Morphometric Analysis of Kas River Basin in Ahmednagar using Remote Sensing And Geographical Information System (GIS) techniques

Pratiksha Sanjay Rane

Shramshkti College of Agricultural Engineering and Technology, Maldad, Sangamner, Ahmednagar, Maharashtra, India.

---***---

Abstract - *Geographical Information system (GIS) and Remote Sensing has become an efficient tool in this present era for the delineation of drainage pattern and water resource management. The Kas basin (183.92 sq km) is a major tributary of the upper Mula Basin in hilly zone of Deccan plateau in Maharashtra (India) and flows on the southern side of the Mula.. The height varies from 525 m to 1041 m. The average annual rainfall is 473 mm, varies from 777 mm at Bramhanwada to 358 mm at Bota.. The Cartosat DEM (Digital Elevation Model) with 32 m x 32 m resolution is used for the morphometric analysis of the basin to derive linear, areal and relief aspects by using the ArcGIS 10.3. Survey Of India (SOI) toposheet number E43I13 having 1: 50,000 scale is used for the study. Strahler's stream order was followed for the further analysis. The drainage pattern of Kas river basin is dendritic type with 6th order trunk stream having mean bifurcation ratio 3.35, main channel length 77.9 km and Channel index is 1.42. The areal aspect such as Elongation ratio, Circulatory ratio, Stream frequency, Drainage density and Length of overland flow (Km) is found to be 0.68, 0.28, 2.68, 2.182 and 0.23, respectively. The relief aspect such as Ruggedness number and watershed slope is 1.088 and 0.022, respectively. Kas basin has moderate texture, elongated in shape, dendric drainage nature and eroded watershed which need protection.*

Key Words: *GIS, Remote Sensing, Morphometric analysis, Cartosat DEM, Kas watershed.*

1] INTRODUCTION

Remote Sensing and GIS techniques are the proven efficient tools in the delineation, updating and morphometric analysis of drainage basin. The drainage basin analysis is important in any hydrological investigation like assessment of groundwater potential and groundwater management. Various important hydrologic phenomena can be correlated with the physiographic characteristics of drainage basins such as size, shape, slope of drainage area, drainage density, size and length of the tributaries etc. (*Rastogi et al., 1976*). Remote sensing data can be used in conjunction with conventional data for delineation of ridgelines, characterization, priority evaluation, problem identification, assessment of potentials and management needs, identification of erosion prone areas, evolving water conservation strategies, selection of sites for check dams and reservoirs etc.,(*Dutta et al.,2002*). The present paper describes the drainage characteristics of Kas basin area in Ahmednagar district obtained through RS & GIS based morphometric analysis. It is felt that the study will be useful to understand hydrological behaviour of basin.

Morphometry is nothing but the mathematical analysis and measurement of configurations of earth shape, surface and dimension of landforms. Morphometric properties gives important information related with the formation & development of hydrologic & geographic properties of watershed. Morphometric analysis also gives a quantitative description of drainage system, as drainage system is important for characterisation of watershed.

Morphometric analysis is also important in order to investigate the pedology, environmental assessment, groundwater management & groundwater potential. It also checks the relief, areal aspect, geometric and linear aspect gives hierarchial order of streams along with number and length of stream segment etc. The areal aspect gives the analysis of basin shape, basin parameter both geometrical and topological (Stream frequency, Drainage density). The relief aspects include dissection index, absolute and relative relief and average slope. Morphometric parameter generally depends upon bed rock, lithology, pedology and geological structures.

Hence, the information related with the geomorphology, hydrology, geology, and land use pattern is highly important for doing trusted study of drainage pattern of the watershed. For quantitative analysis of the watershed involving various components such as stream segments, stream order , basin perimeter & area, elevation difference, slope and profile of land has majorly responsible for the natural development of basin (Horton, 1945). As the first and majorly important work on basin morphometry analysis was carried out by Horton (1932, 1945). Then, Horton's study in various ways modified and developed by several Geomorphologist and Geohydrologist, which was mainly Strahler (1952), Schumm (1956), Melton (1957), Strahler (1957), Chorley *et al.* (1984). In recent decades, the morphometric analysis of the various River basins, have been done by many researchers and scientist (Esper, 2008; Magesh *et al.*, 2011; Bhagwat *et al.*, 2011; Singh *et al.*, 2014; Sujatha *et al.*, 2014; Gaikwad and Bhagat (2017) have studied morphometric parameters for watershed prioritization. In this study an attempt has made to understand the morphometric characteristics of Kas river basin which helps to understand the basin area, topographic relation, agriculture, forestation and regional planning.

2] **Objective**

The objective of the present study is to analyze the linear, areal and relief morphometric parameters of Kas river basin by using geo-spatial techniques.

3] Case Study

The Kas basin (183.92 sq km) is a major tributary of the upper Mula Basin in hilly zone of Deccan plateau in Maharashtra (India) and flows on the southern side of the Mula.. The height varies from 525 m to 1041 m. The average annual rainfall is 473 mm, varies from 777 mm at Bramhanwada to 358 mm at Bota. Kas is tributary of river Mula and receives water from many minor streams. A small stream that has its source in Badruddin dongar joins the Kas Nadi from the south. Shallow, very shallow, slightly deep well drained soils are observed with 68.03 % area under crop lands. About 93% basin area observed fine calcareous soil on gently sloping lands with severe and moderate erosion. About 7.42% lands especially on hill slopes are covered by sparse forests and 16.96% by shrubs and grasses. Majority of population in the region is living below poverty line and facing many problems for livelihood.

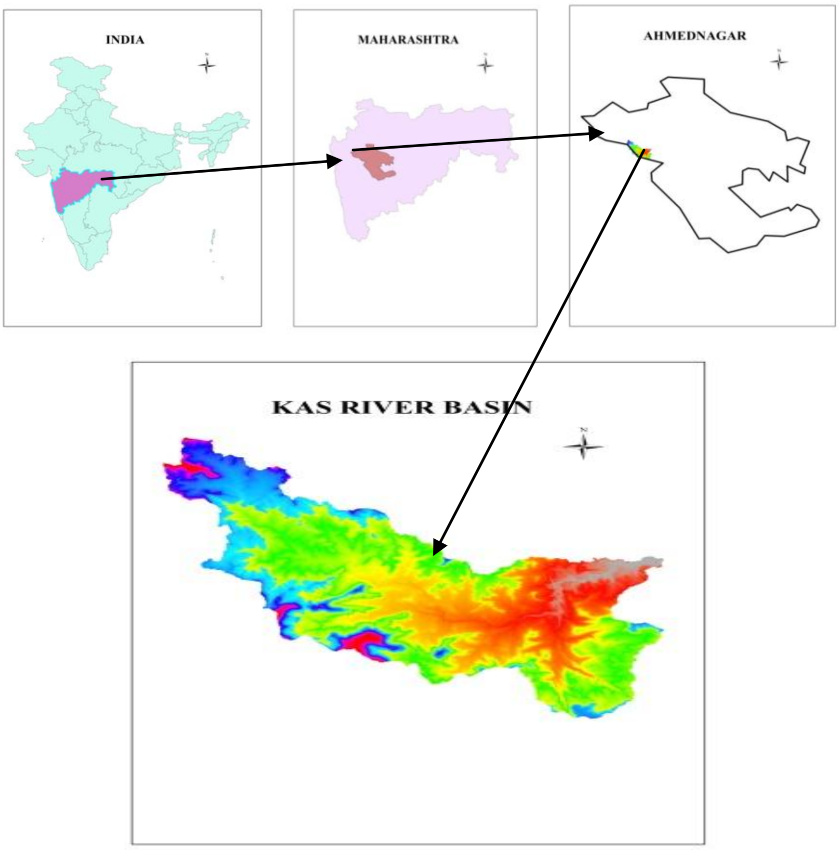

Fig. 1 Location of Study map

4] Data Used and Methodology

In this study of morphometric analysis of Kas river basin remote sensing and GIS (Geographic Information System) technique is used. The remotely sensed data rectified by using the Survey of India (SOI) topographical maps of about scale 1: 50,000 and analysed by using ArcGIS 10.3 by using DEM (Digital Elevation Model) and toposheet. Topographical map: SOI (Scale 1: 50,000) Number E43I13; Cartosat (DEM) with 32 m x 32 m spatial resolution.SOI topographic map is georeferenced using WGS-1984 datum, Universal Transverse Mercator (UTM) zone 43N projection in ArcGIS 10.3. In this study the Strahlers law is used for giving the stream order to the branch by considering first unbranched stream as first order stream then next when two first order streams join together then it is designated as second order. When second order stream joins together to form third order and so on then number of streams are counted and recorded.

5] Result and discussion

5.1 Linear aspect

The liner aspects of drainage network such as Stream Orders (Sµ), Stream Number (Nµ), Bifurcation ratio (Rb), Stream Length (Lu), Mean Stream Length (Lum) and Stream Length Ratio (Lur).

1) Stream order (Su)

Stream order designation is the first step in morphometric analysis of drainage basin depending on hierarchy (Strahler, 1952). It is found that the Kas river basin is a 6th order trunk stream. It is found that the maximum stream order frequency of the Kas river is observed in case of first-order streams and then for second order and then decreses upto last highest order stream.

2) Stream Number (Nu)

The summation of order wise stream segments is known as stream number. Stream number is an inverse of stream order. Stream numbers of 1st, 2nd, 3rd, 4th, 5th, 6th streams are 365, 91, 28,7, 2 and 1 respectively. As the basin has 1st order stream has more number of stream number so it is responsible for sudden removal of water after heavy rainfall.

3) Stream length (Lu)

Total stream lengths calculated by using SOI topographical sheets and ArcGIS software. In Hortons law the Geometric similarity preserved in watershed of increasing order (Strahler, 1964).

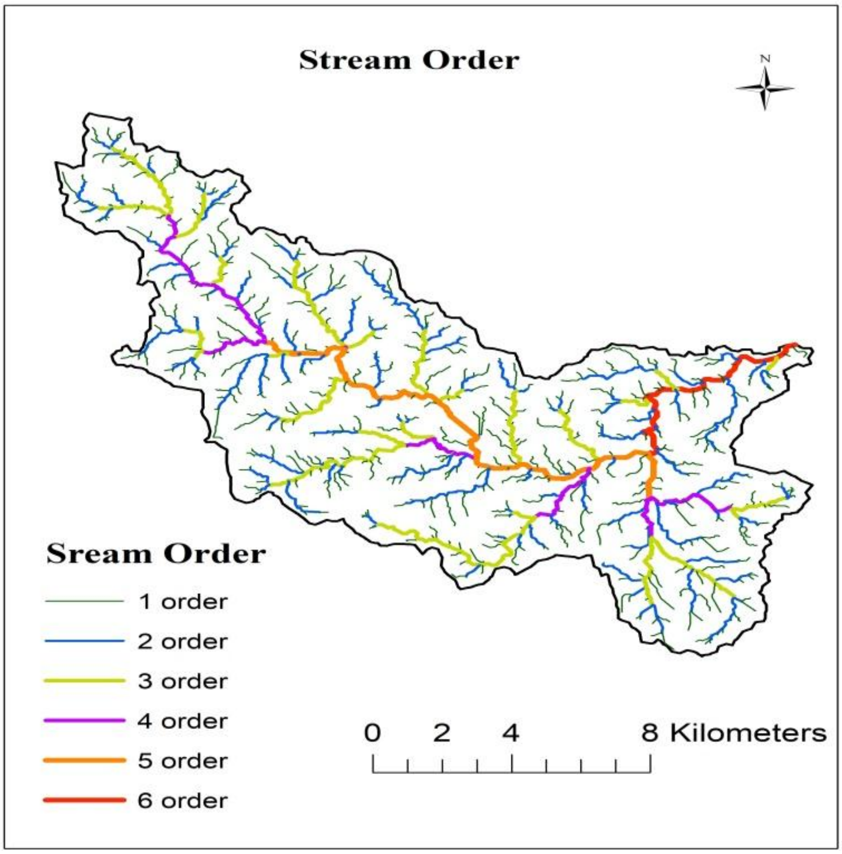

Fig. No.2 Stream Order of Kas Basin

4) Mean Stream Length (Lum)

Mean stream length (Lum) is related to drainage network components and contributing watershed surface (Strahler, 1964). It is calculated by dividing the total length of stream of an order by total number of segments in the order.

5) Stream Length Ratio (Lurm)

Horton (1945) calculated the length ratio by dividing the main length of segment (Lu) of order to mean length of segments of next lower order (Lu-1) which is constant throughout the successive orders of basin. When stream length ratio increase from lower order to higher order indicates mature geographic stage of basin.

6) Bifurcation ratio (Rb)

Bifurcation ratio is calculated by dividing the number of stream segments of given order (Nu) to the number of streams in the next higher order (Nu+1). Bifurcation ratio is an index of relief and dissertation. Bifurcation ratio is a dimensionless property. Lower values (<5) of bifurcation ratio indicates that watershed has less structural disturbances (Strahler, 1964) and drainage pattern has been not distorting. A higher value (>5) of bifurcation ratio indicates that strong structural control on the drainage pattern and the lower values indicates that watershed is not affected by structural disturbance. The results show that bifurcation ratio is found 3.35 shows drainage pattern is controlled by geological structure.

7) Weighted mean Bifurcation ratio (Rbwm)

Strahler (1953) used a weighted mean bifurcation ratio in order to arrive at a more representative bifurcation ratio by multiplying the bifurcation ratio of each successive pair of orders by total number of streams in this ratio and then calculated the mean of sum of these values. The obtained value of Rbwm for this is 3.84.

8) Length of main channel (Cl)

Length of main channel (Cl) is the length along the longest watercourse from outflow point of watershed to the uppermost watershed boundary. The length of main channel (Cl) is computed by using ArcGIS 10.3 software, which is 27.14 km.

9) Channel Index (Ci) & Valley Index (Vi)

For the measurement of valley length, channel length and shortest distance between the mouth and source of river (Adm). Adm is used for the computation of Channel index and valley index. The calculated Channel Index (Ci) & Valley Index (Vi) is found to be 2.08 and 1.19 respectively.

10) RHO coefficient

RHO coefficient is calculated by dividing the stream length ratio to the bifurcation ratio. The relation between the drainage density and physiographic development of basin is determined by RHO coefficient (Horton, 1945). RHO coefficient is influenced by factors like climatic, biologic, anthropogenic and geomorphologic factors.

Table 1 : Stream Order, Streams Number,Bifurcation Ratios in Kas river basin

Su	Nu	Rb	Nu-r	Rb*Nu-r	Rbwm
I.	365				3.84
II.	91	4.0	456	1824	
III.	28	3.25	119	386.75	
IV.	7	4	35	140	
V.	2	3.5	9	31.5	
VI.	1	2	3	6	

Total	494	16.75	622	2388.25	
Mean		3.35			

Su: Stream order, Nu: Number of streams, Rb: Bifurcation ratios, Rbm: Mean bifurcation Ratio*,

Nu-r: Number of stream used in the ratio, Rbwm: Weighted mean bifurcation ratios

Table 2: Stream Length and Stream Length Ratio in Kas river basin

Su	Lu	Lu/Nu	Lur	Lur-r	Lur*Lur-r	Luwm
I.	196.08	0.53				
II.	104.39	1.14	2.1	300.47	630.987	
III.	58.81	2.10	1.8	163.2	293.76	1.94
IV.	20.08	2.8	1.3	78.89	102.557	
V.	19.03	9.51	3.4	39.11	132.974	
VI.	8.94	8.94	0.9	27.97	25.173	
Total	401.33	25.02	9.5	609.64	1185.451	
Mean			1.9			

Su: Stream order, Lu: Stream length, Lur: Stream length ratio, Lurm: Mean stream length ratio*

Lur-r: Stream length used in the ratio, Luwm: Weighted mean stream length ratio.

Table 3 : Linear aspect of Kas river basin

Sr.No	Morphometric parameter	Formula	Reference	Result
1	Stream Order (Su)	Hierarchical Rank	Strahler (1952)	1 to 6
2	1st Order Stream (Suf)	Suf = N1	Strahler (1952)	365
3	Stream Number	(Nu = N1+N2+ …Nn	Horton (1945)	494
4	Stream Length (Lu) Kms	Lu = L1+L2 …… Ln	Strahler (1964)	401.33
5	Stream Length Ratio (Lur)	See table 2	Strahler (1964)	0.9-9.5
6	Mean Stream Length Ratio (Lurm)	See table 2	Horton (1945)	1.9
7	Weighted Mean Stream Length Ratio (Luwm)	See table 2	Horton (1945)	1.94
8	Bifurcation Ratio (Rb)	See table 1	Strahler (1964)	2-4
9	Mean Bifurcation Ratio (Rbm)	See table 1	Strahler (1964)	3.35
10	Weighted Mean Bifurcation Ratio (Rbwm)	See table 1	Strahler (1953)	3.84
11	Main Channel Length (Cl) Kms	GIS Software Analysis	-	27.14
12	Valley Length (Vl) Kms	GIS Software Analysis	-	22.45
13	Maximum Aerial Distance (Adm) Kms	GIS Software Analysis	-	13.01
14	Channel Index (Ci)	Ci = Cl / Adm (H & TS)	Miller (1968)	2.08
15	Valley Index (Vi)	Vi = Vl / Adm (TS)	Miller (1968)	1.19
16	Rho Coefficient (ρ)	ρ = Lur / Rb	Horton (1945)	0.56

5.2 Areal aspect

The areal aspect of the drainage basin (watershed) such as Drainage density (Dd), Stream frequency (Fs), Drainage Texture (Rt), Form Factor (RF), Elongation ratio (Re), Circularity ratio (Rc), Length of overland flow (Lg), Constant of channel maintenance (C), Lemniscate (k), Infiltration Number (If), Basin perimeter (P) were calculated.

1) Length of basin (Lb)

Basin length is the longest dimension of basin parallel to principal drainage line (Schumm, 1956). It is calculated according to Schumm (1956) as it is found to be 22.45 km.

2) Basin area (A)

Area has the same importance like other parameter that is the total stream length. The basin area is computed by using the ArcGIS 10.3 software, which is 183.92 km^2.

3) Basin Perimeter (P)

The outermost boundary of basin that enclosed the area called the basin perimeter. Basin perimeter is an indicator of watershed size and shape. The basin perimeter is computed by using the ArcGIS 10.3 software, which is found to be 90.55 km.

4) Length area relation (Lar)

The relation between the stream length and basin area is given by equation

5) Lemniscate's (k)

For the determination of the slope of basin Chorely (1967) gives a Lemniscate's value. It is determined by using the formula $k= Lb^2/4*A$ where Lb is basin length in km and A is the area of basin in km^2. The computed value of k is found to be 0.68.

6) Form factor (Ff)

Form factor is also known as an index as it is dimensionless form used to represent the different basin shapes (Horton, 1932). Form factor varies between 0.1 to 0.8. Higher value of form factor indicates basin is circular type while the smaller value indicates enlongated basin. The range of form factor for elongated basin is <0.78 and for circular is >0.78. In case of Kas river basin the form factor value is 0.36 which indicates basin is elongated.

7) Elongation ratio (Re)

Elongation ratio is defined as the ratio of diameter of a circle of the same area as the basin to maximum basin length (Schumm, 1956). According to Strahler states that elongation ratio varies between 0.6 to 1.0 over a wide variety of climatic and geologic types. The slope of watershed is classified with the help of elongation ratio, i.e elongated (0.5-0.7), less elongated (0.7-0.8), oval (0.8-0.9), circular (0.9-0.10). The elongated ratio of Kas river basin is 0.68, which represents that the basin is elongated.

8) Texture ratio (Rt)

Texture ratio is ratio between the first order streams and perimeter of basin (Rt= NI/P) and its depends on lithology, relief aspects of terrain and infiltration capacity. Texture ratio is an important parameter in order to morphometric analysis as it depends on infiltration capacity, relief aspects of terrain and lithology. The texture ratio of this basin is found to be 4.03.

9) Circulatory ratio (Rc)

Circularity ratio is dimensionless property and express as the degree of circulatory of the entire basin. Circularity value varies between 0 to 1 but value closes to 1. Circulatory ratio is calculated by dividing the watershed area to the area of a circle having the same perimeter as that the watershed. Length and frequency of tributaries, geological structures, land use/land cover, climate, relief and slope of the basin affect the circularity ratio. The circulatory ratio of this basin is found to be 0.28 which indicates mature dendritic streams.

10) Drainage texture (Dt)

Drainage texture is calculated by dividing the stream segments of all orders to the perimeter of that area (Horton, 1945). The five drainage texture classification given by the Smith (1950) i.e., very fine (>8), fine (6 to 8), moderate (4 to 6), coarse (2 to 4), very coarse (<2). The drainage texture of basin is calculated to be 5.45 indicates that the texture is moderate.

11) Compactness coefficient (Cc)

Compactness coefficient (Cc) is calculated by dividing the perimeter of watershed to circumference of circular area, which is equal to the area of watershed. Compactness coefficient depends only on the slope but not on the size of watershed. The Cc of given basin is found to be 1.89.

12) Fitness ratio (Rf)

Fitness ratio is the ratio of the main channel length to the length of watershed perimeter. Fitness ratio is a measure of topographic fitness (Melton 1957). The fitness ratio for Kas basin is 0.29.

13) Wandering ratio (Rw)

The ratio of main stream length to the valley length is known as wandering ratio (Rw) (Smart & Surkan 1967). The straight line distance between outlet of basin and remost point on the ridge is called the valley length. In this study wandering ratio is found to be 1.21.

14) Watershed Eccentricity (τ)

The expression for watershed eccentricity, which is: $\tau = [(|Lcm^2 Wcm^2|)]^{0.5}/Wcm$ Wcm Where: τ = Watershed eccentricity, Lcm = Straight length from the watershed mouth to the centre of mass of the watershed, and Wcm = Width of the watershed at the centre of mass and perpendicular to Lcm. The watershed eccentricity is a dimensionless property. For the given watershed the watershed eccentricity, is computed to be 1.04.

15) Centre of Gravity of watershed (Gc)

Centre of Gravity of watershed (Gc) is calculated by measuring the length from the outlet of watershed to a point on stream nearest to the center of of watershed. The centre of gravity of watershed calculated by using the ArcGIS-10.3 software, which is latitude 19.15N and longitudes 74.64E.

16) Sinuosity Index (Si)

The pattern of channel of a drainage basin is equal to sinusity. The ratio of channel length to down valley distance is sinuosity. Sinusity value varies between 1 to 4 and more. Sinuosity index is generally used for the Geomorphologists, Hydrologists and Geologists. The computed hydraulic, topographic and standard sinuosity index which are 82%, 17.59%, and 1.74 respectively.

17) Stream frequency (Fs)

The number of stream segment per unit area is called stream frequency. Stream frequency also known as channel frequency (Horton 1932). The stream frequency of watershed found to be 2.68.

18) Drainage Density (Dd)

The stream length per unit area in region of watershed is called drainage density

(Horton, 1952). The drainage density calculated by using spatial analyst tool in ArcGIS-10.3. The range for Dd are vary as very coarse (<2), coarse (2-4), moderate (4-6), fine (6-8) and very fine (>8). The basin has Dd found to be 2.182 which indicates coarse drainage basin.

19) Infiltration Number (If)

Infiltration number is the product of drainage density (Dd) and stream frequency (Fs) i.e. If= Dd*Fs. Higher value of infiltration number means lower the infiltration capacity and higher runoff (Horton1964). The infiltration number (If) is found to be 5.84 for the basin which indicates basin has lower value of infiltration capacity and higher runoff.

20) Drainage pattern (Dp)

Drainage pattern (Dp) helps in identifying the stage of erosion. In drainage pattern influence of slope, lithology and structure reflects. The study area has dendritic and radial pattern. Howard (1967) related drainage patterns to geological information's.

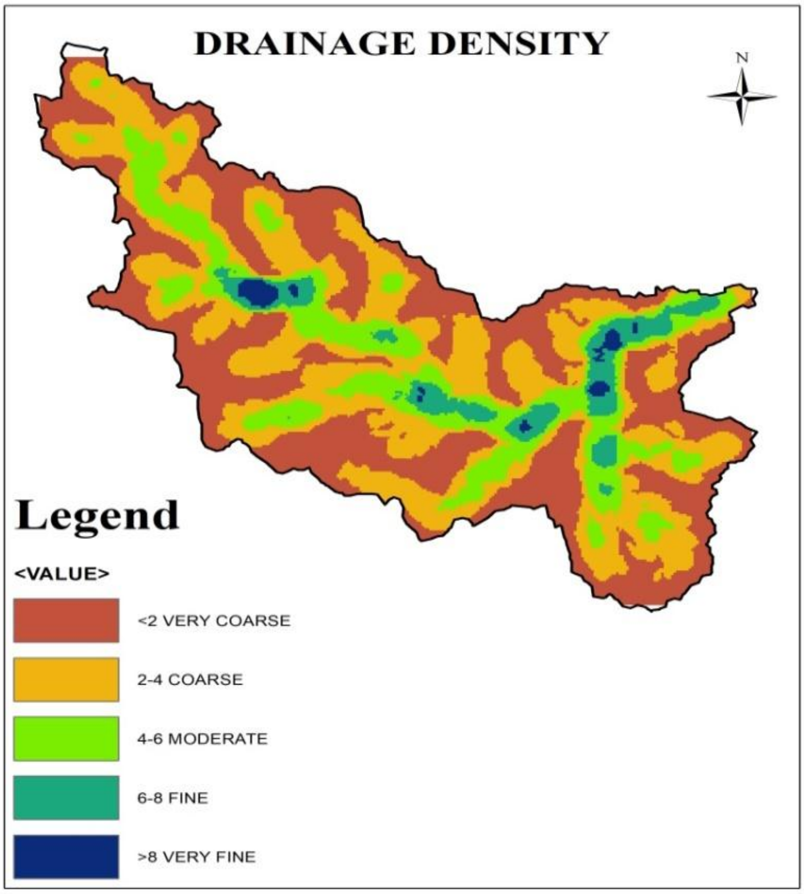

Fig no.3 Drainage density

21) Length of Overland flow (Lg)

Length of Overland flow (Lg) is equal to the half the reciprocal of drainage density. Higher the value of length of overland flow indicates lower relief and vice versa. The range for the values of length of overland flow are in three classes as low value (<0.2), moderate value (0.2-0.3) and high value (>0.3). Lower value indicates high relief, more runoff and less infiltration where as higher value of Lg gives gentle slope, more infiltration and reduced runoff. Length of Overland flow (Lg) is computed to be 0.23 means it has hifh relief , more runoff and less infiltration.

22) Constant of Channel Maintenance (C)

Constant of Channel Maintenance is the inverse of drainage density. Constant channel maintenance of watershed is computed to be 0.46.

Table 4 : Areal aspect of Kas river basin

Sr.No	Morphometric parameter	Formula	Reference	Result
	Length from W's Center to Mouth of W's (Lcm) kms	GIS Software Analysis	-	11.30
	Width of W's at the Center of Mass (Wcm) kms	GIS Software Analysis	-	7.81
	Basin Length (Lb) kms	GIS Software Analysis	-	22.45

	Mean Basin Width (Wb)	Wb = A / Lb	Horton (1932)	8.19
	Basin Area (A) Sq kms	GIS Software Analysis	Schumm(1956)	183.92
	Basin Perimeter (P) kms	GIS Software Analysis	Schumm(1956)	90.55
	Relative Perimeter (Pr)	Pr = A / P	Schumm(1956)	2.03
	Length Area Relation (Lar)	$Lar = 1.4 * A^{0.6}$	-	31.98
	Lemniscate's (k)	$k = Lb^2 / 4A$	Chorley (1957)	0.68
	Form Factor Ratio (Rf)	$Ff = A / Lb^2$	Horton (1932)	0.36
	Shape Factor Ratio (Rs)	$Sf = Lb^2 / A$	Horton (1956)	2.74
	Elongation Ratio (Re)	$Re = 2 / Lb * (A / \pi)^{0.5}$	Schumm(1956)	0.68
	Elipticity Index (Ie)	$Ie = \pi * Vl^2 / 4 A$	-	2.1
	Texture Ratio (Rt)	Rt = N1 / P	Schumm(1965)	4.03
	Circularity Ratio (Rc)	$Rc = 12.57 * (A / P^2)$	-	0.28
	Circularity Ration (Rcn)	Rcn = A / P	Strahler (1964)	2.03
	Drainage Texture (Dt)	Dt = Nu / P	Horton (1945)	5.45
	Compactness Coefficient (Cc)	$Cc = 0.2841 * P / A^{0.5}$	-	1.89
	Fitness Ratio (Rf)	Rf = Cl / P	Melton (1957)	0.29
	Wandering Ratio (Rw)	Rw = Cl / Lb	-	1.21
	Watershed Eccentricity (τ)	$\tau = [(\lvert Lcm^2Wcm^2\rvert)]^{0.5}/Wcm$	-	1.04
	Centre of Gravity of the Watershed (Gc)	GIS Software Analysis	-	74.64E & 19.15N
	Hydraulic Sinuosity Index (Hsi) %	Hsi = ((Ci - Vi)/(Ci - 1))*100	-	82
	Topographic Sinuosity Index (Tsi) %	Tsi = ((Vi - 1)/(Ci- 1))*100	-	17.59
	Standard Sinuosity Index (Ssi)	Ssi = Ci / Vi	-	1.74
	Stream Frequency (Fs)	Fs = Nu / A	Horton (1932)	2.68
	Drainage Density (Dd) km / kms²	Dd = Lu / A	Horton (1932)	2.182
	Constant of Channel Maintenance (kms² / km)	C = 1 / Dd	Schumm(1956)	0.46
	Drainage Intensity (Di)	Di = Fs / Dd	Faniran (1968)	1.23
	Infiltration Number (If)	If = Fs * Dd	Faniran (1968)	5.84
	Drainage Pattern (Dp)		Horton (1932)	Dn & Ra
	Length of Overland Flow (Lg) kms	Lg = 1/ (2 * Dd)	Horton (1945)	0.23

5.3 Relief aspect

Relief refers to the relative height of points on surface and lines with respect to the horizontal base of reference. Relief expresses the magnitude of the vertical dimension of the landform.

1) Maximum basin relief (H)

Maximum basin relief (H) is the elevation difference between the highest Point in the catchment and the catchment outlet. The basin relief is found to be 1041m reveals that basin has undulating terrain having high kinetic energy of water results in severe soil erosion.

2) Relief ratio (Rhl)

The elevation difference between the highest point and lowest point of watershed on the valley floor is the total relief of river basin. The ratio between the total relief of basin and the longest dimension of basin parallel to main drainage line is relief ratio (Schumm, 1956). In this study area of river basin relief ratio found to be 0.022.

3) Relative relief (Rhp)

Relative relief is calculated by using the formula given by the Melton (1957) is Rhp= H*100/P, where P is perimeter in meter & H is total basin relief. Relative relief is found to be o.55.

4) Absolute relief (Ra)

Absolute relief is the difference between the given location and the sea level. The absolute relief is calculated by using ArcGIS-10.3 and which is found to be 1041 m.

5) Ruggedness Number (Rn)

The surface unevenness or roughness is measured by the ruggedness number (Rn). The product of basin relief and drainage density is the ruggedness number (Strahler, 1968). Ruggedness number is usually combines the slope steepness along with the length. The ruggedness number for the study area is 1.088.

6) Melton Ruggedness number (MRn)

The slope index that gives special representation of the relief ruggedness within the watershed is called the Melton Ruggedness number (MRn). The study area has the MRn is 36.79.

7) Gradient ratio (Rg)

The indicator of the channel slope wich enables the assessment of of runoff volume (Sreedevi, 2004). The Rg for the study area is 0.022.

8) Hypsometric analysis (Hs)

The value of integral and the form of hypsometric curve both are important elements in the topographic form. It shows the variation in regions differ in geologic structure and the stage of development. The starting of hypsometric curve is large and it decreases at the stage of maturity and old age (Strahler, 1952).

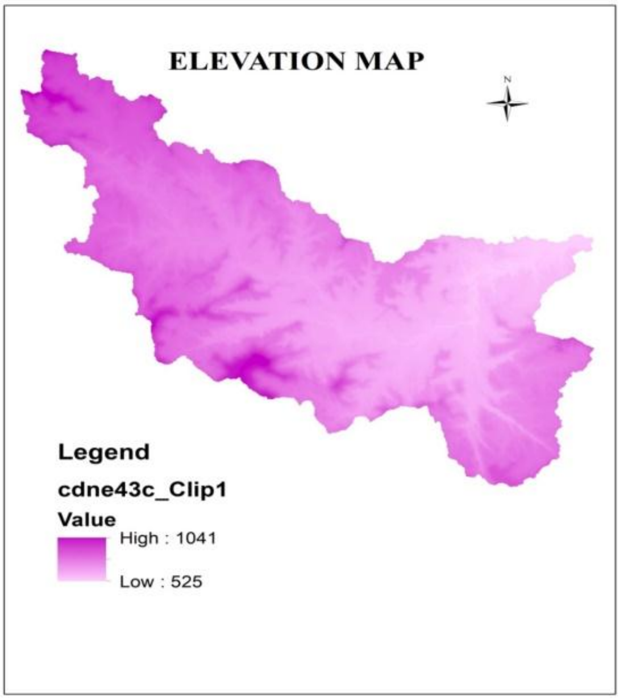

Fig. No.3 Elevation Map of Kas Basin

Table 5 : Hypsometric data of Kas river basin

Sr.No	Altitude Range (m)	Height (m) h	Area (Kms²) a	h / H	a / A
1	>1000	475	0.710	1	0.003
2	900-1000	375	7.259	0.789	0.039
3	800-900	275	40.04	0.578	0.217

4	700-800	175	93.93	0.368	0.510
5	600-700	75	168.74	0.157	0.917
6	525	0	183.92	0	1

A= 183.92 km^2

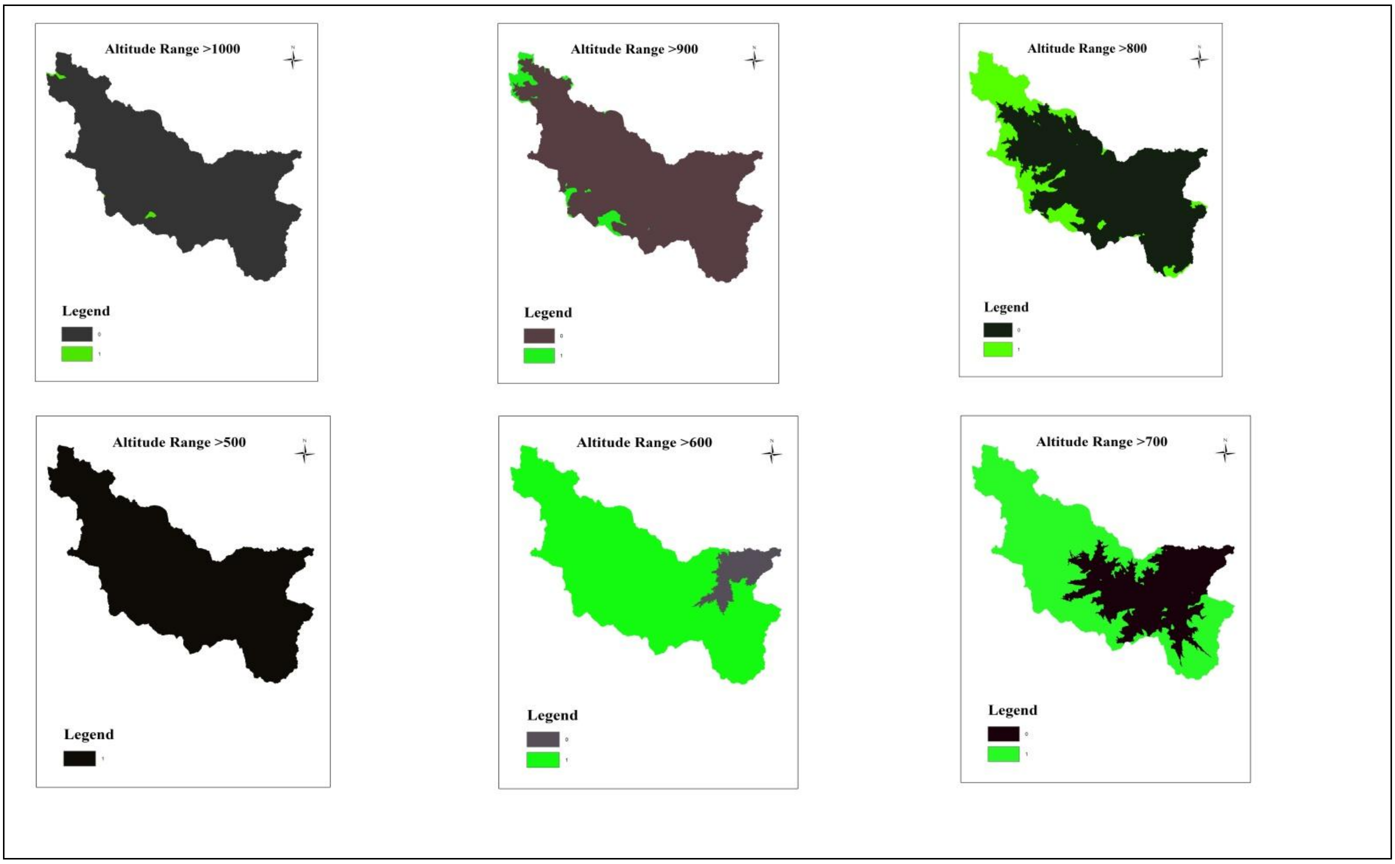

Fig. No.4 Hypsometric Analysis of Kas River Basin

Table 6 : Relief aspect of Kas river basin

Sr.No	Morphometric parameter	Formula	Reference	Result
1.	Height of Basin Mouth (z) m	GIS Analysis / DEM	-	542
2.	Maximum Height of the Basin (Z) m	GIS Analysis / DEM	-	1041
3.	Total Basin Relief (H) m	H = Z - z	Strahler (1952)	499
4.	Relief Ratio (Rhl)	Rhl = H / Lb	Schumm(1956)	0.022
5.	Absolute Relief (Ra) m	GIS Software Analysis		1041
6.	Relative Relief Ratio (Rhp)	Rhp = H * 100 / P	Melton (1957)	0.55
7.	Dissection Index (Dis)	Dis = H / Ra	-	0.48
8.	Gradient Ratio (Rg)	Rg = (Z - z) / Lb	-	0.022
9.	Watershed Slope (Sw)	Sw = H / Lb	-	0.022
10.	Ruggedness Number (Rn)	Rn = Dd * (H / 1000)	-	1.088
11.	Melton Ruggedness Number (MRn)	MRn = H / $A^{0.5}$	Melton (1957)	36.79
12.	Contour Interval (Cin) m	GIS Software Analysis	-	10m
13.	Relative Height (h/H)	(h/H)	Strahler (1952)	1 to 0
14.	Relative Area (a/A)	(a/A)	Strahler (1952)	0 to 1

6] CONCLUSIONS

The present study conclude that Cartosat -DEM and GIS based evaluation of drainage morphometric parameters and their influence on landforms, soils and eroded land characteristics. The prioritization of watershed based on the linear aspect (La), Areal aspect (Aa), Relief aspect (Ra). Length ratio, bifurcation ratio and stream order of basin indicates that the basin is sixth order basin with dendritic type of drainage pattern. Higher first order stream results in easily disposal of water hence the groundwater recharge is less. Form factor, Elongation ratio and Circulatory ratio shows the basin type is elongated. Drainage texture shows that the basin texture is moderate that implies it has more risk of soil erosion and infiltration ratio indicates basin has lower infiltration capacity and higher runoff. From the maximum basin relief the terrain is undulating type having kinetic energy of water is high results higher runoff.

7] ACKNOWLEDGEMENT

I extend my gratitude to Shramshkti College of Agricultural Engineering and technology Maldad, Tal-Sangamner, Dist-Ahmednagar for providing the opportunity to prepare this research work. I thankful to JD INFOTECH, Aurangabad, Maharashtra for providing Technical Assistance during IN-PLANT Training program.

8] REFERENCES

1. Akash M. Pandule (2019), "Morphometric Analysis of Sina Basin using GIS and Remote Sensing Techniques" e-ISSN: 2395-0056, Volume: 06 Issue: 4 | Apr 2019, www.irjet.net p-ISSN: 2395-0072.

2. Amit Bera1*, Bhabani P. Mukhopadhyay1, Debasish Das2 (2018), "Morphometric Analysis of Adula River Basin in Maharashtra, India using GIS and Remote Sensing techniques", Geo-spatial Data in Natural Resources, 13-35, 2018 (Online Edition), A. Bera et al.

3. Bhagwat T. N., Shetty, A.and Hegde, V. S.(2011),Spatial variation in drainage characteristics and geomorphic instantaneous unit hydrograph (GIUH); implications for watershed management-A case study of the Varada River basin, Northern Karnataka.Catena, 87(1), 52-59.

4. Broscoe A.J (1959), "Quantitative Analysis of Longitudinal Stream Profiles of Small Watersheds", Project N. 389-042, Tech. Bep.18, Geology Department, Columbian University, ONR, Geography Branch, NewYork.

5. Chorley, R. J., Schumm, S. A. and Sugden, D. E., (1984) Geomorphology: London. Methuen and Co. London.

6. Chorley R.L. (1967), "Models in Geomorphology", in R.J. Chorley and P. Haggett (eds.), Models in Geography, London, pp 59-96.

7. Esper Angillieri, M. Y., (2008) Morphometric analysis of Colangüil river basin and flash flood hazard, San Juan, Argentina.Environmental Geology, 55(1), 107-111.

8. Faniran A. (1968), "The Index of Drainage Intensity - A Provisional New Drainage Factor", Australian Journal of Science, 31, pp 328-330.

9. Gaikwad R. and Bhagat, V., (2017) Multi-Criteria Watershed Prioritization of Kas Basin in Maharashtra India: AHP and Influence Approaches. Hydrospatial Analysis, 1(1), 41-61.

10. Grind GIS, section available online at - www.india.wris.nrsc.gov.in [Accessed on 22/04/2019 at 1.45]

11. Horton R.E. (1932), "Drainage Basin Characteristics", Transactions, American Geophysical Union, 13, pp 350-61.

12. Horton R.E. (1945), "Erosional Development of Streams and their Drainage Basins",Bulletin of the Geological Society of America, 56, pp-275-370.

13. Kartic Bera1, Jatisankar Bandyopadhyay2 (2013), "Prioritization of Watershed using Morphometric Analysis through Geoinformatics technology: A case study of Dungra sub-watershed, West Bengal, India , ISSN 2277 – 9450.

14. M.L.Waikar1 and Aditya P. Nilawar2, (2014), "Morphometric Analysis of a Drainage Basin Using Geographical Information System: A Case study", ISSN: 2321-3124

15. Magesh N. S., Chandrasekar, N., and Soundranayagam, J. P., (2011), Morphometric evaluation of Papanasam and Manimuthar watersheds, parts of Western Ghats, Tirunelveli district, Tamil Nadu, India: a GIS approach. Environmental Earth Sciences, 64(2), 373-381.

16. Melton M.A. (1957), An analysis of the relations among elements of climate, Surface properties and geomorphology, Project NR 389042, Tech. Rep. 11, Columbia University.

17. Musande V.G., Pawar D.H., Palaskar M.S., Irrigation Water Management In Scarcity Area: A Case Study Of Sina Medium Irrigation Project, 4th International R&D Conference On Water and Energy for 21st Century, 28-31 January 2003,Aurangabad, Maharastra, India

18. Pareta K. (2003), "Morphometric Analysis of Dhasan River Basin, India", UttarBharat Bhoogol Patrika, Gorakhpur, 39, pp 15-35.

19. Pareta K. (2004), "Hydro-Geomorphology of Sagar District (M.P.): A Study through Remote Sensing Technique", Proceeding in XIX M. P. Young Scientist Congress, Madhya Pradesh Council of Science & Technology (MAPCOST), Bhopal.

20. Pareta K. (2005), "Rainfall-Runoff Modelling, Soil Erosion Modelling, Water Balance Calculation, and Morphometric Analysis of Molali Watershed, Sagar, Madhya Pradesh using GIS and Remote Sensing Techniques", proceeding in 25th International Cartographic Congress, INCA.

21. Pareta K. (2011), "Geo-Environmental and Geo-Hydrological Study of Rajghat Dam, Sagar (Madhya Pradesh) using Remote Sensing Techniques", International Journal of Scientific & Engineering Research, 2(8) (ISSN 2229-5518), pp 1-8.

22. Schumm S.A. (1954), "The relation of Drainage Basin Relief to Sediment Loss",International Association of Scientific Hydrology, 36, pp 216-219.

23. Schumm S.A. (1956), "Evolution of Drainage Systems & Slopes in Badlands at PerthAnboy, New Jersey", Bulletin of the Geological Society of America, 67, pp 597-646.

24. Singh K.J. (2017), Area Submergence of Tipaimukh Dam, India, International Journal of Engineering Technology Science and Research. Vol.4, Issue 3, pp 266-274.

25. Strahler A.N. (1952), "Hypsometric Analysis of Erosional Topography", Bulletin of the Geological Society of America, 63, pp 1117-42.

26. Strahler, A.N (1956), "Quantitative Slope Analysis", Bulletin of the GeologicalSociety of America, 67, pp 571-596.

27. Strahler, A.N (1964), "Quantitative Geomorphology of Drainage Basin and Channel Network", Handbook of Applied Hydrology, pp 39-76.

28. Sujatha, E. R., Selvakumar, R. and Rajasimman, B., 2014. Watershed prioritization of Palar sub-watershed based on the morphometric and land use analysis.Journal of Mountain Science, 11(4), 906-916.

29. Ravindra Gaikwad, Vijay Bhagat (2018), "Multi -Criteria Watershed Prioritization of Kas Basin in Maharashtra (India): AHP and Influence Approaches ,Maharashtra (India), gcj3.17010105.