ISSN 2229-5518

Geoinformatic Approach for Watershed Characterization in Kasari Basin of Maharashtra, India

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Abstract: The quantitative investigation of morphometric parameters has got immense importance not only in river basin evaluation but also in soil and water conservation and natural resources management at micro watershed level. In view of that present research aims to evaluate morphometric parameters viz linear, areal and relief features of Kasari watershed by using geospatial techniques. The Kasari river is a major tributary of Panchganga river in mega Krishna basin covers an area of about 630.64 Km2 located in Kolhapur district of Maharashtra. Standard methods of Strahler's, Horton's, Miller's, Chorley's and Schumm's were applied to examine linear, aerial and relief morphometric characteristics. The results reveals that higher potential of soil erosion is possibly observed in sub basins of KS1, KS4, KS5 and KS7 respectively and priority should be given to them in order to conservation and management of soil and water resource.

Key words: Morphometric Analysis, Cartosat DEM, GIS environment, Erosion

1. INTRODUCTION

The quantitative investigation of morphometric parameters has got immense importance not only in river basin evaluation but also in soil and water conservation and natural resources management at micro watershed level. Land, water and vegetation are the life supporting natural resources which are being degrading very rapidly with population explosion and uncontrolled use of the natural resources. So, with respect to that above mentioned natural resources should be proficiently studied and conserved at watershed scale.

Geology, relief and climate are the key determinants of running water ecosystems functioning at the basin scale (Frisseletal, 1986). 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). Now a day, a major emphasis have been given by geomorphologists is on the development of quantitative and more precise physiographic methods and techniques to describe the evolution and developmental behavior of the surface drainage networks in the world.

Morphometric analysis of watershed provides a quantitative description of the drainage system which is an important aspect of the characterization of watershed (Strahler, 1964). The

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contain essential information concerning its structure and growth because all hydrologic and geomorphic processes occur within the watershed. Morphometric assessment of watershed provides quantitative description of the drainage system, which is an important aspect of characterization of watershed (Strahler, 1964).

Advanced GIS techniques are now a day used for assessing various terrain and morphometric parameters of the drainage basins and watersheds, as they provide a flexible environment and powerful tool for the manipulation and analysis of the spatial information. The hydrological response of a river basin can be interrelated with the physiographic characteristics of the drainage basin such as size, shape, slope, drainage density and length of the streams, etc. (Chorley, 1969., Geography and Willing, 1973). So, morphometric investigation of watershed is vital step toward basic understanding of the basin dynamics.

ISSN 2229-5518

Development of satellite Remote Sensing and Geographic Information System (GIS) open up a new vista in the evaluation and assessment of the basin morphometry with great precision. GIS techniques are now day's used for assessing various terrain and watersheds, as they provide a flexible environment and powerful tool for the manipulation and analysis of spatial information (Pareta et al., 2011)

In view of that present research aims to evaluate morphometric parameters viz linear, areal and relief features of Kasari watershed by using geospatial techniques.

Study Area

The Kasari watershed is a major tributary of Panchganga river in mega Krishna basin covers an area of about 630.64 Km^2 located in Kolhapur district of Maharashtra. The geographic location of study area lies in between 16^0 39′ 51″ N to 16^0 55′ 13″ N latitude and 73^0 42′ 51″ E to 74^0 42′ 51″ E longitude respectively. The river Kasari rises near the village Gajapur and flows south-east upto Dhangarwadi for about 16 Km and then eastward for a streach of about 40Km. The main stream is quite wide and receives its water from a fairly large triangular area lying between watersheds of Vishalgad range in the north and the Waghjai in the south. The river receives important southern tributary called Mangari near the Bhogaon village and from this village it develops into a wide alluvial plain in which the river has developed meanders (Kolhapur District Gazetteers, 1960).

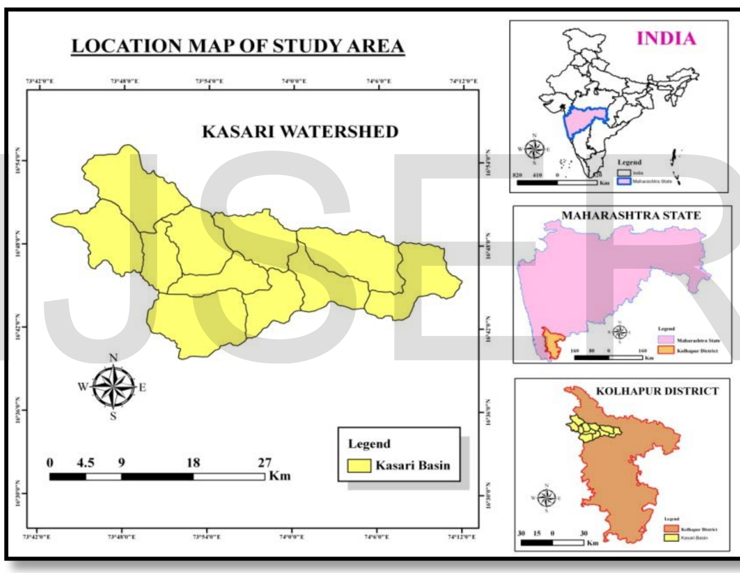


Fig.1

2 Data-base and Methodology

The present study mainly concerned to evaluate morphometric characteristics of Kasari river basin at sub watershed level using geospatial techniques. To do the same both SOI (Survey of India) Toposheets (47 E/12, E/16 , H/13, L/1, L/2) and Cartosat DEM data (30 m resolution) were used in Gis environment. At the outset, Cartosat data used as input in ArcSWAT to delineate main watershed as well as eleven sub watersheds. Toposheets georeferenced, Mosaiced and Subset has done in ArcGIS 9.3. Certain morphometric characteristics like as area, perimeter and length, stream orders and numbers were directly calculated in software. Standard methods of Strahler's, Horton's, Miller's, Chorley's and Schumm's were applied to examine linear, aerial morphometric characteristics. Microsoft office Excel 2007 software has been used to calculate as per given standard formulae of morphometric parameters. Certain relief characteristics viz. absolute relief, relative relief, watershed slope, ruggedness number and dissection index have been evaluated using CartoDEM data with spatial analyst tools of ArcGIS 9.3.

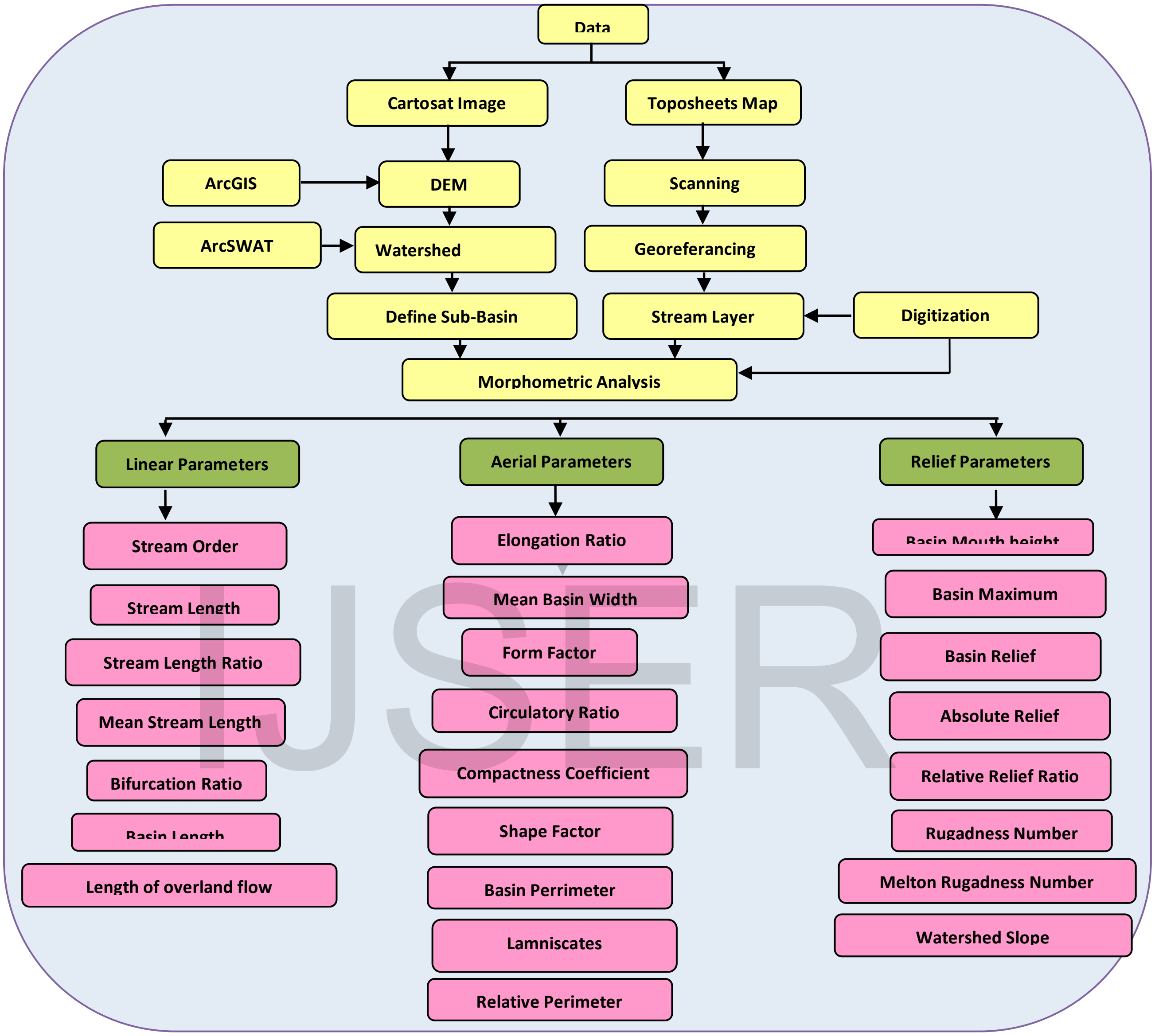


Fig.2 Methodology chart

3 Result and Discussion

The quantitative assessment of the configuration of the earth's surface provides the basis to investigate the geomorphologic characteristics of the earth. Fluvial work of drainage network greatly control the evolution of erosion land forms in basin (Pawar-Patil et al., 2013).The linear, aerial and relief characteristics of the watershed are the principal aspects of fluvial geomorphology. In view of that researchers have carried out certain morphometric aspects of Kasari watershed. Kasari basin covers about 630.64 km^2 of an area which has been divided into 11 sub-basin from KS1 to KS11, having geographical area from 33.99 km^2 to 78.91 km^2.

Linear parameters:

Drainage network is a significant indicator of the process of landform development in a geographical unit (Panhalkar et al, 2012). Linear parameters of river network include Stream order (U), Stream numbers (Nu), Basin Length (Lb), Stream length (Lu), Stream length ratio (RL), Mean stream length ratio (Lurm), Bifurcation Ratio (Rb), Mean Bifurcation ratio (Rbm) and Length of overland flow (Lof) etc.

Stream Order (Su):

Stream ordering is the foremost important step of quantitative analysis of the basin. At the outset stream ordering has introduced by Horton (1952), but latter his method has modified by strahler (1952). Here the researchers have carried out the stream ordering of Kasari watershed with Strahler's method. The Stream ordering is a measure of stream branching in watershed .In general, an N^{th} order streams is a tributary formed by two or more streams of order (N-1) and streams of lower order. The Kasari basin has 7^{th} order stream which is being draining in the lower reaches of the basin in sub basins of KS8, KS9, KS10 and KS11 respectively **(Table.1).**

1. Stream Number (Nu)

The order wise total number of stream segments is known as stream numbers. According to Horton (1945), 'number of stream segments of each order form an inverse geometric sequence with order number'. The total number of streams Kasari watershed is 3381 **(Table 1)** of which 1^{st} order stream segments are showing higher numbers i.e. 2567. Maximum number of 1^{st}order stream segments are occurred in KS7 (406) followed by KS1 and KS5 respectively **(Table 1).** It reveals that the 1^{st} order streams are highest in number in all sub-watersheds which decreases as the order increases and the highest order has the lowest number of streams.

2. Stream Length (Lu)

The total stream length of the kasari watershed is 2192.63 km of which stream length of first order segments contributes 1366.78 km. **(Table 3).** The stream lengths of 1st order streams are high in all watersheds in Kasari basin. Horton's law of stream lengths supports the theory that geometrical similarity is preserved generally in watershed of increasing order (Strahler, 1964).

3. Mean Stream Length (Lum)

It is the dimensionless property obtained by dividing the total length of the stream of an order by total number of stream of the same order. Mean stream length is mainly concerned to drainage network and its contributing watershed surface (Strahler, 1964). In Kasari watershed it fluctuates from 0.53 to 41.17 and in sub basin level analysis, it ranges from 0.46 to 14.75.

4. Stream Length Ratio (Lur)

The stream length ratio is the ratio of mean of segments of order (Lu) to mean of segments of next lower order (Lu-1) (Horton 1945). The stream length ratio of Kasari basin ranges in 0.32 to 1.21 and changes of stream length ratio from one order to another indicating their late youth stage of geomorphic development (Sing and Sing, 1997). The 7^{th} order stream length ratio observed in lower reaches sub basins of KS8, KS9, KS10 and KS11.

5. Bifurcation Ratio (Rb) and Mean Bifurcation Ratio (Rbm)

The bifurcation ratio (Rb) is the ratio of the number of stream segments of given order 'Nu' to the number of streams in the next higher order (Nu+1). According to Strahler (1957), 'bifurcation ratio shows a small range of variation for different regions or for different environment except where the powerful geological control dominates'. The order wise irregularity in Rb is mainly due to geological and lithological progression of the drainage basin. The lower value of Rb depicts the less structural disturbances (Strahler, 1964). The Rb of main Kasari basin ranges from 2.0 to 6.04 and at sub basin level it fluctuates in between 1.0 to 4.8 respectively **(Table.1)**. The mean bifurcation ratio (Rbm) is simple average of the Rb's of all order and highest value of Rbm is occurred in KS9 i.e. 3.87 followed by KS10 and KS6 respectively **(Table 1).** In Kasari sub basins the highest value of Rbm is profoundly points to physically powerful structural control on the drainage pattern.

6. Basin Length (Lb)

Basin length is the longest dimension of the parallel to the principal drainage line (Schumm, 1956). The calculated basin length of Kasari watershed is 51.08 km and in sub watersheds, it is fluctuating from 9.72 km to 16.36 km. Lb is affecting the form factor and shape factor of watershed.

7. Length of Over Land flow (Lg)

Length of over land flow is the length of the runoff of the rainwater on the terrain before it is localized in to definite channels (Horton, 1945). It is usually equal to half the reciprocal of the

ISSN 2229-5518

drainage density of the basin. In this study, Lg of Kasari watershed is 0.58 Km, which illustrates low surface runoff in the watershed. Sub watersheds of KS9 and KS11 are showing comparatively high Lg i.e., 0.77 and 0.76 respectively.

Drainage Texture Assessment

1. Stream Frequency (Fs)

Horton (1932) has introduced the 'Stream frequency' i.e. the total number of stream segments of all order per unit area. Generally high stream frequency is related to impermeable sub surface material, sparse vegetation, high relief and low infiltration capacity of the region (Pawar-Patil et al, 2013). The Kasari basin represents 5.36 of Fs. The sub basin level assessment of Fs shows that KS4 is having highest Fs (7.61) followed by KS1, KS7 and KS5 respectively. The lowest value of Fs occurs in KS11 (3.14) followed by KS9, KS10 respectively **(Fig.4).**

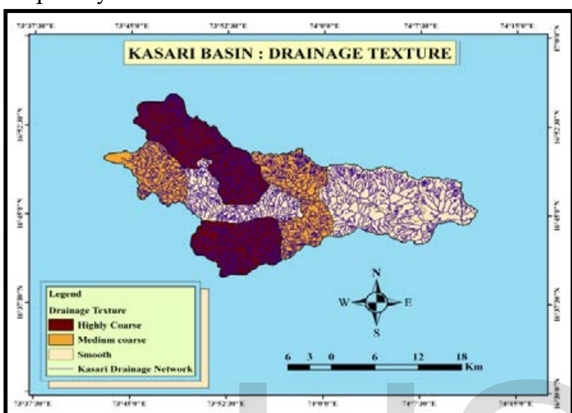


Fig.3

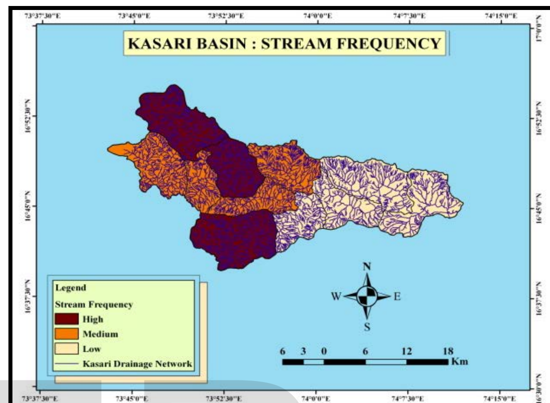


Fig.4

2. Drainage Density (Dd)

Drainage density (Dd) is the stream length per unit area in a region (Horton, 1945, Strahler, 1952). It is crucial aspect of drainage morphometry to study the landscape dissection, darainage intensity, and runoff potential, infiltration capacity of the land, climatic condition and vegetation cover of the basin. The average Dd in Kasari basin is 3.48 km/km^2 which is moderate in nature. The value of is Dd fluctuating from 2.60 km/km^2 to 4.20 Km/Km^2 in sub basins. The highest value of Dd observed in KS4 followed by KS7, KS5 and KS1 respectively which indicating that weak and impermeable subsurface material, scanty vegetation and mountainous relief characteristics.

Drainage Texture (Dt)

Drainage texture is expression of relative spacing of drainage lines in a basin which is obtained by dividing the total number of stream segments of all order by perimeter of the basin. It is important aspect of fluvial geomorphology affects the underlying lithology, infiltration capacity and relief aspect of the basin. Smith (1950) has postulated the classification scheme of Dt i. e., very coarse (<2), coarse (2-4), moderate (4-6), fine (6-8) and very fine (>8). The Dt of Kasari watershed is 21.35 which indicate very fine type **(Table 2)**. The sub basins of KS7, KS4 and KS1 are having fine texture showing high erosion potential while KS11 and KS9 are exhibiting moderate drainage texture **(Fig.3)**

Drainage Intensity (Di)

Drainage intensity (Di) is defined as the ratio of the stream frequency to the drainage density of respective basin (Faniran, 1968). The Kasari watershed is showing very low drainage intensity i.e. 1.54 which indicates that drainage density and stream frequency inadequately affect on the extent to which the surface has been lowered by agents of denudation. The sub watersheds of KS4, KS2 having relatively high Di while KS11 and KS9 showing low Di in Kasari basin **(Table.4).**

Infiltration Number (If)

Faniram (1968) has defined that 'Infiltration number is the product of stream frequency and drainage density which expresses the infiltration characteristic of the watershed. There is positive relationship between infiltration

ISSN 2229-5518

number and runoff, that higher the If lower will be the infiltration and higher will be the runoff

Aerial Aspect

1. Basin Area (A)

The researchers have calculated the basin area by using ArcGis-9.3 software and it is important aspect of aerial characteristics of watershed. Basin area affects on the certain morphometric parameters viz. Basin width, Form factor, shape factor and Circulatory ratio of watershed etc. The main Kasari watershed is covering an area of about 630.64 km^2 of which KS7 having maximum area i. e. 85.01 sq. km followed by, KS1 and KS10 of sub watersheds respectively.

2. Basin Perimeter (P) and Relative Perimeter (Pr)

Basin perimeter is the outer limit of watershed that defines its area. It is important aspect which measured along the water divides and always used as an indicator of size and shape of the watershed. The perimeter of Kasari watershed is 158.33 km and among the sub watersheds KS11 and KS3 is having highest and lowest perimeter respectively **(Table 4)**.

The relative perimeter is the ratio of basin area and perimeter (Schumm, 1965). It is high in KS7 and low in KS6 respectively.

3. Lemniscates (K)

Lemniscates (K) value states the slope of the watershed. The K value of Kasari basin is 4.14 which reveal that the watershed occupies the maximum area in its regions of inception with large number of higher order. The K value of Sub watersheds in Kasari basin is fluctuating from 2.77 to 3.11. **(Table 4)**

4. Form Factor (Rf)

Horton (1932), has declared that form factor is the ratio of basin area to square of the basin length. This is an important dimensionless property which enumerates the shape of the basin. The value of form factor would always be less than 0.754 (for perfectly circular watershed). Form

and vice versa. The If of Kasari basin is 18.64.

factor of Kasari basin is 0.32 and it ranges from 0.32 to 0.36 in sub basins **(Fig.6)**. It means that Kasari watershed is moderately elongated in shape and flow for longer duration.

5. Elongation Ratio (Re)

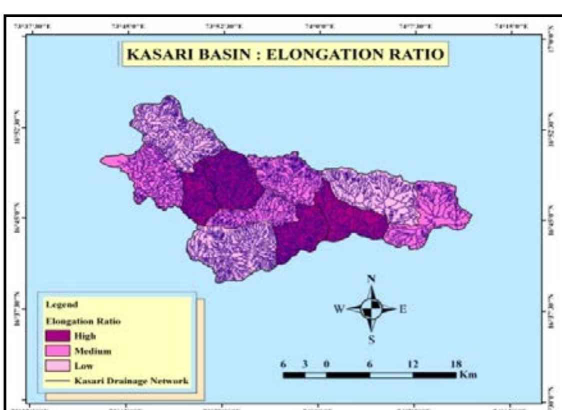
'Elongation ratio' (Re) is the ratio of diameter of a circle of the same area as the basin to the maximum basin length (Schumm, 1965). According to Strahler this ratio ranges from 0.6 to 1.0 over varied climatic and geologic types. The elongation ratio runs between 0.63 and 0.68 in all sub basins. The lowest and highest elongation ratio reveals in KS1 and KS3 respectively. The Re value of whole Kasari basin is 0.55 which represented that the watershed is moderately elongated **(Fig.5)**.

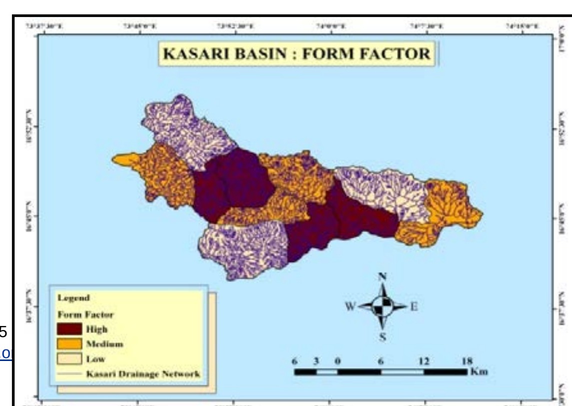
6. Circulatory Ratio (Rc)

Circulatory ratio is defined as the ratio of watershed area to the area of a circle having the same perimeter as the watershed and it is pretentious by the lithological character of the watershed (Pareta & Pareta, 2011). Miller (1953), noted that the basin having circulatory ratio between 0.4 to 0.5 indicates that the basin is highly elongated and highly permeable homogeneous geologic material. The circulatory ratio of Kasari watershed is 0.32 and in sub watershed level it fluctuates from 0.41 to 0.66, which characterize that sub basins are highly elongated, low discharge of runoff and highly permeability of sub soil.

7. Compactness Coefficient (Cc)

Compactness coefficient of a watershed is the ratio of the perimeter of watershed to circumference of circular area, which equals the area of the watershed (Gravelius, 1914). It is independent of size of watershed and dependent only on the slope. The computed Cc of the Kasari watershed is 1.78 and it ranges in between 1.24 to 1.57 in the sub basins **(Table 2)**.





ISSN 2229-5518

Relief Characteristics

Fig.5

1. Absolute Relief (Ra)

Absolute relief is the difference between a given location and sea level. The absolute relief of Kasari watershed is 946 mt. and the sub watersheds fluctuating in between 946 mt. (KS1) to 750 mt. (KS9) concerned to absolute relief **(Table 4)**.

2. Basin Relief (H)

Basin relief is the difference between the highest point of watershed and the lowest point on the valley floor. The Kasari watershed is having 483 mt.'basin relief which is being one of the vital factor to exaggerate the runoff in the basin. The basin relief in sub watersheds is highest in KS5 (448 mt.) and lowest in KS2 (269 mt.) respectively **(Table 2 & Fig.7)**

3. Relative Relief Ratio (Rhp)

The relative relief ratio is computed by using Melton's (1957), formula viz. Rhp = (H*100)/P, where P is perimeter which in meters. The Rhp of main Kasari watershed is 0.31 and in sub watersheds it is being fluctuating from 1.49 to 0.67 for KS3 and KS2 respectively **(Table 4)**.

4. Watershed Slope (Sw)

Watershed slope is nothing but the relief ratio which is the ratio between the total relief of the basin and the basin length. According to Schumm (1956), that the sediments loose per unit area is closely correlated with relief ratios. In the present study the value of watershed slope for Kasari watershed is 0.028, which is quite low **(Table 2 & Fig.8)**. The base rock, average basin relief is affecting the watershed slope. There may be correlation between relief ratio and hydrological

Fig.6

characteristics of the basin. Normally the areas having moderate to high basin relief and slope are illustrated high value of relief ratio and it is mainly observed due to loose and anti-resistant base rock and high slope.

5. Ruggedness number (Rn) and Melton Ruggedness number (MRn)

Ruggedness number (Rn) is the product of the basin relief and the drainage density. The ruggedness value of Kasari basin is 1.68 and in sub basins it ranges in between 0.73 to 1.73 in KS9 and KS5 respectively **(Table 2)**. The moderate value of Rg is expressing that area is moderately prone to soil erosion.

The melton's ruggedness number is specially being used for the representation of the relief ruggedness in the basin. The Kasari basin has 19.23 MRn which is moderate in nature. MRn ranges in between 34.30 to 74.44 which are observed in KS2 and KS3 respectively **(Table 2)**.

6. Dissection Index (Dis)

Dissection index (Dis) is the crucial aspect of relief being explored to know the degree of dissection or vertical erosion and illustrates the phases of terrain and landscape development. The value of Dis is generally ranges between '0' (Absence of vertical erosion/ flat surface) to '1' (Vertical cliffs or escarpments). The Dis value of Kasari watershed is 0.51 showing watershed is moderate to moderately high dissected. On the basis of dissection index, it is observed that the sub watersheds of KS5 and KS6 are highly dissected.

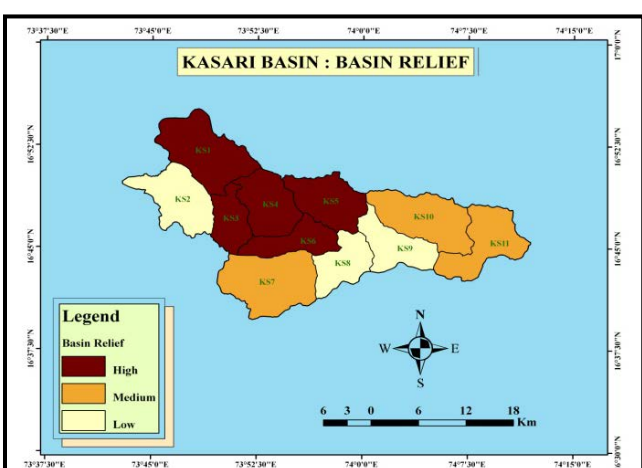


Fig.7

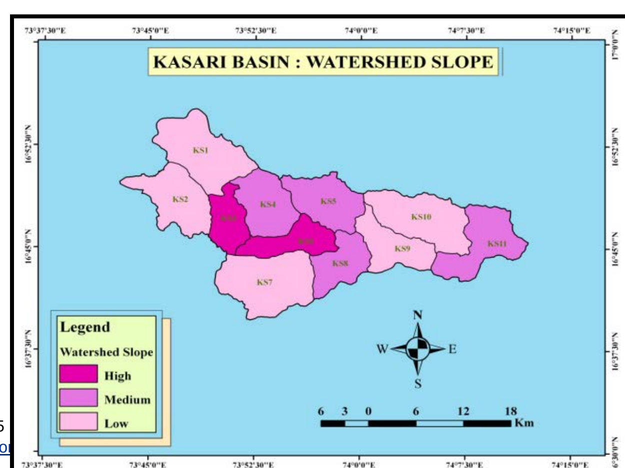


Fig.8

ISSN 2229-5518

Conclusion:

Watershed characterization is one of the vital important aspects of planning for the implementation of the development and management programmes at sub watershed level. The study reveals that the data collected form remote sensing sensors (Cartosat-DEM) and processing as well as analysis done by using GIS in order to evaluate drainage morphometric parameters is quite relevant and precise technique than traditional methods.

RS and GIS based approach assists to carry out different morphometric parameters and to explore the relationship between them in Kasari basin.

The results of different morphometric aspects at sub basin scale illustrate that those sub basins are having higher value of linear parameters e.g. drainage density, stream frequency, bifurcation ratio, stream length ratio, length of overland flow etc. and relief aspects e.g. absolute and relative relief, relief ratio, ruggedness number, dissection index etc. are showing greater erosion potential and those sub basins showing lower value of aerial parameters such as elongation ratio, circulatory ratio, form factor, compactness coefficient are also associated with higher degree of soil erosion potential and vice versa.

In view of that higher potential of soil erosion is possibly observed in sub basins of KS1, KS4, KS5 and KS7 respectively **(Fig.9)**. The location of these sub basins are in the higher reaches of Kasari basin profoundly at northern and southern hilly flanks and priority should be given to them in order to conservation and management of soil and water resource.

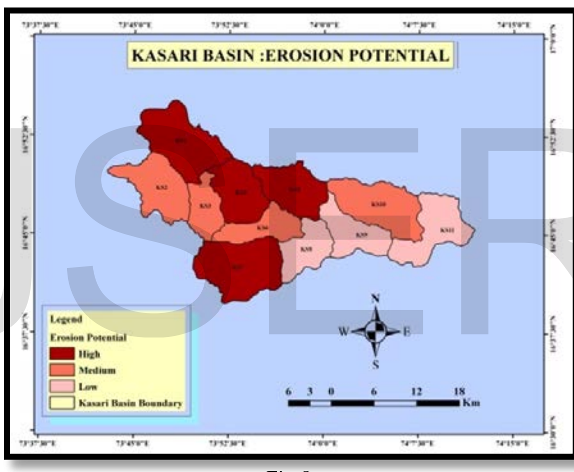


Fig.9

Table 1.

Sub-Basins	Stream order wise numbers							Bifurcation Ratios						
	1St	2nd	3rd	4th	5th	6th	7th	Rb1	Rb2	Rb3	Rb4	Rb5	Rb6	Mean Rb
KS1	376.00	90.00	22.00	6.00	2.00	1.00	0.00	4.18	4.09	3.37	3	2	0	1.77
KS2	262.00	70.00	15.00	3.00	1.00	1.00	0.00	1.34	3.74	4.66	5	3	2	2.51
KS3	142.00	36.00	7.00	2.00	0.00	1.00	0.00	3.94	5.14	3.5	2	0	0	1.44
KS4	308.00	71.00	18.00	4.00	1.00	1.00	0.00	4.4	3.94	4.5	4	1	0	2.63
KS5	248.00	62.00	16.00	4.00	1.00	0.00	0.00	4	3.89	4	4	0	0	2.26
KS6	168.00	45.00	8.00	1.00	0.00	1.00	0.00	3.73	5.56	8	1	0	0	3.15
KS7	406.00	94.00	23.00	5.00	2.00	1.00	0.00	4.32	4.09	4.6	2.5	2	0	1.95
KS8	175.00	42.00	10.00	1.00	1.00	2.00	1.00	4.17	2.2	10	1	0.5	2	2.12
KS9	122.00	32.00	6.00	1.00	0.00	0.00	1.00	3.81	5.33	6	1	0	0	3.87
KS10	219.00	50.00	15.00	2.00	0.00	0.00	1.00	4.38	3.33	7.5	2	0	0	3.53
KS11	141.00	38.00	11.00	3.00	0.00	0.00	1.00	3.71	3.45	3.67	3	0	0	3.01
Kasari_basin	2567	630	151	25	5	2	1	4.07	4.17	6.04	5	5	2	4.38

Table 2.

	Morphometric Analysis of Kasari Basin							
Sub_Basin	Dr_Tex	Com_Coef	Ba_Min_Ht	Ba_Max_Ht	Bsn_Relf	Wt_Slope	Rug_Nubr	Mel_Rg_No
KS1	11.81	1.34	504.00	946.00	442.00	0.028	1.68	49.75
KS2	8.72	1.45	489.00	758.00	269.00	0.020	0.91	34.30
KS3	6.46	1.41	483.00	917.00	434.00	0.045	1.55	74.44
KS4	12.55	1.24	497.00	927.00	430.00	0.034	1.64	59.07
KS5	9.55	1.32	477.00	925.00	448.00	0.035	1.73	60.69
KS6	6.47	1.55	477.00	910.00	433.00	0.040	1.58	68.91
KS7	13.25	1.23	483.00	906.00	423.00	0.026	1.67	45.88
KS8	7.34	1.37	473.00	845.00	372.00	0.034	1.38	57.31
KS9	4.46	1.49	471.00	750.00	279.00	0.024	0.73	40.68
KS10	6.95	1.36	472.00	895.00	423.00	0.028	1.21	49.38
KS11	4.45	1.57	463.00	873.00	410.00	0.030	1.07	52.20
Kasari Basin	21.35	1.78	463.00	946.00	483.00	0.028	1.68	19.23

Table 3.

Sub-Basins	Order wise Stream Length (in km)							Stream Length Ratio					
	1st	2nd	3rd	4th	5th	6th	7th	2nd	3rd	4th	5th	6th	7th
KS1	189.53	60.05	24.17	12.36	12.53	0.06	0.00	031	0.4	0.51	1.01	0.005	0
KS2	126.85	44.72	16.62	10.53	3.17	6.14	0.00	0.35	0.37	0.63	0.3	1.93	
KS3	79.47	23.79	8.60	5.12	0.00	5.20	0.00	0.3	0.36	0.59	0	1.01	0
KS4	143.64	38.40	22.85	5.33	4.56	7.65	0.00	0.27	0.59	0.23	0.86	1.69	0
KS5	131.58	40.46	21.60	10.88	6.08	0.00	0.00	0.31	0.53	0.50	0.56		0
KS6	89.68	31.76	8.62	5.25	0.00	8.20	0.00	0.34	0.27	0.61	0	1.56	
KS7	223.44	62.79	22.67	12.53	14.13	0.27	0.00	0.28	0.36	0.55	1.13	0.02	
KS8	100.28	27.56	12.25	1.82	0.17	6.61	7.11	0.28	0.44	.015	0.09	38.88	1.07
KS9	72.96	25.05	7.89	1.88	0.00	0.00	14.76	0.34	0.31	0.23			7.85
KS10	121.92	49.66	21.46	6.89	0.00	0.00	11.26	0.40	0.43	0.32			1.63
KS11	87.43	39.66	14.68	12.08	0.00	0.00	8.04	0.45	0.37	0.82			0.66
Kasari basin	1366.78	443.92	181.41	84.67	40.65	34.14	41.17	0.32	0.41	0.47	0.48	0.84	1.21

Table 4.

	Morphometric Analysis of Kasari Basin						
Sub_Basin	Dr-Intensity	Infiltration-No.	Absolute_Rel	Relativ_relief_ratio	Dis_index	Rel_Perimeter	Lanmiscates
KS1	1.66	23.88	946.00	1.05	0.46	1.87	3.11
KS2	1.69	19.33	758.00	0.67	0.35	1.52	3.01
KS3	1.54	19.85	917.00	1.49	0.47	1.17	2.77
KS4	1.81	31.96	927.00	1.40	0.46	1.65	2.95
KS5	1.57	23.43	925.00	1.29	0.48	1.57	2.96
KS6	1.55	20.68	910.00	1.26	0.48	1.14	2.97
KS7	1.58	24.68	906.00	1.05	0.47	2.12	3.14
KS8	1.48	20.39	845.00	1.18	0.44	1.33	2.86
KS9	1.32	8.94	750.00	0.77	0.37	1.29	2.9
KS10	1.36	11.26	895.00	1.02	0.47	1.78	3.08
KS11	1.20	8.22	873.00	0.94	0.47	1.41	3.01
Kasari Basin	1.54	18.64	946	0.31	0.51	3.98	4.14

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