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MORPHOMETRIC STUDY OF DARNA RIVER UPPER BASIN BY USING REMOTE SENSING AND GIS

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- **Introduction-**

Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms (Agarwal, 1998; Obi Reddy et al., 2002).The morphometric analysis of the drainage basin and channel network play a dynamic role for understanding the hydro-geological behaviour of drainage basin and precise the predominance of climate, geology, geomorphology and structure. The quantitative analysis of morphometric parameters is found to be of immense utility in river basin evaluation, watershed prioritization for soil and water conservation and natural resources management. Drainage basin analysis is also very important in any hydrological investigation like assessment of groundwater potential and management. Detailed morphometric analyses provide an insight on basin evolution and further its role on development of drainage morphometry on landforms and their characteristics. The use of GIS and remote sensing to prepare management and planning of natural resources of the geography is widely acknowledged. Progress in these technologies offers many advantages of taking a synoptic view of the natural resources, natural features at a glance to quicker planning and management of the end user related issues.

Remote sensing and GIS technology has been used for morphometric analysis of river basins carried out using (Ali et al., 2013; Ali & Ali, 2014). In the present study, evaluation of various morphometric parameters is described using ArcGIS10.2 software for Darna upper basin, Nashik. The mathematical calculation of linear, aerial and relief aspects were done to decipher the various geomorphometric parameters for planning and development of Darna basin and it is helpful to management of Natural resources used in water conservation.

- **Study Area -**

The study area extends between 19°36’ N to 19°48’ N. latitudes and 73°39’ E. to 73°44’E longitudes which comprises the area of Darna river upper basin and it covers around 389.6 sq. km. area. Darna river is one of the tributaries of Godavari basin in Nashik District of Maharashtra state which rises on the northern slopes of Kulung hill at elevation 1040 meters in Sahyadri ranges about

13 km. south-east of Igatpuri. The upper catchment area receives high rainfall (3000-4000 mm.) and annual temperature ranges between 18°C to 38°C. It has long and meandering course and its bed is wide and sandy.

Location of Study Area

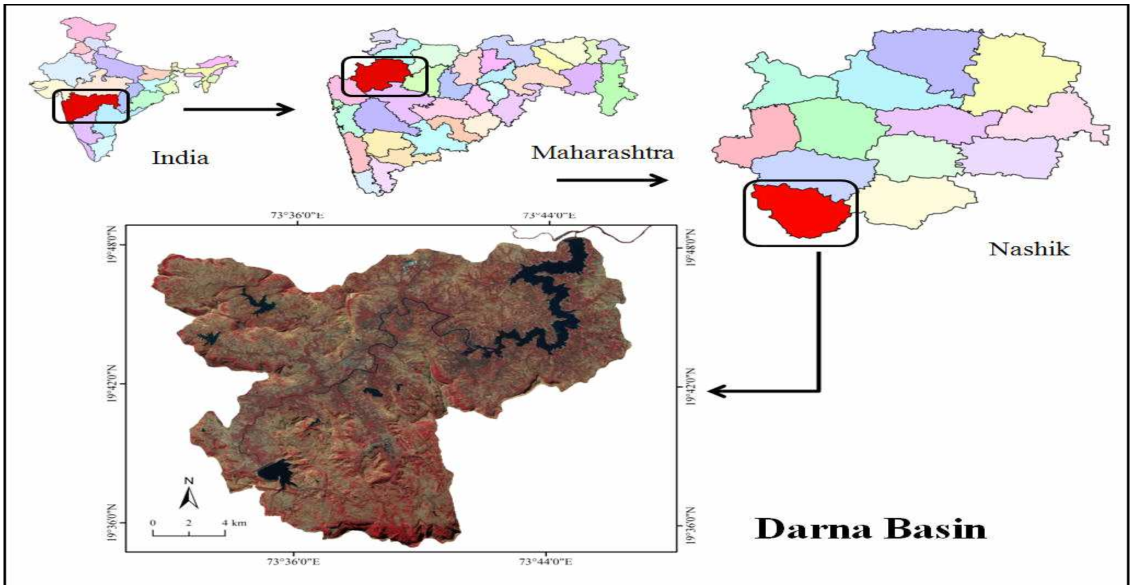

Fig.-1

- **Objective of the Study-**
  - To perform the morphometric analysis of the Darna river upper basin focusing on aerial, linear and relief aspects.

- **Methodology-**

To full fill the above objective, the entire methodology of the present work is focused on the application of Morphometric analysis of the upper basin of Darna river. The survey of India (SOI) Toposheets numbers 47 E/9, 47 E/10, 47 E/13 and 47 E/14 on the scale of 1:50000 used for preparation of base map for stream network. The topographical maps are geo-referenced and rectified using Arc GIS Software Ver.10.2 and digitized the drainage network of the river using Global mapper software. Stream ordering method as suggested by the Strahler will be employed. The different morphometric parameters will be calculated by using various formulas.

- **Results and discussion-**

Methods of calculating morphometric parameters

Morphometric Parameters	Methods	References
Stream Order(U)	Hierarchical order	**Strahler, 1964**
Stream Length (Lu)	Length of the stream	Horton, 1945
Mean stream length (Lsm)	Lsm = Lu/Nu where, Lu=Stream length of order 'U' Nu=Total number of stream segments of order 'U'	Horton, 1945
Stream length ratio(Rl)	Rl=Lu/Lu-1; where Lu=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 segment of order'u'; Nu+1=Number of segment of next higher	Schumn,1956
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, Bh =Basin relief; Dd=Drainage density	Schumn,1956
Drainage density (Dd)	Dd = L/A where, L=Total length of streams;A=Area of watershed	Horton, 1945
Stream frequency (Fs)	Fs = N/A where, N=Total number of streams; A=Area of watershed	Horton, 1945
Texture ratio (T)	T = N1/P where,N1=Total number of first order streams; P=Perimeter of watershed	Horton, 1945
Form factor (Rf)	Rf=A/(Lb) 2 ;where, A=Area of watershed, Lb=Basin length	Horton, 1945
Circularity ratio (Rc)	Rc=4πA/P2 ;where, A=Area of watershed, π=3.14, P=Perimeter of watershed	Miller, 1953
Elongation ratio (Re)	Re=2√(A/π)/Lb ;where, A=Area of watershed, =3.14, Lb=Basin length	Schumn,1956
Length of overland flow (Lof)	Lof = 1/2Dd where, Dd=Drainage density	Horton, 1945
Constant channel maintenance (C)	Lof = 1/Dd where, Dd=Drainage density	Horton, 1945

Table-1

- **Linear aspects-**

Linear aspects includes drainage parameters such as stream order (Nu), stream length (Lu), Mean Stream Length (Lsm), Stream Length Ratio (Rl), Bifurcation Ratio (Rb) and Mean Bifurcation Ratio

(Rbm).

Stream order(Nu)-

Stream order is based on hierarchic ranking of streams proposed by Strahler (1964). In present study, Darna watershed has sixth stream order. With increasing stream order the number of stream is decreases. The total numbers of streams are 1815 in that 1380 are first orders, 334 are second orders, 79 are third orders, 18 are fourth order, 3 is in fifth order and 1 is in sixth order. (Fig.-2,Table-2)

Linear aspects of upper Darna basin

Stream order	Stream number	Stream length (km)	Mean stream length (Km)	Stream length ratio	Bifurcation ratio (Rb)
1	1380	741.65	0.54	-	-
2	334	216.21	0.65	1.20	4.13
3	79	92.72	1.17	1.8	4.23
4	18	37.66	2.09	1.79	4.39
5	3	38.98	12.99	6.21	06
6	1	50.14	50.14	3.86	03
Total/ Mean	**1815**	**1177.36**	**11.26**	**2.972**	**4.35**

Table-2

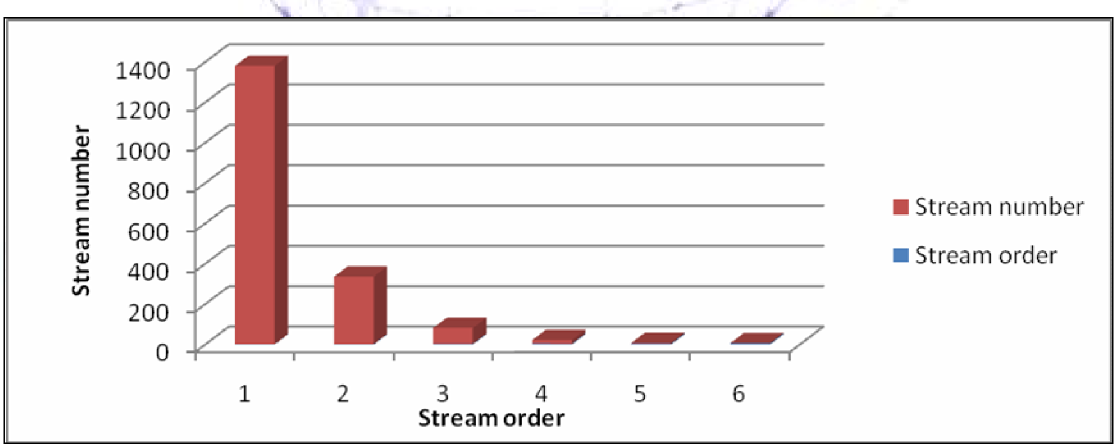

Fig.-2 Stream Number Vs Stream order

Stream length(Lu)-

It shows the total length of streams in a particular order. The numbers of streams of various orders in watershed were counted and lengths were measured with help of Arc GIS 10.2. Generally, the total length of stream segments decreases with stream order. Generally the total length of stream segments decreases with increasing stream order (Fig.-3, Table 2).

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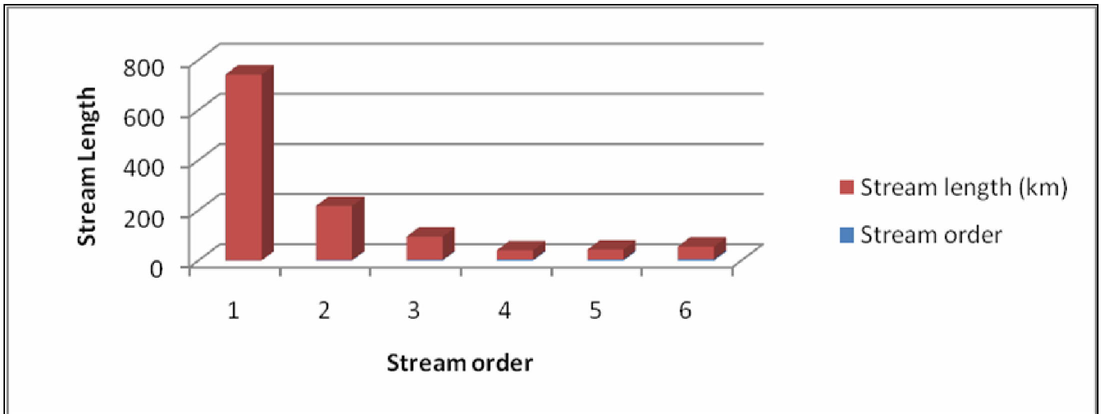

Fig.-3 Stream length Vs Stream order

Mean Stream Length(Lsm) -

The mean stream length of a channel is a dimensional property and reveals the characteristic size of drainage network components and its contributing basin surfaces (Strahler, 1964). The mean stream length (Lsm) is calculated by dividing the total stream length of order by the number of streams. The calculated mean stream length of Study area is 0.54 for first orders, 0.65 for second orders, 1.17 for third orders, 2.09 for fourth, 12.99 for fifth and 50.14 for sixth order orders respectively.

Stream Length Ratio (Rl)-

Stream length ratio is defined as the ratio of the mean stream length of given order to the mean stream length to the next order and it has been shows the relationship between the surface flow and the discharge of the basin. The total stream length ratio of the study area is 2.972 which show the youth stage of the Darna lake catchment study area for geomorphic development.

Bifurcation ratio(Rb)-

It is the ratio of the number of a given order to the number of streams of the next higher order (Schumm, 1956). Horton (1945) considered bifurcation ratio (Rb) as an index of relief and dissection Bifurcation ratio of the upper Darna basin is ranges between 3 to 6 and mean bifurcation is 4.35 that shows the natural drainage system developed over easily erodible rocks and areas underlain by heavily jointed rocks.

- **Aerial Aspects**

Aerial Aspect includes drainage parameters such as Drainage Density (Dd), ,Stream Frequency (Fs), Form Factor (Rf), Circulatory Ratio (Rc), Elongation Ratio (Re).

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Aerial aspects of upper Darna basin

Morphometic parameters	Symbols/ formula	Value
Area (Sq. Km)	A	389.6
Perimeter (Km)	P	114.53
Basin order	-	6
Drainage density (Km/sq.km)	Dd=Lu/A	3.02
Stream frequency	Fs=Ns/A	4.66
Basin length (km)	Lb	58.93
Elongation ratio	Re=2*√ (A/ii)/Lb	0.38
Circularity ratio	$Rc= 4\ ii\ A/P^2$	0.37
Form factor	$Ff=A/Lb^2$	0.11
Length of overland flow (Lg)	Lg= 1/2Dd	0.17
Constant Channel maintenance (Cc)	Lof=1/Dd	0.33
Basin Relief (Bh)	Highest elevation-lowest elevation	1530-582=948m (0.948km)
Relief ratio	Rh=Bh/Lb; Where, Bh=Basin relief;Lb=Basin length	0.02
Ruggedness number(Rn)	Rn=Bh * Dd or Dd*(Bh/1000)	2.86

Table-3

Drainage Density (Dd) -

Strahler (1964) noted that low Dd is favoured where basin relief is low, while high Dd is favored where basin relief is high. The result shows the value 3.02 per square kilometers in study area suggesting that the upper Darna basin area has low drainage density shows coarse drainage texture, with plain and lower degree of slope highly permeable subsoil, dense vegetation cover.

Stream Frequency (Fs) -

Horton introduced stream frequency (Fs) or channel frequency which is the total number of stream segments of all orders per unit area (Horton, 1932. The stream frequency of study area is 4.66 per square km which can be attributed to high relief, high runoff and low infiltration capacity.

Form Factor (Rf) -

Horton (1932) defined Form factor (Rf) as a dimensionless ratio of basin area (A) to the square of basin length (Lb). For upper Darna basin the value of form factor is 0.11 that indicates high erosion in catchment region and leading to elongated shape of the basin.

Circularity Ratio (Rc)

Miller (1953) defined circulatory ratio (Rc) as the ratio of the area of the basin (A) to the area of circle having the same circumference as the perimeter of the basin (PAccording to Miller the basin of the circularity ratio ranges 0.4 to 0.5 which indicates strongly elongated and highly permeable homogenous geologic materials of the drainage basin.

Elongation Ratio (Re)

It is the ratio between the diameter of the circle with the same area as that of the basin (A) and the maximum length (L) of the basin. The Re value of the Darna Lake Catchment is 0.38 which indicates the drainage basin is more elongated with moderate relief and moderately steep ground slope.

- **Relief Aspect**

Relief Aspect includes Relief Ratio, Length of Overland Flow, and Constant of Channel Maintenance (Table 5).

Relief Ratio (Rh)

The elevation difference between the highest and lowest points on the valley floor of a sub-watershed is its total relief, whereas the ratio of maximum relief to horizontal distance along the longest dimension of the basin parallel to the principal drainage line is Relief Ratio (Rh) (Schumn, 1956). It measures the overall steepness of a drainage basin and is an indicator of intensity of erosion processes operating on the slopes of the Basin. The Rh normally increases with decreasing drainage area and size of a given drainage basin (Gottschalk, 1964). Rh for the basin is 0.02.

Length of Overland Flow(Lg)-

Length of overland flow was described by Horton (1933 – 1945) as a component of total runoff in a drainage basin. Upper Darna basin shows the value of length of overland flow is 0.17 means Study area is structurally complex due to the low value of length of overland flow. On an average most of the drainage basins in its late youth and early mature stages have minimum length of overland is found.

Constant of Channel Maintenance(Cc)-

Schumm (1956) has used the inverse of drainage density as a property termed constant of channel maintenance. The constant channel maintenance of the Darna river catchment region is 0.36 km2/km. upper Darna basin has low constant channel maintenance in the river bed and is mostly up of basalt hard rock having low Erosibility and low permeability. This area is under the influence of high structural disturbance, steep to very steep slope and high surface runoff.

- **Conclusion**

The study of morphometric analysis of upper Darna basin using Remote sensing and GIS software which are very helpful to analysis the drainage basin easily and accurately. The study of area concluded that areas drained by drainage orders have Bifurcation ratio between 3 to 6, indicating that and mean bifurcation is 4.35 that shows the natural drainage system developed over easily erodible rocks and areas underlain by heavily jointed rocks. The Drainage density (Dd) shows the value 3.02 per square kilometers in study area suggesting that the Darna upper basin has low drainage density shows coarse drainage texture, with plain and lower degree of slope highly permeable subsoil, dense vegetation cover. The shape parameters (Rc=0.37, Re=0.38 and Rf=0.11) indicate the elongated shape of the basin and in association with some areal (Dd, Dt etc.) parameters show that it has highly permeable subsoil, dense vegetation cover and a lower peak flow of longer duration hence, flood flows of such elongated basins are easier to manage than of the circular basin. The Study area shows the value of length of overland flow is 0.17 means study area is structurally complex due to the low value of length of overland flow. On an average most of the drainage basins in its late youth and early mature stages have minimum length of overland is found. In Geomorphology major prominence is to describe the evolution and behaviour of surface drainage network which involves the measurement of various stream properties that are important for the hydrological studies point of view include the linear, aerial and relief aspect of the watersheds.

References-

1. **Ali S.A., and Khan N. (2013):** "Evaluation of Morphometric Parameters- A Remote Sensing and GIS Based Approach", Open Journal of Modern Hydrology, Vol.-3,pp.- 20-27.
2. **Ali U., and Ali S.A.(2014):** " Analysis of Drainage Morphometry and Watershed Prioritization of Romushi - Sasar Catchment, Kashmir Valley, India using Remote Sensing and GIS Technology", International Jounal of Advanced Research,Vol.- 2 (12), pp.- 5-23.
3. **Bhatt C.M., Chopara R., and Sharma,P.K.(2007):** "Morphometric analysis in anandpur sahib area, Punjab (India) using remote sensing and GIS approach", Journal of Indian Soc. Remote Sensing, Vol.-35(2), pp.- 129 -139.
4. **Chow V.T.(1964):** " Handbook of Applied Hydrology", New York: McGraw Hill Inc.
5. **Clarke J.I.(1966):** " Morphometry from Maps. Essays in Geomorphology", New York: Elsevier Publ. Co., pp.-235-274.
6. **Horton R.E. (1932):** Drainage Basin Characteristics. Transactions of American Geophysics Union, Vol.-13, PP. -350-361.
7. **Nag S.K., and Anindita L. (2011):** " Morphometric Analysis of Dwarakeswar Watershed, Bankura District, West Bengal India, using Spatial Information technology", International Journal of Water Resource and Environmental Engineering Vol.- 3(10), pp.-212-219.
8. **Singh S., and Singh M.C.(1997):** "Morphometric Analysis of Kanhar River Basin", National Geographical Journal of India,Vol.- 43 (1), pp.-31-43.
9. **Strahler A.N.(1957**): Quantitative Analysis of Watershed Geomorphology. Transactions of American Geophysical Union. Vol.-38, pp.- 913-920.
10. **Syed Ahmad Ali., Mohsen Alhamed., and Umair Ali (2016):** " Morphometric Analysis of Abdan Basin, Almahfid Basement Rock, Yemen: using Remote Sensing and GIS", Cloud Publications, International Journal of Advanced Remote Sensing and GIS, 2016, Vol.- 5(3), pp. - 1605-1617.