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Original Research Paper

Morphometric Analysis of Nanjangud Taluk, Mysore District, Karnataka, India Using GIS Techniques

G. Mahadevaswamy, D. Nagaraju, C. Papanna, P. C. Nagesh* and Krishna Rao*
Department of Studies in Geology, University of Mysore, Manasagangothri, Mysore-570 006, Karnataka, India
*Department of Studies in Geology, University of Bangalore, Bangalore-570 001, Karnataka, India

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ABSTRACT

An attempt has been made to study drainage morphometry and its influence on hydrology of Nanjanagud taluk. For detailed study, data for preparing DEM, aspect grid and slope maps, geographic information system (GIS) was used in evaluation of linear, areal and relief aspects of morphometric parameters. The study reveals that the elongated shape of the area is mainly due to guiding effect of thrusting and faulting. In all 41 sub-basins in Nanjangud taluk have been selected for the study. Quantitative morphometric analysis has been carried out for linear, relief and aerial aspects for all the sub-basins. The streams up to fourth order can be seen in all the sub-basins. The morphometric analysis reveals that Hullahalli sub-basin has lower value of drainage density, stream frequency, elongation ratio, relief ratio and infiltration number indicating highly permeable sub-soil materials under dense vegetation cover. Except Hullahalli sub-basin, all the other sub-basins show fractured, resistant, permeable rocks and drainage network seems to be not affected by tectonic disturbances.

INTRODUCTION

The drainage basin analysis is important in any hydrological investigation like assessment of groundwater potential, groundwater management, pedology and environmental assessment. Hydrologists and geomorphologists have recognized that certain relations are most important between runoff characteristics and geographic characteristics of drainage basin system. 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 contributories. The quantitative analysis of drainage system is an important aspect of characteristics of a taluk (Strahler 1964). Drainage pattern refers to spatial relationship among streams or rivers, which may be influenced in their erosion by inequalities of slope, soils, rock resistance, structure and geological history of a region. Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms (Clarke 1966). This analysis can be achieved through measurement of linear, aerial and relief aspects of the basin and slope contribution (Nag & Chakraborty 2003). The drainage basin analysis is carried out quantitatively for six sub-watersheds of Nanjangud taluk. The quantitative drainage analysis is done aspectwise such as linear aspects, aerial aspects and relief aspects. The main objective of the present study is to derive the different drainage characteristics of the Nanjangud taluk and to understand the relationship among them.

STUDY AREA

Nanjangud taluk lies on south-western parts of Mysore district and forms almost a plain boundary except for a few isolated hillocks to the south and west. These hills rise 600 to 700 feet above the general level of the boundary, which is at an elevation of 2400 feet above MSL. The highest peak lying on the south-western corner of the taluk is 3108 above MSL. The hills are bare and stand out prominently in this flat stretch of the boundary. The general slope is from south to north and there is a small but gradual and wide depression seen on the northern parts of the taluk following the Kabini river basin and another small and narrow depression is seen on the western parts of the taluk through which Nugu river flows. Similarly another wide depression is seen in the central portion of the taluk where Gundal river flows sluggishly; the northern parts of the taluk are drained by Kabini river, a major tributary of the river Cauvery.

The study area is bounded between north latitude 11°5' 30" to12°12'30" and east longitude 76°22'30" to 76°56'30". Toposheets Numbers 57D/12 and 57D/16 provide the physiographic coverage of the study area (Fig. 1). Total extent of the study area is 981.60 sq. km covering parts or whole of 184 villages falling in Nanjangud taluk. The state highway connecting Mysore to Coimbatore passes at the south-western corner of the study area for a short distance.

Table 1: Morphometric analysis of different sub-basins.

S. No.	Sub-basin Name	Stream order	Basin area (sq.km)	Stream order				Stream length in km				Perimeter (km)	Basin length (km)
				N1	N2	N3	N4	L1	L2	L3	L4		
1	Hullahalli	ll	211.5	37	14			86	20			170	41
2	Kadaburu	ll	16	14	4			11	6			32	10
3	Nellithalpura	ll	21.5	6	3			8	5			28	12
4	Kagalhundi	ll	62.5	17	5			21	17			45	16
5	Madduvinahalli	lll	106.5	36	12	1		43	29	8		78	25
6	Ballurhundi	lV	85.5	64	14	1	1	38	32	5	2	71	25
7	Kongahalli	lll	38.5	21	5	2		32	8	5		42	19
8	Mallahalli	lll	25	12	6	1		17	15	4		30	12
9	Allere	lll	62.5	27	8	1		30	15	2		51	22
10	Yechagundlu	ll	12	9	4			9	5			20	8
11	Kasavanahalli	ll	37	22	7			33	25			39	15
12	Yelachagiri	ll	18.5	8	3			11	10		4	32	14
13	Kurlapura	ll	53	9	7			11	15			46	19
14	Tandavapura	ll	57.5	21	10			25	16			53	18
15	Hulimavu	ll	26	14	5			20	7			35	11
16	Devardsanahalli	ll	39	10	3			12	5			39	15
17	Nerle	lV	46.5	15	4	1	1	27	19	10		42	19
18	Devanur	lll	20.5	27	7	1		35	26	2		36	16
19	Hosuru	ll	40.5	13	4			16	10			40	15
20	Mallipura	lll	42	20	8	1		38	6	7		48	22
21	Chinnamballi	lll	31.5	39	10	1		51	22	4		60	18
22	Karepura	ll	37	29	10			34	14			40	16
23	Hanumanapura	ll	11.5	4	2			5	8			28	10
24	Podavullamarahalli	lll	36	18	7	1		24	20	5		40	13
25	Konanura	ll	21.5	17	3			14	15			27	10
26	Doddahomma	ll	8.5	8	2			10	5			16	6
27	Taravalli	ll	23	16	6			24	14			35	13
28	Kalkunda	lll	46	22	7	1		22	21	1		40	14
29	Gejjiganahalli	lll	31	20	7	1		25	20	4		39	10
30	Salhundi	lll	13	9	4	2		12	10	5		22	8
31	Alatturu	ll	21.5	7	3			15	10			29	12
32	Nandigundapura	ll	35	9	4			11	13			40	13
33	Thayui	ll	13.5	6	4			5	8			27	10
34	Bankanahalli	ll	6.5	3	1			6	3			15	5
35	Hediyala	ll	12.5	6	2			10	5			38	11
36	Ramapura	lll	34.5	15	4	1		14	11	2		40	13
37	Gaddanapura	ll	38.5	18	6			24	15			45	15
38	Halepura	ll	52	14	6			18	21			70	18
39	Hemmaragala	lll	72	9	4	1		28	15	2		52	20
40	Kugaluru	lll	98	22	5	2		32	20	6		100	35
41	Hadinaru	ll	20.5	6	1			10	21			25	10

Table 1 Cont.... on page 132

Nanjangud-Gundlupet and Nanjangud-Chamarajanagar are the other important roads passing through the area. All the interior villages have a good network of roads with good communication facilities.

Data used and methodology: Survey of India toposheet on 1:50.000 scale bearing No. 57D/12, 57D/16, 58A/13 have been used for drainage map. IMSD technical guidelines (NRSA 1995) have been used to delineate the sub-watershed boundary. Digital based drainage map was prepared by digitization and assigning the stream order by layer concept in Cad Overlay 2000. Quantitative morphometric parameters such as stream length, bifurcation ratio and basin area have been analysed by use of geographical information system using ARC/INFO environment.

RESULTS AND DISCUSSION

The drainage characteristics of the six sub-watersheds were determined (Table 1). The drainage pattern of all the sub-watersheds shows dendritic to sub-dendritic, with general stream flow direction from southwest to northeast.

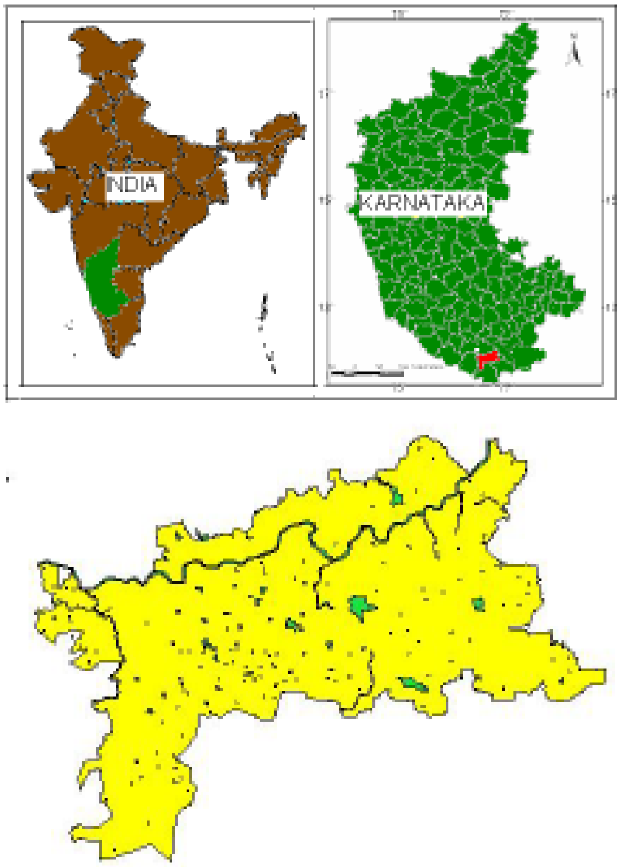

Fig. 1: Location map of the study area.

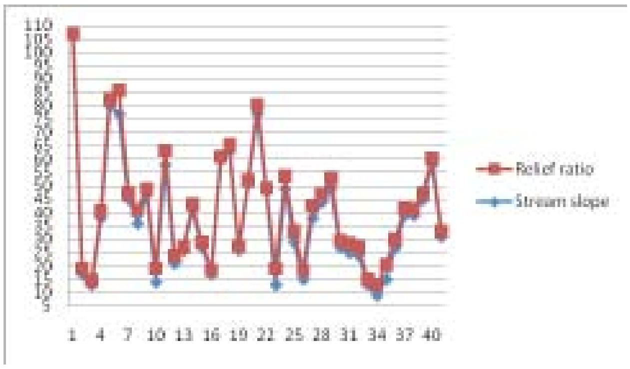

Fig. 2: Relief ratio and stream slope in the study area.

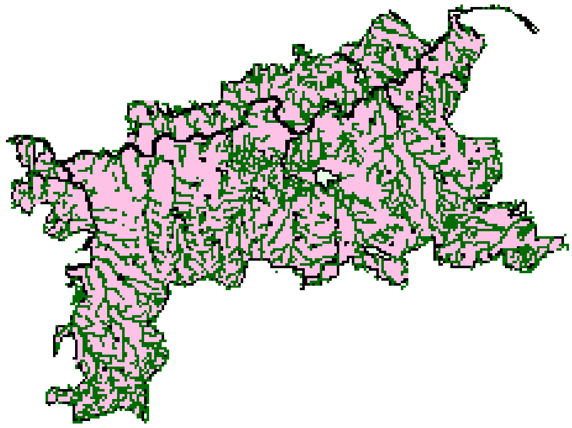

Fig. 3: Drainage of the study area.

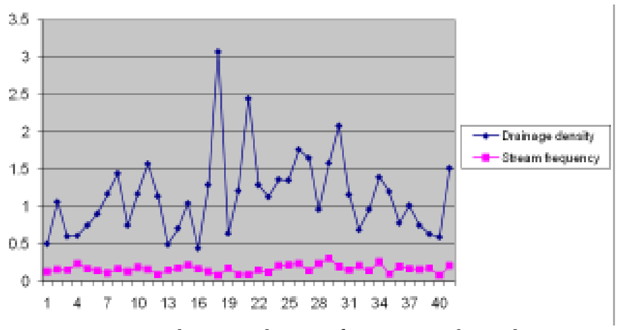

Fig. 4: Drainage density and stream frequency in the study area.

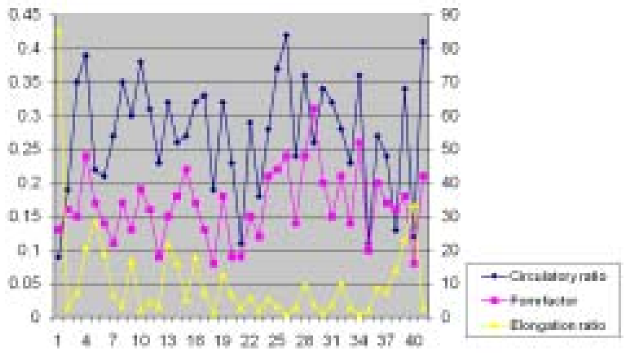

Fig. 5: Circulatory ratio, form factor and elongation ratio in the study area.

Linear aspects

Stream order: The first step in any drainage basin analysis is the designation of stream orders, which are helpful not only to index the size and scale but also to afford and approximate index of the amount of stream flow which can be produce by a particular network. In the present study, ranking of streams has been carried out based on the method proposed by (Strahler 1964). The streams up to forth order can be seen in all the sub-watersheds excepting Balurhundi and Nerle sub-watershed (Table 1).

Stream number: The counts of stream channels in its order are known as stream number. The number of the stream segments decreases as the order increases, the higher stream order indicates lesser permeability and infiltration. It is observed from the Table 1 that the maximum frequency is in case of the first order streams. It is also noticed that there is a decrease in stream frequency as the stream order increases.

Stream length: The stream lengths of the various segments are measured with the help of GIS software. All the sub-

Cont.... Table 1

S. No.	Sub-basin Name	Stream length in km			Stream Length Ratio	Relief Ratio	Elongation Ratio (E)
		L1	L2	L3			
1	Hullahalli	86	20		2.59	0.98	85.5
2	Kadaburu	11	6		0.42	2	3.05
3	Nellithalpura	8	5		0.32	1.67	7.21
4	Kagalhundi	21	17		0.93	2.5	20.8
5	Madduvinahalli	43	29	8	1.95	2.4	28.7
6	Ballurhundi	38	32	5	1.88	8.8	19.24
7	Kongahalli	32	8	5	1.1	2.11	6.68
8	Mallahalli	17	15	4	0.88	5	3.52
9	Allere	30	15	2	1.15	1.82	16.84
10	Yechagundlu	9	5		0.34	5	2.08
11	Kasavanahalli	33	25		1.42	5.33	4.78
12	Yelachagiri	11	10		0.51	2.86	3.3
13	Kurlapura	11	15		0.63	1.05	21.89
14	Tandavapura	25	16		1	2.22	16.34
15	Hulimavu	20	7		0.66	1.82	5.07
16	Devardsanahalli	12	5		0.42	1.33	18.13
17	Nerle	27	19	10	1.46	1.05	7.3
18	Devanur	35	26	2	1.54	2.5	1.35
19	Hosuru	16	10		0.63	1.33	12.78
20	Mallipura	38	6	7	1.24	0.91	7.01
21	Chinnamballi	51	22	4	1.88	3.33	2.61
22	Karepura	34	14		1.17	1.25	5.78
23	Hanumanapura	5	8		0.32	6	2.06
24	Podavullamarahalli	24	20	5	1.2	4.62	5.36
25	Konanura	14	15		0.71	4	3.23
26	Doddahomma	10	5		0.37	3.33	0.98
27	Taravalli	24	14		0.93	4.62	2.82
28	Kalkunda	22	21	1	1.07	2.86	9.75
29	Gejjiganahalli	25	20	4	1.2	4	3.97
30	Salhundi	12	10	5	0.66	2.5	1.27
31	Alatturu	15	10		0.61	3.33	3.75
32	Nandigundapura	11	13		0.59	3.08	10.34
33	Thayui	5	8		0.32	2	2.84
34	Bankanahalli	6	3		0.22	4	0.95
35	Hediyala	10	5		0.37	5.46	2.11
36	Ramapura	14	11	2	0.66	3.08	8.93
37	Gaddanapura	24	15		0.95	2.67	7.7
38	Halepura	18	21		0.95	2.22	14.1
39	Hemmaragala	28	15	2	1.1	2	23.34
40	Kugaluru	32	20	6	1.42	2.29	33.56
41	Hadinaru	10	21		0.76	2	2.75

Table 1 Cont....

watersheds show that the total length of stream segments is maximum in first order streams and decreases as the stream order increases (Table 1).

Mean stream length: The mean stream length is a dimensionless property, characterizing the size aspects of drainage network and its associated surface (Strahler 1964). It is obtained by dividing the total length of stream of a order by total number of segments in the order. Due to variation in slope and topography, the Hullahalli sub-watershed shows that the mean stream length of the given order is greater than that of the lower order and less than that of its next higher order.

Stream length ratio: It is the ratio between the mean lengths of streams of any two consecutive orders. Horton's law (Horton 1945) 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. All the sub-watersheds in the study area show variation in stream length ratio between streams of different orders. Changes of stream length ratio from one order to another order indicates their late youth stage of geomorphic development (Singh & Singh 1997).

Cont.... Table 1

S. No.	Sub-basin name	Bifurcation Ratio	Drainage Density	Stream Frequency	Form Factor	Circularity Ratio	Length of flow
1	Hullahalli	25.5	0.5	0.13	0.126	0.09	106
2	Kadaburu	9	1.06	0.16	0.16	0.196	17
3	Nellithalpura	4.5	0.6	0.15	0.15	0.345	13
4	Kagalhundi	11	0.608	0.24	0.244	0.388	38
5	Madduvinahalli	16.3	0.75	0.17	0.17	0.219	80
6	Ballurhundi	20	0.9	0.14	0.14	0.213	77
7	Kongahalli	9.3	1.17	0.11	0.11	0.274	45
8	Mallahalli	6.3	1.44	0.17	0.17	0.349	36
9	Allere	12	0.75	0.13	0.13	0.302	47
10	Yechagundlu	6.5	1.17	0.19	0.19	0.377	14
11	Kasavanahalli	14.5	1.57	0.16	0.16	0.306	58
12	Yelachagiri	5.5	1.14	0.09	0.09	0.227	21
13	Kurlapura	8	0.49	0.15	0.15	0.315	26
14	Tandavapura	15.1	0.71	0.18	0.18	0.257	41
15	Hulimavu	9.5	1.04	0.22	0.22	0.267	27
16	Devardsanahalli	6.5	0.44	0.17	0.17	0.322	17
17	Nerle	5.25	1. 29	0.13	0.13	0.331	60
18	Devanur	11.66	3. 07	0.08	0.08	0.199	63
19	Hosuru	8.6	0.64	0.18	0.18	0.318	26
20	Mallipura	9.66	1.21	0.09	0.09	0.229	51
21	Chinnamballi	16.66	2.44	0.09	0.09	0.109	77
22	Karepura	19.5	1.29	0.15	0.15	0.291	48
23	Hanumanapura	3	1.13	0.12	0.12	0.184	13
24	Podavullamarahalli	8.66	1.36	0.21	0.21	0.283	49
25	Konanura	10	1.35	0.22	0.22	0.371	29
26	Doddahomma	5	1.76	0.24	0.24	0.417	15
27	Taravalli	11	1.65	0.14	0.14	0.236	38
28	Kalkunda	10	0.96	0.24	0.24	0.361	44
29	Gejjiganahalli	9.33	1.58	0.31	0.31	0.256	49
30	Salhundi	5	2.08	0.2	0.2	0.338	27
31	Alatturu	5	1.16	0.15	0.15	0.321	25
32	Nandigundapura	6.5	0.69	0.21	0.21	0.275	24
33	Thayui	5	0.96	0.14	0.14	0.233	13
34	Bankanahalli	2	1.39	0.26	0.26	0.363	9
35	Hediyala	4	1.2	0.1	0.1	0.109	15
36	Ramapura	6.66	0.78	0.2	0.2	0.271	27
37	Gaddanapura	12	1.01	0.17	0.17	0.239	39
38	Halepura	10	0.75	0.16	0.16	0.133	39
39	Hemmaragala	4.66	0.63	0.18	0.18	0.335	45
40	Kugaluru	9.66	0.59	0.08	0.08	0.123	58
41	Hadinaru	3.5	1.51	0.21	0.21	0.412	31

Bifurcation ratio: Horton (1945) and Strahler (1952) have defined the bifurcation ratio as the ratio of the number of streams of one order to the number of the next higher order. Strahler (1957) demonstrated that bifurcation ratio has a small range of variation for different regions or for different environments except where the powerful geological control dominates. It is observed from the Table 1, that the bifurcation ratio is not same for one to another. These irregularities are dependent upon the geological and lithological developments of the drainage basin (Strahler 1964). The mean bifurcation ratio may be defined as the average of bifurcation ratios of all orders, and all sub-watersheds falling under normal basin category (Strahler 1952).

Relief aspects

Relief ratio: Difference in the elevation between the highest point of a basin (on the main divide) and the lowest point on the valley floor is known as the total relief of the river basin. The relief ratio may be defined as the ratio between the total relief of a basin and the longest dimension of the basin parallel to the main drainage line (Schumm 1956). The possibility of a close correlation between relief ratio and hydrologic characteristics of a basin suggested by Schumm who found that sediments loose per unit area is closely correlated with relief ratios. In the study area, the values of relief ratio vary from 0.005 to 0.08 (Table 1, Fig. 2)). It has been observed that 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.

Aerial aspects

Drainage density: The drainage of the study area is shown in Fig. 3. Drainage density is the total length of all the streams in the basin to the area of whole basin. Drainage density in the study varies between 1.17 and 3.07 indicating low drainage density (Table 1, Fig. 4). According to Nag (1998), low drainage density generally results in the areas of highly resistant permeable subsoil material, dense vegetation, low relief and coarse drainage texture. High drainage density is resultant of weak or impermeable subsurface material, sparse vegetation, mountainous relief and fine drainage texture.

Stream frequency: Horton (1932) introduced stream frequency as the number of stream segments per unit area. It is obtained by dividing the total number of stream to the total drainage basin area. The low value of 0.08 was observed in Devanur sub-watershed, while high value of 0.31 in Gejiganahalli sub-watershed. Increase in stream population with respect to increase in drainage density has been noticed in all sub-watersheds. The stream frequency of the study area is shown in Fig. 4.

Form factor: The ratio of the basin area to the square of basin length is called the form factor. It is a dimensionless property and used as a quantitative expression of the shape of basin form. Lower values of form factor are observed in sub-watersheds lead to circular shape (Fig. 5).

Circulatory ratio: Circulatory ratio is the ratio between the area of the basin and the area of the circle having the same perimeter as that of the basin. In the present study, all the sub-watersheds expect Hullahalli show less than 0.09 indicating that they are elongated, while Hullahalli sub-watershed shows more or less circular and is characterized by high to moderate relief and drainages system structurally controlled (Fig. 5).

Elongated ratio: Schumm (1956) defined elongated ratio as the ratio of diameter of the circle of the same area in the basin to the maximum basin length. Values near to 1.0 are typically regions of very low relief. Whereas values in the range between 1.6 to 2.6 are generally associated with strong relief and steep ground slope. The lowest values of 0.98 (Doddahomma) and 85.8 (Hullahalli) indicate high relief and steep slopes, while remaining sub-watershed indicate plain land with low relief and low slope (Fig. 5).

CONCLUSION

Quantitative analysis of drainage network found the dendritic to sub dendritic drainage pattern with third order streams in all sub-watersheds except Balurhundi and Nerle sub-watersheds. Stream frequency of all sub-watersheds shows positive correlation with drainage density. The variation in values of bifurcation ratio among the sub-watersheds is ascribed to the difference in topography and geometric development. Balurhundi sub-watershed shows coarse drainage texture resulting in higher value of drainage density, stream order, elongation ratio and less length of overland flow. Except Balurhundi sub-watershed, all the other sub-watersheds show fractured, resistance and permeable rocks, and drainage network has not affected by tectonic disturbances.

REFERENCES

Clarke, J. I. 1996. Morphometry from Maps. Essays in Geomorphology. Elsevier Publication. Co. New York, pp. 235-274.

Horton, R.E. 1932. Drainage basin characteristics. Trans. Am. Geophysical. Union, 13: 350-361.

Horton, R.E. 1945. Erosional development of streams and their drainage basins: Hydrophysical approach to quantitative morphology. Geological Society, Am. Bull., 56: 275-370.

Nag, S.K. 1988. Morphometric analysis using remote sensing techniques in the Chaka sub-basin, Purulia district, west Bengal. J. Indian Soc. Remote Sensing, 26(1&2): 69-76.

Nag, S.K. and Chakraborthy, S. 2003. Influence of rock types and structures in the development of drainage network in hard rock area. J. Indian Soc. Remote Sensing, 31(1): 25-35.

NRSA 1995. Integrated Mission for Sustainable Development. Technical Guidelines. National Remote Sensing Agency, Hyderabad.

Schumm, S.A. 1956. Evolution of drainage system and slopes in Badlands at Perth, Ambony, New Jersey. Geol. Soc. Am. Bull., 67: 31-43.

Singh, S. and Singh, M.C. 1997. Morphometric analysis of Kanhar river basin. National Geographical. Journal of India, 43(1): 3-43.

Strahler, A.N. 1952. Hypsometric (area-altitude) analysis of erosional topography. Bull. Geol. Soc. Am., 63.

Strahler, A.N. 1964. Quantitative geomorphology of drainage basins and channel networks. In: V.T. Chow (ed.), Handbook of Applied Hydrology, McGraw Hill Book Company, New York, Section 4-11.