

Soil Erosion Zonation Mapping in Parts of Hulgi Watershed using Remote Sensing and GIS Techniques – A Case Study

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Abstract Soil erosion is a continuous process that is relatively unnoticed in the Western Ghats region of Karnataka. Soil erosion is one of the most significant and widespread form of soil degradation that has environmental and economic impacts. Economically, soil erosion affects the productivity of land and hence conservation strategies assume lead roles in the development programs. It is therefore desirable to identify soil erosion in a watershed in order to plan structural works and other means of reducing the problem. The present work is a case study undertaken in parts of Hulgi watershed, a tributary of Bhadra River in the Western Ghats region. RS and GIS are employed to prepare thematic maps such as drainage, LULC, hydro geomorphology, slope, soil, and geology maps. These thematic maps are integrated on GIS platform after assigning weighted capability values to each unit in all the layers. Soil erosion zonation map prepared for the watershed indicates that 49%, 24%, 14% and 13% of the total geographical area is prone to very high, high, moderate and low soil erosion respectively. The present study demonstrates the efficiency of RS and GIS in generating soil erosion zonation mapping. Such maps are valuable resources for action planners to suggest suitable measures for overall development of the watershed.

Key Words: Land degradation, Soil erosion, rainfall-runoff, Land Use Land Cover, Integration, Remote Sensing and GIS techniques, soil erosion

1 INTRODUCTION

THE main factor acting against the sustainability of agricultural production is land degradation. Among the different land degradation processes, soil erosion is the biggest threat to the conservation of soil and water resources. It is a serious environmental problem as it removes nutrient rich soil and increase sediment in the rivers and reservoirs and reducing their storage capacity and life span. It can result to direct economic loss as fertility of the land decreases due to removal of fertile topsoil. Soil erosion has accelerated in most parts of the world in recent decades due to population pressure and limited resources, which have also led to the increased and more continuous use of steeper lands for agriculture. Increasing population, deforestation, land cultivation, uncontrolled grazing, and higher demands for fire wood often cause soil erosion. Soil erosion is one form of soil degradation along with soil

compaction, low organic matter, loss of soil structure, and poor internal drainage problems.

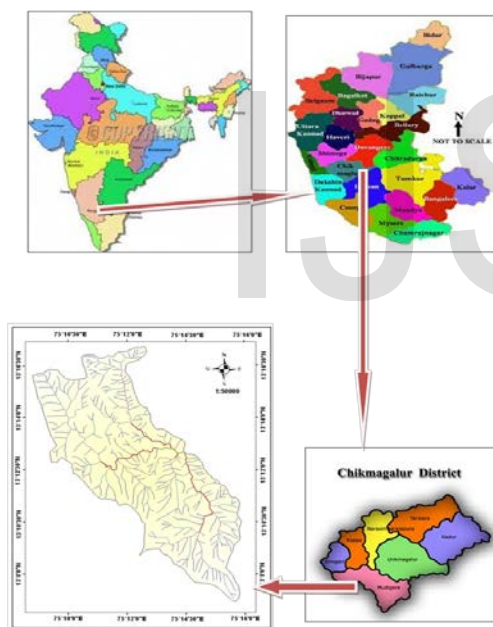
These forms of soil degradation, serious in themselves, usually contribute to accelerated soil erosion. Erosion hazard is a major land degradation problem in mountainous environment. Consequently, many models have been developed for quantifying soil loss or pinpointing areas suffering from soil erosion. Soil erosion and surface runoff result in serious environmental impacts on water conservation and water resources, especially through sediment delivery that dramatically influences water quality and aquatic habitat. Soil erosion types are related to time such as past soil erosion, present soil erosion, and future soil erosion. In order to ensure sustainable management of natural resources and to implement necessary soil conservation techniques, the areas with soil erosion risk should be determined and classified according to potential erosion risk levels. The mechanical erosion of soils is a natural feature of the high tropical islands which are subjected to extremely heavy rainfall. GIS proved to be an effective tool in handling spatial data available at different scales, voluminous point data such as soil information, rainfall, temperature etc. and socioeconomic data and to perform integrated analysis of data on various resources of any region and to arrive at optimum solutions for various problems.

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2 STUDY AREA

The study area namely Singarahole watershed or Kachigehole is located in Mudigere taluk of Chikmagalore district, Karnataka. It is a tributary of Bhadra River. The watershed covers an area of 68.34 sq km and located between 1308'0" to 13015'30" N latitude and 7509'30" to 75015'30" E longitude. The study area comes under Kudremukh national park in the Western Ghats. The mean annual rainfall of the study area is 6500mm. The major part of the study area lies in Mudigere taluk. The southern and western sides of the park form the steep slope of the Western Ghats ridge line, with the altitude varying from 100 m - 1892 m (peak). During March to May - Temperature varies from 23°C to 25°C. (Summer Season) June to September forms the monsoon season. From November month onwards up to February - Temperature is minimum i.e., 19°C to 25°C.

Location Map of Singarahole watershed



3 MATERIALS AND METHODS

The materials used in the preparation of various thematic maps are as follows:

3.1 SURVEY OF INDIA TOPOSHEET MAP In order to delineate the Singarahole watershed, SOI toposheet maps no. 48/O3, 48/O4, 48/O8 toposheets are also used to prepare drainage, contour, slope maps etc. **Satellite imagery:** IRS LISS III satellite image is used to generate and update various

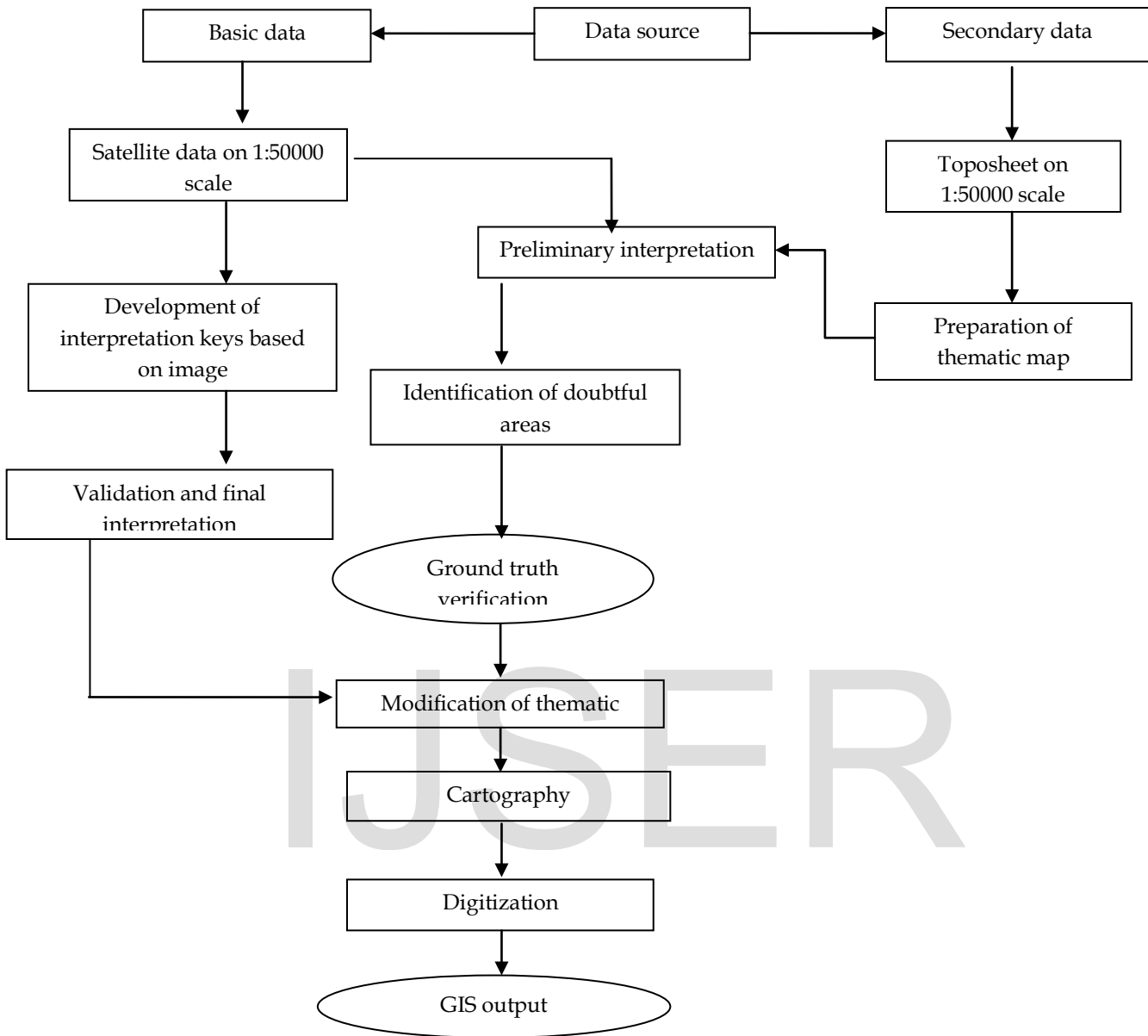
thematic maps such as hydrogeomorphology, geology, soil and land use and land cover maps.

Softwares used:

ERDAS 9.2: The ERDAS 9.1 software incorporates the functions of both images processing and GIS. These functions include importing, viewing, altering and analyzing raster and vector datas. The vector data structure in ERDAS imagines is based on the Arc info data model. In the present study, this software is used to rectify the toposheet, thematic layers prepared on the transparent sheets and the satellite data. Supervised classification of Satellite data is also carried out using the software.

GIS Software: Arc Map 9.1 and Arc View 3.2(a): These two GIS software were used for digitization, composition, updating of attribute table and integration of thematic layers to generate erosion zonation mapping. The preparation of thematic maps such as land use and land cover, Hydro - geomorphology maps, Geology/Lithology maps, Soil maps, slope maps etc., are discussed below. And also discussed about Methodologies followed to preparation of different thematic maps during the course of the present study in the Flow-chart.

3.2 METHODOLOGY: As suggested by IMSD (1995), different thematic layers such as Slope, Geomorphology, LULC, Geology, Soil, and Stream Order were finalised after ground truth verification. For identification of soil erosion potential zonation mapping each theme is further divided into different classes based on erosion capability. (Adinarayana J., et al)



Flow chart : Methodology of Preparation of Thematic Maps

4 RESULTS AND DISCUSSIONS

4.1 INTEGRATION OF THEMATIC MAPS

The objective of the study is to identify the erosion zonation identification in the study area. In order to obtain the desired result, the thematic map prepared and discussed in the previous chapter has to be integrated. Integration of thematic layers such as land use and land cover map, slope map, soil map, lithology/geology map, hydro-geomorphology map is the final and important step of the study. In this step suitable capability values have been assigned to each component of the thematic layer and classified them into four categories. The capability values assigned to different thematic maps and their units are given in table-9. The steps followed for integration of layers are discussed in the following paragraphs.

INTEGRATION OF HYDRO-GEOMORPHOLOGY AND SLOPE LAYERS

The Hydro-geomorphology layer is one that represents different land forms formed due to fluvial action. The thematic layer consists of three types of landforms. Each one of them is assigned a capability value depending upon its erosion property.

Slope layer is one of the major properties for the land utilization point of view. As the slope increases the erosion rate also increases. Based on the slope category, capability values are assigned.

In the process of integration, the 3 polygons of Hydro-geomorphology layer intersected with the 64 polygons of Slope layer. The resultant intersected map Hydro-geom_Slope consists of 66 polygons.

INTEGRATION OF HYDRO-GEOM_SLOPE LAYER AND LITHOLOGY LAYER

Integration of Hydro-geom_Slope layer and Lithology map based on the rock types and their water retention capacity and capability values are assigned to lithology layer.

In this process the integration of 66 polygons of Hydro-geom_Slope layer integrated with the 2 polygons of Lithology layer. The resultant integrated map Hydro-geom_Slope_Litho layer encloses 70 polygons.

INTEGRATION OF HYDRO-GEOM_SLOPE_LITHO LAYER AND SOIL LAYERS

Integration of Hydro-geom_Slope_Litho layer and Soil map based on texture, structure, soil type and capability values are assigned to soil layer. In this process the integration of 70 polygons of Hydro-geom_Slope_Litho layer intersected with the 30 polygons of Soil layer. The resultant integrated map Hydro-geom_Slope_Litho_Soil layer encloses the 177 polygons.

INTEGRATION OF HYDRO-GEOM_SLOPE_LITHO_SOIL LAYER AND LAND USE LAND COVER LAYER

Integration of Hydro-geom_Slope_Litho_Soil layer and Land use Land cover mainly depends resource of a basin forms and base for various developmental activities and different features of the earth. And also depends on the capability values have been assigned to each classes of Land use Land cover layer. In this process the integration of 177 polygons of Hydro-geom_Slope_Litho_Soil layer intersected with the 52 polygons of Land use Land cover layer. The resultant integrated map Hydro-geom_Slope_Litho_Soil_Lulc layer encloses 483 polygons.

By this way integrating all the layers, the resultant final integrated layer of the study area is obtained. By reclassifying and dissolving the features, Soil erosion prone zones are identified and classified in to 4 categories like "Low", "Moderate", "High" and "Very high". Figure (4.11) shows the final soil erosion zonation map of Singesarahole watershed.

Table: Area statistics of Soil Erosion Map

Description	Area in Sqkm	Area in Percentage
High	17.26	24%
Low	9.40	13%
Moderate	9.69	14%
Very high	34.30	49%
Total	68.34	100%

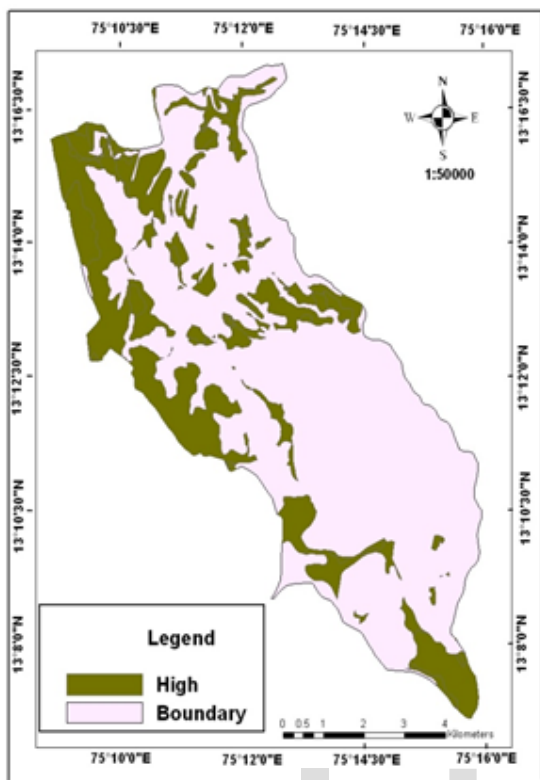


Fig-4.10: Soil Erosion Map of Singarahole watershed, Chikmagalore district

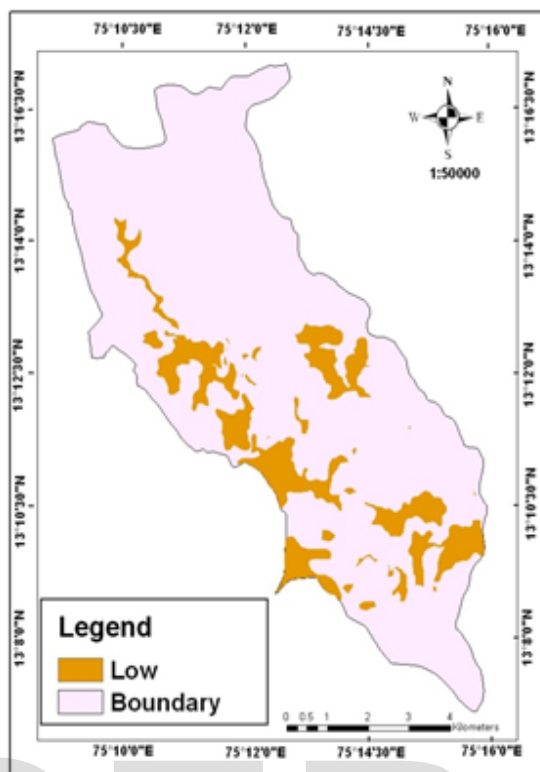


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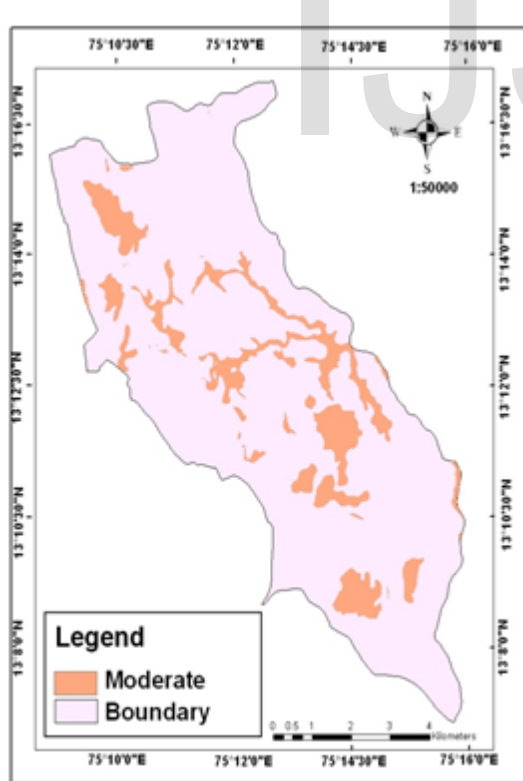


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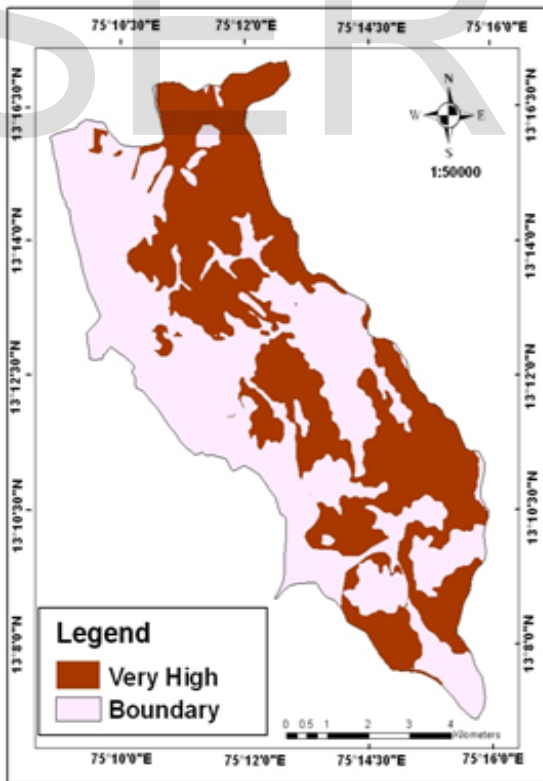


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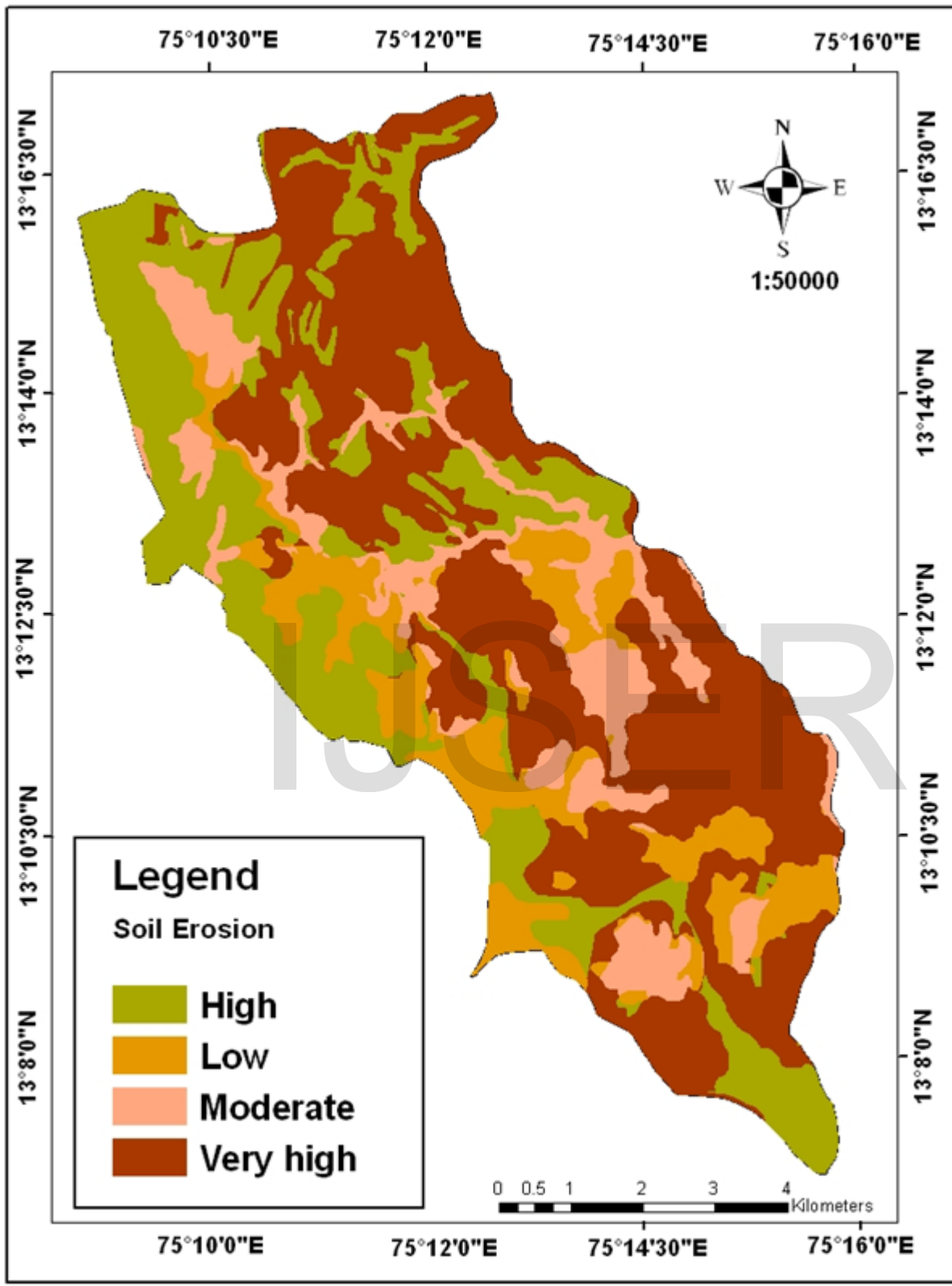
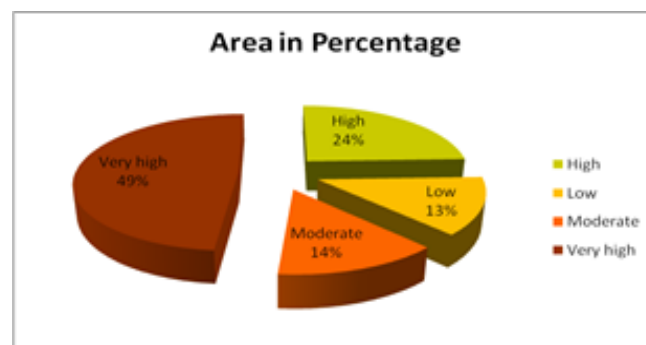


Fig 4.11 Soil Erosion Zonation Map of Singasarahole subwatershed

Capability values assigned to categories/ classes

SL.No	Thematic layer	Categories	Weighted Capability Value (WCV)	Capability Value (CV)
1	Slope	0-3%	5	1
		3-5%	10	2
		5-15%	15	3
		15-35%	20	4
		35-90%	25	5
2	Geomorphology	Pediment	10	1
		Structural hill	20	2
		Waterbody mask	5	0
3	Land use and Land cover	Dense forest	5	1
		Plantation	10	2
		Open scrub	15	3
		Settlements	20	4
4	Geology/Lithology	Metabasalt including thin Iron stone	5	1
		Basal polymict conglomerate	10	2
5	Soil	Clayey loam	20	4
		Sandy clay	15	3
		Sandy Clay Loam	10	2
		Sandy Loam	5	1



5 SUMMARY AND CONCLUSIONS

5.1 SUMMARY

Soil erosion is affected by the spatial topography, vegetation, soil properties, and land use. GIS is a very useful tool to deal with the large number of spatial data and the relationship from various sources in the erosion modeling process.

A Geographic Information System (GIS) is an arrangement of computer hardware, software, and geographic data that people interact with to integrate, analyze, and visualize data; identify relationships, patterns, and trends; and find solutions to problems. The system is designed to capture, store, update, manipulate, analyze, and display studied data and used to perform analyses (ESRI, 2005).

In land use and land cover categories of the Singarahole sub-watershed there are mainly four classes have been classified. The area mainly covered by open scrub forest. The main agricultural activity in the study area is during Kharif season.

The drainage in this study area shows parallel and dendritic drainage pattern. It shows that the water flows on hard rock terrain and it not undergone tectonic activity. In this area exhibits upto fifth order streams.

The soil resource map of Singarahole sub-watershed is prepared by using satellite image and 1:50000 SOI Toposheet and in this area we can find clayey skeletal, fine loamy, habitation mask, loamy skeletal and waterbody mask of the total geographical area of sub-watershed.

The slope map of Singarahole sub-watershed is prepared based on the contour information available on 1:50000 SOI topo maps. The slope map for the study area has been prepared based on distance between the contours and seven categories were identified as 0-1 nearly level, 1-3 very gently slope, 3-5 gentle slope, 5-10 moderately slope,

5.2 CONCLUSIONS

Soil erosion may be a slow process that continues relatively unnoticed, and it may occur at an alarming rate causing serious loss of top soil. Soil erosion and its associated impacts is one of the most important of today's environmental problems. The approach used in this study

10-15 strongly slope, 15-35 moderately steep slope and greater than 35 as very steep slope.

The lithology or geology map is prepared based on the different litho units and the study area composed of Metabasalt including thin iron stone and Basal polymict conglomerate in geographical area of sub-watershed.

The Hydro-geomorphology map is prepared based on the satellite data and of IRS LISS III image and geomorphic units and landforms were delineated using the photo interpretation elements and structural information present in the study area. It study area is mainly covered by Pediment, structural hills and water body mask.

In the given study area the transport network and the settlement map shows that there is moderate transport network. In Singarahole we can find three categories of roads such as metalled road, Unmetalled road and Cart-track.

The integrated thematic maps provide accurate information on soil erosion. After examining individual resource maps/unit, capability was evaluated and each class were assigned by the weighted capability value. By evaluating this value, the areas where erosion is more is estimated and suitable soil erosion control measures are recommended. In the Singarahole area, erosion is taking place in hilly areas where slope is predominant.

based on the integration of Remote sensing, and GIS is helpful to evaluate soil loss in large areas. The study area is characterized by undulating topography dominated by high altitude hills with an upland plateau flanked by steep slopes. Major portion of the area is covered with tea plantations followed by forest land. This study demonstrates that RS and GIS technique is very valuable

tools in predicting soil erosion process (Biswajeet Pradhan, et al 2010). Visual interpretation is very useful for hydrological studies. This is an important conclusion for developing countries where supervised computer classification techniques are very expensive, while high maintenance requirements and skilled persons are needed to operate them.

The study has revealed the Remote sensing and GIS can be used successfully for the analysis of sub-watershed condition in term of land use and soil erosion and helps to develops models for sustainable land use.

5.3 RECOMMENDATIONS

SOME OF THE FOLLOWING MEASURES CAN BE IMPLEMENTED TO PREVENT SOIL EROSION:

- The use of contour ploughing and windbreaks.
- Leave unploughed grass strips between ploughed lands (strip cropping)
- Make sure that there are always plants growing on the soil, and that the soil is rich in humus.
- Avoid overgrazing.
- Allow indigenous plants to grow along riverbanks.
- Trees, shrubs and groundcovers are also effective perimeter treatment for soil erosion prevention, by insuring any surface flows are impeded.
- Construction of boulder check dams across first order streams will helps to control runoff and in turn sediment gets arrested across these structure and avoid sediments being carried downstream.

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