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Morphometric parameters of Aleng river basin, Manipur.

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Abstract

The morphometric parameters of a drainage basin are important for characterizing hydrological conditions and geomorphic processes operating in the area. Present study deals with the morphometric analysis of the Aring basin, located between longitudes 93.64°E and 93.71°E and latitudes 24.85°N and 25.01°N in the western part of Manipur covering 121.7 km^2 area. Morphometric analysis of Areng basin carried out using DEM data, GIS software (MapInfo-11.0) and Survey of India (SOI) topographic maps on 1:50, 000 scales reveals that it is a 6th order stream. Based on 3th order stream, Aleng basin has been designated as29 numbers of 3rd order basins.Results of the linear, areal and relief aspects suggests that the Aleng is a semi-elongated to elongated basin characterized by moderate to high relief, moderate to gentle slope which is further justified by the low value of constant of channel maintenance. Most of the basin show fine texture, suggesting high velocity, low permeable lithology and dense vegetable with heavy rainfall.Study of longitudinal profile, value of SL/K increase when river channel crosses the tectonically faulted and folded area. The hypsometric integral value also indicatesthat basin is in mature stage. Mean Bifurcation ratio value ranges from 2.0 to5.75 suggests morphological and structural control on the development of drainage network in the area, drainage density and fine drainage texture suggests high runoff in the area.

Keywords: ijai,River basin, morphometry, DEM, GIS, drainage network.

1. Introduction

Drainage basin morphometry refers to the measurements of Basin Shapes. In other words, it is carried out for identification of role of tectonics, bedrock geology, climate and vegetation covers which are helpful in development of geomorphology (Strahler, 1964). Morphometric features such as basin shape and basin relief influences the nature of hydrographs and hydrological variables. Drainage pattern provides information on the topography and underlying geological structure. Pioneering work on the drainage basin morphometry has been carried out by Horton(1932, 1945), Miller(1953), Smith (1950), Strahler(1964) and others. Recently many authors (Narendra and Nageswara (2006), Pirasteh *et al.*, (2010), Pareta and Pareta (2011), Dwivedi (2011) Bagyaraj and Gurugnanam (2011), Mishra *et al.*, (2011), Zende and Nagarjan (2011), Panhalkar and Pawar (2011), Doad *et al.*, (2012), Ramu *et al.*, (2013), Thakur *et al.*, (2014) and many others have attempted to generate more precise data on morphometric parameters using satellite data and GIS tools.

2. Study area

Aleng/Iring River is one of the important tributary of Ijai river and integral part of Barak river system of northeast India. It is a rainfed river originated from kabui Khullen of Koubru hill ranges of Senapati district, Manipur State. The Aleng basin lies between longitudes 93.64°E and 93.71°E and latitudes 24.85°N and 25.01°N and covering an area of 121.7 km^2(shown in Fig 1).

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Fig. 1: Location map of Aleng River

Geological formation exposed in the present study area dominantly belongs to Barail group of rocks. They are usually light to brownish grey, fine to medium grained sandstones often interbeded with shales giving rise to typical turbidite character. Petrographically they are greywacke to subgraywake in composition.

3. Methodology

The drainage map of the study area have been prepared using survey of India (SOI) toposheet on 1:50,000 scale with sufficient ground truth. The morphometric parameters of the present study area were carried out using ASTER-DEM data and GIS techniques. The main objective of the study was to fulfill by computing the geomorphic parameters by using DEM data and GIS Software (Map Info-11.0). Using these parameters: Basin Relief (B_h), Area of the Basin(A_3), Basin Length (Lb), Hypsometric Integral (HI), Basin Elongation Ratio (R_e), Longitudinal River Profile, Stream Gradient Index (SL), etc. were calculated to accesses the tectonic properties of the study area.

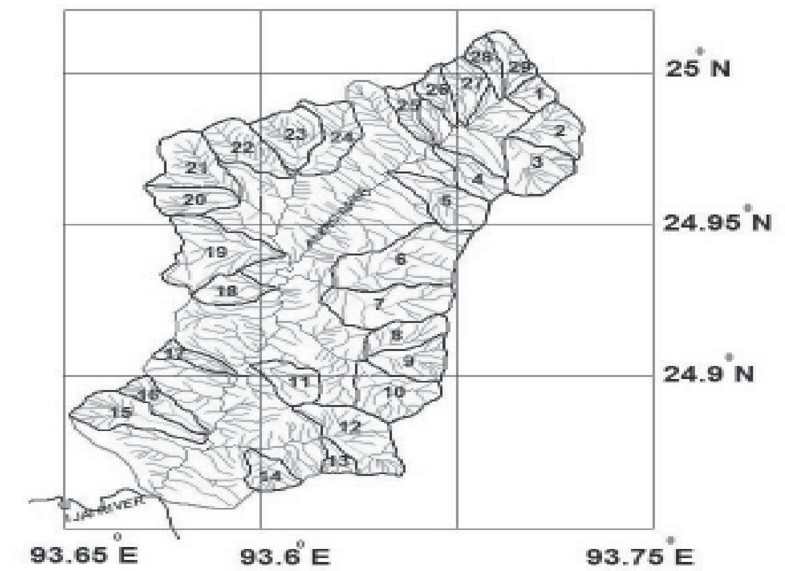

Fig. 2 : Sub basin map of Aleng Basin

4. Results and discussion

The total drainage area of Areng basin is 121.7 km2 and having 6-order streams.For the detailed morphometric analysis, a total number of twenty-nine 3rd order basins have been classified from the drainage map of the study area.Further, systematic description of the geometry of the drainage basin requires measurements of (j) linear (ii) aerial and (iii) relief aspects of the channel network, which are discussed below (Table-1):

Table 1: Morphometric parameters of 3rd order basin

Basin No	C	A3	Lb (Km)	Basin Alt (Km)	D_d	F_s	R_e	R_{l21}	R_{l32}	R_{b12}	R_{b23}	R_{bm}	R_n	R_h	R_t	Bh (Km)
1	0.24	1.01	1.32	1.27	4.25	14.53	0.57	1.65	10.26	1.00	10.00	5.50	0.20	0.35	3.54	0.45
2	0.30	2.22	2.00	1.52	3.32	7.89	0.86	2.21	12.105	2.50	2.00	2.25	0.14	0.34	2.03	*0.76*
3	0.24	2.83	2.17	1.78	4.11	8.55	0.84	2.73	1.78	3.50	4.00	3.75	0.19	0.38	2.97	1.02
4	0.26	1.68	2.53	1.56	3.82	6.02	0.88	4.68	2.06	7.00	2.00	4.50	0.27	0.47	2.57	0.96
5	0.23	2.73	3.12	1.56	4.28	8.82	0.50	1. 8	1.27	1.25	4.00	2.63	0.19	0.34	1.89	1.04
6	0.24	5.51	4.08	1.56	4.20	9.10	0.60	1.77	1.78	4.00	3.00	3.50	0.21	0.35	2.68	1.04
7	0.19	4.02	3.02	1.44	5.26	8.47	0.53	2.23	3.11	3.50	2.00	2.75	0.15	0.34	1.82	0.92
8	0.25	1.83	2.44	1.3	4.08	9.52	0.55	1.68	13.22	2.67	3.00	2.83	0.19	0.34	2.02	0.69
9	0.26	2.13	2.20	1.28	3.89	5.36	0.58	3.38	1.44	3.00	2.00	2.50	0.25	0.38	1.47	0.67
10	0.29	3.09	2.47	1.28	3.49	5.13	0.60	7.35	0.57	5.50	2.00	3.75	0.30	0.33	1.84	0.68
11	0.25	1.82	2.13	1.1	3.94	5.77	0.67	7.25	0.73	4.33	3.00	3.67	0.14	0.19	2.21	0.69
12	0.28	3.83	2.47	1.6	3.55	5.85	0.58	17.71	0.17	4.50	2.00	3.25	0.20	0.25	1.79	0.95
13	0.19	2.73	3.12	1.56	5.41	9.08	0.50	2.69	1.144	2.00	2.000	2.00	0.10	0.28	1.49	1.04
14	0.22	1.37	1.78	1.16	4.50	5.99	0.62	6.40	0.65	3.50	2.000	2.75	0.13	0.25	1.67	0.70
15	0.29	2.83	3.58	1.18	3.43	5.76	0.86	6.79	0.54	4.83	6.00	5.42	0.20	0.21	3.41	0.82
16	0.25	1.54	2.83	1.06	4.03	7.36	0.62	7.61	0.44	8.00	2.00	5.00	0.18	0.25	2.25	0.70
17	0.20	0.97	2.30	1.18	5.01	11.61	0.79	3.92	1.62	2.33	3.00	2.67	0.08	0.27	2.54	0.78
18	0.44	1.61	2.24	1.4	2.28	2.28	0.74	3.91	1.02	2.75	4.00	3.38	0.45	0.25	1.41	0.98
19	0.35	4.53	3.29	1.22	2.89	3.74	0.75	7.70	0.54	6.00	2.00	4.00	0.32	0.31	1.68	0.75
20	0.29	1.93	2.47	1.57	3.51	5.26	0.65	2.61	2.01	4.60	5.00	4.80	0.30	0.26	2.76	0.85
21	0.24	3.12	2.94	1.52	4.17	6.83	0.64	3.03	3.43	2.33	3.00	2.67	0.24	0.44	1.98	0.80
22	0.25	2.53	2.86	1.4	3.98	4.85	0.73	3.91	1.49	4.25	4.00	4.13	0.19	0.23	2.16	0.78
23	0.26	2.63	2.33	1.4	3.89	6.21	0.64	3.87	0.94	2.67	3.00	2.83	0.22	0.35	1.98	0.78
24	0.231	2.58	2.91	1.34	4.34	7.059	0.677	4.60	1.19	6.00	3.00	4.50	0.19	0.27	2.598	0.72
25	0.237	1.26	2.30	1.38	4.21	7.507	0.748	6.89	0.59	4.00	3.00	3.50	0.16	0.30	2.512	0.78
26	0.254	1.18	2.33	1.43	3.94	7.096	0.627	3.84	1.60	3.00	3.00	3.00	0.18	0.28	2.174	0.79
27	0.211	1.76	2.51	1.52	4.75	8.553	0.519	3.73	2.74	9.50	2.00	5.75	0.20	0.28	2.767	0.87
28	0.241	1.13	2.38	1.62	4.14	6.055	0.459	7.90	0.30	7.00	2.00	4.50	0.23	0.23	1.794	0.82
29	0.244	1.45	2.40	1.66	4.11	6.025	0.504	4.46	0.62	2.50	4.00	3.25	0.24	0.28	1.732	0.84

4.1 Linear aspects

Linear aspects are described by studying parameters like stream order no, stream length, stream length ratio, and bifurcation ratio etc.

4.2 Stream order

The designation of stream order is the 1st step in drainage basin analysis and is based on hierarchic ranking of streams. Stream ordering was done in accordance with Strahler's (1957) scheme.The Aleng basin has been designated as a 6th order basin. The stream order and the total number of stream segments in each order for the different sub-basins have been given in table-1.

4.3 Stream length (L_u)

The stream length is calculated on the basin of Law proposed by Horton (1945) for all the entire sub-basin. Thus it suggests homogenous lithology in the study area. The law holds true in case of Aleng basin also. The length of the 1st order stream is maximum. Thus total stream length of 1st order is 182.29km, of 2nd order is48.022 km and of 3rd order is 36.80 km.

4.4 Stream length ration (R_1)

Horton (1945) defines the stream length ratio is the ratio of the total stream length of one order to that of the next lower order. The stream length ratio has an important relationship with the surface flow discharge and the erosional stage of the basin. The stream length ratio of Aleng basin ranges from 1.65to 17.71 (R_{l21}) and 0.17to 13.22 (R_{l32}). This variation is due to differences in slope and topographic condition of the study area.

4.5 Bifurcation ration (R_b)

Bifurcation ratio is defined as the ratio of the number of streams of any given order to the number of streams in the next lower order. This term was introduced by Horton in 1932. Bifurcation ratio of a drainage basin is controlled by the underlying lithology and climatic condition of the area. In the study area, the values of bifurcation ratio (R_{b12}) ranges from 1 to 9.5(average 4.70) while (R_{b23}) from 2 to 10 (average 3.17). The mean bifurcation ratio (R_{bm}) ranges from 2 to 5.75 (average 3.62). This is indicative of variation in lithology, climate and rock structure of the drainage. The mean bifurcation ratio also indicates that less structural control of the study area.

4.6 Areal aspect

Shape of the basin is mainly governed by areal aspects and it can be studied by calculated elongation ratio(R_e), form factor (R_f), circularity ratio(R_c), drainage density(D_d), stream frequency(F_s), Drainage texture(R_t), constant of channel Maintenance(C) etc.

4.7 Drainage density (D_d)

Horton (1945) defined drainage density as the sum of the stream lengths per unit area. It is related to various features of landscape dissection such as valley density, channel head source area, soil and rock properties, relief and landscape evolution processes. Strahler (1964) noted that low drainage density is favoured when basin relief is low and vice versa. For 3rd order basin, drainage density values range from 2.28 to 5.41 km^{-1}.According to Smith (1950) and Strahler (1957) this value of D_d in the study area is indicating low to moderate drainage density. Here low drainage density leads to coarse drainage texture while the high drainage density leads to fine drainage texture.

4.8 Stream frequency (F_s)

According to Horton (1945) stream frequency is defined as the ratio of total number of stream segments of all the orders in the basin to the total area of the basin. In the study area the stream frequency ranges from 2.28 to 14.53 /km^2. It is mainly depends on the lithology of the basins and reflects the texture of the drainage network of the basin.

4.9 Drainage texture (R_t)

Drainage texture is the total number of stream segments of all orders per perimeter of the area and it depends on the underlying lithology, infiltration capacity and relief aspects of the terrain Horton, 1945). The drainage texture of all the 3rd order basins is ranges from1.41 to 3.54 km^{-1}. Generally, texture below 4 is designated as coarse and 4 to 10 is intermediate (Smith, 1950). All the 3rd order basin having a value less than 4.So,the entirebasin falls within the categories of coarse texture.

4.10 Elongation ration (R_e)

According to Schumm(1956), elongation ratio is defined by the ratio of diameter of the circle having the same area of the basin and the maximum basin length. It is actual representation of the shape of the river basins. According to Strahler (1964), the elongation ratio usually ranges from 0.5 to 1.0 over a wide variety of climatic and geologic type. It can be grouped into four categories i.e., circular (>0.9), oval (0.8 – 0.9), less elongated (0.7 – 0.8) and elongated

(<0.7). In the study area, the values of basin elongation of all 3rd order basinsvary from 0.46 -0.88. This value is indicating elongate to less elongated. This high value of elongation ratio shows moderate relief.

4.11 Relief aspects

The relief aspects determined includes basin relief (B_h), relief ratio (R_h)and ruggedness number (R_n). The results of the analysis are:

4.12 Basin relief (B_h)

Relief or basin relief is the difference in elevation between the highest and lowest point of the basin. The basin relief of Ijai basin ranges from 0.45 to 1.04 km. Variation in relief is mainly influenced by lithology, structure, slope, climate, vegetated cover etc. It is also an important factor in understanding the denudational characteristics of the basin.

4.13 Relief ration (R_h)

When basin relief is divided by maximum basin length gives the Relief Ratio (Schumm, 1956). So, it is the length ratio equal to the tangent of the angle formed by two planes intersecting at the mouth of the basin, one representing the horizontal and the other passing through the highest point of the basin (Schumm, 1963). There is also a correlation between hydrological characteristics and relief Ratio of the drainage basin. The R_n normally increases with decreasing drainage area and size of sub- basin of a given drainage basin (Gottschalk, 1964).The relief ratio of the study area varies from 0.19 to 0.47. The value of relief ratio increases annual sediment loss also increases with strong relief and steep slope.

4.14 Ruggedness number (R_n)

Ruggedness number is the product of basin relief (Bn**)** and drainage density (D_d) (Schumm, 1956). In the present study area,the values of R_n range between 0.08 to 0.47, indicating that the basin lies in a hilly terrain.

4.15 Hypsometric analysis

Hypsometric Analysis is the study of distribution of ground surface area or horizontal cross sectional area of land mass with respect to elevation. The idea of hypsometry was first introduces by Lonbein et al (1947) and later extended by Strahler (1952). According to Ritter (2002), Hypsometric Curve and Hypsometric Integral are important indicators of watershed/basin condition. Two very simple and common approaches used to measure the earth's surface/landscape are: Hypsometric Curve and Hypsometric Integral.Strahler (1952, 1964) interpreted the shapes of hypsometric curves by analyzing numerous drainage basins.In the present study, Hypsometric Integral is estimated using the Elevation Relief Ratio Method proposed by Pike and Wilson (1971). The relation is as follows:

$$HI = \frac{E_{mean} - E_{min}}{E_{max} - E_{min}}$$

,Where, E_{mean} = Mean elevation value, E_{min} = Minimum elevation value, E_{max} = Maximum elevation value.

In theory, hypsometric values ranges from 0 to 1 in which value closer to 0(zero) indicates highly eroded region and value closer to 1(one) indicates slightly eroded region. Antonio Pedrera et al (2009). According to Strahler (1952), tentative boundaries between different stages are as follows:

(i) Above 60% : Inequillibrium (youthfull) stage.

(ii) 60% to 35% : Equilibrium (mature) stage.

(iii) Below 35% : Monadnock (old) stage.

Thus the shape of Hypsometric Curves and the Hypsometric Integral values provide valuable information not only of the erosional stage of the basins but also on the tectonic, climatic and lithological factors controlling it (Willgoose and Hancock, 1998; Huang and Niemann, 2006). For the present investigation, in addition to hypsometric analysis of Aleng river is considered. Hypsometric percentage data for Aleng basin are shown in table 2.

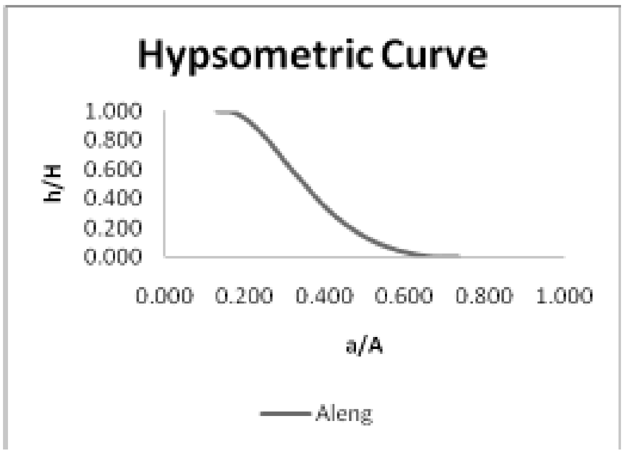

Fig. 3 : Hypsometric curves of Aleng Basin

Table 2 : Hypsometric percentage data

Sl. No.	Name of Basin	mean	minimum	maximum	Hypsometric Integral	
1	Aleng river	1000	300	1800	0.46667	46.60%

It is found that the percentage hypsometric Integral value is 46.60% for Aleng river basin also indicate that the basin is in mature stage.

4.16 Longitudinal profile

Longitudinal profile of a river is a graph of elevation against distance along the channel. The slope or gradient of a river is best illustrated by longitudinal profile of a river. It can also be used to establish the effects of uplift, warping and subsidence along the river course.

In the study area, longitudinal profile (fig 4) has been prepared by height against the horizontal distance using GIS software and Microsoft Office Excil with SOI topographic map (scale 1:50,000). This profile is characteristically concave upwards. Logitudinal profile of Ijai basin has been analysed using the Hack's Gradient Index (Hack, 1973, Seeber and Gornitz 1983, Marh, 1986).

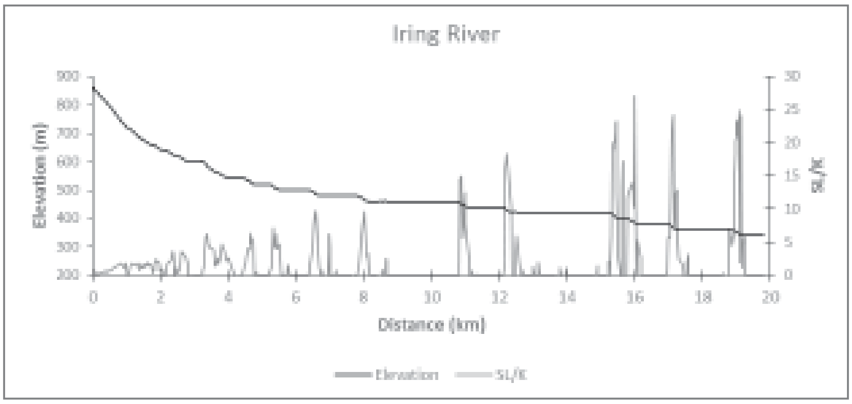

Fig. 4 : Longitudinal Profile of Aleng River

5. Conclusion

The present study indicates that GIS software constitute as an efficient tool in delineation and analysis of drainage basin. Based on the stream order, Aleng basin has been designated as 6th order basin. Detailed morphometric study of all 3rd order sub basins indicates the total number of streams in each sub basin decrease as order increases. The dentritic to sub-dentritic patterns are most common in the basin and variation in stream length ratio might be due to change in slope and topography. Moreover less number of streams in a given basin shows the presence of mature topography and at the same time presence of a large number of streams indicates the topography is still undergoing erosion. The drainage density of all 3rd orderbasins indicates that the nature of sub-basin is permeable, heavy dense vegetation and low relief. The values of streamfrequenciesalso indicate permeable sub-soil material. Drainage texture is coarse indicating medium lithology. Shape parameters of all the 3rd orderbasins like circularity ratio, elongation ratio, and form factor suggest that most of the sub-basins are almost semi-elongated to elongated. It is taken to be a good area of ground water potential.Study of longitudinal profile suggested that the values of knick points (SL/K >1) increase when river channel crosses the tectonically faulted and folded area. The hypsometric integral value also indicates that basin is in mature stage. Mean Bifurcation ratio value ranges from 2.0 to 5.75 suggests morphological and structural control on the development of drainage network in the area, drainage density and fine drainage texture suggests high runoff in the area.

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References

Antonio, P., Jose,V.P.,Pena, J.G.,Zaldiver, Jose, M. A., Antonio, A., 2009. “Testing the sensitivity of geomorphic indices in areas of low rate active folding”, Geomorphology 105, 218-231.

Bengal, J. Indian Soc. Remote Sensing 26(1&2): 69-76.

Bagyaraj, M. and Gurugnanam, B., 2011,: Significance of morphometry studies, soil characteristics, erosion phenomena and landform processes using remote sensing and GIS for Kodaikanal Hills, A Global Biodiversity Hotpot in Western Ghat, DindigulDistrct, Tamil Nadu, South India. Res. Jour. Env. And Earth Sci, 3(3):221-233.

Doad, A.P., Warghat, S.R. and Khadse, S.P., 2012, Morphometric Analysis for Hydrological studies using GIS: A case study. Int. jour. Engg. Res. and Tech., v. 1 (5): 1-8.

Dwivedi, S.C., 2011:, Morphometric Analysis of four sub-watershed in Bah area, of Agra District using Remote Sensing andGIS techniques, 12thEsri India user conference.

Gottschalk, L.C.,1964, Reservoir sedimentation *In:* I.T. Chow (ed), Handbook of Applied Hydrology; McGraw Hill Book Company, New York, section 7-I

Gupta, B.L.,1999, Engineering Hydrology, 3rd Ed. Runoff. 46-56.

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

Horton, R.E.,1945, Erosional development of streams and their drainage basin: Hydrophysical approach to quantitative morphology. Geol. Soc. Am. Bull. 56:275-350.

Miller, V.C.,1953, A quantitative geomorphic study of drainage basin characteristics on the Clinch Mountain area, Virgina and Tennessee, Proj. NR 389 -402, Tech Rep 3, Columbia University, Department of Geology, ONR, New York.

Mishra, A., Dubey, D.P. and Tiwari, R.N., 2011, Morphometric Analysis of Tons basin, Rewa District, Madhya Pradesh, based on watershed approach, Earth Science India, v. 4 (III): 171-180.

Narendra, K., and Nageswara R. K., 2006, Morphometry of the Mchadrigedda Watershed Visakhapatnam district, Andhra Pradesh using GIS and Resource Sat data, Jour. Indian Soc. Remote Sensing , 34: 101-110.

Pareta, K., and Pareta, U., 2011, Quatitative morphometric analysis of a watershed of Yamuna basin, India using ASTER(DEM) data and GIS , International Journal of Geomaticsand Geosciences, v. 2, (1): 248-269.

Pirasteh, S., Sarfraj, H.O., Pradhan, B. and Attarzadeh, I., 2010, Litho-morphotectonic analysis using Landsat ETM data and GIS techniques, Zaros Fold Belt (ZFB), SW Iran. International Geoinformatics Research and Development, Journal, v. 1 (2): 28-36.

Panhalkar, S., and Pawar, C.T., 2011, Watershed Development prioritization by applying Werm Model and GIS techniques in Vedganga Basin (India), ARPM Journal of Agricultural and Biological Science, v., 6, (10): 38-44.

Smith, K.G.,1950, Standard for grading textures of erosional topography. Am. Jour. Sci. 248: 655 – 668.

Strahler, A.N., 1957, Quantitative analysis of watershed geomorphology. Trans. Amer. Geophys. Union, v.38: 913 – 928.

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

Schumm, S.A., 1956, Evolution of Drainage systems and slopes in badlands at perth Amboy,

New Jersey Bull. Geol. Soc. America, v. 67: 597 – 646.

Schumm, S.A., 1964, Sinuosity of alluvial rivers on the Great Plains. Bull. Geol. Soc. America,v.74:1089–1100.

Willgoose and Hancock, 1998, Revisiting the hypsometric curve as an indicator of form and process in transport limited catchment, Earth Surface Processes and landform 23: 511 – 623.

Zende, A.M., and Nagarjan, R., 2011, Drainage morphology Approach for water resources development of sub-watershed in Krishna Basin, International Journal of computer and communication Technology, v. 2, Issue- VI.

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