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Morphometric study of Sweta Nadi Basin, Salem District, Tamil Nadu, India: GIS approach

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Abstract

The study of watershed characteristics is necessitated for working out a comprehensive development plan of the watershed for optimum use of its resources. The morphometric analysis can be achieved through measurement of linear, aerial, and relief aspects of the watershed. In the present study, quantitative morphometric analysis is carried out for 15 sub-watersheds of Sweta Nadi Basin, which is located in Salem district, Tamil Nadu. It will be the input to evaluate the basin hydrology, water resources, input and output component in the hydrology cycle. The Geographical Information System (GIS) has been made in this study, since it is an excellent tool for the management of large bodies of spatially extensive data with all the advantage of a computer environment; precision, consistency and absence of computational error. This powerful tool holds a very large potential in the field of regional and micro-level spatial planning particularly in sub-watershed planning and management.

Keywords: morphometry, bifurcation ratio, mean stream length, stream frequency, drainage density and relief ratio

1. Introduction

Morphometric is the measurements and mathematical analysis of the configuration of the earth's surface. Shape and dimension of its landforms (Clarke, 1996) [3]. The quantitative analysis of drainage system is an important aspect characteristic of watershed (Strahler, 1964) [16]. The Morphometric study of the drainage basin is aimed to acquire accurate data of measurable features of stream network of the drainage basin. A major emphasis in geomorphology over the past several decades has been on the development of quantitative physiographic methods to explain the evolution and behavior of surface drainage networks (Horton, 1945; Leopold & Maddock, 1953; Abrahams, 1984) [5, 7, 1]. Geographical information (GIS) techniques are used for assessing various terrain and morphometric parameters of the drainage basins and watersheds, as they provide a flexible environment and a powerful tool for the manipulation and analysis of spatial information. In the present study stream number, order, frequency, density and bifurcation ratio are derived and tabulated on the basis of areal linear and relief properties of drainage channels using GIS based on drainage lines as represented over the topographical maps (scale 1:50,000).

2. Study Area

The Sweta Nadi basin lies in the districts of Namakkal, Salem, Tiruchirappalli and Perambalur of Tamil Nadu State. The Sweta Nadi originates from the northern parts of Kolli hills in Namakkal District. It is located between 11^0 15' N and 11^0 45' N latitudes and 78^0 15' E and 78^0 58' E longitudes (as read from the survey of Indian Topographic sheets C44A6 (58 I/6), C44A7 (58 I/7), C44A10 (58 I/10), C44A11 (58 I/11) and C44A15 (58 I/15). The river originates from the northern parts of Kolli hills, a part of Manmalai, adjoining Kolli hills and Palakkadu Malai in Pachamalai. The total geographical area of the basin is 1,034.43 Sq.km (1,03,443 ha) within 82 Revenue villages. The study area is based upon the three major relief orders such as the hills, uplands, and the plains. The river runs over 116 kms from the west to the east, and joins Vellar River, which runs into the Bay of Bengal (Fig.1).

3. Materials and Methods

The study area delineated from SOI topographical map (Fig.2) were digitization work has been carried out for entire analyses of basin morphomerty using GIS Software (Arc GIS 10). The stream order was calculated using the method proposed by Strahler (1952) stream ordering technique. The sub-watershed was demarcated based on the elevation, slope and outlet point that have been given in village name from 1 to 15. The sub watershed number was designated with names in tables. Quantitative morphometric analysis was carried out in all the 15 sub watersheds independently for determining their linear, areal and relief aspects.

4. Results & Discussion

The present area surface water divided marks the heights elevation, slope and outlet point on the area for detailed quantitative analysis have been done and the study area is divided into 15 sub watershed named by villages name and from 1 to 15 (Table.2). The sub watersheds were designated with village name and number in the tables. The Various morphometric parameter of the Sweta basin have been computed and summarized as follows.

A. Linear Aspects

Drainage network of the Sweta basin is presented Stream links (the different drainage lines) and the nodes (the stream junctions) characteristics linear aspects of the basin. The linear aspects include the stream order (u), Stream length (Lu), Mean stream length (Lsm), Stream length ratio (Rl) and Bifurcation Ratio (Rb), were determined and results have been presented in Table.3

Stream Order (u) and Stream Number (Nu)

The Primary step in any drainage basin analysis is order designation, stream orders and is based on a hierarchic ranking of streams. Ranking of streams has been carried out based on the method proposed by Strahler (1964) [16]. The smallest fingertip tributaries are designated as order 1. Where two first order channels join, a channel segment of 2nd order is formed and so forth. It has been formed that the study area us in 7th order drainage basin. Sweta Nadi Basin has 3,738 stream segments, out of which 74.50% of segments (2842) come under I order stream, 17 % of segments (664) in II order, 4.25 % of segments (236) in III order, 1.29 % of segments (48) in IV order, 0.37 % of segments (14) in V order, 0.26 % 0f segment (10) in VI order and 0.03 % (1) segment is under VII order stream respectively. A perusal of the table. 2 indicates that among 15 sub-watersheds, lowers reaches of Vembavur Sub watersheds has the highest stream order of 7, which has been formed due to the confluence of Sweta Nadi (Vembavur). The upper reaches of Mullukuruchi watershed has more number of first order (467) and second order (104) streams, while third order (27) streams are found in more in Mullukuruchi sub watershed. Thus the law of lower the order higher the number of streams is implied throughout the basin. The sub watersheds namely, Mullukuruchi, Solakkadu, Lakshmanapuram and Palakkadu are associated with the hilly terrains. Therefore, they have more number of streams with the total of 686, 512, 349 and 326 respectively, whereas Periyammapalayam sub watershed has only 61 total streams, which indicates the flat terrain of the watershed It is observed that the variation in order and size of the watersheds is largely due to physiographic, structural conditions of the region and infiltration capacity of the soil.

Drainage patterns of stream network from the basin have been observed as mainly dendritic type which indicates the homogeneity in texture and lack of structural control. This pattern is characterized by a tree like or fernlike pattern with branches that intersect primarily at acute angles. While in some parts of the basin represent parallel type indicating that the topographical features are dipping, folded and highly jointed in the hilly terrains. A parallel drainage pattern consists of tributaries that flow nearly parallel to one another and all the tributaries join the main channel at approximately the same angle. Parallel drainage suggest that the area has a gentle, uniform slopes and with less resistant bed rock. A radial drainage pattern forms when water flows downward or outward from a hill or dome. The radial drainage pattern of channels produced can be linked to a wheel consisting of a circular network of parallel channels flowing away from a central high point (Jensen, 2006). The properties of the stream networks are very important to study the landform making process (Strahler and Strahler, 2002) [13].

Stream Length (Lu)

Stream length is one of the most important hydrological feature of the basin as it reveals that the surface run-off behaviors. The number of streams of various orders in sub-watersheds is counted and their length form mouth to drainage divide is measured (Table.2). The stream length (Lu) has been calculated for all the 15 sub watersheds. The total stream length of the watershed is 2461.77 km. the large sub watersheds such as Solakkadu (87.44 Sq.km), Vembavur (106.72 Sq.km), Udumbiyam (104.29 Sq.km), Mullukuruchi (87.44 Sq.km) and Lakshmanapuram (85.28 Sq.km) have the total stream length of 294.95 km, 224.96 km, 197.29km, 287.67km and 231.10km respectively. Whereas, Periyammapalayam sub watersheds has less stream length of 57.40 km. Mullukuruchir sub watershed has the highest first order, second order, third order, and fifth order stream lengths of 60.02km, 169.04km, 24.42km, 16.88km and17.31km, respectively, which define more undulating topography. Further, fourth order stream length is more in Tembadi sub watershed (26.64 km), where all streams are confluence here due to flatness of terrain in periyammapalayam and Vembavur sub watersheds. The length of Seventh order stream is 17.89 km, only found in Vembavur sub watershed. This change may indicate flowing of streams from high altitude, lithological variations and moderately steep slope.

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) [16]. The mean stream length (Lsm) has been calculated by dividing the total stream length of order by the number of streams. Table.3 indicates that Lsm in the Sub watersheds ranges between 1.03 km to 4.26 km found at Kadampur sub watersheds and Udumbiyam sub watersheds respectively. Lsm of any given order is greater than that of the lower order and less than that of its next higher order in the basin. This might be due to variations in relief, slope and lithology of the area.

Stream Length ratio (Rl)

It is the ratio between the mean lengths of streams of any two consecutive orders. Horton's law (1945) [5] of stream length states that the mean length of stream segments of each of the successive orders of a basin tends to approximate a direct geometric series, with stream lengths increasing towards higher stream order. Stream Length Ratio (Rl) in these sub-watersheds varies between 0.11 and 0.90 km found at Udumbiyam and Ettikkadu sub-watersheds respectively as like Lsm. This variation might be due to changes in slope and topography. All sub-watersheds in the present study area have changes from one order to next order representing their late youth stage of geomorphic development. It is the ratio of the number of streams of a given order to the number of streams of the next higher order (Schumm, 1956). Horton (1945) [5] considered bifurcation ratio (Rb) as an index of relief and dissections. According to Strahler (1957) [14], Rb shows only a small variation from region to region or different environments except where powerful geological control dominates. It is observed from Table. 3 that the Rb value is not uniformly decreasing from one order to its next order in most of the sub-watersheds, which denotes the geological control and lithological development on all sub-watersheds of the study area.

The mean bifurcation ratio (Rbm)

The mean bifurcation ratio (Rbm) may be defined as the average of bifurcation ratios of all orders. In the present study area, higher mean bifurcation ratio (3 to 4) has been observed in Mullukuruchi, Solakkadu, Ulipuram pudur, Palakkadu and Tondamandurai, which indicates strong structural control (Strahler, 1964) [16]. 7 sub-watersheds have medium mean bifurcation ratio and Udumbiyam, Periyammapalayam sub watersheds has very low mean bifurcation ratio of 1.9 with less structural control on the drainage pattern (Fig.2c).

B) Areal Aspects

Area (A) and perimeter (P) of the sub-wagersheds are the important parameters in quantitative morphology. Watershed area is an imperative morphometric attribute as it is related to the spatial distribution of a number of significant attributes such as drainage density (D), texture ratio (Rt), stream frequency (Fs), form factor (Rf), elongation ratio (Re), circularity ratio (Rc) and length of overland flow (Lg) were calculated and results have been given in (Table.4).

Drainage Density (Dd)

Drainage density is the total length of all the streams in the watershed to the area of watershed. It helps in determining the permeability and porosity of the watershed and an indicator of landform elements in stream eroded topography, Drainage density (Dd) is the measure of the total length of the stream segment of all orders per unit area. It expresses the closeness and spacing of streams. High drainage density is due to the regions of weak or impermeable surface materials, sparse vegetation, and mountainous relief. The average drainage density of the Sweta basin is 2.37 which refer the moderate drainage density. And for all sub watersheds the drainage density is changing from 1.6 to 3.28. In 1.6 in Periyammpalayam sub watershed and 3.28 in Mullukuruchi sub watershed. High drainage density (> 3) is found in Mullukuruchi sub watershed, which covers 8.45 % (87.45 sq.km) of the total study area. Moderate drainage density (2 – 3) is noticed in 9 sub watersheds with 56.96 % area (589.24sq.km) and low drainage density (< 2) is recorded in 5 sub watersheds, which constitute for 34.58% (357.75sq.km) of the total area of the watershed (Fig.2a).

Texture Ratio (Rt)

Texture ratio (Rt) is an important factor in the drainage morphometric analysis, which reflects the relief characteristics of the terrain, infiltration capacity and lithology. Low drainage density leads to coarse drainage texture, whereas high drainage density results into fine drainage texture. Horton (1945) [5] defines drainage texture as the total number of segments of all order per perimeter of that area. Smith (1950) classified drainage density into five different textures, *<2-very coarse texture, 2-4 coarse, 4-6 moderate coarse texture, 6-8 fine texture, >8 very fine texture.* With the above facts, Mullukuruchi and Solakkadu has the very fine texture as it the highest texture ratio of 15.05 and 10.21 with low infiltration capacity because it lies in the altitude area and water is running towards low lying areas. Lakshmanapuram watershed has fine texture ratio of 6.48. Periyammapalayam, Kondayampalli and Naripadi sub-watersheds has coarse texture ratio2.0, 2.84 and 3.59, denoting very coarse texture and high infiltration capacity due to its flatness and the remaining 8 sub-watersheds are under moderate coarse texture ratio (Fig.2b).

Stream frequency (Fs)

Stream frequency (Fs) of a basin may be defined as the number of streams per unit area (Horton, 1932) [4] classified in to four different stream frequency, poor (0.1-0.5), moderate (0.5-2.5), high (2.5-3.5) and very high (above 3.5). Stream frequency resembles drainage density of the sub-watersheds. Stream frequency of Mullukuruchi (7.84), Solakkadu (4.53), Kadampur (3.61), Naripadi (3.73), Krishnapuram (4.19), Palakkadu (3.60) and Lakshnanapuram (4.09) watersheds have very high stream frequency. Respectively Fs mainly depend on the lithology of the watersheds and reflect the texture of the drainage network. It is found that the Fs and the drainage density values of the watersheds are positively correlated. This indicates that the increase in stream population is connected to that of drainage density. High stream frequency of Ulipuram pudur (3.26), Ettikkadu (3.42), Tembadi (3.23), Tondamandurai (2.71) and Vemvavur (2.75) the remaining sub -watersheds are under moderate (Fig.2f).

Form Factor (Ff)

Form factor is defined as the ratio of basin area to the square of the basin length .The values of form factor would always be less than 0.7854 (perfectly for a circular basin). Smaller the value of (Ff) more elongated will be the basin. The form factor for all watersheds varies from 0.09-1.45, But the whole Sweta Nadhi basin have 0.5 Ff. The observation shows that the Krishnapuram (0.09) and Udumbiyam (0.14) watersheds are highly elongated while as the Kondayampalli (0.87) less elongated (Fig.2g). The values of form factor (Ff) for Sweta Nadhi indicates that the whole watersheds are elongated. The elongated watershed with low value of form factor (Ff) indicates that the basin will have a flatter peak flow for longer duration. Flood flows of such elongated basins are easier to manage than from the circular basin.

Elongation ratio (Re)

The values of elongation ratio generally vary from 0.6 to 1.0 over a wide variety of climate and geologic types. Values close to 1.0 are typical of regions of very low relief, whereas values in the range 0.6 to 0.8 are usually associated with high relief and steep ground slope. Schumn (1956) [11], defined elongation ratio as the ratio between the diameter of the circle of the same area as the drainage basin and the maximum length of the basin. Analysis of elongation ratio indicates that the areas with higher elongation ratio values have high infiltration capacity and low runoff. A circular basin is more efficient in the discharge of runoff than an elongated basin. Kondayampalli (1.05) and Ettikkadu (1.36) sub watersheds are circular in shape, which indicate moderate to high relief and steep slopes and remaining sub-watersheds are under less elongated to more elongated ratio (Fig.2e). Elongated shape represents plain land with low relief and low slope. These values can be grouped in to three categories namely (a) circular (>0.9), (b) oval (0.9 to 0.80, (c) less elongated (<0.7).

Circulatory Ratio (Rc)

Miller (1953) define circularity ratio as the ratio of the basin area to the area of a circle having the same circumference parameter as the basin. It is a dimensionless index to the form outline of drainage basins. The ratio is influenced by the length and frequency of stream, geological structure, vegetation cover, climate, relief and slope of the basin. In the present study the Rc values for all sub watersheds vary from 0.30 to 0.58 which shows that the watersheds are almost elongated (Fig.2d). This anomaly is due to diversity of slope, relief and structural conditions prevailing in these watersheds.

Length of Overland Flow (Lg)

Surface runoff follows a system of downslope flow paths from the drainage divide to the nearest channel. R.E. Horton (1945) [5] defined length of overland flow (Lg) as the length of the flow path, projected to the horizontal of channel flow from a point on the drainage divide to a point on the adjacent stream channel. Lg is approximately half the average distance between stream channels and is therefore approximately equal to half the reciprocal of drainage density. The computed value of length of overland flow for all sub-watersheds ranges from 0.61 to 1.20 excluding Kondayampalli (1.12), Udumbiyam (1.06) and Periyammapalayam (1.20) sub watersheds are low drainage density and low relief whereas the values of Lg are low in case of Mullukuruchi (0.61) Solakkadu (0.77) Naripadi (0.74), and Lakshnanapuram (0.74) indicating high relief.

C) Relief Aspects

The relief aspects include Relative Relief (R) and Relief Ratio (Rh) of the sub-watersheds (Table.5).

Relative Relief (R)

The maximum height of the watershed is 1287 m found at Solakkadu -watershed and the minimum height of 104 m at the mouth of the watershed i.e. Vemvavur sub-watershed. Notably Solakkadu sub-watershed has the highest relative relief of 1009 m, whereas Vembavur sub-watershed has the extremely low relative relief of 35 m (Fig.2h). Solakkadu - watershed is the steep sloping area due to its maximum elevation, whereas Vemvavur sub-watershed is very gentle sloping area with low relief, high infiltration capacity and hence, more groundwater potential.

Relief Ratio (Rh)

The gravity of water flow, low infiltration and high runoff conditions are the indicators of the highest relief and vice-versa. 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) (Schunm, 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 areas with high relief and steep slope are characterized by high value of relief ratios. Low value of relief ratios are mainly due to the resistant basement rocks of the basin and low degree of slope (Mahadevaswamy G. et. Al). Relief ratio represents the overall steepness of a watershed and is an indicator of intensity of erosion processes operating on the slopes of the sub watershed. Ettikkadu sub-watershed in the extreme central part of the watershed and Vembavur sub-watershed occupy the highest and lowest relief ratio of 210.9 m and 4.18 m respectively (Fig.2i).

5. Tables and Figures

Table 1: Present study the Morphometric analysis is carried out using mathematical formulae given bellow.

Sl. No.	Morphometric Parameters	Formula/ Definition/Methods	Reference
		A. Linear aspect:	
1	Stream order	Hierarchical rank of streams	Strahler (1952)
2	Bifurcation Ratio (Rb)	Rb=Nu/Nu+1 Nu=Total no. of stream segments of order "u" Nu+1= Number of segments of the next higher order	Schumm (1956)
3	Mean Bifurcation Ratio (Rbm)	Rbm= Average of Bifurcation ratios of all orders	Strahler (1957)
4	Stream Length (Lu)	Length of the stream (Km)	Horton (1945) [5]
5	Mean Stream Length (Lsm)	Lsm=Lu/Nu Lu=Total stream length of order 'u' Nu=Total no. of stream segments of order 'u'	Horton (1945) [5]
	Stream Length Ratio (Rl)	Rl= Lu/Lu-1 Lu=Total stream length of the order 'u' Lu-1=Total stream length of its next lower order	Horton (1945) [5]
		B. Relief Aspects:	
6	Relative Relief (R) (or) Basin Relief (Bh)	R = H-h H=Maximum height (m) h=Minimum height (m)	Strahler (1952)
7	Relief Ratio (Rh)	Rh= R/Lb R= Relative relief (m) Lb= Basin length (m)	Schumm (1956)
		C. Arial Aspect:	
9	Drainage Density (Dd)	Dd=Lu/A Lu=Total stream length of all orders (Km) A=Area of the Basin (Km2)	Horton (1945) [5]
10	Texture Ratio (Rt)	T=Nu/P Nu=Total no. of streams of all orders P=Perimeter(Km)	Smith (1950)
11	Stream Frequency (Fs)	Fs= Nu/A Nu= Total no. of streams of all orders 37 A=Area of the Basin (Km2)	Horton (1945) [5]
12	Form Factor (Ff)	Ff=A/Lb2 A=Area of the Basin (Km2) Lb2= Square of the basin length (m)	Horton (1932) [4]
13	Elongation Ratio (Re)	Re=2√(A/Pi)/Lb A= Area of the Basin (Km2), Pi=3.14 Lb=Basin length (m)	Schumm (1956)
14	Circularity Ratio (Rc)	Rc=4*Pi *A/P2 A= Area of the Basin (Km2), Pi=3.14 P2 =Square of the perimeter (Km)	Miller (1953)
15	Length of Overland Flow (Lg)	Lg=1/D*2 Lg=Length of overland flow Dd=Drainage density	Horton (1945) [5]

Table 2: Stream Order and Stream Length of Sub-watersheds of Sweta Nadi Basin

	Number of Stream(Nu)									Stream Length in Km (Lu)							
sl	**Name of the Sub watersheds**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**total**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**total**
1	Mullukuruchi	467	104	27	9	2	-	-	686	60.02	169.04	24.42	16.88	17.31	-	-	287.67
2	Solakkadu	396	86	21	5	3	1	-	512	159.40	60.88	35.92	20.73	16.51	1.50	-	294.95
3	Ulipuram pudur	132	41	9	1	1	-	-	184	63.67	35.45	18.14	9.28	6.58	0.00	-	133.13
4	Kondayampalli	77	26	7	1	-	1	-	112	45.40	26.10	17.33	1.05	-	7.93	-	97.82
5	Ettikkadu	139	40	10	3	1	1	-	194	76.56	28.25	20.84	4.70	1.34	6.26	-	137.96
6	Kadampur	97	28	4	3	-	-	-	132	49.71	20.68	16.50	5.58	-	-	-	92.47
7	Naripadi	93	25	5	1	-	1	-	125	56.10	17.36	5.74	11.51	-	0.23	-	90.94
8	Krishnapuram	173	35	7	2	-	1	-	218	70.79	28.75	18.52	8.53	-	5.42	-	132.01
9	Udumbiyam	191	48	13	5	-	1	-	258	106.95	47.34	15.95	-	-	27.05	-	197.29
10	Periyammapalayam	45	12	3	1	-	-	-	61	28.87	14.09	3.41	11.03	-	-	-	57.40
11	Palakkadu	236	54	11	2	1	1	-	305	104.98	41.15	23.02	19.98	9.50	0.01	-	198.63
12	Lakshmanapuram	265	61	16	4	3	-	-	349	130.02	46.71	27.22	12.03	15.11	-	-	231.10
13	Tembadi	168	44	10	5	2	1	-	230	91.48	34.56	15.02	26.64	1.32	0.62	-	169.63
14	Tondamandurai	119	21	7	5	1	2	1	156	53.94	27.39	11.21	13.78	-	9.47	0.04	115.82
15	Vemvavur	244	39	9	1	-	-	1	294	138.25	43.37	23.38	2.07	-	-	17.89	224.96

Source**:** Compiled by Author.

Table 3: Linear Aspects of Sub-watersheds of Sweta Nadi Basin

sl	Name	Mean Stream Length (Lsm)	Stream Length Ratio (Rl)	Rb1	Rb2	Rb3	Rb4	Rb5	Rb6	Rb7	Mean Bifurcation Ratio (Rbm)
1	Mullukuruchi	2.50	0.67	5.49	2.00	12.56	5.50	-	-	-	3.65
2	Solakkadu	2.00	0.35	5.60	5.10	5.20	2.67	4.00	-	-	3.22
3	Ulipuram pudur	2.75	0.33	4.22	5.56	10.00	2.00	0.00	-	-	3.11
4	Kondayampalli	1.86	0.19	3.96	4.71	8.00	-	1.00	-	-	2.53
5	Ettikkadu	1.79	0.90	4.48	5.00	4.33	-	2.00	-	-	2.26
6	Kadampur	1.03	0.22	4.46	8.00	2.33	-	-	-	-	2.11
7	Naripadi	2.03	0.38	4.72	6.00	6.00	-	-	-	-	2.39
8	Krishnapuram	1.94	0.22	5.94	6.00	4.50	-	-	-	-	2.35
9	Udumbiyam	4.26	0.11	4.98	4.69	3.60	-	-	-	-	1.90
10	Periyammapalayam	2.00	0.57	4.75	5.00	4.00	-	-	-	-	1.96
11	Palakkadu	3.26	0.33	5.37	5.91	6.50	3.00	2.00	-	-	3.25
12	Lakshmanapuram	1.57	0.38	5.34	4.81	5.00	2.33	-	-	-	2.50
13	Tembadi	1.35	0.44	4.82	5.40	3.00	3.50	3.00	-	-	2.82
14	Tondamandurai	1.55	0.31	6.67	4.00	2.40	6.00	1.50	3.00	-	3.37
15	Vembavur	3.46	0.13	7.26	5.33	10.00	-	-	1.00	-	3.37

Source**:** Compiled by Author.

Table 4: Areal Aspects of Sub watersheds of Sweta Nadi basin

Sl. No	Name of the Watersheds	Area of Basin in sq.km (A)	Length of Basin in km (Lb)	Perimeter in km (P)	Drainage Density in km (Dd)	Texture Ratio (Rt)	Stream Frequency (Fs)	Form Factor Ratio (Ff)	Elongation Ratio (Re)	Circulatory Ratio (Rc)	Length of Overland flow(Lg)
1	Mullukuruchi	87.45	20.60	45.57	3.29	15.05	7.84	0.21	0.51	0.53	0.61
2	Solakkadu	112.92	23.95	50.15	2.61	10.21	4.53	0.20	0.50	0.56	0.77
3	Ulipuram pudur	56.44	14.71	39.16	2.36	4.70	3.26	0.26	0.58	0.46	0.85
4	Kondayampalli	54.63	7.93	39.42	1.79	2.84	2.05	0.87	1.05	0.44	1.12
5	Ettikkadu	56.78	6.26	45.52	2.43	4.26	3.42	1.45	1.36	0.34	0.82
6	Kadampur	36.53	13.25	31.06	2.53	4.25	3.61	0.21	0.51	0.48	0.79
7	Naripadi	33.48	14.09	34.81	2.72	3.59	3.73	0.17	0.46	0.35	0.74
8	Krishnapuram	52.06	23.47	46.72	2.54	4.67	4.19	0.09	0.35	0.30	0.79
9	Udumbiyam	104.30	27.05	61.16	1.89	4.22	2.47	0.14	0.43	0.35	1.06
10	Periyammapalayam	34.57	15.26	30.51	1.66	2.00	1.76	0.15	0.43	0.47	1.20
11	Palakkadu	84.65	25.49	56.03	2.35	5.44	3.60	0.13	0.41	0.34	0.85
12	Lakshmanapuram	85.29	24.92	53.89	2.71	6.48	4.09	0.14	0.42	0.37	0.74
13	Tembadi	71.10	17.64	39.26	2.39	5.86	3.23	0.23	0.54	0.58	0.84
14	Tondamandurai	57.52	17.09	40.90	2.01	3.81	2.71	0.20	0.50	0.43	0.99
15	Vembavur	106.73	17.89	54.76	2.11	5.37	2.75	0.33	0.65	0.45	0.95

Source**:** Compiled by Author.

Table 5: Relief aspects of Sweta Nadi sub watersheds

Sl.No	Name	Maximum Height (H)	Minimum Height (h)	Relative Relief (R) =H-h	Basin length(Lb)	Relief Ratio (Rr)
1	Mullukuruchi	1120	317	803	20.59	38.98
2	Solakkadu	1287	308	1009	23.94	42.13
3	Ulipuram pudur	870	314	556	14.71	37.79
4	Kondayampalli	620	287	333	7.93	42.00
5	Ettikkadu	971	278	693	6.26	110.70
6	Kadampur	688	101	587	13.25	44.30
7	Naripadi	992	385	607	14.09	43.08
8	Krishnapuram	1071	221	850	23.47	36.22
9	Udumbiyam	660	144	516	27.05	19.07
10	Periyammapalayam	319	148	171	15.26	11.20
11	Palakkadu	1028	151	877	25.49	34.40
12	Lakshmanapuram	1031	297	734	24.92	29.45
13	Tembadi	896	156	740	17.64	41.95
14	Tondamandurai	717	131	586	17.09	34.28
15	Vembavur	139	104	35	17.89	1.95

***Source*:** Compiled by Author.

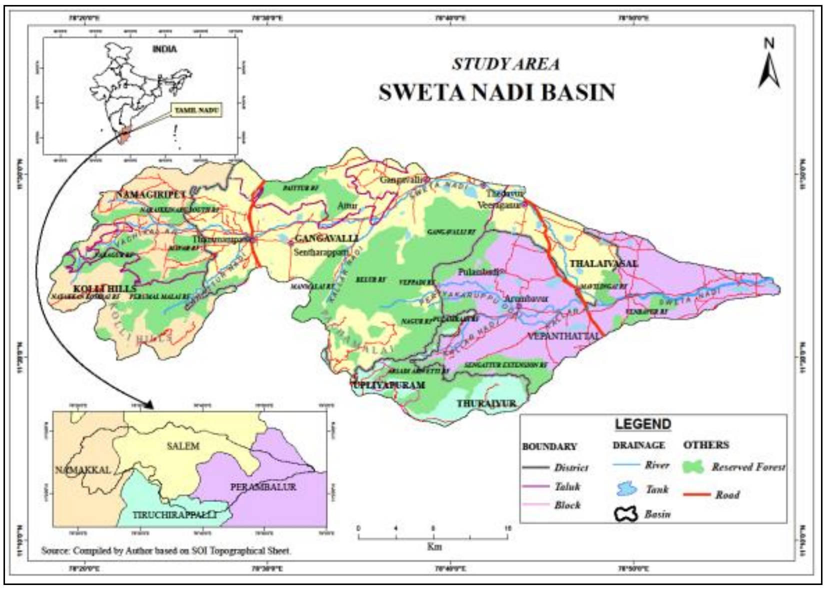

Fig 1: Study Area

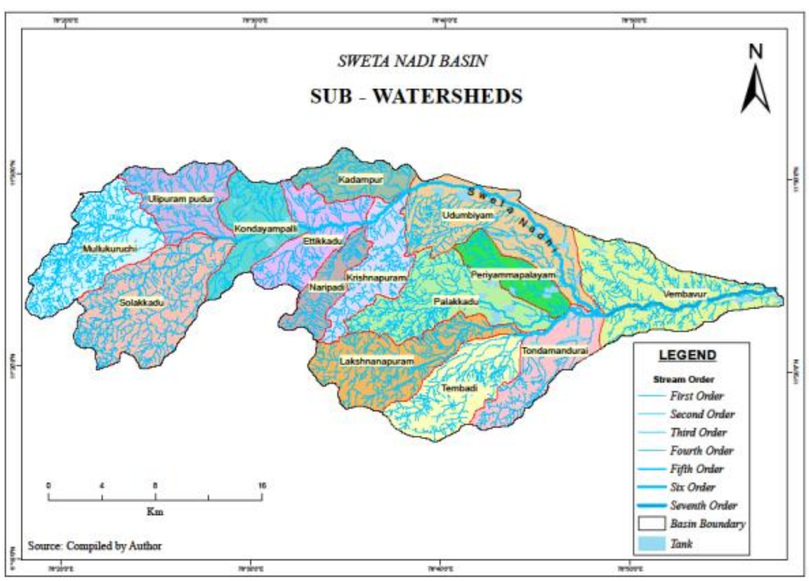

Fig 2: Sub-watersheds and Stream Orders

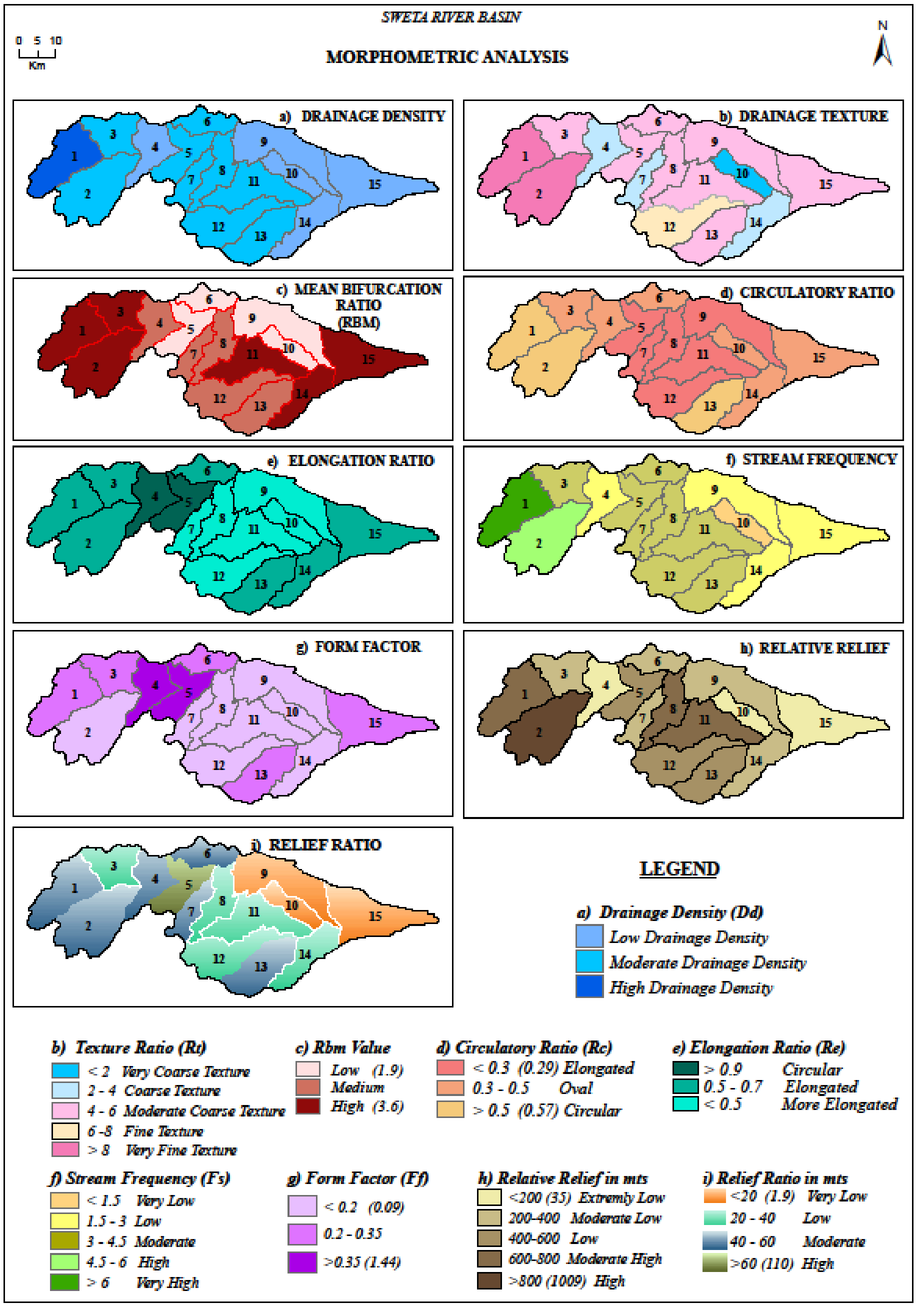

Fig 3: Morphometric Analysis (a, b, c, d, e, f, g, h & i)

6. Conclusions

The present study demonstrates that remote sensing techniques and GIS play a vital role for the preparation of updated drainage map in a timely and cost-effective manner and Morphometric analysis. Detailed morphometric study of watersheds represents dendritic (This is the most common pattern. This type of drainage pattern is characterized by irregular branching of tributary streams flowing in many directions and at almost any angles, although usually at less than a right angle). To sub-dendritic drainage pattern, indicating homogenous litho logy and variations in the values of ruggedness ratio among the watersheds attributed to the difference in topography and geometric development.

With the above morphometric analysis, drainage system and its characteristics have been examined for each sub-watersheds in the study to identify the constraints of sub-watersheds in all aspects. According to this, Mullukuruchi, Ulipuram pudur, Solakkadu sub watershed in western part of the study area, Kondayampalli, Kadampur, Ettikkadu, Naripadi, Krishapuram, Palakkadu, Lakshapuram, Tembadi in central part of the study area, Udumbiyam, Periyammapalayam, Tondamandurai, Vembavur sub - watersheds in Eastern part of the study area and few sub -watersheds the hilly area in the western and central part of the study area are characterized by high altitude, high drainage density and more stream frequency with fine texture ratio, which imply impermeable subsistence sub-surface material, low infiltration capacity and low groundwater potential of these areas. Therefore, they have more constraints due to drainage characters and so, they are not cultivated with agricultural crops. However, the valley slopes of these micro-watersheds are practiced by Tapiaco, Turmeric, coffee, tea, spices and cardamoms and forest plantation like teak, softwood, silkcotton and timber. It is reverse in Kondayampalli, Udumbiyam, Periyammapalayam, Tondamandurai and Vembavur lower reaches sub-watersheds, running from west to east in the central part of the study area, which have more groundwater potential due to high infiltration capacity, low relief low drainage density and less stream frequency. Hence, these areas are well suited for cultivating paddy, banana, sugarcane, maize, cholam, and cotton and coconut plantation.

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