. 2 Assign marks of six catchments of MPKV central campus (west)

Assign marks of six catchments of MPKV central campus (west)							
Sr. No	Priority	Catchments					
		A	B	C	D	E	F
	Assigned weightage						
1.	First Priority	20	10	0	10	10	5
2.	Second Priority	12	0	8	12	4	0
3.	Third Priority	0	6	6	6	6	9
4.	Fourth Priority	2	2	2	2	6	2
5.	Fifth Priority	1	1	3	0	0	2
	Total	35	19	19	30	26	18
	Compound value (Cp)	**3.88**	**2.11**	**2.11**	**3.33**	**2.88**	**2.00**
	Priority	**1st**	**4th**	**5th**	**2nd**	**3rd**	**6th**

IV. CONCLUSION

Aspermorphometricanalysis compound value shows high to low priority for catchments A, D, E, B, C and F with compound value (C_p) as 3.88, 3.33, 2.88, 2.11, 2.11 and 2.00 respectively hence catchment A got first priority and then D, E, B, C, F as second, third, fourth, fifth and sixth respectively

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