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GIS BASED PRIORITIZATION OF SUBBASINS BASED ON MORPHOMETRIC ANALYSIS FOR CONSERVATION PLANNING: A CASE STUDY OF TAVARJA LAKE CATCHMENT IN GODAVARI RIVER DRAINAGE BASIN OF MAHARASHTRA,INDIA.

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ABSTRACT

Morphometric analysis is important in any hydrological investigation and it is useful in development and management of drainage basin. A systematic morphometric analysis helps to understand the liner, areal and relief aspects of the drainage basin. In the present study I"ve focused mostly on the use of morphometric indices for prioritization of watershed for conservation and management. The present study area is Tavarja reservoir catchment located in Latur district of Maharashtra. It is part of river Godavari covering geographical area of 250.52 Km².Overall 72 micro watershed have been taken up for prioritization of sub watersheds for conservation planning. The drainage map of the study area is generated through SOI toposheet (1: 50000). Stream characteristics includes number and length of streams of different orders, drainage density, drainage frequency, bifurcation ratio, stream length ratio, basin relief, drainage density, texture ratio, circularity ratio, elongation ratio etc. The ranks obtained from morphometric parameters were compared to ascertain the validity of ranks. The micro-watersheds were grouped into very severe, severe and slight erosion zones.

Keywords: Morphometric analysis, sub-watershed prioritization, conservation planning.

1. Introduction

A watershed is an ideal geomorphic unit for management and planning to achieve sustainable development of the region. The significant factor for the planning and development of a watershed are its physiography, drainage, soil, landuse land cover (LULC), geology and available water resources. Morphometric analysis could be used for prioritization of micro-watershed. [1] A watershed has homogeneity of geomorphic sculpturing processes. Watersheds are natural geohydrologic units that are most appropriate for appraisal of available natural resources and subsequent planning and developmental initiative.

The quantitative analysis of morphometric parameters is found to be immense utility in watershed priorization for soil and water conservation and natural resource management at micro level [Strahler, 1964].[2] A systematic morphometric analysis helps to understand linear, areal and relief aspects of the drainage basin. It also demonstrates the priorization of sub-watershed for conservation and management [Nag and Chakraborty, 2003]. [3]

Land can be treated on **"Top to bottom"** or **"ridge to valley"** approach. A land laying in a valley can not be improved if the land at upper reaches is not treated. Treatment of land in a scattered manner will not lead to watershed development.

While undertaking watershed conservation work, it is not practical to consider the whole area at once. Thus the whole watershed is devided into smaller unites such as sub watersheds or micro-watersheds, by considering its drainage system. [4]

GIS technique can be used for detailed morphometric analysis and watershed prioritization studies. The input parameters required for morphometric analysis and watershed prioritization studies can be generated by GIS. The use of GIS can not only make this task relatively easy but accurate as well.GIS procedure for morphometric analysis and prioritization of watersheds. M.A. Khan et al. (2001). [5] In the present study, morphometric analysis and prioritization of sub-watersheds are carried out for 71 sub watersheds of Tavarja dam catchment of Latur district of Maharashtra.

1.1 Aims and Objectives of the present study

1. The main objective of the present study is to analyze the morphometric parameters of the study area for the prioritization of sub watersheds.
2. To suggest the conservation planning using Morphometry.
3. To generate action plans in the micro watershed for land and water resource improvement to increase the sustainability.

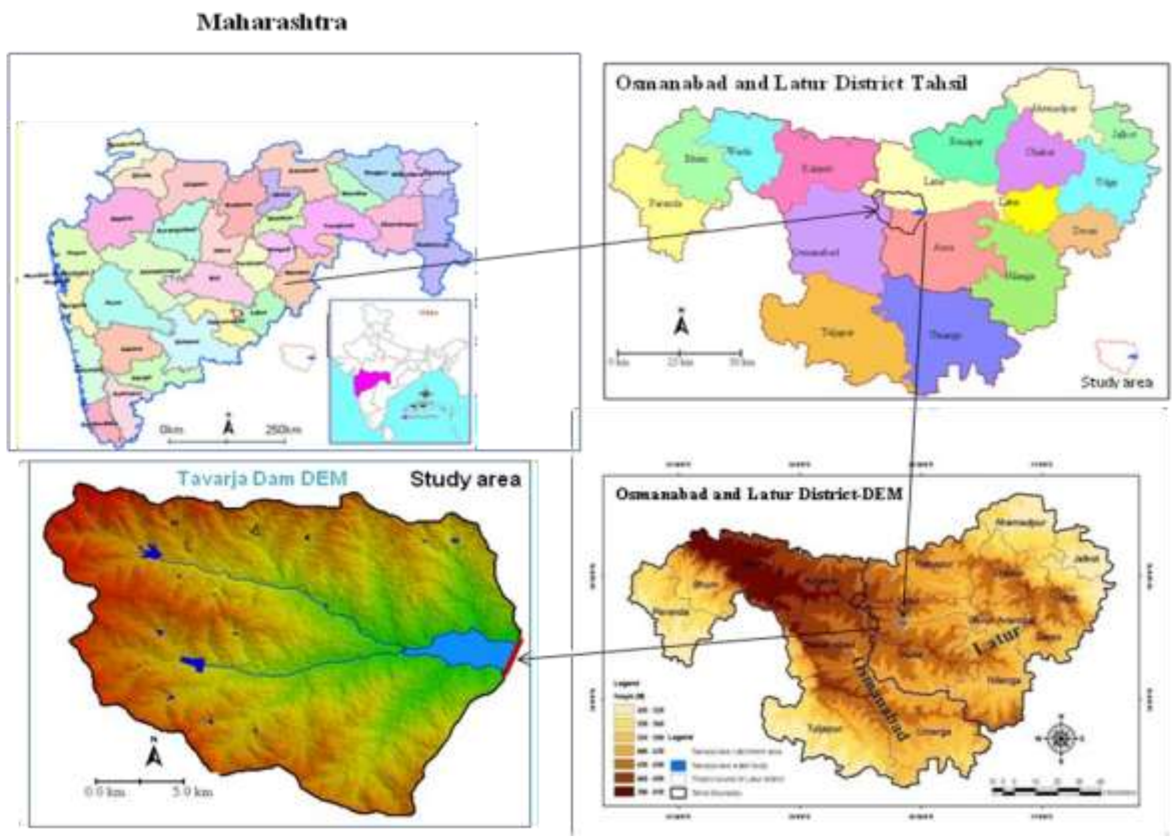
2. Geographical Setup of the study area

2.1. Location

The Tavarja dam catchment extends between 18º23"00" North latitude to 76º31"00" North latitudes and 76º14"00" East longitude to 76º31"00" East longitudes. It is a 6th order channel basin of study area. It is one of the watershed of river Godavari. It is a right hand tributary of river Manjara. It lies part of the Latur and Ausa tahsils of Latur district and Osmanabad tahsils of Osmanabad district. It is roughly elongated in shape and most of its area comes under agricultural land. Location of study area is a part of draught prone region of Maharashtra.

The study area attains maximum elevation of 703mts at NW side of the watershed and minimum of 610mts above MSL.The total geographical area of the Tavarja reservoir catchment is 250.52 km². According to Mutreja Tavarja dam catchment can be classified as macro watershed (area 200 to 500 Km²) .The location map of the study area is shown in fig. No.1

LOCATION MAP OF THE STUDY AREA



2.2. Geology

The entire study area is occupied by basic flow of Deccan traps considered to be upper cretaceous to lower Eocene age. The lava flow has been broadly classified into „aa" flows.

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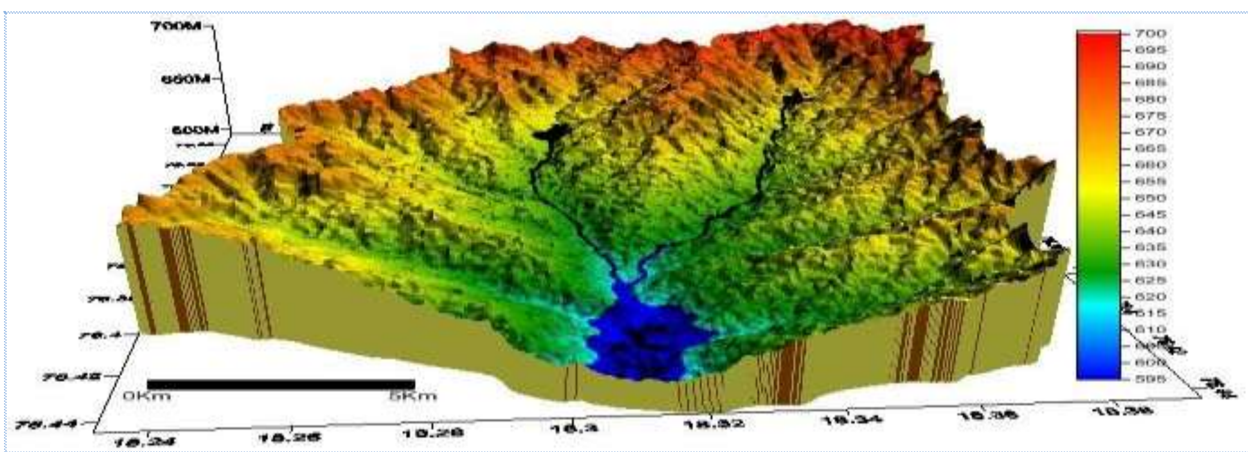
Though this part lies at peninsular shield of India and it is considered as stable continental region because it is seismically stable. Therefore it is known as Deccan shield of India; but the 1993 Latur earthquake indicates the seismic vulnerability of the study area.

The Deccan basalt flows occurring in the study area are compact basalt. All the flows are of „aa" type and their exposed thickness varies from 5 to 50 mts. The formation of Deccan traps took place at the close of Mesozoic era. The Red or brown bole bed at the bottom of flow is persistent and varies in thickness from 0.2 mts to 1.5 mts. [6]

2.3. Physiography

The Maharashtra state is devided into Western Konkan coast, Western Ghats (North Sahyadri) and North Deccan plateau (Maharashtra plateau). The total study area is a part of Balaghat plateau. It is located at front part of Balaghat range. Waterdevide region is characterised by waste land, because waterdevide is characterised by sub undulated hill ranges of Balaghat range. It‟s slope is moderate slope as well as depth of the soil is very less as compare to middle and downward of the watershed. Therefore the slope direction lies from West to East in general.

Map no.2. Tavarja Dam Catchment-3D Views



2.4. Climate

The study area falls in the tropical climatic region. It lies in drought prone region of Maharashtra. Rainfall ranges in between 80 to 100 cm. While mean maximum

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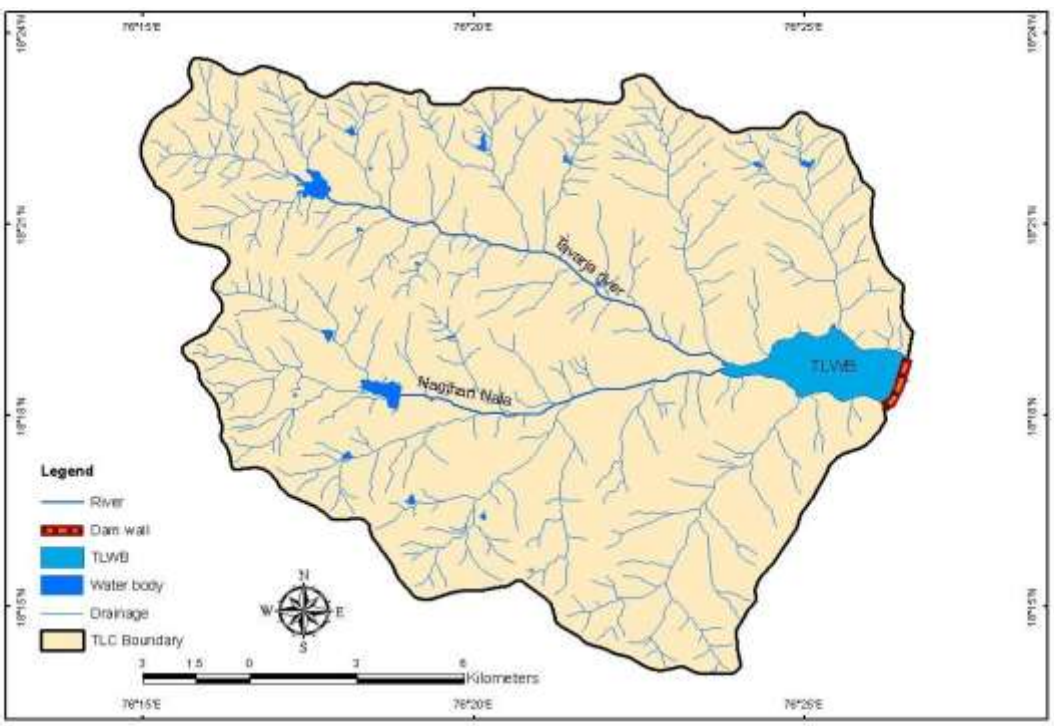
temperature 45 ºC and men minimum temperature experiences 15ºC. Annual evaporation rate of the study area lies in between 6.60 to 7. 00 mm/year.

2.5. Drainage Pattern

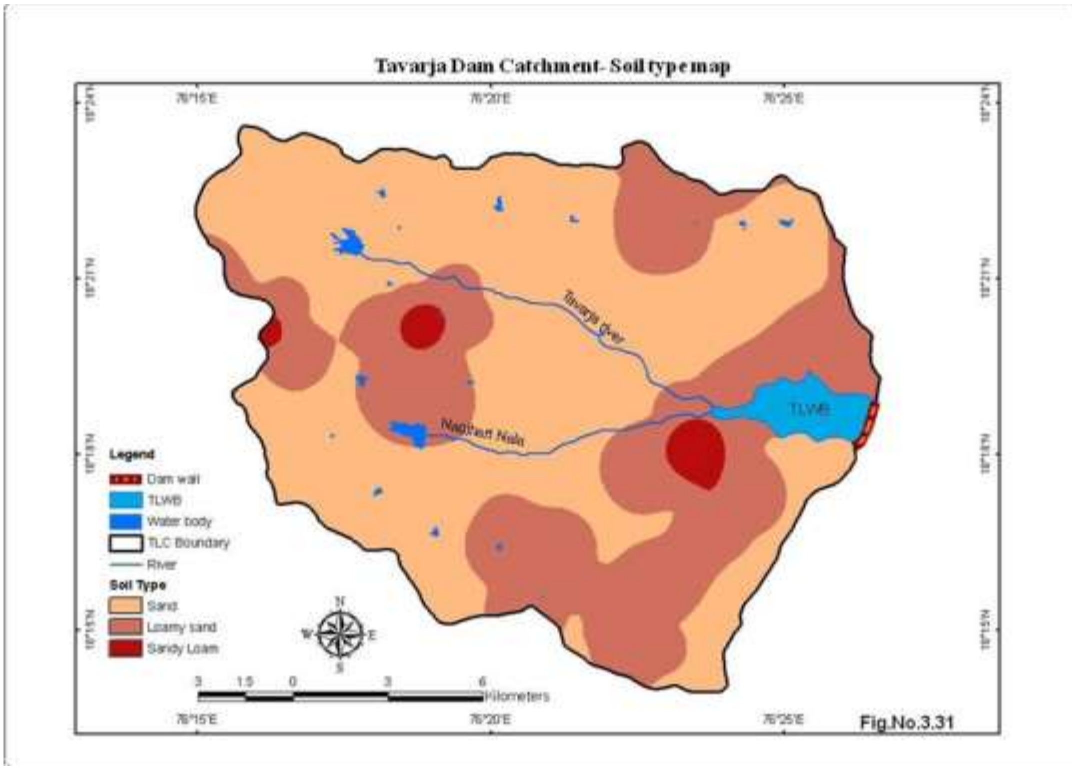
The study area exhibits dendritic drainage pattern. The overall drainage system is well developed and sub channels are non-perennial in nature. Tavarja dam is the largest reservoirs existing in this region other major streams are mainly controlled by the small reservoir. In short the drainage basin of the study area is dense and well developed. It is a 6th order channel basin. During summer season small amount of water is available only in the downstream portion of the main stream.

Map No.3 Tavarja Dam Catchment- Drainage pattern



2.6. Soils

The colour of the soil varies from light black to dark black. The loamy sand is most common soil type in this area. Along hillside slopes soil is less compact in comparison with the agricultural soil. Deep black color soil is also observed in the study area and is under intensive agriculture. Due to litho-climatic structure, the soil cover in most parts has been steadily eroded away over the years and siltation process occurs at dam site**. Fig No.4**



2.7. Natural Vegetation

The study area comes under the agricultural region of draught prone region of Maharashtra. The natural vegetation types are the combined result of climate, soil, topography and biotic factors. The most important is climatic factors which influences the vegetation cover and type as whole. The trees seen in this region are thorny bushes and Babul (acacia) and in the plains are mango, neem etc. The area under forest is very low, which is about 5.23% out of the total geographical area. In short the total geographical area is characterised by scattered type of dry deciduous forest types. Most of the trees are located along the streams channels of Tavarja river.

2.8. Socio-Economic Aspects

The data for villages in the study area is summarized in the following table No.1

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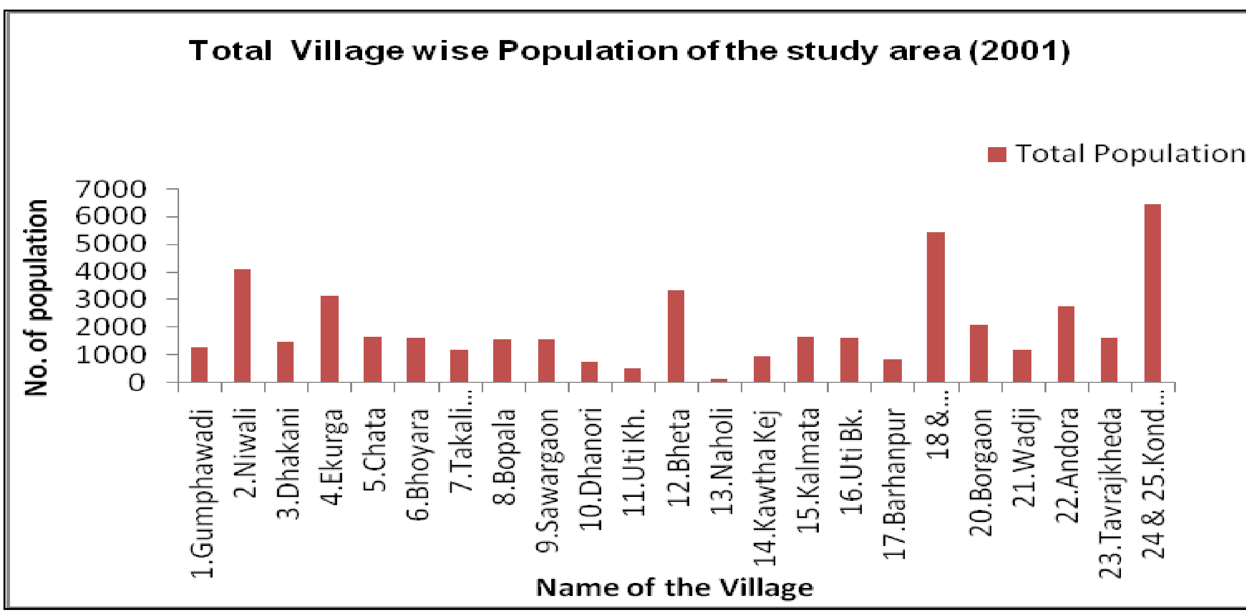
Table-No.1. Tavarja dam: Demographic data district census handbook-2001

Sr.No.	Name of the village	No. of households	Total Pop^n	Total working Pop^n
1.	Gumphawadi	252	1231	663
2.	Niwali	799	4076	1946
3.	Dhakni	271	1421	737
4.	Ekurga	589	3097	1315
5.	Chata	292	1630	833
6.	Bhoyra	330	1573	808
7.	Takli (Shiradhon)	272	1161	625
8.	Bopla	351	1546	703
9.	Savargaon	277	1525	616
10.	Dhanori	121	720	319
11.	Utti- Khurd	85	474	229
12.	Bheta	610	3302	1504
13.	Naholi	20	113	56
14.	Kavtha kej	194	904	449
15.	Kalmatha	279	1617	777
16.	Utti Bk	287	1509	796
17.	Barhanpur	159	822	403
18.	Bhada & Waswadi	1007	5439	2377
19.	Borgaon	415	2062	981
20.	Wadji	212	1127	562
21.	Andhora	555	2711	1183
22.	Tavarjkheda	340	1567	626
23.	Kond & Kondwadi	1354	6434	2650
Total		**9071**	**46141**	**21158**

(Source: District Census Handbook-2001)

Fig. No. 5.



3. Methodology

3.1. Data Acquisition

Data for the present study is acquired from the following sources:

1. **Toposheet:** S.O.I. Topographical map on 1:50000 scale was used as base map. The study area falls in survey of India toposheet no – 56 B/7, 56 B/8, 56 B/11 & 56 B/12. It was published in 1972.
2. **Google Earth Image:** The image was acquired from Google Earth Programme 2012.
3. **Soil data:** The data was obtained from soil samples collected during field work.
4. **GPS survey:** The entire watershed area was tracked with the help of GPS. The soil sample points were tracked by using GPS.
5. **GSI maps:** The Geological Survey of India maps for the Latur and Osmanabad districts Selected from GSI maps, Pune.

3.2. Mapping

1. Base map Preparation: This was done using Toposheet no. 56 B/7, 56 B/8, 56 B/11 & 56 B/12 (1:50000) covering the study area. The data from topographical was processed in surfers and Global mapper (version 11.00 and 12.00) softwares. Rectification of base map was done in Global mapper software.

2. Digitization of Layers: The contours, streams etc. layers were digitized from the toposheet in Global mapper software and these layers used for further analysis.

3. Preparation of Thematic maps: Various thematic maps have been prepared in the surfer software by the technique of spatial interpolation.

4. Extraction of Micro- watershed: This was done by using Global mapper version 12.00 software and Arc-GIS software.

5. Extraction of Morphometric Parameters: The morphometric parameters are calculated based on the formulas suggested by (Horton, 1945), (Strahler, 1964), (Schumm, 1956), (Miller, 1953) and (Nookaratam et.al.2005) given in result section of the article.

Morphometric parameters like stream order, stream length, bifurcation ratio, relief ratio etc. Hence, the ranking of sub watershed has been determined by assigning the highest priority/rank based on highest value incase of linear parameters and lowest value incase of shape parameters (table).After the ranking has been done based on every single parameter, the ranking values for all the linear and shape parameters of each sub-watershed were added up for each of the range sub watersheds to arrive at compound value.

Further based on Karnataka state Remote Sensing Application Centre (KSRSAC) classification, watershed is again classified into sub watershed; Macro watershed (50-500 Km^2), Meso watershed (30-50 Km^2), Mini watershed (10-30 Km^2), and micro-watershed (3-10 Km^2).Hence Tavarja reservoir catchment is covering geographical area of about 250.52 Km^2. However watershed classification is done based on drainage pattern and ridge line.

Table No.2. Methods of calculating morphometric parameters

Aspect	Morphometric parameters	Methods	References
LINEAR	Stream order (u)	Hierarchical order	Strahler,1964
	Stream length (lu)	Length of the stream	Hortan,1945
	Mean stream length (Lsm)	Lsm=Lu/Nu where,Lu= stream length of order „U" , Nu=Total number of stream segments of order „U"	Hortan,1945
	Stream length ratio (Rl)	Rl=Lu/Lu-1; where, Nu=Total stream length of order „U" Lu-1= Stream length of next lower order	Horton,1945
	Bifurcation ratio (Rb)	Rb=Nu/Nu+1; where Nu= Total number of stream segments of order „u";Nu+1= Number of segments of next higher order	Schumn,1956
RELIEF	Basin relief (Bh)	Vertical distance between the lowest and highest points of watershed	Schumn,1956
	Relief ratio (Rh)	Rh=Bh/Lb; where, Bh= Basin relief; Lb= basin length	Schumn,1956
	Ruggedness number (Rn)	Rn= Bh× Dd Where, L= Total length of streams A= Area of watershed	Schumn,1956

Conti……

(Source: Morphometric analysis for micro-watershed prioritization V.B. Rekha et.el.)

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Aspect	Morphometric parameters	Methods	References
ARIAL	Drainage density (Dd)	Dd=L/A where, L= total length of streams; A= Area of watershed	Hortan,1945
	Stream frequency(Fs)	Fs=N/A where, N= Total number of streams; A= Area of watershed	Hortan,1945
	Texture ratio (T)	T=N1/P where, N1=Total number of first order streams; P= perimeter of watershed	Hortan,1945
	Form Factor (Rf)	$Rf= A/(Lb)^2$ where, A= Area of watershed Lb= Basin length	Hortan,1932
	Circulatory ratio (Rc)	$Rc= 4\pi A/P^2$; where A= Area of watershed, π= 3.14, P= Perimeter of watershed	Miller,1953
	Elongation ratio (Re)	$Re=2\int(A/\pi)Lb$; where, A= Area of watershed π= 3.14, Lb= Basin length	Schumn,1956
	Length of overland flow(Lof)	Lof=1/2 Dd where, Dd=Drainage density	Horton, 1945
	Constant channel maintenance ©	Lof=1/Dd where, Dd=Drainage density	Horton, 1945

(Source: Morphometric analysis for micro-watershed prioritization V.B. Rekha et.el.)

4. Result

4.1. Morphometric Analysis

The Tavarja dam watershed has been devided in to 17 mini watershed units and 17 mini watersheds has been further sub devided into 72 micro-watersheds.

In the present study, the parameters considered for the assessment of micro watersheds are the morphometric characteristics. The stream ordering is carried out using Strahler‟s method. The fundamental parameters namely number of streams; stream length, area, perimeters and basin length are derived from the drainage layer.

Morphometric analysis consists of calculation of drainage basin parameters like bifurcation ratio, drainage density, stream frequency, drainage texture, form factor, Elongation ratio, circulatory ratio, compactness constant, length of overland flow, ruggedness number etc. following fig no.6 shows Morphometry of sub basins.

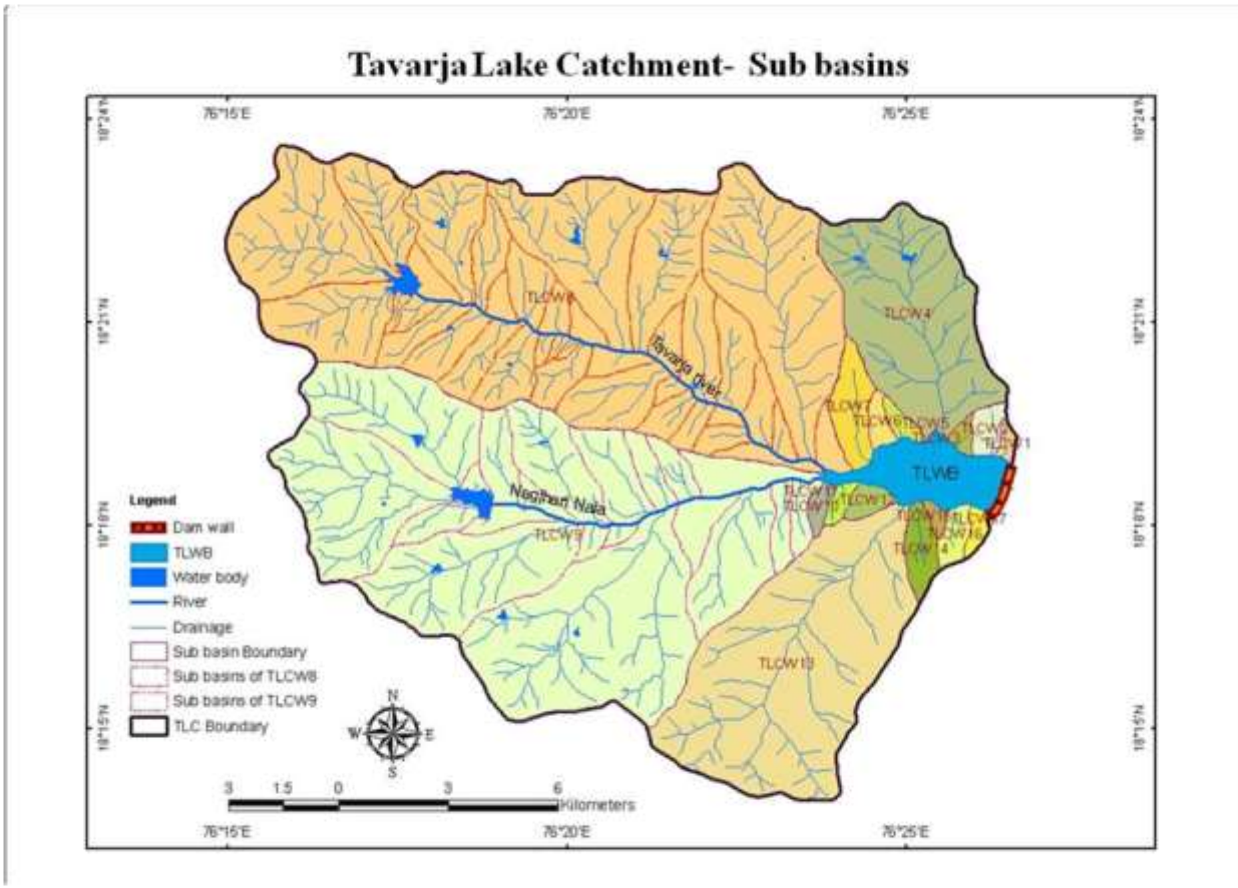

Table no.3 Mean steam length (Lsm) of Tavarja reservoir catchment

Name	Stream order	Lu	Nu	Lsm
Tavarja reservoir catchment	1.	254.4	354	0.72
	2.	96.54	89	1.05
	3.	41.88	20	2.09
	4.	42.03	6	7.00
	5.	05.97	2	2.98
	6.	04.71	1	4.71

- Lu= Stream length of order „U" (km) **Total= 18.55**
- Nu= Total number of stream segments
- Lsm=Mean stream length (LSM=18.55/6=**3.091)**

4.1.1. Bifurcation Ratio (Rb)

Bifurcation ratio is defined as ratio of number of streams of a given order (Nu) to number of streams of next higher order (Nu+1).It is related to the branching pattern of a drainage network. It can be calculated by following formula;

Rb=Nu/Nu+1

∴ **Rb=3.35** (Moderate sloping basin & natural stream segments)

Where, Nu=Total number of stream segments of order „U"

Nu+1= Number of segments of next higher order (Schumn, 1956)

Bifurcation ratio is dimensionless. The value of bifurcation ratio varies between3-5, which indicates natural stream segments. Mean variation ratio varies from about 2 for flat basin and 3 to 5 for moderate sloping and above 5 mountains, hilly and dissected basin. The higher the bifurcation ratio, the higher the rate of erosion. It requires higher the priority for conservation planning [7]

4.1.2. Drainage Density (Dd)

Horton has introduced drainage density (Dd) as an expression to indicate the closeness of spacing of channels. It is a value measurement of intensity of dissection. The significance of drainage density is recognized as a factor determining the time travel by water (Shumm, 1956).

In general it has been observed over a wide range of geologic and climatic types, that low drainage density is more likely to occur in regions of highly permeable sub soil material under dense vegetative cover and where relief is low. The low drainage density favors high groundwater percolation and accumulation. In contrast high Dd is favored in regions of weak or impermeable subsurface materials, sparse vegetation and mountains relief (Nag, 1998).The higher the drainage density the higher the rate of priority of sub basin prioritization because of high rate of soil loss**.** [8]

Dd=Lu/A

∴**Dd=1.78**

Where, Lu= total stream length of all orders

A= area of basin (Km^2)

(Horton, 1945)

4.1.2. Stream Frequency (F_S]

High value of drainage frequency produces more runoff in comparison to others. The higher the stream frequency, the higher the erosion rate of particular micro watershed and also requires high priority for basin priorization.

$$F_S = Nu/A$$

$$\therefore F_s = 1.88$$

Where, Nu=Total number of streams of all orders

A= Area of basin in Km²

(Horton, 1945)

4.1.4. Drainage Texture (D_t)

Drainage texture meanse the relative spacing of drainage lines. Drainage texture depends upon the underplaying Lithology, infiltration capacity and relief aspect of the terrain. D_t is total number of stream segments of all orders per perimeter of that area (Horton, 1945) Smith (1950) has classified drainage texture 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).In the present study the drainage texture of the watershed is 8.05.It indicate that category is very fine drainage texture. Lower the drainage texture, the higher the priority for sub basin prioritization.

$$D_t = Nu/p$$

$$\therefore D_t = 8.05 \text{ (Very fine)}$$

Where, Nu= Total number of streams of all orders

P= basin perimeter in Km.

(Horton, 1945)

4.1.5. Form Factor (Rf)

The values near to 0 indicate highly elongated shape and those near to 1 indicates perfectly circular shape. The elongated watershed with low value of **Rf** indicates that the basin will have a flatter peak flow for longer duration. Flood flows of

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such elongated basins are easier to manage than from the circular basin. The shape indices have an inverse relationship with soil erosion. The lower the form factor, the higher the rate of soil erosion it requires high priority of sub basin prioritization.

$$\mathbf{Rf = A/Lb^2}$$

∴ **Rf =0.63**

Where, A= area of the basin Km^2

Lb= basin length

(Schumm, 1956)

4.1.6. Elongation Ratio (Re)

According to Schumm (1965)," elongation ratio is defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length. Strahler states that this ratio runs between 0.6 and 1.0 over a wide variety of climatic and geologic types. The varying shapes of watershed can be classified with the help of index of elongation ratio i.e. circular (0.9-0.10), oval (08-09), less elongated (0.7-0.8), elongated (0.5-0.7) and more elongated (< 0.5). The elongation ratio of the Tavarja dam watershed as **Re=0.85.** It meanse Tavarja dam watershed is Oval in shape. The lower the elongation ratio, higher the priority level of sub basin conservation.

$$\mathbf{Re=2\int (A/\pi)/Lb}$$

Re=0.85(Oval shape)

Where, A= Area of watershed **π**= 3.14, Lb= Basin length

(Miller, 1953)

4.1.7. Circularity Ratio (Rc)

It is influenced by the length and frequency of streams, geological structure, landuse land cover, climate, relief and slope of the watershed. The high value of circularity ratio indicates the late maturity stage of topography. The lower the rate of circulatory ratio, the higher the rate of soil erosion at a particular micro-watershed.

$$\mathbf{Rc = 4\times\pi\times A/P^2}$$

Rc=1.62

π = π value i.e.22/7 or 3.14

A= Area of watershed

P^2= Square of the perimeter, Km

4.1.8. Compactness Constant (Cc)

According to Gravelius (1914), compactness coefficient of a watershed is the ratio of perimeter of watershed to circumference of circular area, which equals the area of the watershed. The Cc is independent of size of watershed and dependant only on the slope. The compactness constant of Tavarja watershed is 0.75 more the compact watershed, more the basin prioritization requires.

$$Cc=0.2821\ P/A^{0.5}$$

Cc=0.75

Where, A= Area of the basin, Km^2

P= Basin perimeter, Km

(Hortan, 1945)

4.1.9. Lemniscate‟s (k)

Chorley (1957), express the lemniscate‟s value to determine the slope of the basin. High lemniscates (k) value for a watershed shows that the watershed occupies the maximum area in its regions of inception with large number of streams of higher order. The higher the Lemniscate‟s value, the higher the soil erosion, requires high priority for sub-basin priorization.

Lemniscate‟s (k) $$K=Lb^2/4\times A$$

K=0.44

Where, Lb= Basin length

A= Area of the basin, Km^2

(Chorley, 1957)

4.1.10. Constant of Channel Maintenance

The inverse of drainage density is termed as constant of channel maintenance „C‟. The unit of C is Km^2/Km. It indicates the Km^2 of watershed surface area required for sustaining 1 linear km. As it is a measure just a reciprocal of drainage density, it expresses the relationship between the drainage development and the character of the development of streams. The lower value of C indicates higher erosion.

Constant Channel Maintenance

C=1/Dd

C=0.56

Where, Dd=Drainage density, Km/Km²

(Schumm, 1956)

4.1.11. Length of Overland flow (Lg)

Horton (1945) used this term to refer to the length of the runoff the rainwater on the groundsurface before it is localized into definite channels. Since this length of overland flow, at an average, is about half the distance between the stream channels, Hortan for the sake of convenience had taken it to be roughly equal to half the reciprocal of drainage density. In this study, the length of overland flow of the Tavarja dam watershed is 0.28 km. This shows low surface runoff of the study area. The higher the value, the higher the soil loss.

Lg=1/2×1/Dd

Lg=0.28

Dd=Drainage density Km/Km² (Hortan, 1945)

4.1.12. Ruggedness Number (R_n)

Ruggedness number is a value for the measurement of ruggedness of the terrain. Strahler"s (1968) ruggedness number is the product of the basin relief and the drainage density and usefully combines slope steepness with its length. Calculated accordingly, the Tavarja dam watershed has a ruggedness number of 0.16.The high ruggedness value of watershed implies that area is more prone to soil erosion and have intrinsic structural complexity in association with relief and drainage density.

Rn = Dd * (H/1000)

Rn=0.16 (Low Rn)

Where,

Dd = Drainage Density, km/km2,

H = Total Basin Relief, highest elevation - lowest elevation, m,

Patton & Baker (1976)

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Table no.3.Morphometric Results of Tavarja drainage Basin

Sr.No	Morphometric Parameters	Values	Sr.No.	Morphometric Parameters	Values
1.	Area	250.52Km	19.	Form Factor (Rf)	0.63
2.	Stream Order (U)	6th	20.	Circulatory Ratio Rc	1.62
3.	Total stream numbers N	472	21.	Elongation Ratio (Re)	0.85
4.	Total no. of sub- basins	17	22.	Ruggedness Number	0.165
5.	Total no of micro-watersheds	71	23.	Length of Overland flow	0.28
6.	Total Stream Length	445.53	24.	No. of 1st order streams	354
7.	Max. length of watershed	21Km	25.	No. of 2nd order streams	89
8.	Relief ΔH	93 M	26.	No. of 3rd order streams	20
9.	Bifurcation ratio Rb	3.5	27.	No. of 4th order streams	06
10.	Texture ratio Dt	8.05	28.	No. of 5th order streams	02
11.	Drainage Density Dd	1.78	29.	No. of 6th order streams	01
12.	Perimeter	44 Km	30.	Length of 1st order streams	254.4km
13.	Relief Ratio (Rh)	4.43	31.	Length of 2ndorder streams	96.54 km
14.	Mean Stream Length (Lsm)	3.09	32.	Length of 3rd order streams	41.88 km
15.	Compactness Constant **(Cc)**	0.75	33.	Length of 4th order streams	42.03Km
16.	Lemniscate‟s (K)	0.44	34.	Length of 5th order streams	05.97km
17.	Stream Frequency	1.88	35.	Length of 6th order streams	04.71Km
18.	**Constant of channel maintance**	0.56	36.	Allowmetric growth	2.4%

5. Sub-watershed Priorization:

The morphometric parameters like drainage density, bifurcation ratio, stream frequency, elongation ratio, form factor can be termed as erosion risk assessment parameters and have been used to prioritize watershed (Biswas et.al.1999).The linear aspect have the direct relationship with soil erosion. Hence the parameter of higher value indicates the possibility of soil erosion. The sub basins of higher value of drainage density. Stream frequency and bifurcation ratio are much more susceptible for soil erosion. Therefore the higher value was rated as rank 1.Second highest value was rated as rank 2 and so on. Shape parameters like elongation

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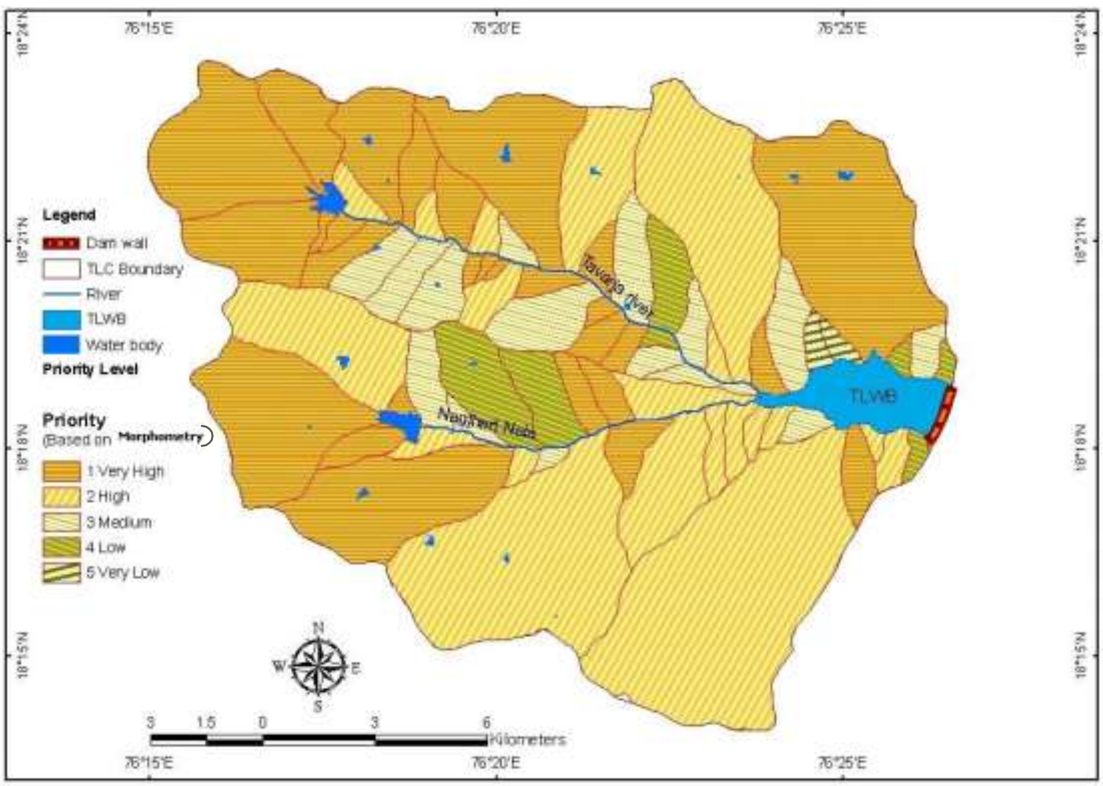
ratio, form factor, and basin shape have inverse relationship with soil erosion (Nooka R. et al. 2005)

Hence, the lower value of shape parameter is an indication of higher risk of erodibility. As per the analysis, rank has been given to each shape parameter. The ranking values of all the parameters were added to assign final prioritized classification has been done. The final priorities have been devided into 3 major classes. (High, medium and low priority)

Fig. No.7.Tavrja dam: Sub-basin Prioritization for Conservation Planning



6. Conclusion

The morphometric characteristics of different sub watershed reflect their relative characteristics with respect to hydro geologic response of watershed. It has been observed that drainage Morphometry derived from various methods fallows standard rules. A result of priorization of sub watershed shows those sub-watersheds: **TLCW 8.1, TLCW.8.6, TLCW.8.8, TLCW.8.11, TLCW.8.13, TLCW.8.14.,**

TLCW.8.16., TLCW.8.17., LCW.8.18., TLCW.8.19., TLCW.8.20., TLCW.8.21., TLCW.8.25., TLCW.8.26., TLCW.8.27., TLCW.8.29., TLCW.8.31., TLCW.8.32., TLCW.8.33., TLCW.9.2., TLCW.9.3., TLCW.9.8., TLCW.9.10.,TLCW.9.11, TLCW.9.13., TLCW.9.17., and TLCW.14.etc. sub-watersheds are more susceptible to soil erosion as per morphometric analysis and it requires very severity to conservation planning.

Although this approach is elementary, it is suitable in micro-level planning and also in development planning for villages in the dam watershed. This approach will help planners in judicious allocation and utilization of available resources. This study would help the local people to utilize the resources for sustainable development of basin area.

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