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ESTIMATION OF SOIL EROSION STATUS FOR LAND RESOURCES MANAGEMENT USING REMOTE SENSING AND GIS: A MODEL STUDY FROM A.P

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ABSTRACT

Hydro-Environmental issues such as planning, design and operations of reservoirs the most importance of soil and water conservation. This study explores the abilities of statistical models to improve the accuracy of rainfall- stream flow-suspended sediment relationships in daily suspended sediment estimation. In this study, soil erosion regions in Vamsadhara Rivr Basin(VRB). The problem of soil erosion is prevalent over about 53% of the total land area of India. Which is not only detrimental to current agriculture production but is a serious threat to survival of mankind Therefore, accurate estimation of suspended sediment concentration carried by rivers is of utmost importance in the soil and water conservation practices in the watershed and also in large number of hydro-environmental issues and environmental impact assessment. Present study using Universal Soil Loss Equation (USLE) developed by United State Department of Agriculture. Maps covering each parameter were integrated to generate a composite map of erosion intensity based on advanced GIS functionality. The map is expected to assist in the identification of priority areas of the basin and would thus help in future planning of a watershed and its sustainable development.

Keywords: Erosion, GIS, Universal Soil Loss Equation, Remote sensing, GIS.

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1. INTRODUCTION

The study is the Vamsadhara river basin having a spatial extent of 10,600 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 figure 1. 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. The relentless increase in human population and changes of life style have put tremendous pressure on the land and water resources causing their degradation and posing a global threat. Soil and water one of the nature`s greatest gifts to man. It takes thousands of years to develop a 5 cm layer of fertile land where as it can be washed away in a single rainstorm event. Water is precious natural resources a basic human needs and a prime national asset. The soil has been termed by the International Soil Science Society as a 'limited and irreplaceable resource'. Growing degradation and loss of soil means that the expanding population in many parts of the world is pushing this resource to its frontier. Judson was one of the first geologists to assess the world soil erosion. stated that more than 50% of the world's pastureland and about 80% of agricultural land suffer from significant erosion.

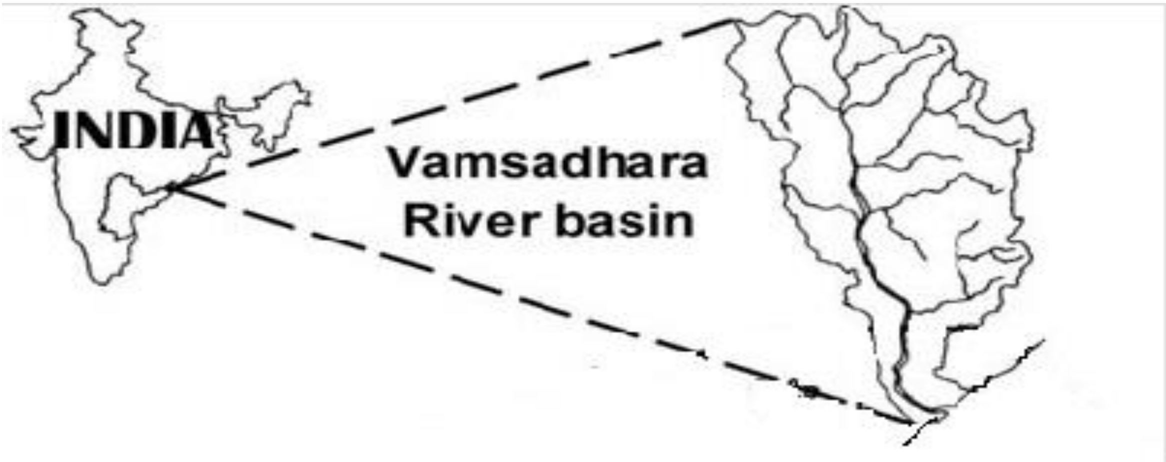


Figure 1 Location Map of study area

Cultivation and land use practices have a long history within the Mediterranean region exploiting soils as a natural resource. The soils are an essential factor contributing to agricultural production and their inadequate management is endangering their quality and productivity.

2. OBJECTIVES

1. Preparation of Drainage map, slope map, soil map using SOI toposheets and satellite data.
2. Estimation of Erosion status using Universal Soil Loss Equation (USLE) for soil management.

3. METHODOLOGY

Agriculture Research Services scientists were developed by Universal Soil Loss Equation. USLE was used to determine quantitatively the erosion rate, taking into consideration other possibilities8. USLE can be stated mathematically as:

$$U = R \times K \times L \times S \times C \times P$$

where *U* is the estimated potential average annual soil loss (tonnes/ha/yr), *R* the rainfall factor (measure of erosion force of soil which is expressed in tonnes/ha/mm/h), *K* the soil erodibility factor, *L* the slope length factor (m), *S* the slope gradient factor (%), *C* the cropping/landuse management, and *P* the soil erosion control practice factor.

$$R = 0.1059abc + 52$$

Where a is the average annual rainfall (mm), b the maximum 24 h rainfall (mm/24 h), and c the maximum 1h rainfall with recurrence interval of 2 years.

In the present study the visual interpretation of satellite imagery has been carried out. It has been generated into different themes namely Drainage map, soil map, rainfall map by using earlier generated thematic maps. 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 land use/land cover map are examined. As the different themes are prepared to finally determine the soil erodible regions, each theme plays a significant role in assessing the soil type in the region is affected by severity in the rainfall along with its infiltration capabilities. Vegetation plays an important role in arresting the soil erosion and the slope of the terrain is vital to assess the soil erosion in the basin. All these factors individually and in relation to each other contribute to the soil erosion. The entire methodology is represented in terms of flow chart below.

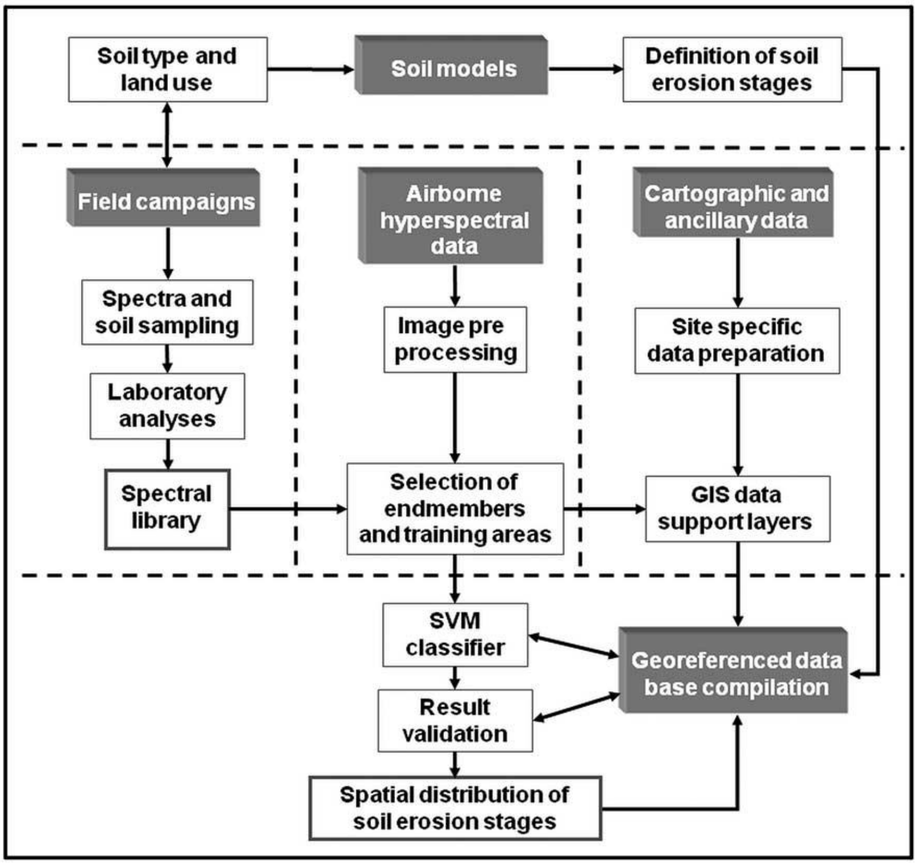


Figure 2 Methodology flow Chart

4. RESULTS AND DISCUSSIONS

4.1 Preparation of Drainage map

Every drainage basin has its own shape. Same indices are proposed to explain the shape and for channel concepts of stream orders proposed stream ordering methods to facilitate much to morphometry analysis. Further more drainage patterns are classified on the basis of their form and structure .The pattern develops in response to underlying topography (sub surface geology). The texture is governed by soil infiltration and the volume of water available in the given period of time to enter the surface. 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. Drainage density is important in hydrology as it is one of the factors that control the speed of runoff following a period of precipitation.

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. High frequencies are observed in the regions of non-homogenous bed rock and thick vegetative cover. The river basin shows almost a positive correlation between drainage density and stream frequency as shown in the below figure:

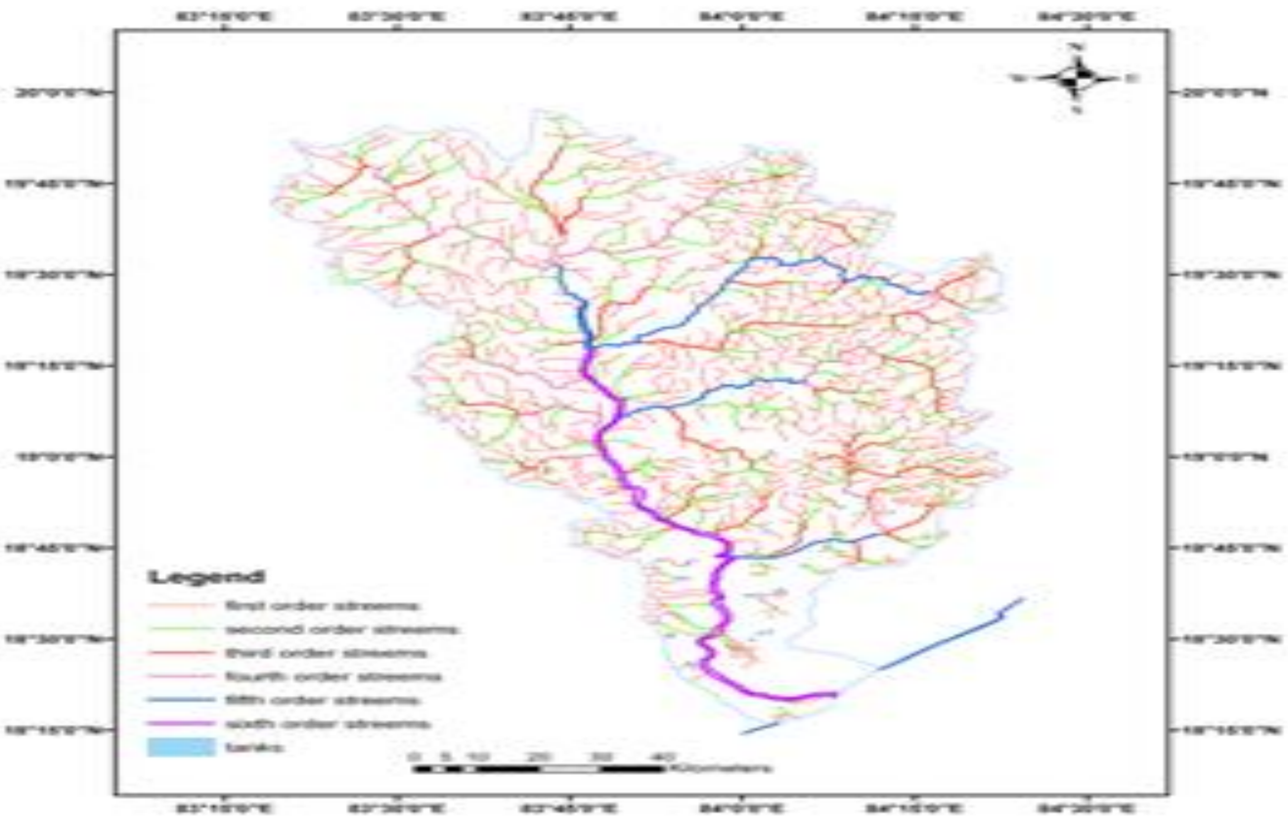
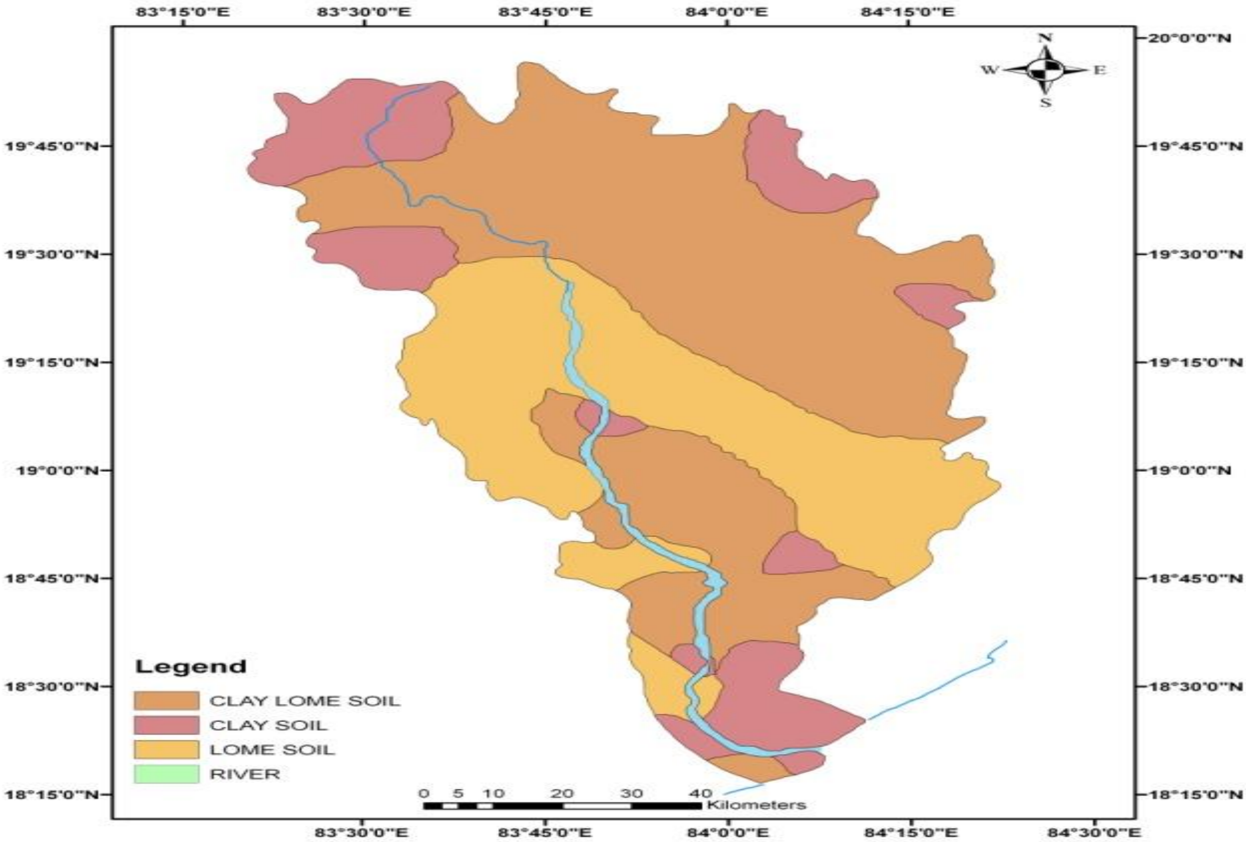


Figure 3 Drainage Map

4.2 Preparation of Soil Map

The soils in the study region show contrasting horizons, in terms of their physical and chemical properties, which was a key condition for using techniques such as soil spectroscopy and hyperspectral imagery. This made it possible to differentiate the soil characteristics affected by erosion processes. For this purpose, the properties of the main soils present in the study region were determined through field and laboratory work and used for establishing the soil models. The resulting models are based on previous work and the current field surveys identified different types of erodible regions and characteristics they are one is **Soil**



erodibility is an estimate of the ability of soils to erosion, based on the physical characteristics of each soil. Generally, soils with faster infiltration rates, higher levels of organic matter and improved soil structure have a greater resistance to erosions. Sand, sandy lam and loam textured soils tend to less erodible than silt, very fine sand, and certain clay textured soils.

Figure 4 Soil map

Table1 Weightage factors of Soil

SI. NO	Description	Weightage Factors	Remarks
1	Loam Soil	3	Low
2	Glay loam Soils	2	Moderate
3	Clay Soils	1	High

4.3. Preparation of Slop Map

Slope Gradient and Length Naturally, the steeper the slope of a field, the greater the amount of soil loss from erosion by water. Soil erosion by water also increases as the slope length increases due to the greater accumulation of runoff. Consolidation of small fields into large ones often results in longer slope length with increased erosion potential, due to increased velocity of water which a greater degree of scouring (carrying capacity for sediment).

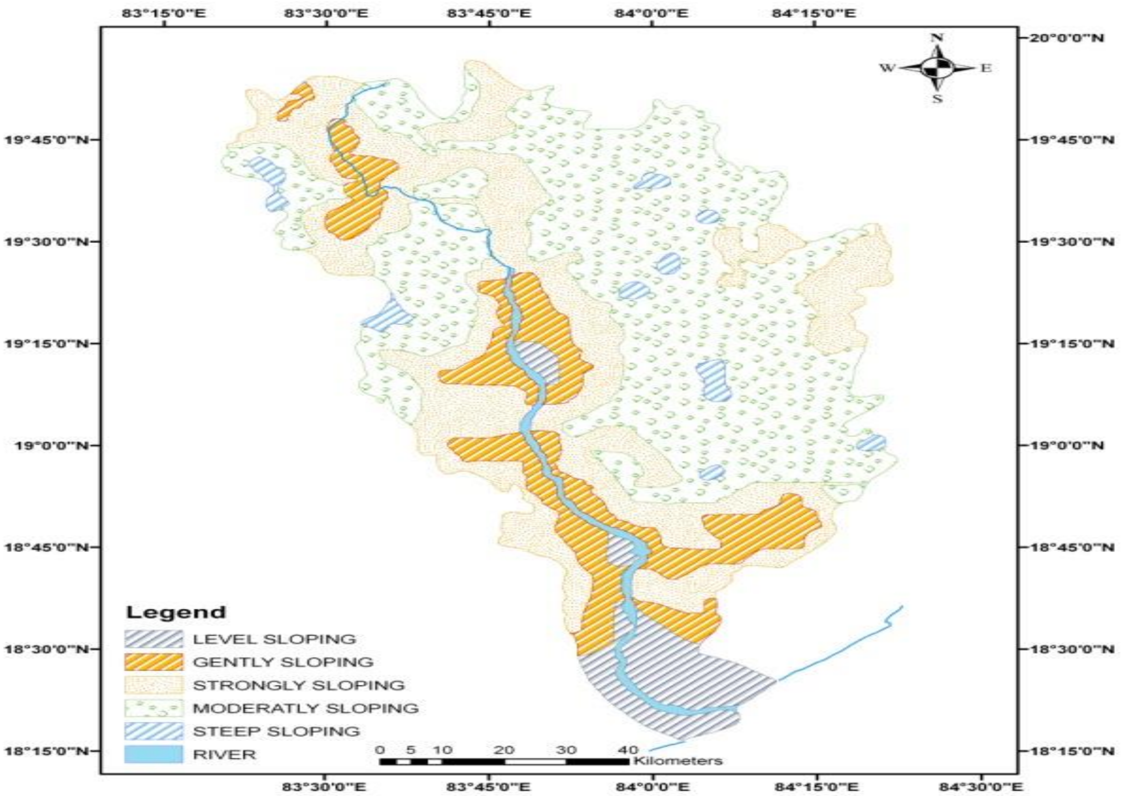


Figure 5 Slope Map

4.4. Preparation of Erosion Map

Vegetation: it is one of the factor for Soil erosion potential is increased if the soil has no or very little vegetative cover of plants and/or crop residues. Plant and residue cover protects the soil from raindrop impact and splash, tends to slow down the movement of surface runoff and allows excess surface water to infiltrate. Different types of effects also identified over the area or region of the study are Sheet and Rill Erosion effect**:** Sheet erosion is soil movement from raindrop splash resulting in the breakdown of soil surface structure and surface runoff, it occurs rather uniformly over the slope. Rill erosion results when surface runoff concentrates forming small yet well-defined channels. Gully Erosion effect: Rainfall may also move soil indirectly, by means of runoff in rills (small channels) or gullies (large channels, too big to be removed by tillage). Rill and gully erosion is the dominant from of water erosion. The age of the erosion process, the nature of soil material and hydrological conditions are factors to the length, width and depth of the gullies. The erosion prone zones that are obtained by index overlay method are shown in Figure.

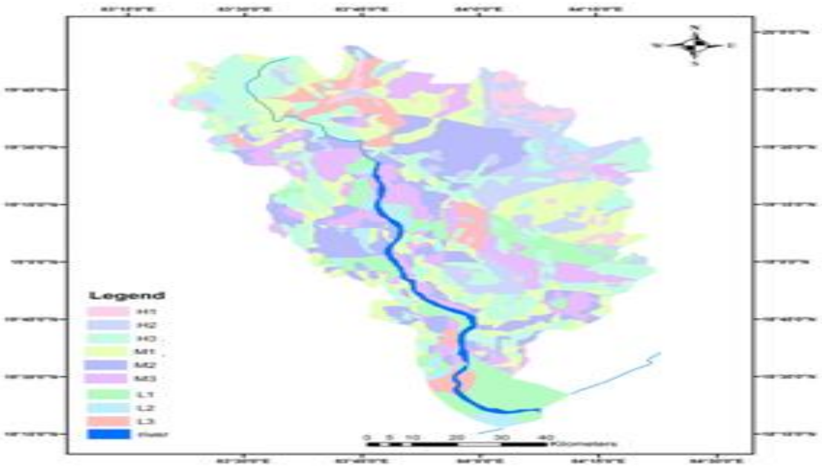


Figure 6 Erosional Map

Zones H1, H2 and H3 (very high, medium high and high) these regions are high in erosion and the area covered by these zones are 644.93 Sq km, 859.61 Sq km, 761.83 Sq km and their percentage areas are 6%, 8% and 7%. The regions are of maximum degradation of vegetative cover. So there is no means to arrest erosion. All the remaining factors being equal (Slope, Rainfall and its associated runoff with it) there is higher amounts of erosion in these regions. The next level of erosion prone zones are demarcated by M1, M2 and M3 (high medium, medium medium, low medium) regions. The vegetation canopy is sparse to thick. Here the soil are mainly with higher percentages of loam soil and the next category clay loam soils in the extreme northern and southern parts of the river basin. All these factors contribute to fairly less amounts of erosion. The cultivable lands are shifting in nature and hence there also among to milder erosion process. The areal extent of M1, M2 and M3 is 1422.16 Sq km, 708.76 Sq km, 813.19 Sq km and their percentage areas are 14%, 7% and 8%.

Table 2 Erosional Index map priority classes

S.No	Priority Class	Indication	Area in Sq Km
1	Very High	H1	644.93
2	Medium High	H2	859.61
3	High	H3	761.83
4`	High Medium	M1	1422.16
5	Medium Medium	M2	708.76
6	Low Medium	M3	813.18
7	Low	L1	1081.73
8	Medium Low	L2	1163.73
9	Very low	L3	2856.5

The regions that are prone to less erosion are richly associated with thick vegetative cover in the few sub basins located in upper catchment as well as the sub basins lying on either side of the main river course in particular in lower reaches. It depends on availability of higher amounts of rainfall and the forest cover. The regions are L1, L2, and L3 and their spatial extent is 1081.92 Sq km, 1163.73 Sq km, and 2856.5 sq km and their percentage areas are 10%, 11% and 29%.

Figure 4 shows the Soils in the study area are identified as loamy, clayey loam and clay soils. More than half of the basin area is covered by clayey soils with high percentage of fines indicating low permeability and hence infiltration loses could be considered minimal. Figure 3 shows the Slope studies indicates the most of the study area is covered with moderate to steep slope. Steep slope areas are covered with sparse vegetation, where the shifting cultivation is also prevailing. The trend of the average rainfall map indicates an increasing trend of isohyets from south west to north east. The concentration of rainfall is more in the eastern part of the basin. The nine erosinal zones are shown in figure 5 as H1, H2,H3, M1,M2,M3 and L1,L2,L3 with H1 showing the highest erodability and L3 the lowest erodability and the aerial extent of each erodible zone is presented. The regions are L1, L2, and L3 and their spatial extent is 1081.92 Sq km, 1163.73 Sq km, and 2856.5 sq km and their percentage areas are 10%, 11% and 29%.

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