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Comparative Morphometric Study of Sub-Watersheds Using Toposheet And Various Dem Data Sets

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ABSTRACT

The difference in areal and relief factors that impact on assessment of hydrological characteristics during the watershed management studies, flood studies, irrigation and other sensitive analysis. To identify and quantify those difference in Morphometric parameters and to determine the most suitable freely available DEM's among ASTER(30m), Cartosat-1(30m), JAXA(30m), SRTM(30m), TanDEM-X(90m) with respect to Toposheets(1:50,000 scale) on the point of reference data for Morphometric study of two sub-watersheds, Study area 1: Kumudavati Sub-watershed (C09PEU03) situated in Chickballapur district, Karnataka state, lies geographically at longitude (77°23'00"E - 77°30'00"E) : (77°23'00"E - 77°30'00"E) and (10°12'00"N - 10°11'00"N) : (10°22'00"N - 10°22'00"N) latitude, It covers an area of 431.08Sq.km with varying elevation from 648m-1160m under Pennar Upper Sub-Basin. Study area 2: Amaravati sub-watershed (C05CAM73) situated in Dindigul district, Tamilnadu state lies geographically at longitude (77°20'00"E - 77°32'30"E) : (77°20'00"E - 77°32'30"E) and (13°22'00"N - 13°22'30"N) : (13°40'00"N - 13°40'00"N) latitude, It covers an area of 146.67Sq.km with varying elevation from 369m-2400m under Cauvery Middle Sub-Basin. Morphometric analysis using GIS techniques,to quantify and compare the drainage systems for sub-watersheds,Morphometric characterization of both sub-watersheds are as follows, Kumudavati is variable of sixth ordered and Amaravati is variable of fifth ordered with drainage networks of Kumudavati as dendritic with moderate to coarse drainage texture, While Amaravati as dendritic with fine to coarse drainage texture, and Stream frequency of Kumudavati is low, while Amaravati is moderate. The values of form factor and circulatory ratio suggest that both Sub-watersheds are elongated. Higher bifurcation ratios of 6th order streams of Kumudavati and 4th order streams of Amaravati suggest that headward erosion is stronger. While, the Hypsometric properties of, both Sub-watershed using hypsometric integral (HI) values where Kumudavati Sub-watershed was found to be 0.23, 0.22, 0.20, 0.20, 0.20, and 0.19 watershed falls under the Monadock(old) stage, while Amaravati Sub-watershed was found to be 0.62, 0.62, 0.63, 0.62, 0.63, and 0.63 watershed falls under the Young stage with ASTER, JAXA and SRTM DEM's suits best with their use as they are very close to contour Area at each contour interval of Toposheet values than that of Cartosat-1 and TanDEM-X DEMs.

Keywords: DEM Data and Toposheets, Morphometric parameters, Hypsometric Integrals and GIS techniques.

1. Introduction:

Quantification and conservation of natural water resources is essential for livelihood where the development of catchment aims at productive utilization of the natural resources in entire area extending from ridge to stream outlet and managed in comprehensive manner, where RS and GIS technologies plays a vital role in the planning, management and development activities. A catchment area covering all land contributed Runoff water to common point where, runoff an important hydrologic variable used in water resources application and management planning. To understand Hydrologic process basin drainage characteristics are fundamental. There are, great number of practical applications of quantitative morphometric analysis using conventional techniques with advancement in geospatial and computer technology. Assessment of drainage basin morphometry has been more accurate and precise while, for understanding the stages of geomorphic evolution and delineation of erosional proneness of watershed, a histogram or cumulative distribution function of elevations in a geographical area from hypsometric curve of Hypsometric analysis is considered as an effective tool to derive, for these studies, DEM data set has a key role in assessing any digital topography which is commonly used to describe 3D geometry of the Earth surface for variety of applications. Satellite images have been increasingly used from past decades to provide DEM's attributes which are normally utilized in several applications. DEM's are created by using various methods namely Stereoscopic Photogrammetry of Air-Borne or Satellite Borne, RADAR or SAR interferometry, LIDAR and conventional surveying. Each method has a limitation depends on price, accuracy, sampling density, preprocessing requirements. The error in several DEM data is widely explored on reasons and significances, a quality of DEM influenced by several factors as well as sensor types, algorithm, terrain type, grid spacing and characteristics. Freely provided DEM's of 30 m resolution by ASTER GDEM, Cartosat-1 or IRS-P5, JAXA, SRTM, and TanDEM-X of 90 m resolution. For these freely available DEM data sets an approach made to determine the most suitable DEM's for morphometric analysis with SOI Toposheets (1:50000 scale) as a point of reference.

2.0 Study Area and Data Products:

2.1 Details of the Study Areas:

Study area 1: Kumudavati Sub-watershed (C09PEU03) situated in Chickballapur district, Karnataka state, lies geographically at longitude (77°23'00"E - 77°30'00"E) : (77°23'00"E - 77°30'00"E) and (10°12'00"N - 10°11'00"N) : (10°22'00"N - 10°22'00"N) latitude, It covers an area of 431.08Sq.km.under Pennar Upper Sub-Basin.

Study area 2: Amaravati sub-watershed (C05CAM73) situated in Dindigul district, Tamilnadu state lies geographically at longitude (77°20'00"E - 77°32'30"E): (77°20'00"E - 77°32'30"E) and (13°22'00"N - 13°22'30"N) : (13°40'00"N - 13°40'00"N) latitude, It covers an area of 146.67Sq.km.under Cauvery Middle Sub-Basin. Fig.3.1 shows the location map of the study area.

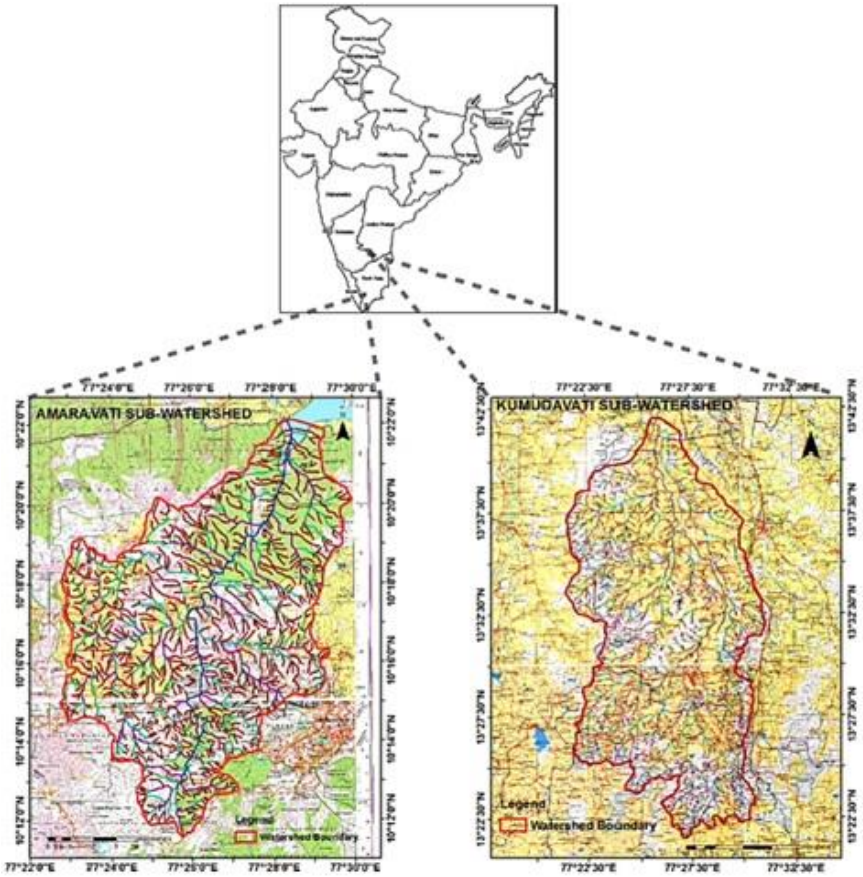

Figure 1. Location Map of study areas and Toposheet nos. (Kumudavati sub-watershed 57G/6, 57G/7, 57G/10 and 57G/11: Amaravati sub-watershed 58F/7 and 58F/8).

2.2 Data Products:

Table 1. Details of data set.

Sl.No	Data Sets	Scale/Resolution	Source
1	Toposheets	1:50000	Survey of India (SOI) topographical maps (1987-88)
2	ASTERDEM	30m	USGS Earth Explorer
3	CARTOSAT-1 DEM	30m	Bhuvan
4	JAXA DEM	30m	Jaxa Portal
5	SRTM DEM	30m	USGS Earth Explorer
6	TanDEM-X DEM	90m	German Earth observation satellite Portal

Table 2. Formulas used for computation of Morphometric Parameters with references.

SL No.	Parameters	Symbol	Formula	Reference
1	**Linear aspects**			
1.1	Stream order	Nu	Hierarchical rank	Strahler (1952)
1.2	Bifurcation ratio	Rb	Rb=Nu/Nu+1	Schumn (1956)
1.3	Stream length	Lu	Length of stream (Kilometers)	Horton (1945)
1.4	Mean Stream Length	Lsm	Lsm=Lu/Nu	Strahler (1964)
1.5	Stream length ratio	RL	RL=Lu/lu-1	Horton (1945)
2	**Areal aspects**			
2.1	Form factor	Ff	$F_f=A/\square^2$	Horton (1945)
2.2	Circularity index	Rc	$R_c = \frac{4\pi A}{P^2}$	Miller (1953)
2.3	Elongation ratio	Re	$Re = \frac{D}{L} = 1.128\frac{\sqrt{A}}{L}$	Schumn (1956)
2.4	Drainage density	Dd	$D_d = \frac{\sum Lt}{A}$	Horton (1945)
2.5	Stream frequency	Fs	Fs=Nu/A	Horton (1945)
2.6	Constant of channel maintenance	C	C=1/Dd	Schumm (1956)
3	**Relief aspects**			
3.1	Watershed relief	R	R = H-h	Schumm (1961)
3.2	Relief ratio	Rr	Rr = R/L	Schumn (1956)
3.3	Relative relief	Rh	Rh = R/L	Schumn (1956)
3.4	Ruggedness number	Rn	Rn = RDd /1000	Schumn (1956)

Table 3. . Formula used for computation of Hypsometric Integral with references.

SL No.	Parameters	Symbol	Formula	Reference
1	Hypsometric Integral	HI	$HI = \frac{(E_{mean} - E_{\min})}{(E_{\max} - E_{\min})}$	Pike and Wison (1971).

3. Methodology:

For any study methodology plays an important role to achieve the objectives, the methodology for extraction of watershed parameters and a Statistical approach to assess accuracy and precision of DEM data sets from ASTER, Cartosat-1, JAXA, SRTM and TanDEM-X DEM's and Toposheet using ArcGIS software.

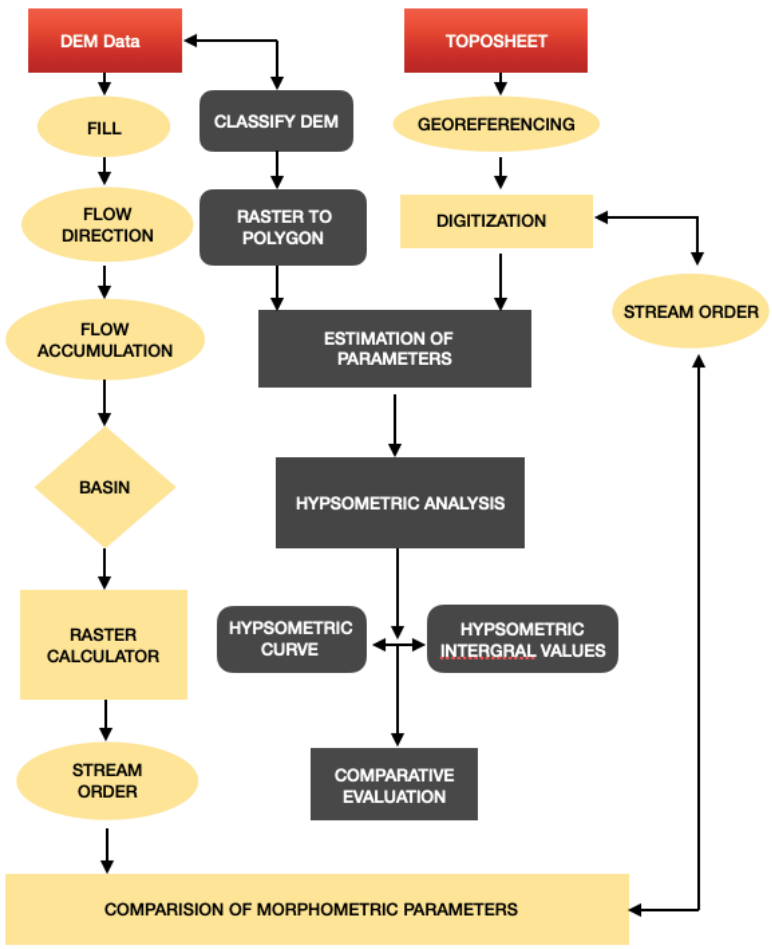

Figure 3. Work flow diagram for extraction of watershed parameters and Hypsometric Analysis.

4. Results And Discussion:

The Morphometric analysis of both sub-watersheds using drainage network and elevation data of Topsheets and that derived from DEMs are given in below Tables and Hypsometric analysis of DEM data sets of both sub-watersheds discussed in the following sections.

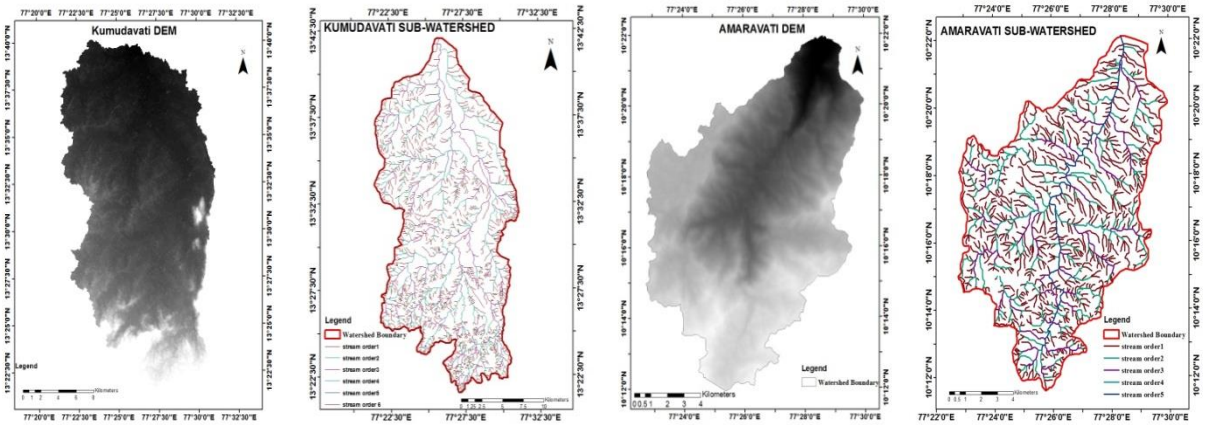

Figure 4.1. DEM and Drainage map of Kumudavati Sub-watershed and Amaravati Sub-watershed.

Table 4.1 (a). Kumudavati Sub-Watershed parameters.

Parameter	ASTER	Cartosat-1	JAXA	SRTM	TanDEM-X	Toposheet
Area(sqkm)	434.48	429.02	429.60	428.86	431.23	431.08
Perimeter (km)	118.55	130.51	133.72	116.12	118.55	109.72
Length (km)	37.77	35.02	36.04	35.67	35.43	36.25
Elevation at remote point (m)	1160.00	1196.00	1105.00	1187.00	1184.00	1096.23
Elevation at mouth point (m)	648.00	621.00	559.00	653.00	653.00	565.11

Table 4.1 (b). Amaravati Sub-Watershed parameters.

Parameter	ASTER	Cartosat-1	JAXA	SRTM	TanDEM-X	Toposheet
Area(sqkm)	144.38	144.86	147.28	147.31	142.53	146.67
Perimeter (km)	62.97	66.19	68.94	68.07	72.50	64.27
Length (km)	19.88	19.26	20.42	20.58	19.59	20.83
Elevation at remote point (m)	2400.00	2501.00	2406.00	2492.00	2488.00	2384.87
Elevation at mouth point (m)	369.00	313.00	219.00	287.00	338.00	236.40

Table 4.2 (a). Linear aspects, Areal aspects and Relief aspects of Kumudavati Sub-Watershed.

Parameter		Stream order	TOPOSHEET	ASTER	Cartosat-1	JAXA	SRTM	TanDEM-X	Units	Remarks
Linear aspect	Flow Accumulation Threshold Values			95	90	95	95	10	No	
	Number of stream segments(N_u)	1st Order	1415	1381	1383	1288	1381	1071	No	
		2nd Order	335	311	579	278	290	221	No	
		3rd Order	78	64	60	56	57	46	No	
		4thOrder	19	13	16	16	13	12	No	
		5thOrder	7	4	5	5	4	5	No	
		6th Order	1	1	1	1	1	1	No	
	Stream Length (L_u)	1st Order	599.24	542.19	493.81	465.06	501.12	417.96	km	Reveals with surface runoff characteristics while smaller lengths are with large slope and larger lengths with flatter gradients.
		2nd Order	214.17	247.34	238.89	235.85	251.91	198.94	km	
		3rd Order	142.43	155.30	134.47	121.27	137.38	128.73	km	
		4thOrder	96.01	71.64	78.85	73.50	74.88	59.24	km	
		5thOrder	23.64	22.21	22.17	28.63	18.54	20.19	km	
		6th Order	41.79	29.42	32.25	29.60	28.28	30.28	km	
	Bifurcation ratio(R_b)	1st Order								Values are well within the range indicating lesser proneness to flooding. From Toposheet R_b>5 indicating it may be either by stronger headward erosion or by Structural disturbances.
		2nd Order	4.22	4.44	2.39	4.63	4.76	4.85		
		3rd Order	4.29	4.86	9.65	4.96	5.09	4.80		
		4thOrder	4.11	4.92	3.75	3.50	4.38	3.83		
		5thOrder	2.71	3.25	3.20	3.20	3.25	2.40		
		6th Order	7.00	4.00	5.00	5.00	4.00	5.00		
	Mean Stream Length (L_{SM})	1st Order	0.42	0.39	0.36	0.36	0.36	0.39	km	
		2nd Order	0.64	0.80	0.41	0.85	0.87	0.90	km	
		3rd Order	1.83	2.43	2.24	2.17	2.41	2.80	km	
		4thOrder	5.05	5.51	4.93	4.59	5.76	4.94	km	
		5thOrder	3.38	5.55	4.43	5.73	4.63	4.04	km	
		6th Order	41.79	29.42	32.25	29.60	28.28	30.28	km	
	Stream Length ratio(R_i)	1st Order								Values so obtained indicates, its due to the variation in slope and topography.
		2nd Order	1.51	2.03	1.16	2.35	2.39	2.31		
		3rd Order	2.86	3.05	5.43	2.55	2.77	3.11		
		4thOrder	2.77	2.27	2.20	2.12	2.39	1.76		
		5thOrder	0.67	1.01	0.90	1.25	0.80	0.82		

		6th Order	12.37	5.30	7.27	5.17	6.10	7.50		
Areal aspects	Drainage density (D_d)		2.57	2.49	2.33	2.22	2.35	1.98	km/sqkm	Texture of watershed indicated from Toposheet and ASTER DEM as moderate while other DEMS indicating as Coarse.
	Compactness Co-efficient		1.60	1.78	1.82	1.58	1.61	1.49		Compactness Co-efficient dependent on slope characteristics.
	Circularity Ratio(R_C)		0.39	0.32	0.30	0.40	0.39	0.45		Elongated
	Elongation ratio		0.62	0.67	0.65	0.66	0.66	0.65		Elongated
	Constant of Channel Maintenance		0.39	0.40	0.33	0.45	0.43	0.50		Indicates the number of Sq.km of watershed required to sustain one linear km of channel.
	Form factor		0.30	0.35	0.43	0.34	0.34	0.33		Elongated
	Stream Frequency(S_F)		4.27	4.14	4.76	3.83	4.05	3.15		Low
	Watershed shape factor		3.28	2.86	3.02	2.97	2.91	3.05		Based on watershed characteristics it affects with various aspects of runoff
Relief aspects	Watershed relief (H)		512.00	575.00	546.00	534.00	531.00	531.12	m	Flat terrain with elevation varying from (512m-575m), Indicating with average drop in elevation in elevation of 0.01, with Lower values of Relative relief and Ruggedness number.
	Watershed relief ratio		0.01	0.02	0.02	0.01	0.01	0.01		
	Relative relief(R_h)		0.0043	0.0044	0.0041	0.0046	0.0045	0.0048		
	Ruggedness number(R_n)		0.0013	0.0014	0.0013	0.0012	0.0012	0.0011		

Table 4.2(b). Linear aspects, Areal aspects and Relief aspects of Amaravati Sub-Watershed.

Parameter		Stream order	TOPOSHEET	ASTER	Cartosat-1	JAXA	SRTM	TanDEM-X	Units	Remarks
Linear aspect	Flow Accumulation Threshold Values			60	60	100	60	06	No	
	Number of stream segments(N_u)	1st Order	693	670	688	410	623	615	No	
		2nd Order	202	145	152	100	138	133	No	
		3rd Order	47	31	33	24	31	27	No	
		4thOrder	9	5	5	3	5	4	No	
		5thOrder	1	1	1	1	1	1	No	
	Stream Length (L_u)	1st Order	333.47	194.50	197.90	163.17	183.63	206.08	km	Reveals with surface runoff characteristics while smaller lengths are with large slope and larger lengths with flatter gradients.
		2nd Order	109.28	111.96	113.39	85.23	97.43	97.41	km	
		3rd Order	58.57	57.53	57.19	43.97	58.56	53.70	km	
		4thOrder	20.27	19.31	21.75	18.96	21.58	18.05	km	
		5thOrder	23.24	13.76	14.25	14.49	12.44	13.03	km	
	Bifurcation ratio(R_b)	1st Order								Values are well within the range indicating lesser proneness to flooding. From Toposheet and all DEM's R_b>5 indicating it may be either by stronger headward erosion or by Structural disturbances.
		2nd Order	3.43	4.62	4.53	4.10	4.51	4.62		
		3rd Order	4.30	4.68	4.61	4.17	4.45	4.93		
		4thOrder	5.22	6.20	6.60	8.00	6.20	6.75		
		5thOrder	9.00	5.00	5.00	3.00	5.00	4.00		
	Mean Stream Length (L_{SM})	1st Order	0.48	0.29	0.29	0.40	0.29	0.34	km	
		2nd Order	0.54	0.77	0.75	0.85	0.71	0.73	km	
		3rd Order	1.25	1.86	1.73	1.83	1.89	1.99	km	
		4thOrder	2.25	3.86	4.35	6.32	4.32	4.51	km	
		5thOrder	23.24	13.76	14.25	14.49	12.44	13.03	km	
	Stream Length ratio(R_i)	1st Order								Values so obtained indicates, its due to
		2nd Order	1.12	2.66	2.59	2.14	2.40	2.19		

		3rd Order	2.30	2.40	2.32	2.15	2.68	2.72		the variation in slope and topography.
		4thOrder	1.81	2.08	2.51	3.45	2.28	2.27		
		5thOrder	10.32	3.56	3.28	2.29	2.88	2.89		
Areal aspects	Drainage density (D_d)		3.77	2.74	2.75	2.21	2.62	2.65	km/sqkm	Texture of watershed indicated from Toposheet is fine textured where, ASTER Cartosat-1,SRTM, TanDEM-X DEM's indicate as moderate while JAXA DEM is indicating as Coarse textured.
	Compactness Co-efficient		1.48	1.55	1.60	1.58	1.71	1.50		Compactness Co-efficient dependent on slope characteristics where Lesser values indicating with flatter terrain.
	Circularity Ratio(R_C)		0.46	0.42	0.39	0.40	0.34	0.45		Elongated
	Elongation ratio		0.68	0.71	0.67	0.67	0.69	0.66		Elongated
	Constant of Channel Maintenance		0.27	0.36	0.36	0.45	0.38	0.34		Indicates the number of Sq.km of watershed required to sustain one linear km of channel.
	Form factor		0.37	0.39	0.35	0.35	0.37	0.34		Elongated
	Stream Frequency(S_F)		6.59	5.88	5.97	3.65	5.60	5.28		Toposheet and all DEM's except JAXA DEM indicate as Moderate while JAXA indivating with Low stream frequency.

	Watershed shape factor		2.74	2.56	2.19	2.88	2.69	2.96		Based on watershed characteristics it affects with various aspects of runoff.
Relief aspects	Watershed relief (H)		2031.00	2188.00	2187.00	2205.00	2150.00	2148.47	m	Hilly Terrain with elevation varying from (2031m-2205m), Indicating with average drop in elevation of 0.10-0.11 with Higher values of Relative relief and Lower Ruggedness number
	Watershed relief ratio		0.10	0.11	0.11	0.11	0.11	0.10		
	Relative relief(R_h)		0.0322	0.0330	0.0317	0.0324	0.0296	0.0334		
	Ruggedness number(R_n)		0.0076	0.0059	0.0060	0.0048	0.0056	0.0056		

From the below **Figure 4.2(a)** and **Figure 4.2(b):**
Stream order v/s Number of streams of both sub-watersheds it can be seen that the numbers of streams maintain a linearity upto order two streams after that the number of streams decrease indicating plain and permeable terrain in the lower regions of the watershed. And in the upper terrain due to sloping topography huge number of first order streams occur while **Stream order Vs mean stream length** As seen by the above graphs this fluctuation in the number of streams in the area may have occurred since the Bifircation ratio is >5 indicating Geological disturbance in the Sub-watersheds.

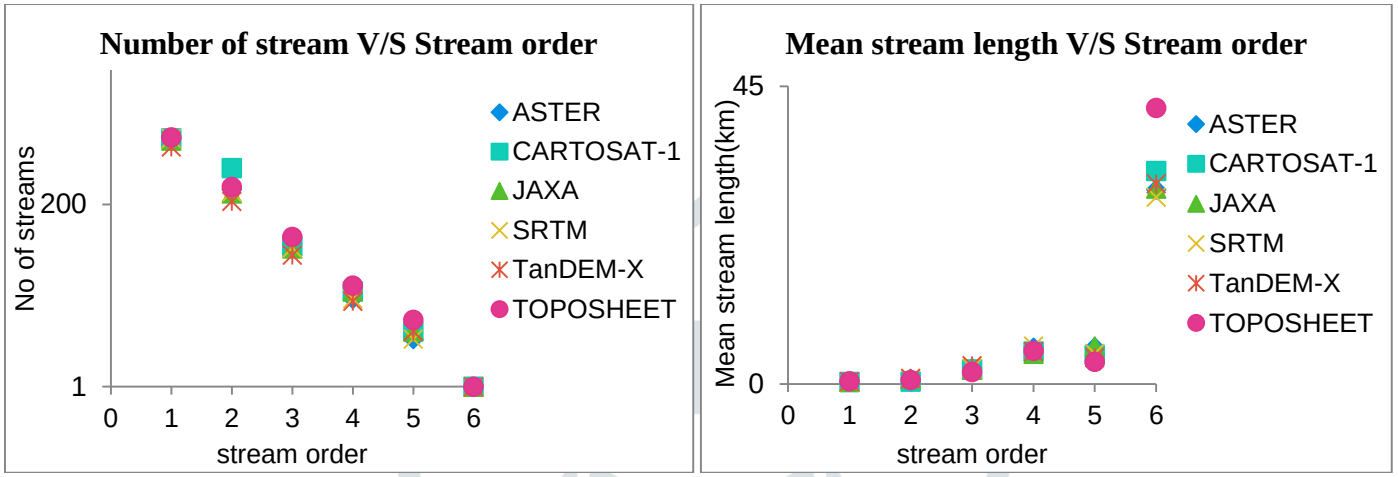

Figure 4.2(a). Stream order v/s Number of streams and Stream order v/s mean stream length by strahler system of stream ordering for Kumudavati Sub-Watershed.

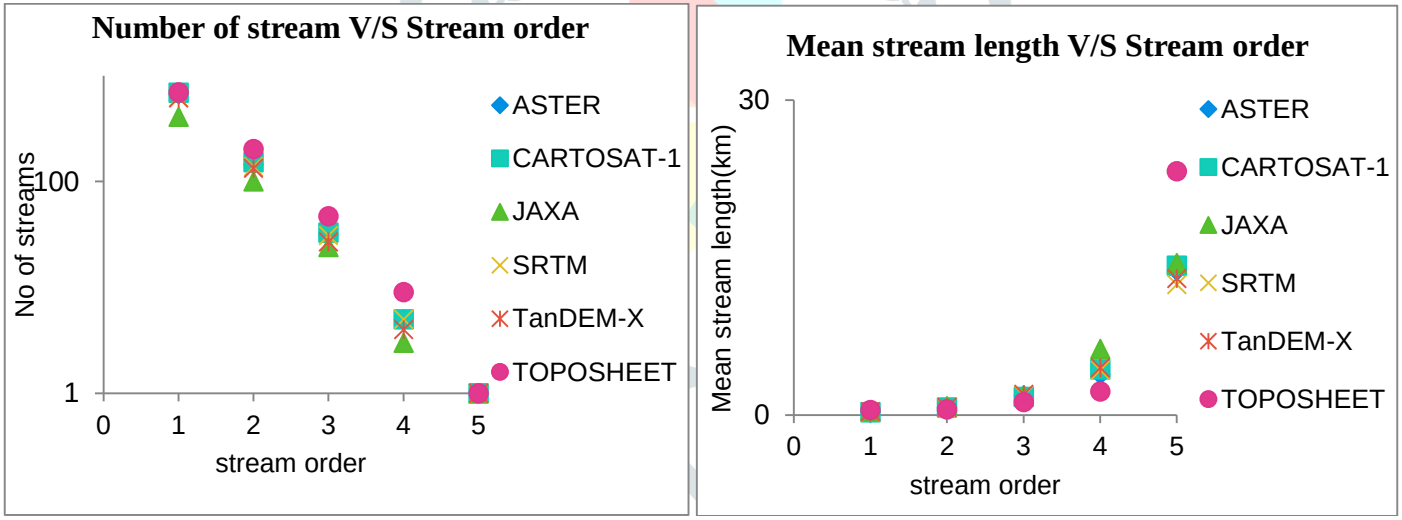

Figure 4.2(b). Stream order v/s Number of streams and Stream order v/s mean stream length by strahler system of stream ordering for Amaravati Sub-Watershed.

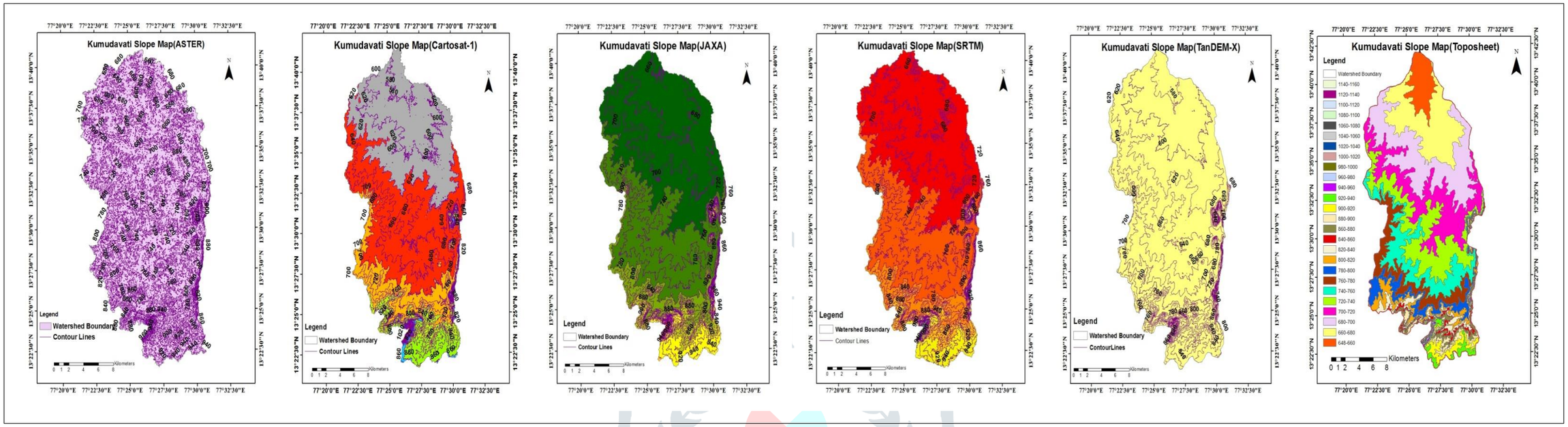

Fig 4.3(a). Slope maps of Kumudavati Sub-watershed.

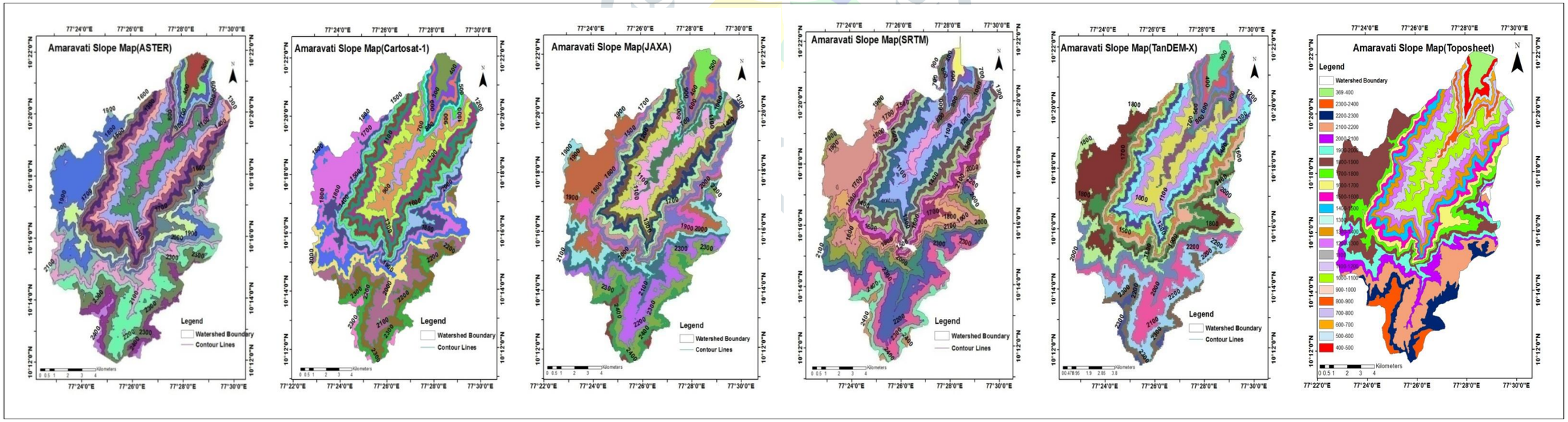

Fig 4.3(b). Slope maps of Amaravati Sub-watershed.

Table 4.3(a). Calculations of Percentage Hypsometric curve of the Kumudavati Sub-watershed from Toposheet.

AREA (sq km)	ALTITUDE CLASS	RELATIVE AREA (X)	ABOVE ALTITUDE	Cumulative X	Altitude (h)	Relative Altitude (Y)	Cumulative Y	Hypsometric Integral
21.09	648-660	0.04	648	1.00	12.00	0.02	0.02	
59.62	660-680	0.13	660	0.95	20.00	0.04	0.06	
74.80	680-700	0.17	680	0.81	20.00	0.04	0.10	
63.87	700-720	0.14	700	0.64	20.00	0.04	0.14	
57.62	720-740	0.13	720	0.50	20.00	0.04	0.17	
44.24	740-760	0.10	740	0.36	20.00	0.04	0.21	
32.60	760-780	0.07	760	0.26	20.00	0.04	0.25	
19.22	780-800	0.04	780	0.19	20.00	0.04	0.29	
13.84	800-820	0.03	800	0.14	20.00	0.04	0.32	
10.53	820-840	0.02	820	0.11	20.00	0.04	0.36	
6.17	840-860	0.01	840	0.09	20.00	0.04	0.40	
7.24	860-880	0.01	860	0.07	20.00	0.04	0.44	
7.76	880-900	0.01	880	0.05	20.00	0.04	0.47	0.19
8.60	900-920	0.01	900	0.04	20.00	0.04	0.51	
5.42	920-940	0.01	920	0.02	20.00	0.04	0.55	
0.52	940-960	0.001	940	0.00	20.00	0.04	0.59	
0.32	960-980	0.001	960	0.00	20.00	0.04	0.62	
0.23	980-1000	0.001	980	0.00	20.00	0.04	0.66	
0.18	1000-1020	0.000	1000	0.00	20.00	0.04	0.70	
0.17	1020-1040	0.000	1020	0.00	20.00	0.04	0.74	
0.10	1040-1060	0.000	1040	0.00	20.00	0.04	0.77	
0.09	1060-1080	0.000	1060	0.00	20.00	0.04	0.81	
0.06	1080-1100	0.000	1080	0.00	20.00	0.04	0.85	
0.03	1100-1120	0.000	1100	0.00	20.00	0.04	0.89	
0.02	1120-1140	0.000	1120	0.00	20.00	0.04	0.92	
0.01	1140-1160	0.000	1140	0.00	20.00	0.04	1.00	

Table 4.4(a). Calculations of Percentage Hypsometric curve of the Amaravati Sub-watershed from Toposheet.

AREA (sq km)	ALTITUDE CLASS	RELATIVE AREA (X)	ABOVE ALTITUDE	Cumulative X	Altitude (h)	Relative Altitude (Y)	Cumulative Y	Hypsometric Integral
3.08	369-400	0.02	369	1.00	31	0.02	0.02	
2.24	400-500	0.02	400	0.98	100	0.05	0.06	
1.89	500-600	0.01	500	0.96	100	0.05	0.11	
1.64	600-700	0.01	600	0.95	100	0.05	0.16	
1.32	700-800	0.01	700	0.94	100	0.05	0.21	
1.70	800-900	0.01	800	0.93	100	0.05	0.26	
3.85	900-1000	0.03	900	0.92	100	0.05	0.31	
11.63	1000-1100	0.08	1000	0.89	100	0.05	0.36	
9.51	1100-1200	0.07	1100	0.81	100	0.05	0.41	
7.57	1200-1300	0.05	1200	0.74	100	0.05	0.46	
7.59	1300-1400	0.05	1300	0.69	100	0.05	0.51	0.63
7.42	1400-1500	0.05	1400	0.64	100	0.05	0.56	
6.21	1500-1600	0.04	1500	0.59	100	0.05	0.61	
6.86	1600-1700	0.05	1600	0.55	100	0.05	0.66	
7.93	1700-1800	0.05	1700	0.50	100	0.05	0.70	
20.14	1800-1900	0.14	1800	0.44	100	0.05	0.75	
6.84	1900-2000	0.05	1900	0.30	100	0.05	0.80	
8.41	2000-2100	0.06	2000	0.26	100	0.05	0.85	
15.67	2100-2200	0.11	2100	0.20	100	0.05	0.90	
8.77	2200-2300	0.06	2200	0.09	100	0.05	0.95	
4.28	2300-2400	0.03	2300	0.03	100	0.05	1.00	

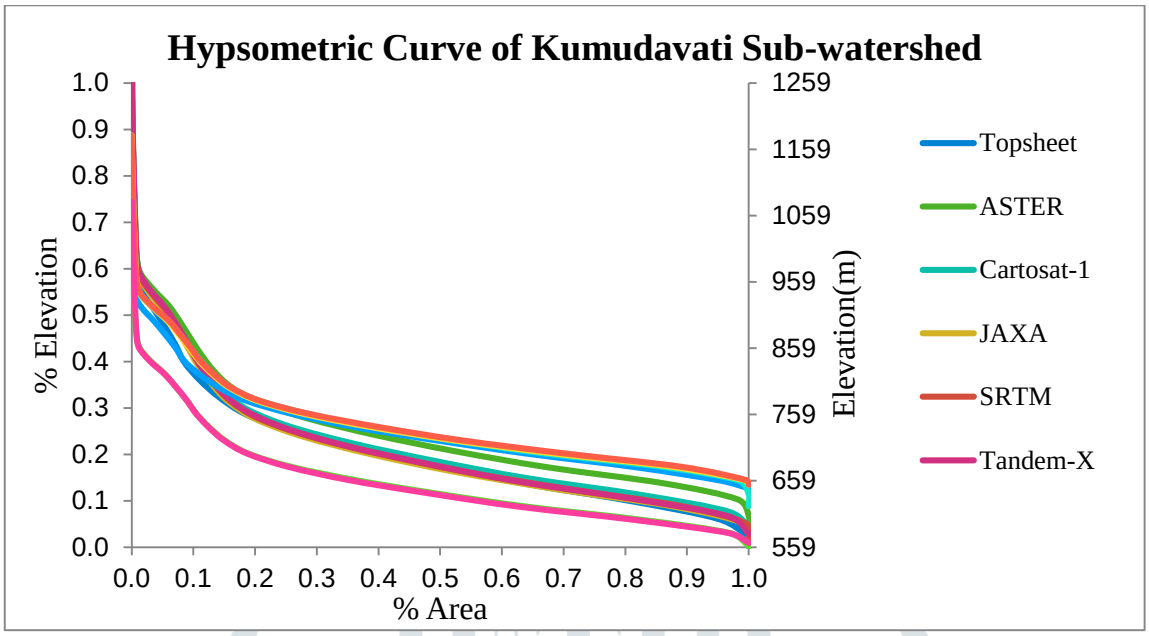

Fig 4.4(a). Comparative Hypsomertic curves of Kumudavati Sub-watershed.

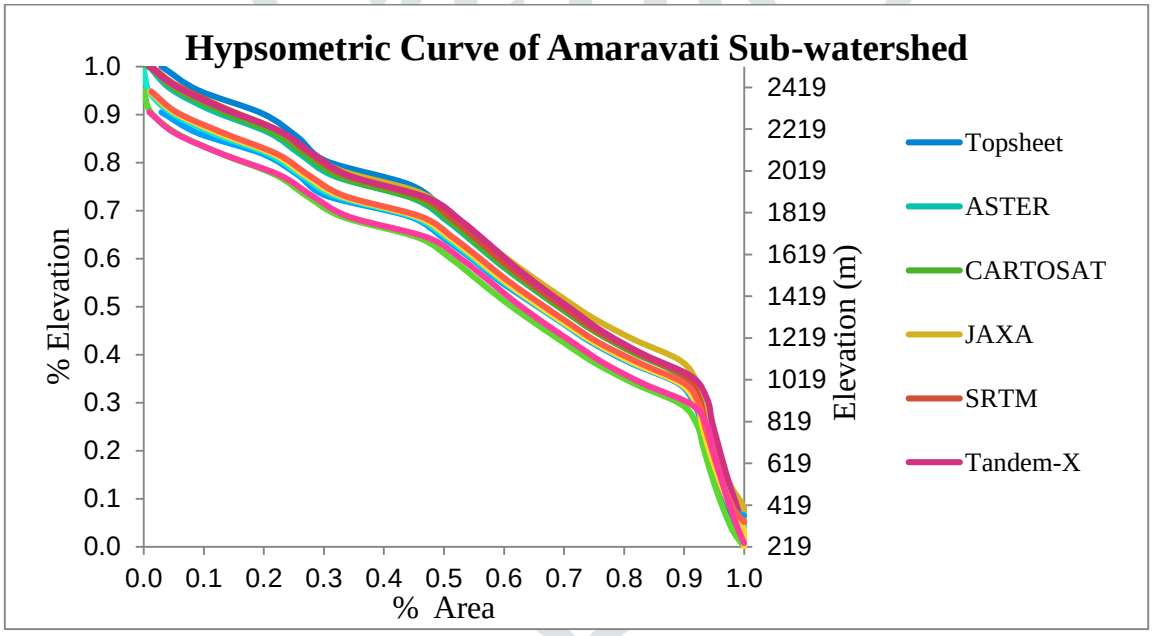

Fig 4.4(b). Comparative Hypsomertic curves of Amaravati Sub-watershed.

The study of hypsometric properties of both Sub-watershed using hypsometric integral (HI) and hypsometric curve retrieved from ASRTER, Cartosat-1, JAXA, SRTM, and TanDEM-X DEM's and Toposheet. For Kumudavati Sub-watershed HI value found to be 0.23,0.22,0.20,0.20,0.20,and 0.19 hence Sub-watershed falls under the Monadock(old) stage, while for Amaravati Sub-watershed HI value found to be 0.62,0.62,0.63,0.62,0.63,and 0.63 which denotes Sub-watershed falls under Young stage.

Table 4.5(a). Cumulative Contour Area computed from different data sets of Kumudavati Sub-watershed.

SL.no	Elevation(m)	Cumulative contour Area (sq km)					
		TOPOSHEET	ASTER	CARTOSAT-1	JAXA)	SRTM	TANDEM-X
1	559-560	0.00	0.00	0.00	0.00	0.00	0.00
2	560-580	0.00	0.00	12.90	0.00	0.00	13.88
3	580-600	0.00	0.00	73.81	0.00	0.00	80.13
4	600-620	0.00	0.00	154.26	0.00	0.00	161.05
5	620-640	0.00	0.06	217.64	0.00	0.00	223.49
6	640-660	21.10	7.53	273.46	3.15	1.80	279.35
7	660-680	80.72	59.16	318.14	53.43	47.04	321.60
8	680-700	155.52	140.23	348.07	134.85	127.97	350.30
9	700-720	219.39	204.83	364.58	205.33	200.63	366.63
10	720-740	277.01	259.92	375.52	262.72	258.50	377.39
11	740-760	321.25	305.74	384.27	309.37	307.40	385.93
12	760-780	353.86	339.96	391.03	342.14	342.11	392.42
13	780-800	373.08	360.25	398.40	361.29	362.12	399.86
14	800-820	386.92	372.15	406.24	372.90	373.84	408.12
15	820-840	397.45	380.77	416.41	381.98	383.16	418.49
16	840-860	403.63	388.14	423.99	388.90	390.11	425.93
17	860-880	410.88	395.22	426.16	396.05	397.37	427.55
18	880-900	418.64	403.08	426.71	403.83	405.03	428.16
19	900-920	427.25	413.75	427.17	413.86	415.63	428.57
20	920-940	432.67	422.70	427.55	422.36	424.55	428.97
21	940-960	433.19	425.39	427.90	425.24	427.82	429.29
22	960-980	433.52	425.98	428.22	425.92	428.38	429.62
23	980-1000	433.75	426.43	428.53	426.36	428.85	429.94
24	1000-1020	433.94	426.79	428.82	426.76	429.22	430.15
25	1020-1040	434.12	427.17	429.04	427.09	429.56	430.41
26	1040-1060	434.23	427.51	429.22	427.44	429.88	430.57
27	1060-1080	434.32	427.81	429.39	427.74	430.20	430.76
28	1080-1100	434.38	428.08	429.49	428.03	430.47	430.88
29	1100-1120	434.41	428.32	429.50	428.26	430.71	430.88
30	1120-1140	434.43	428.53	429.50	428.45	430.90	430.88
31	1140-1160	434.45	428.71	429.50	428.62	431.08	430.88
32	1160-1180	434.45	428.89	429.50	428.76	431.22	430.88
32	1180-1196	434.45	428.93	429.50	428.78	431.23	430.88

Table 4.5(b). Cumulative Contour Area computed from different data sets of Amaravati Sub-watershed.

SL.no	Elevation(m)	Cumulative contour Area (sq km)					
		TOPOSHEET	ASTER	CARTOSAT-1	JAXA	SRTM	TANDEM-X
1	219-300	0.00	0.00	2.84	0.00	0.00	2.58
2	300-400	3.08	2.59	5.06	3.11	1.34	4.73
3	400-500	5.32	4.72	6.94	5.35	3.17	6.51
4	500-600	7.21	6.54	8.57	7.17	4.74	8.09
5	600-700	8.84	8.15	10.05	8.87	6.18	9.61
6	700-800	10.16	9.60	11.46	10.29	7.58	10.96
7	800-900	11.86	11.01	15.29	11.65	8.74	14.41
8	900-1000	15.72	15.20	26.78	15.64	12.39	25.57
9	1000-1100	27.35	26.91	36.60	27.10	23.77	35.73
10	1100-1200	36.86	36.51	44.44	36.92	33.22	43.50
11	1200-1300	44.43	44.28	51.98	44.78	40.60	50.98
12	1300-1400	52.02	51.75	59.13	52.31	47.87	58.17
13	1400-1500	59.44	58.90	65.55	59.40	54.59	64.49
14	1500-1600	65.65	65.24	71.97	65.70	60.61	71.07
15	1600-1700	72.51	71.79	79.95	72.26	66.90	78.82
16	1700-1800	80.44	79.79	98.63	80.21	74.68	97.62
17	1800-1900	100.58	98.57	107.34	99.06	93.22	106.40
18	1900-2000	107.42	106.92	114.93	107.82	101.93	114.02
19	2000-2100	115.82	114.61	128.05	115.43	109.67	127.04
20	2100-2200	131.50	128.24	139.27	128.84	123.13	138.54
21	2200-2300	140.26	138.37	145.56	139.85	134.25	144.79
22	2300-2400	144.54	143.50	147.27	145.79	140.32	146.61
23	2400-2500	144.54	144.81	147.27	147.28	141.65	146.61
24	2500-2501	144.54	144.81	147.27	147.28	141.65	146.61

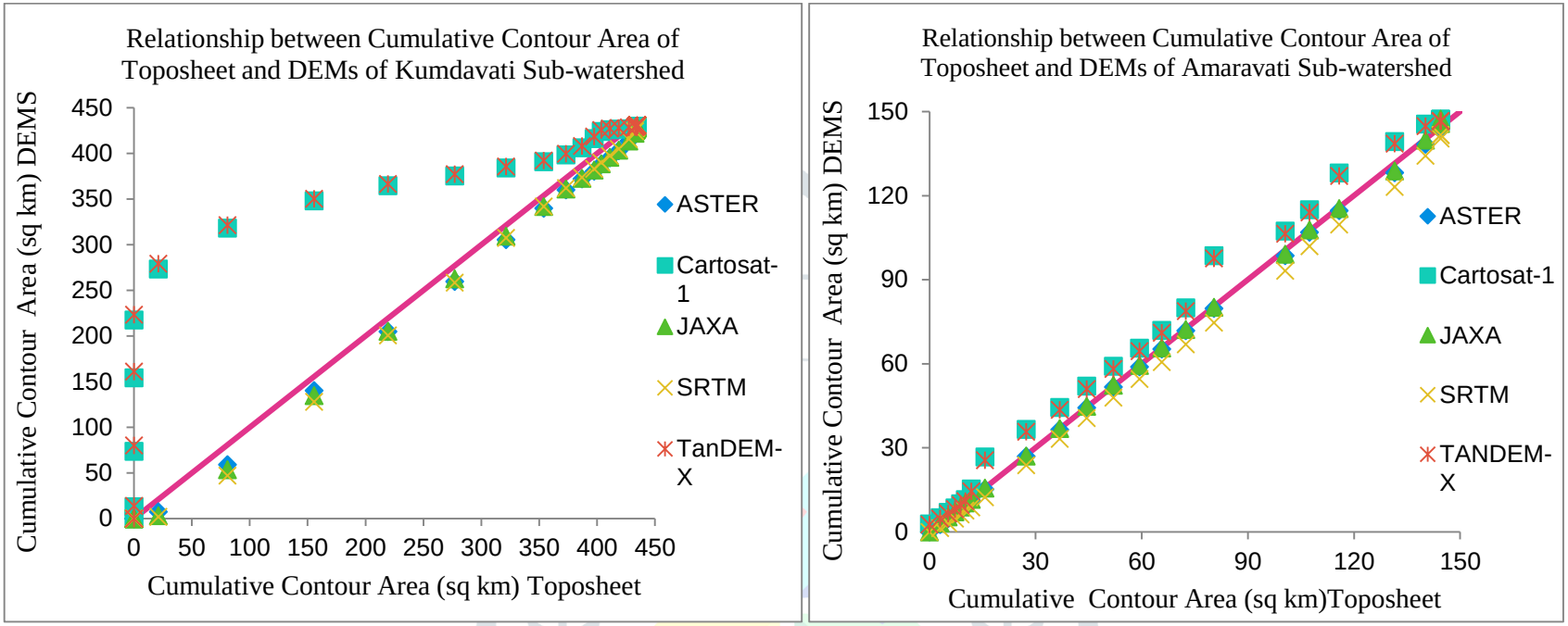

Fig 4.5. Relationship between Cumulative Contour Areas of Toposheet and all DEMs of both sub-watersheds.

From Fig 4.5 it represents variations in contour Area at each contour interval of DEM data sets in comparative Hypsometric analysis of both sub-watersheds in which it determines how much closer they appear to Toposheet data intern defining their accuracy towards results. From graphs in the above figure it clearly shows ASTER, JAXA and SRTM DEM data lying nearer to Toposheet values hence with their use as data would result best in Flat terrained Kumudavati sub-watershed, where as in Hilly terrain Amaravati sub-watershed ASTER, JAXA and SRTM DEM suits best with their use are they are very close to Toposheet values than that of Cartosat-1 and TanDEM-X DEMs.

5.0. Conclusions.

The DEM's used for Morphometric analysis plays vital role in Sensitive analysis of Hydrological studies, hence for the studies choosing carefully among freely available DEM's is a prime factor such that the areal and relief factors doesn't contribute the negative effect in obtaining the desired and accurate result. In the present study the Flow accumulation with proper Threshold values becomes a key factor for obtaining accurate streams and their numbers with orders which, intern result in getting a desired Marphomertic parameters. While the Hypsometric analysis with the HI values and hypsometric curves revealing how much close does the data of DEM's associate with Toposheet data sets in Cumulative Contour Areas of both sub-watersheds, with this sort of resemblance result it offers freedom for choosing the suitable DEM's. From results of present study areas revealed that ASTER, JAXA and SRTM DEM's suits best with close relative values of Toposheet data while Cartosat-1 and TanDEM-X DEM's didn't exist closely with the Toposheet data.

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