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An Integrated Study of Morphometry Analysis and Physical Characteristics Evaluation for Resource Management of River Basin Using Geoinformatics: A Model Study from Part of Vamsadhara River Basin

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Abstract: Indian subcontinent has many perennial Rivers and sub basins supporting the thriving of cultures and livelihood. One of the basins (water shed) in southern India is the Vamsadhara river basin, which covers a large part of the geographical area. The main objective of the paper is measuring the physical characteristics using various topographical representations and correlation coefficients. Vector layer and thematic layers methods are mainly used to preparing the various parameter and characteristics of maps. The present study to find the study of erosion prone zones by integrating various thematic layers and studying various correlations between the morphometric parameters of the sub basins. Mushrooming with varied topography, soil types and the socioeconomic diversities makes this one its kind. The comparisons with recently overlain satellite imagery to tract the changes happened in the years are carried out and suggesting means to facilitate to the soil erosion zones to prevent them.

Keywords: Physical characteristic information maps, GIS, Remote Sensing.

1. INTRODUCTION

The basin forms part of Orissa and Andhra Pradesh States. The water flow is along the south easterly direction. The area includes mineral soils of various textures as well as organic soils. Remote Sensing has shown great potential in agricultural mapping and monitoring due to its advantages over traditional procedures in terms of cost and time effectiveness in the availability of information over larger areas. In agriculture, Remote Sensing has been employed to the development of precision farming for the better crop production and environmental protection. The river basin in Orissa and Andhra Pradesh States[1] is bounded on the north by the Mahanadi basin, on the northeast by the basin, on the west by the basin and on the east by the Bay of Bengal. The catchment area is mostly hilly. Since the surface is mostly covered with kankar area and murum area, the run -off is moderate in the basin. is an important east flowing river between Mahanadi and Godavari.

2. DISCRIPTION OF STUDY AREA

The study is the river basin having a spatial extent of 10,515 km^2. It is one of the largest basin in southern India. The survey of India topographic maps that cover the entire watershed are 65M/5-16, 65N/9, 65N/13-15, and 74/1-8 and B/1-3 and 74B/5. It is located in between the $83^0 15^1$ and $84^0 57^1$ E longitude and $18^0 15^1$ and $19^0 57^1$ N latitude as shown in Figure 1 the individual sub basins are shown in Figure 2. The river rises

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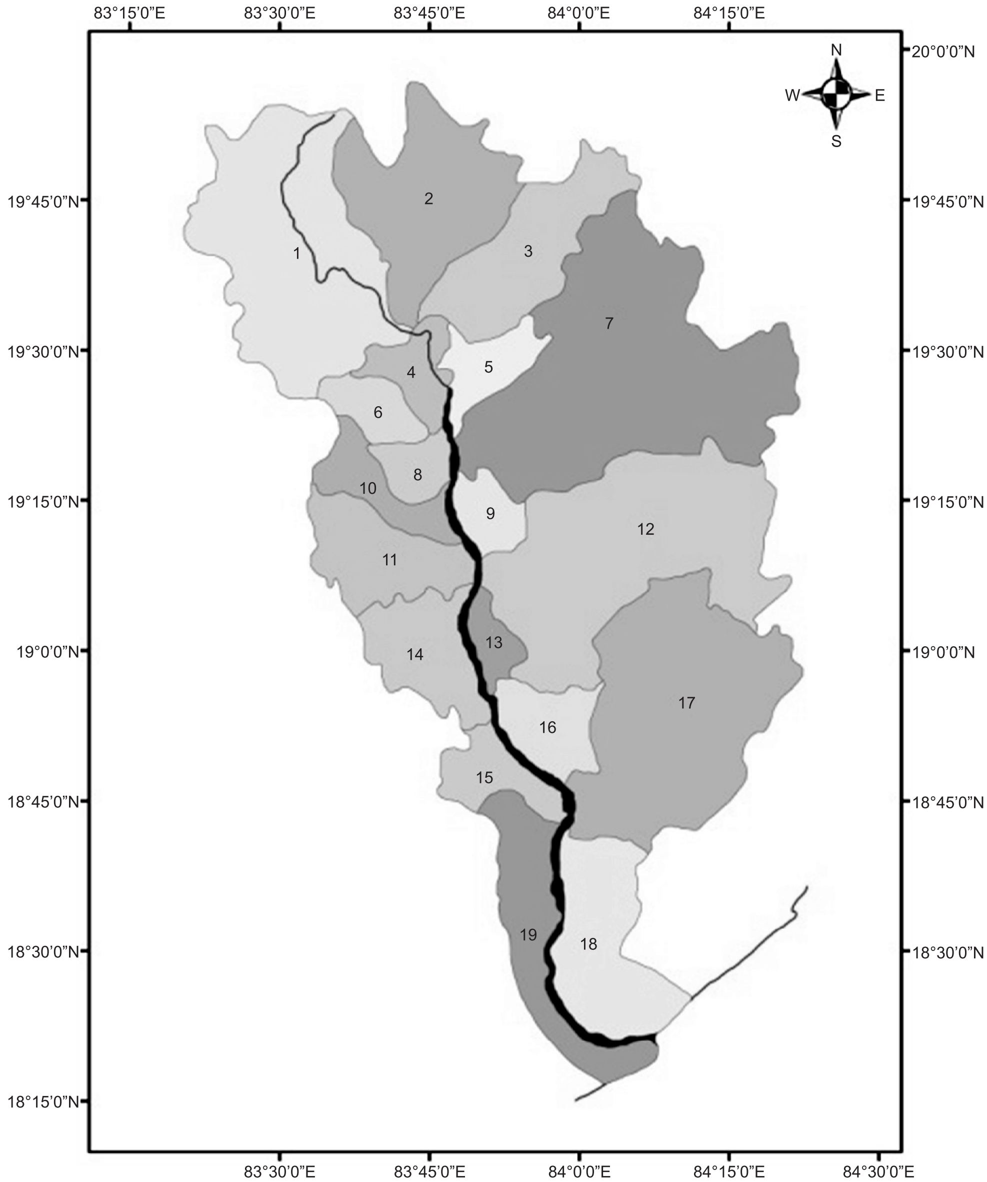

Figure 1: Sub Basins

just south of the Belagad village in the undivided phulbani district of Orissa at an elevation of about 600m. The total length of the river is about 221 km of which 125km is in Andhra Pradesh. The important between Orissa and Andhra Pradesh and 73 km is in Andhra Pradesh. The important tributaries of Vamsadhara are Chuvaldhua, Poladi, Gungudu, Sannanoi and Mahendratanaya, Bhangipedda, Peddadedda and Bellagedda. The catchment area of the Vamsadhara River is 10,515 km^2 is taken up for the examination of the problem. The river is prone to frequent floods . This is interstate drainaage basin between Andhra Pradesh and Orissa. The river joints the sea at Kalingapatnam after traversing 230 kms in both the states which 8,611 km^2 lies in Orissa State (1.178 km^2 in Phulbani, 191 km^2 in Kalahandi, 4,056 km^2 in Koraput and 3,501 km^2 in Ganjam districs) and 1,904 km^2 lies in Andhra Pradeh State (221 km^2 in Vizianagaram and 1,683 km^2 in Srikakulam districts)[2].

3. METHODOLOGY

In the present study the visual interpretation of satellite imagery has been carried out. The has been generated into different themes namely Drainage map, soil map, Slope map and Isohyetal (rainfall) map by using earlier generated thematic maps. Land use/Land cover map is compared with Awifs satellite imagery. Finally Soil erosion map and morphometry quantifiers are evaluated from the available statistical values. Comparative study has been made using soil erosion map generated from index method and Awifs land use/land cover map are examined as shown in Figure 2.

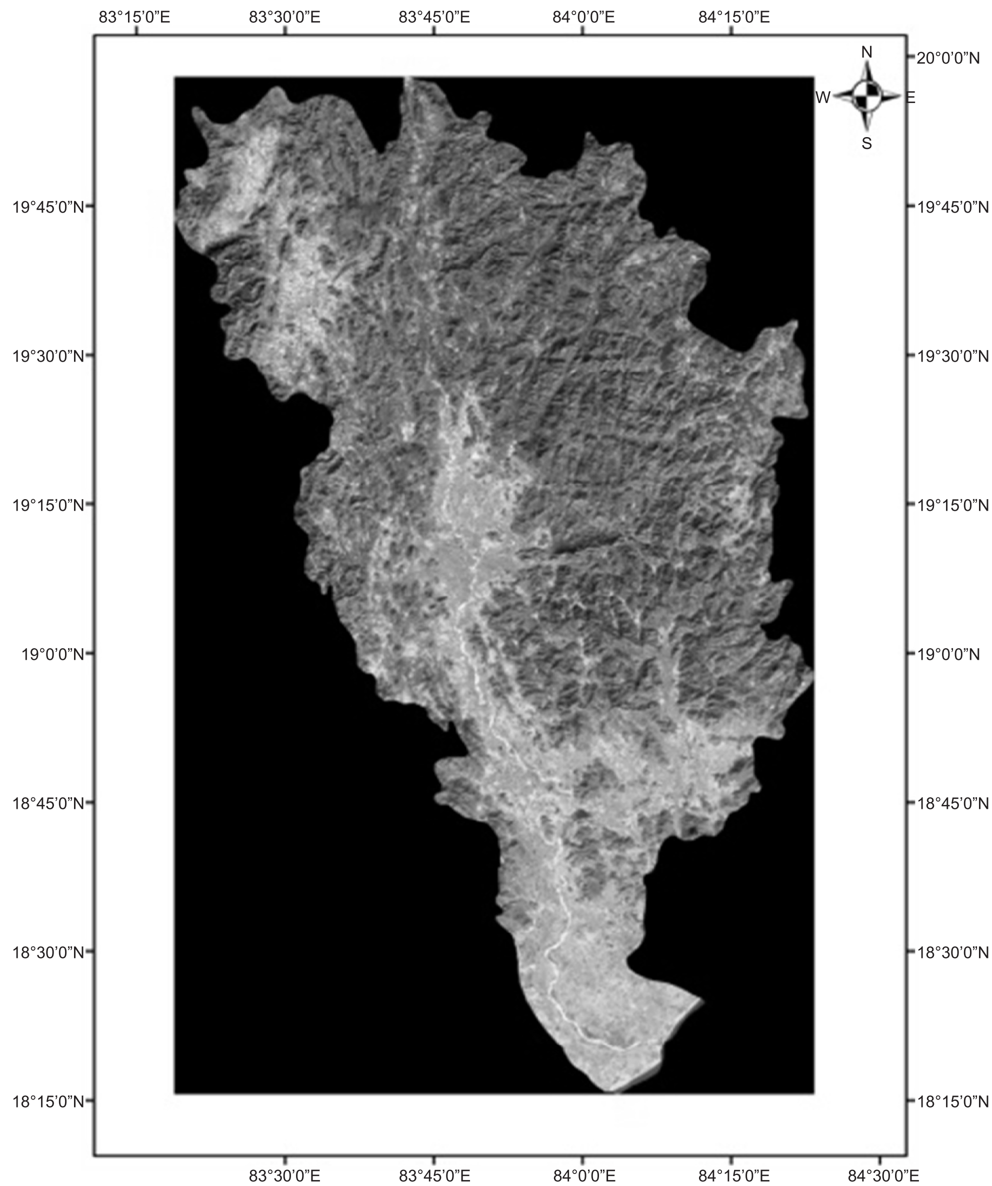

Figure 2: Awifs Data

3.1. Data Collection

Different data products required for the study include SOI toposheets bearing the numbers 65M/5-16, 65N/9, 65N/13-15, and 74/1-8 and B/1-3 and 74B/5. on 1:50,000 scale, data of IRS–1D LISS-III satellite imagery obtained from National Remote Sensing Centre (NRSC) and collateral data collected from related Government organizations and demographic data. Data Input and Conversion Satellite imageries collected from NRSC are geo-referenced using the ground control points with SOI toposheets[3] as a reference and further merged to obtain high resolution output in ERDAS Image processing software. The study area is then delineated and subset from the data based on the latitude and longitude values and a final hard copy output is prepared for further interpretation.

3.2. Database Creation and Analysis

Creating a GIS spatial database is a complex operation, which involves data capture, verification and structuring processes. Raw geographical data are available in many different analogue and digital forms such as toposheets, satellite imageries and tables. Out of all these sources, the source of toposheet is of much concern to natural resource scientist and an environmentalist. In the present study, different thematic layers viz., Drainage, Geomorphology, Land use/Land cover, Slope, Structures, Ground water potential, Ground water Infiltration, Physiography, Transport network maps are generated from toposheet and satellite data using visual interpretation technique. The study-based maps are converted to digital mode using scanning and automated digitization process. These maps are prepared to a certain scale and show the attributes of entities by different symbols or coloring. The location of entities on the earth's surface is then specified by means of an agreed co-ordinate system. It is mandatory that all spatial data in a GIS are located with respect to a frame of reference. For most GIS, the common frame of reference co-ordinate system is that of plane, Orthogonal Cartesian co-ordinates oriented conventionally North-South and East-West. This entire process is called geo-referencing. The same procedure is also applied on remote sensing data before it is used to prepare thematic maps from satellite data. This digitized data is then exported to ARC/INFO and further processed in Arc View GIS software to create digital database for subsequent data analysis[4].

4. RESULTS AND DISCUSSION

4.1. Base Map

A topographic map is a representation of the shape, size, position and relation of the physical features of an area. The base map is prepared using SOI toposheet on 1:50,000 scale and updated with the help of satellite imagery. It consists of various features like the drainage, soil, slope, rainfall, vegetation etc. delineated from the toposheet. The map thus drawn is scanned and digitized to get a digital output[5]. The information content of this map is used as a baseline data to finalize the physical features of other thematic maps. Since the toposheets are very old all the features like roads, railways, settlements etc are updated with the help of rectified and scaled satellite imageries of the area.

4.2. Drainage Pattren

The drainage map prepared from the toposheet forms the base map for the preparation of thematic maps related. All the rivers, tributaries and small stream channels shown on the toposheet are extracted to prepare the drainage map. All the drainage lines are examined very closely and final drainage map is prepared. The catchment area of the study area is about 10,515 square kilometers as shown in Figure 3.

4.3. Slope:

Slope is the combined results of many factors like geological structure, absolute and relative relief, climate, vegetation cover, drainage texture and frequency, etc. It is one of the significant morphometric attributes in study of land forms of a drainage basin. Computation of slope angels from field measurements involves tedious and time-consuming procedures. Several techniques of the derivation and computation of average slope from topographical maps have been suggested by various works. The effects of slope length on soil erosion are confounded by slope gradient, slope shape and slope-induced alterations in soil properties[6]. Other factors remaining the same, soil erosion supposedly in proportion to some power of slope length.

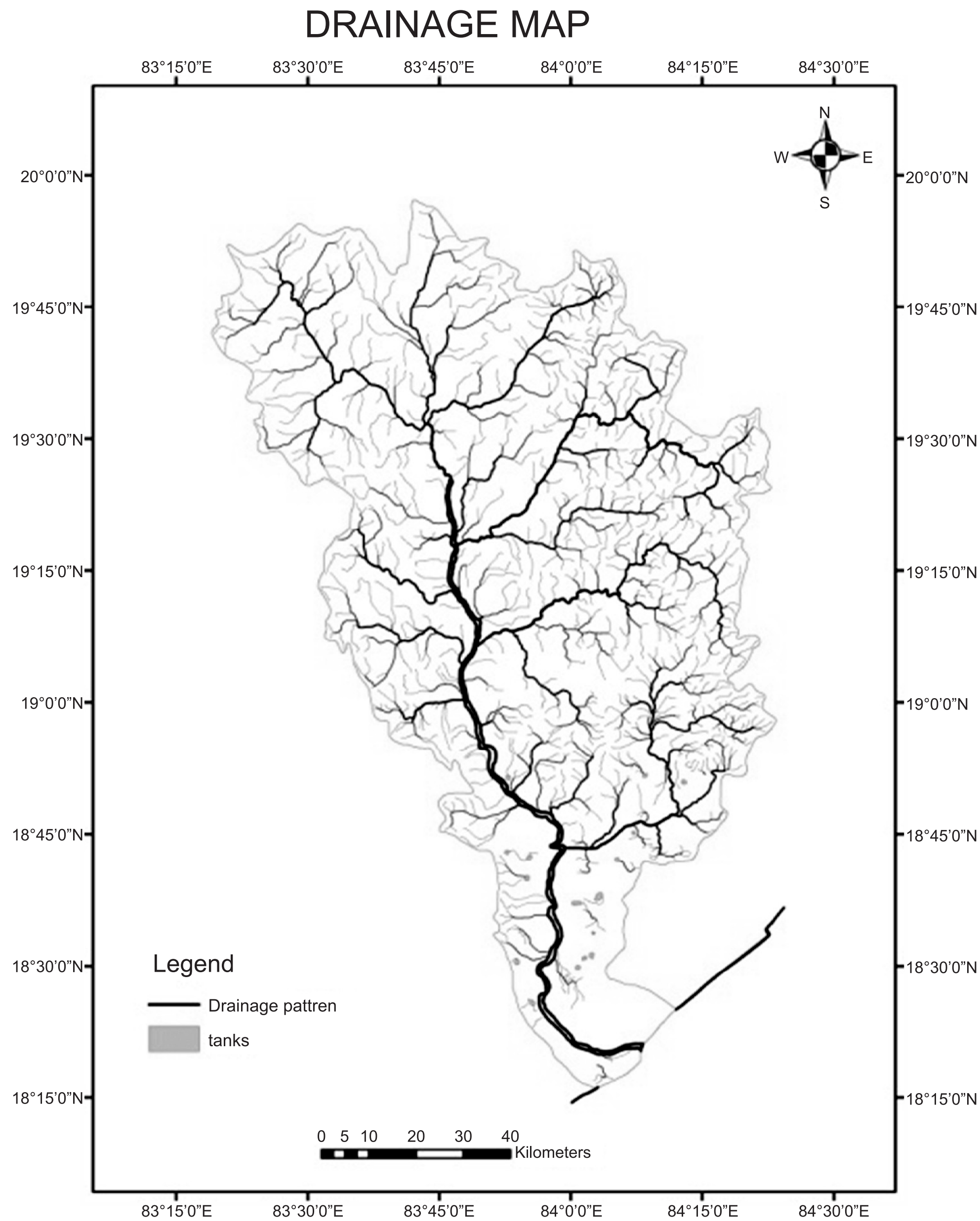

Figure 3: Drainage Pattern

Higher erosion on longer slopes may be due to increased runoff velocity on longer slope lengths, and therefore, due to increase in rill ersion. Because the effects of slope length on erosion are related to runoff velocity, the length-effect may be easily altered by soil and crop management, the canopy characteristics and percent ground cover. Hence slope plays a vital role in soil erosion process. Slope, aspect and altitude are the important terrain parameters that influence microclimate, temperature regime, and run off which plays significant role in soil development, vegetation and agricultural crop productivity. The density of contours on the map are used for preparing the slope map that gives various groups/categories of slopes such as defined in the technical guidelines for integrated study as shown in Figure 4.

4.4. Rain Fall

Rainfall plays a prominent role in assessing soil erosion. The intensity of rainfall and the infiltration capabilities of soil all affect the levels of soil erosions. Many runoff models have been investigated over

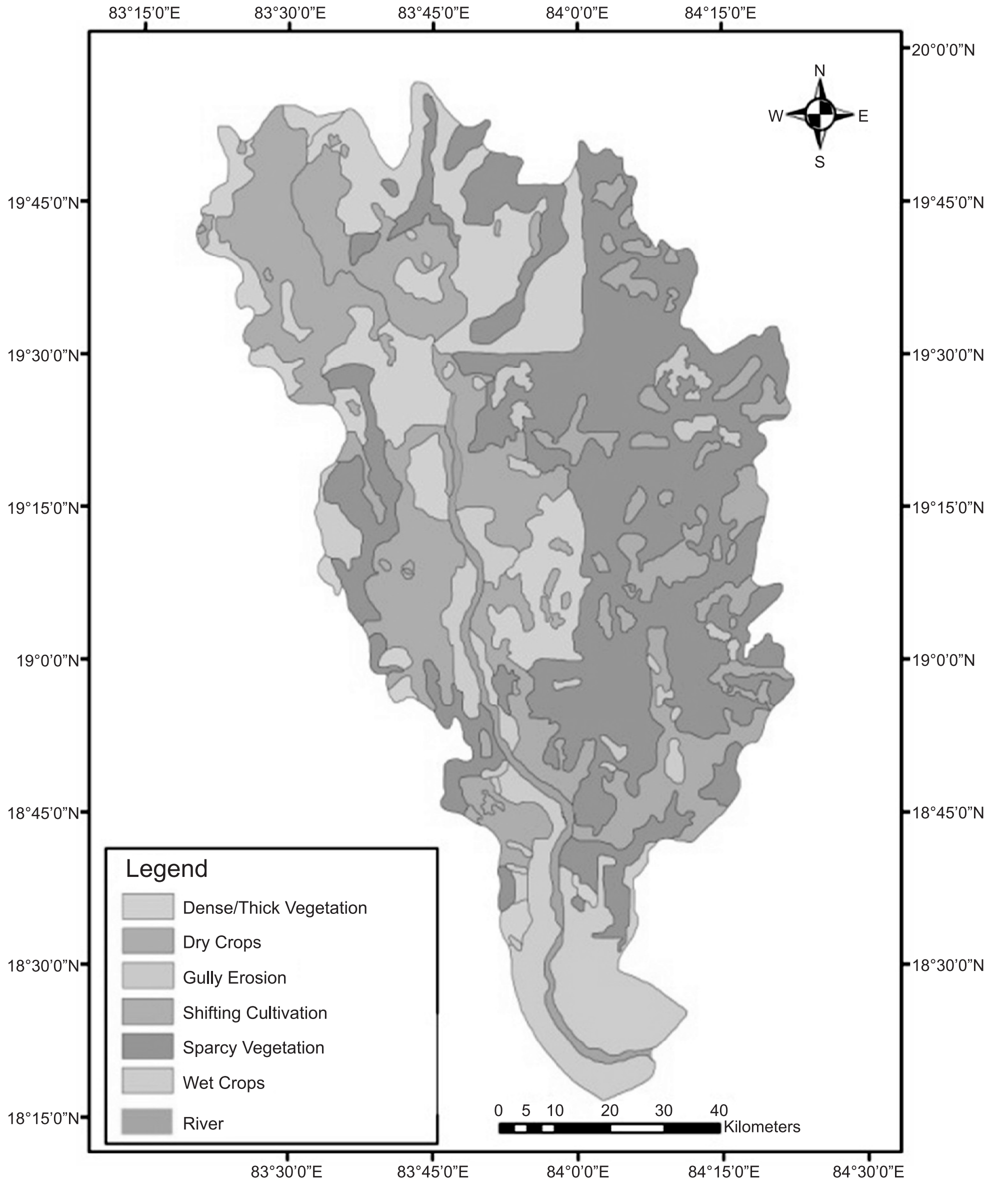

Figure 4: Slope Map

the past to quantify the erosion process. A field portable rainfall simulator was employed to determine the infiltration and soil erosion. The results indicate that infiltration capacity decreases as total bulk density and coarse fragment content increase. The suspended sediment concentration of the overland flow was found to increase as the volume of the runoff increased as shown in Figure 6. However, variability in suspended sediment concentrations was high for the highest runoff volume which suggests that other factors such as soil, texture, slope gradient and surface armoring also have important effects. Global climate has changed over the past century. Precipitation amounts and intensities are increasing. Soil erosion is likely to be more affected than runoff by changes in rainfall and cover, though both are likely to be significantly impacted; percent erosion and runoff will likely change more for each percent change in rainfall intensity and amount associated with changes in storm rainfall intensity will likely have a greater impact on runoff and erosion than simply changes in rainfall amount alone; changes in ground cover have a much greater impact on both runoff and erosion than changes in canopy cover alone. The results do not imply that future changes in rainfall will dominate over changes in land use, since land use changes can often be drastic. Given the types of precipitation changes that have occurred over the last century, and the expectations regarding changes over the next century, the study suggest that there is a significant potential for climate change to increase global soil erosion rates unless offsetting conservation measures are taken. Hence, rainfall plays an important factor in soil erosion assessment[7]. To assess the soil erosion factors the statistical data of rainfall is collected to prepare the thematic information in the Vamsadhara river basin. Shown below is the areal distribution of precipitation Figure 5 the distribution in area Table 2.

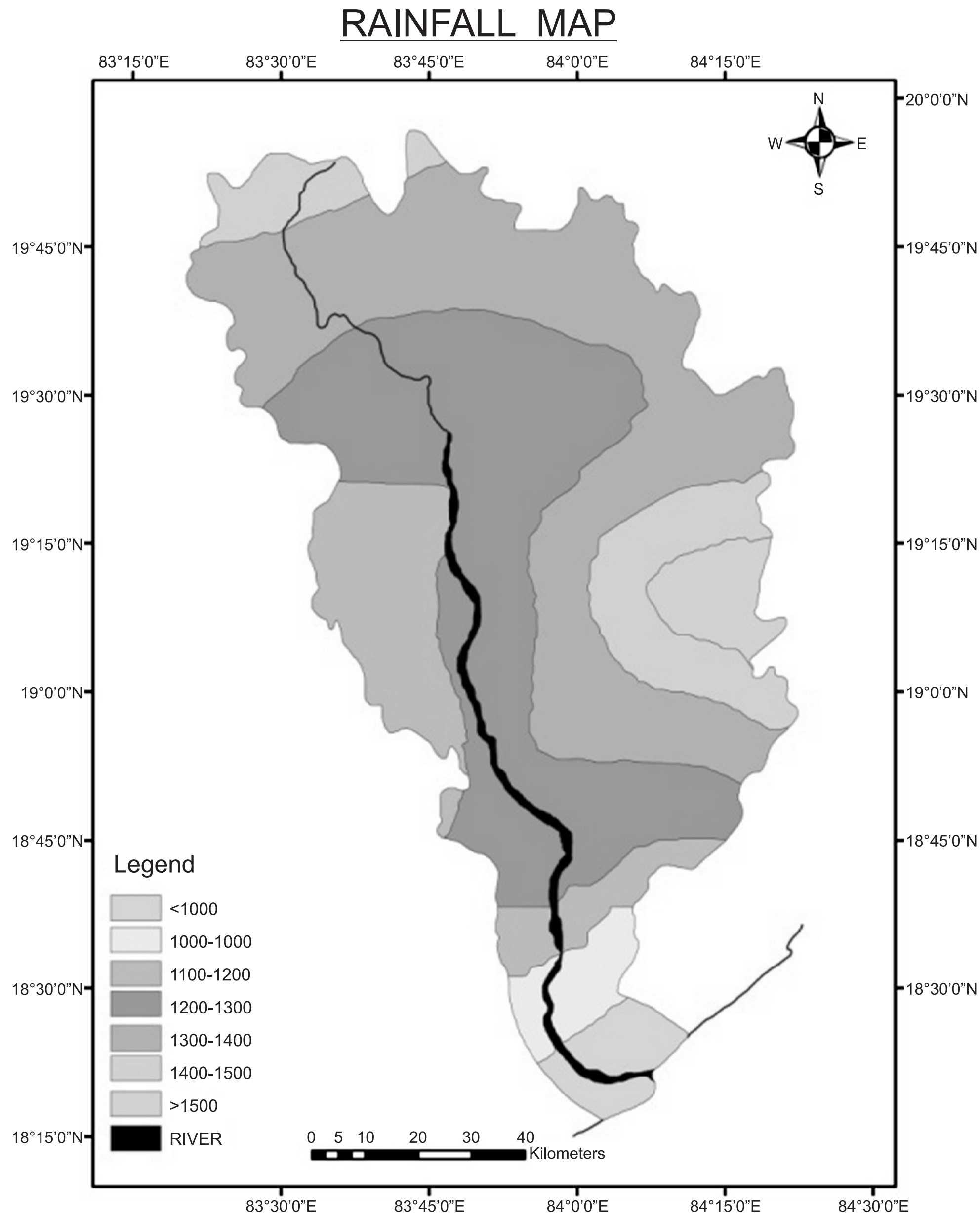

Figure 5: Rainfall Map

4.5. Land Use/Land Cover

Thematic map is obtained from the earlier classified source for land use classification using ERDAS 9.2 Imagine Software. It is a supervised classification model. The land use classes are Dense/thick vegetation, Dry Crops, Gully erosion, Shifting cultivation, Sparse vegetation, Wet crops. The generation of classification is by maximum likelihood classifier. It gives the land use code, segment number of pixels in each land use classes, the threshold value used, percentage of image occupied by each land use class etc. In the entire river basin 17% of the area is under thick vegetation. Dry crop cultivation amounts to 31% besides shifting cultivation of 3% in total river basin area. Vegetation is spares in 36% of the entire basin. Wet crops covers

11% and gully eroded lands are 2%.In the present study, the imaginary has been carried out and classified into different classes, namely Dense/thick vegetation, Dry crops, Gully erosion, Shifting cultivation, Sparse vegetation, Wet crops. After classification of satellite data land use/ land cover map is digitized into vector form in polygon mode as shown in Figure 6. Various land use pattern are given different colors of easy identification and use/land cover classes[8].

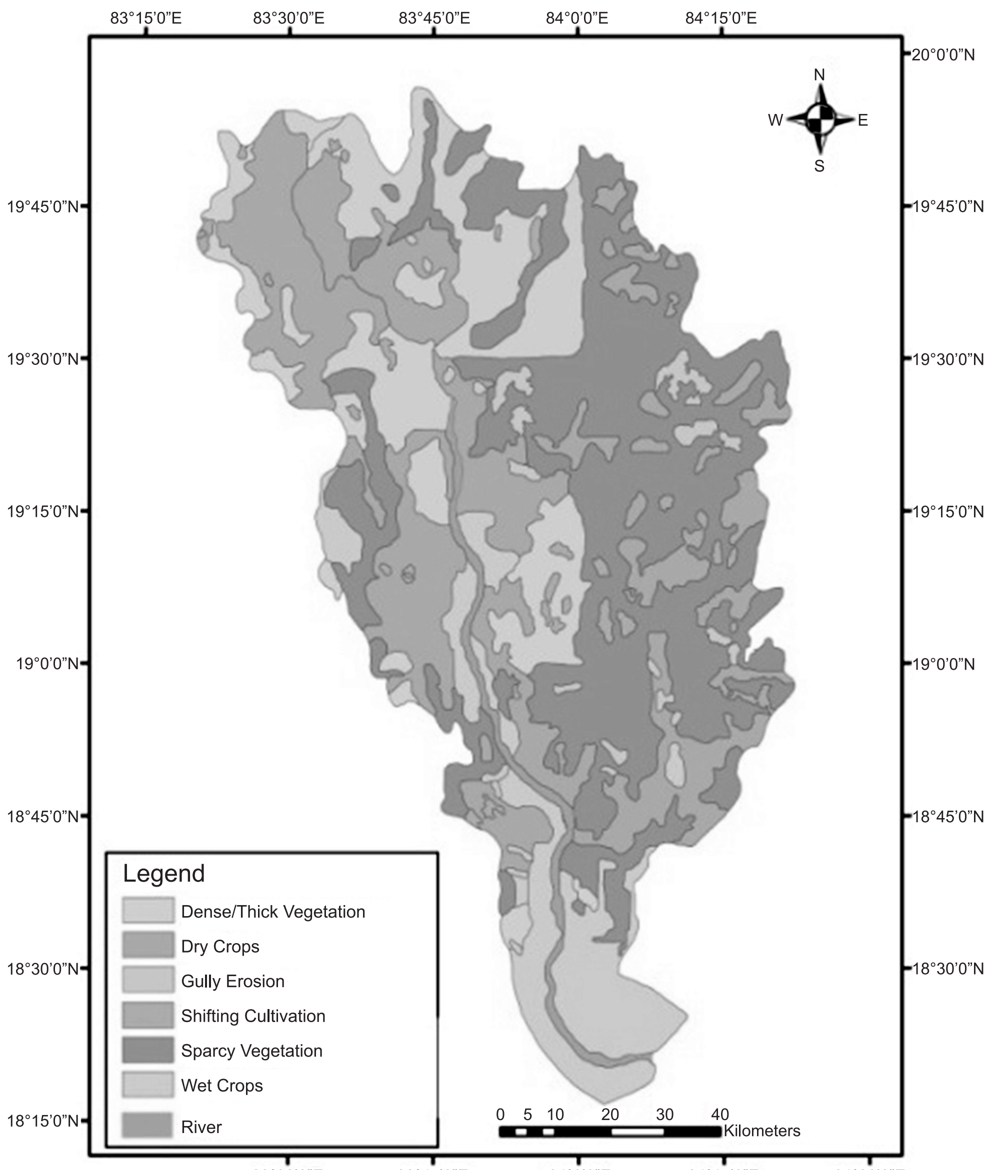

Figure 6: Landuse/Landcover

4.6. Morphometry Analysis

4.6.1. Drainage Density

An important indicator of the linear scale of landform elements in stream eroded topography is Drainage Density. An increase in the drainage density means a proportionate decrease in the size of individual drainage units, such as the first order drainage basins. The study of drainage density parameter is associated with rock type, relief, runoff and slope[9]. Drainage density is important in hydrology as it is one of the factors that control the speed of runoff following a period of precipitation. Drainage density is calculated for each sub-basin and the results are presented in Table 1.

The sub-basin 18 is poorly drained in comparisons with the other sub-basins. The low drainage density of the sub-basin 18 is because of its high infiltration soils with very low relief. Similarly the sub-basin 19 has a drainage density more than the sub-basin 18 because this is occupied by steep hills on the north western side. The high drainage density is obtained for the sub-basins 2, 3, 5 and 10. This is correlated with dense vegetation and high relief[10]. Except basin nos. 9, 18 and 19 the order basins are well drained and could be classified as excellent type of drainage. The basin No.18 is poorly drained and the sub basins 9 and 19 have medium drained densities as shown in Figure 7.

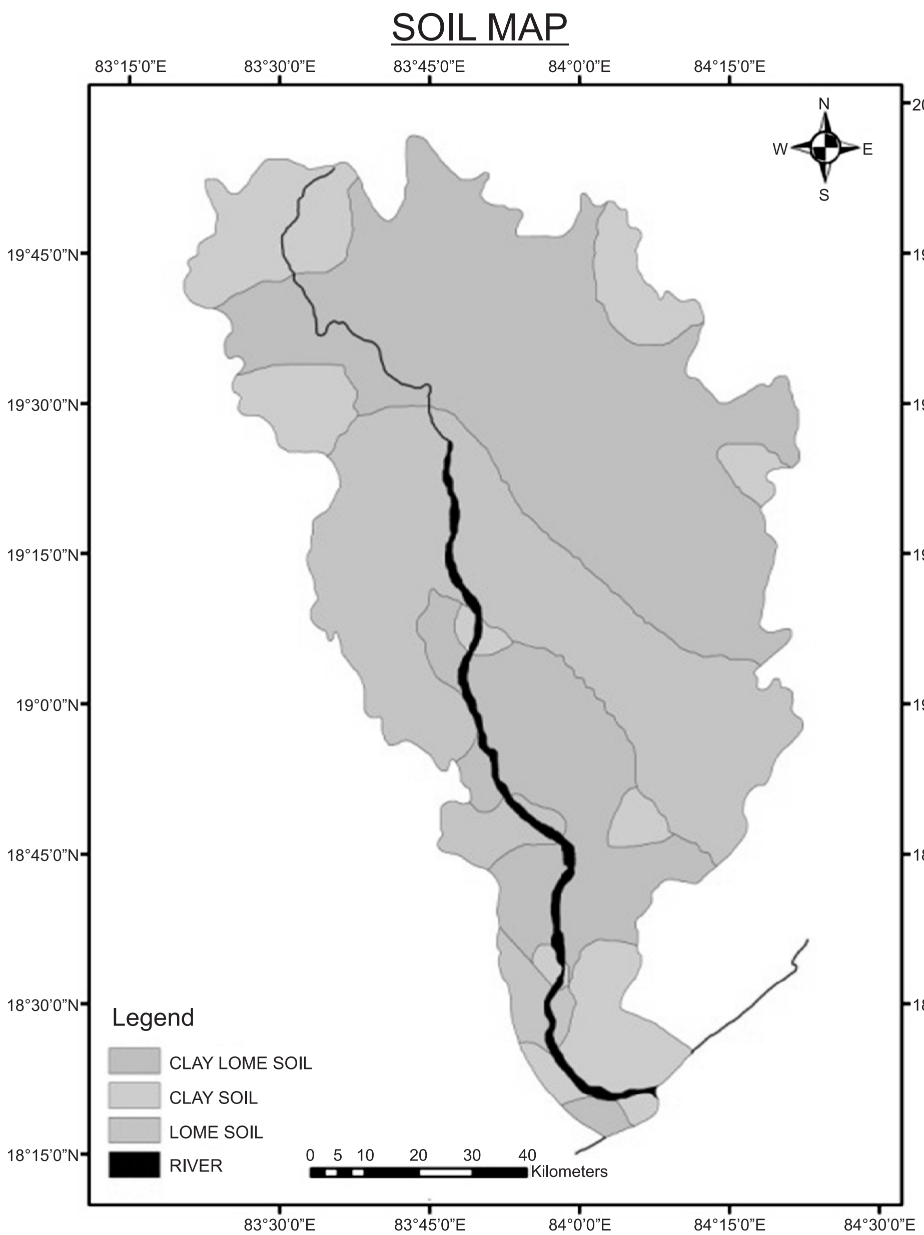

Figure 7: Soil Map

4.6.2. Stream Frequency

Stream is an important parameter, along with drainage density. Generally it is used as a supplementary measure of the fineness of the texture of the topography. It is associated with litho logy, degree of slope, stage of fluvial cycle and amount of surface runoff. analyzed in detail the relationships between drainage density and stream frequency for the study area shown in (Appendix-1) as sub-basins. High frequencies are observed for the sub basins 2, 3, 5 and 6(more than 6.0) in the regions of non-homogenous bed rock and thick vegetative cover[11]. The river basin shows almost a positive correlation between drainage density and stream frequency as inferred from the linear correlation coefficient value (0.92).

4.6.3. Texture Ratio

The texture of topography depends upon a number of variable factors which may be divided into two classes, natural factors and map factors. The natural factors that influence texture ration are climate, vegetation, rock (soil type), rainfall intensity, infiltration capacity, relief and stage of development[12]. In general, weak rocks, unprotected by vegetation produce fine texture; massive resistant rocks cause course texture. Sparse vegetation of arid climates causes finer textures than those developed in similar rocks in a humid climate[13]. Texture tends to be coarse in the initial and early stages of the erosion cycle, finest in early maturity when relief is greatest as shown in the Table 2 and as shown in Figure 8.

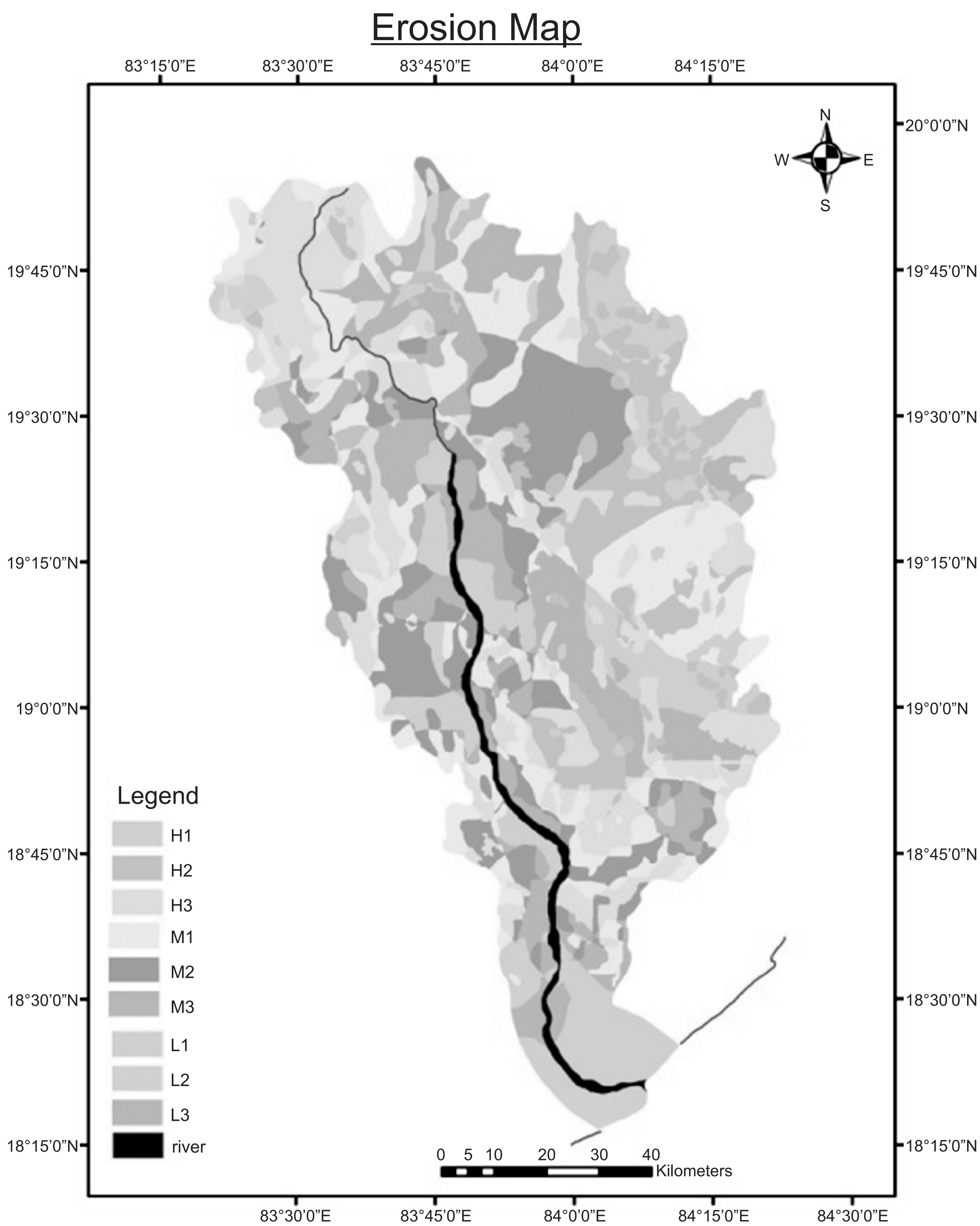

Figure 8: Erosinal Map

5. CONCLUSION

The correlation coefficients between stream frequency and rainfall, slope are 0.899, 0.71 respectively. Shows that the slope increases stream frequency also increases, as rainfall is more stream frequency also increases. As a result the runoff increases as it is highly correlated with stream frequency. The correlation coefficients between texture ratio and basin elongation is 0.012, rotundity factor and basin elongation is 0.005, drainage density and form is 0.01. The factors are poorly correlated. The numbers of structures per km do not necessarily depend on the elongation of the basin and so on. Ruggedness and slope has correlation coefficient of -.613 and basin circularity to ruggedness number has -0.83, ruggedness number to denote the product of drainage density and relative relief.

Table 1
Physical Parameters

Sub Basin. No.	*Average Relief (m)*	*Average Slope (mm)*	*Average Rainfall (mm)*	*Average Runoff (mm)*	*Stream Frequency (Number/Sq. km)*	*Drainage Density (km)*	*Texture Ratio*
1	629.6	11 1	1348.2	496.6	3.90	2.54	27.35
2	572.3	13 3	1346.3	654.7	6.30	3.76	33.17
3	746.8	15 45	1311.3	673.9	6.20	3.57	2.84
4	247.4	11 54	1250.0	589.0	5.60	2.95	15.88
5	294.0	12 17	1250.4	589.6	6.32	3.81	13.74
6	663.1	15 06	1250.6/1290.6	615.6/655.6	6.10	3.27	15.83
7	573.9	14 30	1919.0	644.3	5.64	3.26	36.94
8	336.8	9 57	1250.0	566.6	4.00	3.20	8.87
9	276.0	4 12	1250.4/1220.4	507.1/407.1	1.95	1.46	5.89
10	661.5	12 15	1251.0	610.7	4.72	3.44	1.17
11	443.0	10 9	1275.5	597.3	4.18	2.88	19.27
12	665.1	15 24	1404.4	728.8	4.28	2.89	25.48
13	348.8	7 42	1250.0	583.5/525.5	3.15	2.17	7.87
14	317.8	7 06	1266.0	486.4	3.72	2.45	13.41
15	351.2	6 30	1228.6	526.2	3.73	2.45	8.64
16	371.0	8 54	1213.3	556.3	3.42	2.49	10.69
17	568.5	12 01	1336.2	662.9/642.9	4.64	2.88	33.64
18	81.8	2 42	1029.4	331.9	0.63	0.27	2.99
19	167.7	3 38	1105.8	368.7	1.10	0.63	3.92

Table 2
Morphometric Parameters

S.NO	*Ruggedness Number*	*From Factor*	*Basin Circularity*	*Basin Elongation Ratio*	*Rotundity Factor*
1	2.85	0.25	0.48	0.56	1.65
2	3.32	0.22	0.42	0.53	1.91
3	3.70	0.14	0.37	0.43	3.33
4	2.33	0.27	0.52	0.58	0.60
5	2.92	0.11	0.33	0.37	4.63
6	3.04	0.18	0.48	0.48	2.60
7	3.58	0.15	0.31	0.43	1.90
8	1.53	0.51	0.66	0.80	1.09

S.NO	*Ruggedness Number*	*From Factor*	*Basin Circularity*	*Basin Elongation Ratio*	*Rotundity Factor*
9	0.86	0.52	0.55	0.81	0.80
10	3.18	0.10	0.34	0.34	0.51
11	3.19	0.19	0.57	0.50	1.90
12	3.65	0.12	0.34	0.38	1.67
13	1.33	0.84	0.40	1.03	1.08
14	1.36	0.36	0.42	0.68	0.82
15	2.20	0.38	0.39	0.70	1.13
16	1.65	0.61	0.45	0.89	0.95
17	3.11	0.18	0.55	0.48	1.68
18	0.20	-	-	-	-
19	0.24	-	-	-	-

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