



Research Article

Mapping of Degraded Lands Using Remote Sensing and GIS Techniques

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ABSTRACT

Study has been carried out to map the areas with erosion using remotely sensed data (*Kharif, Rabi and Summer Season*) from Indian Remote Sensing (RS) satellite (IRS P-6) LISS III sensor. Remotely sensed data provide timely, accurate and reliable information on degraded lands at definite time intervals in a cost effective manner. It was observed that the data enabled better delineation of small units of eroded areas. Satellite data has been used for qualitative assessment of areas, being subject to soil erosion. Based on length and degree of slope from SRTM, land use /cover and soil characteristics as revealed by IRS-LISS-III data and other related ancillary data, three soil erosion categories namely sheet erosion, gullied, and stony waste was found in Rajgarh district of Madhya Pradesh. The eroded areas were infested distinctly on the FCC. The sheet erosion occupied 58365 hectares followed by gullied 1519 hectares. The stony waste is encountered in 923 hectares area. The extent and geographical distribution of degraded lands like sheet erosion, gullied and stony waste areas will be used as an input for future planning reclamation conservation programs.

Key words: Remote sensing, Soil erosion, Land use land cover

Introduction

Land is the most valuable resource for production of food, fiber, fuel and many other essential goods required to meet human and animal needs. However, it is facing serious threats of deterioration due to unrelenting human pressure and utilization incompatible with its capacity. Land degradation in general, implies temporary or permanent recession from a higher to a lower status of productivity through deterioration of physical, chemical and biological aspects. It is a complex ensemble of surface processes (e.g. wind erosion, water erosion, soil compaction, Salinization, and soil water-

logging). These can ultimately lead to "Desertification". As the increasing world population places more demands on land for food production etc., many marginal arid and semiarid lands will be at risk of degradation. Though conventional soil surveys provide information on land degradation; they are slow, time consuming and expensive. Among the new technologies emerged for studying natural resources, remote sensing and GIS are effective technologies for detecting, assessing, mapping, and monitoring the land degradation.

The systematic efforts in the application of remote sensing technology in the study of natural resources has resulted in the development of well established methodologies for mapping and monitoring of various degraded land in a cost

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effective manner. In India, initially aerial photographs were used in deriving information on degraded lands (Kamphorst and Iyer 1972; Iyer *et al.* 1975). The application of remotely sensed data in mapping degraded lands space borne sensors started with the launch of the first Earth Resources Technology Satellite ERTS-1 / Landsat-1. However, the satellites Landsat-TM, SPOT and Indian Remote Sensing Satellites with better spatial and spectral resolution, enabled to map and monitor degraded lands more efficiently. Many studies were carried out on mapping eroded lands (Venkataratnam and Rao, 1977; Rao *et al.* 1980), ravines (NRSA, 1981; Karale *et al.*, 1988). 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.

Throughout the world the concern for the environment is increasing day by day due to physical, chemical and biological degradation of the natural resources that have led to the ecological imbalances. The over-exploitation and mismanagement of land resources have resulted in the degradation of land, a major environmental issue in the contemporary times. Nearly 175 million hectares of land in India is subject to one or other kind of degradation process (Das, 1985). Soil degradation is a severe problem. The information of the degraded land is scanty, and needs to be collected. Hence, the study was carried out with the objective being delineation of land use/Cover and degradation map using satellite data.

Material and Methods

Study area Rajgarh district (Fig 1) is located in the Northern part of *Malwa* plateau. It forms the North Western part of Division of Bhopal.

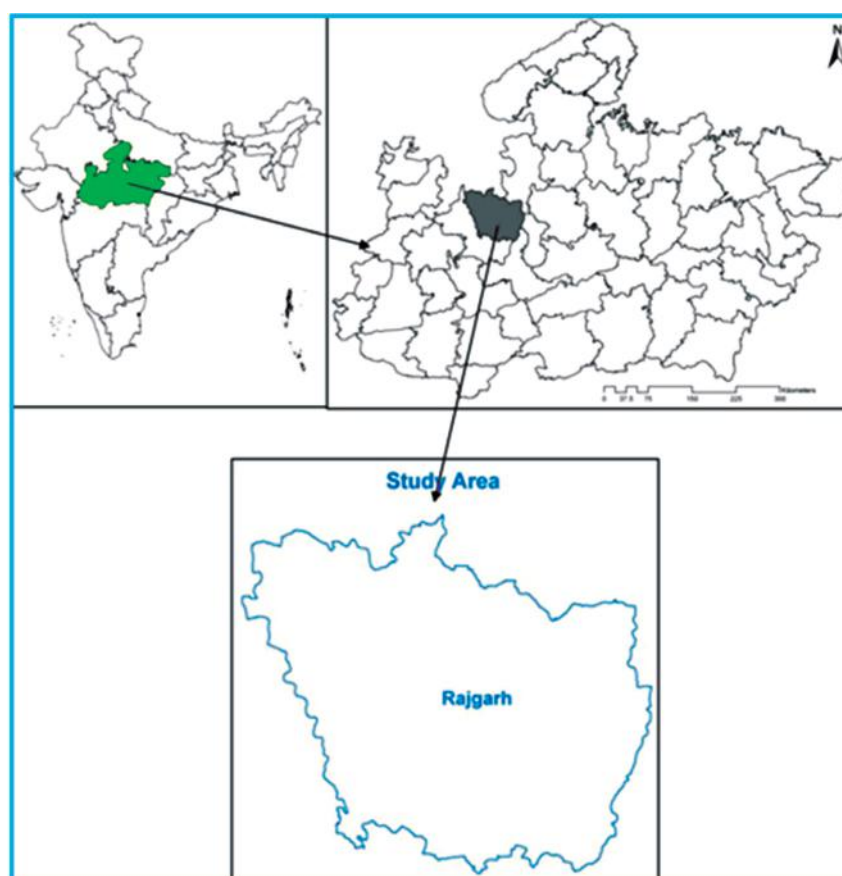


Fig. 1. Location map of study area

The district extends between the parallels of Latitude 23° 27' 12" North and 24° 17' 20" North and between the meridians of Longitude 76° 11' 15" and 77° 14' East. The total geographical area of the district is 6154 Sq.km. with a population of 1546541 according to census 2011. IRS-P6 LISS-III (FCC) images of October-November 2005, January 2006 and April 2006 were used. The data therefore represents *Rabi*, *Kharif* and *Zaid* seasons. The standard false color composite (FCC) images of the study area was prepared using bands 4 (NIR) 3 (Red), and 2 (Green) and discrimination of features were made by visual interpretation (on screen) using these images. The interpretation key was based on the relationships between ground features and image elements, like, texture, tone, shape, location and pattern. A flow chart indicating the general procedure for Land Degradation Mapping (LDM) is shown in the (Fig 2). IRS-LISS-III Satellite data was used for qualitative assessment of areas, being subject to soil erosion. Based on length and degree of slope from SRTM, land use / land cover and soil characteristics as revealed by *Rabi*, *Kharif* and

Zaid seasons satellite data and other related ancillary data, three soil erosion classes namely Sheet Erosion, Gullied, and Stony Waste could be mapped. Representative sample sites were selected for ground truth data collection. During field visits, features of topography and soil profiles were studied; site characteristics and soil samples were also collected for laboratory analysis. The preliminary interpreted maps were modified using field data and soil chemical analytical data; final maps were prepared with appropriate legend.

Results and Discussion

Land Use /Land Cover

The knowledge of land use and land cover is important for many planning and management activities as it is considered as an essential element for modeling and understanding the earth feature system. Land use is defined as to the human activity or economy related function associated with a specific piece of land, while the

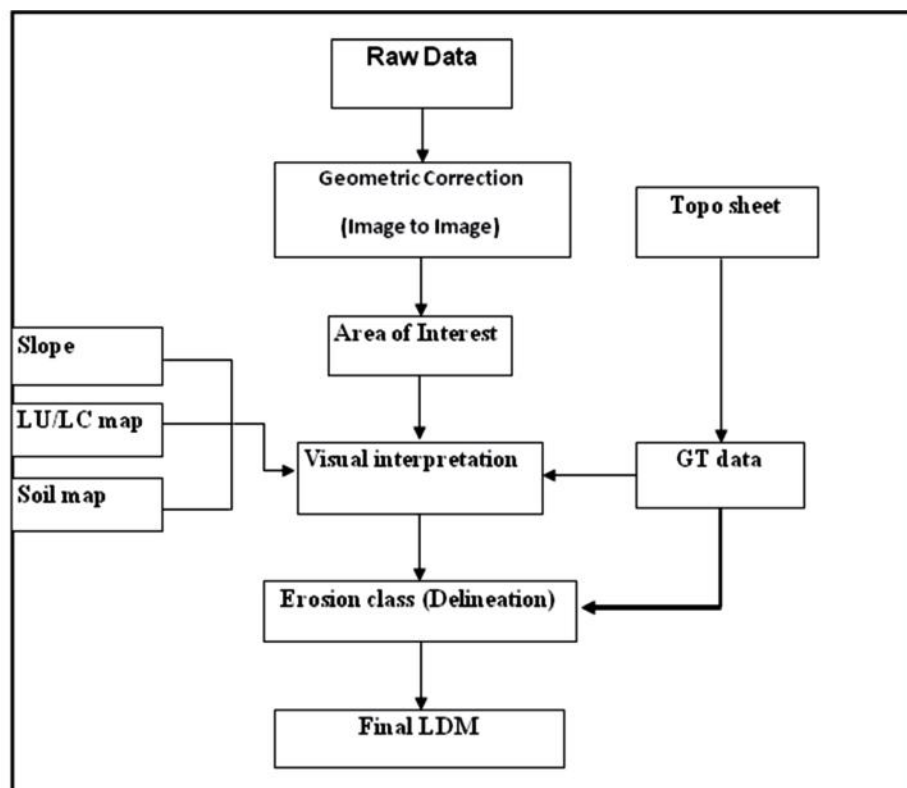


Fig. 2. Flow Diagram for generation of land degradation map

term land cover relates to the type of feature present on the surface of the earth (Lillesand and Kiefer, 2000). The remote sensing technology has found its acceptance worldwide for rapid resource assessment and monitoring, particularly in the developing world. The synoptic view of the area allows better monitoring capability, especially when the coverage is repetitive, interval is short, and resolution of the image is high. Remote sensing provides data in several discrete bands, enabling creation of false colour composites (FCC) and the interpretation accuracy is thereby increased visually and digitally. It provides real-time and unbiased base line information (Gupta, 2001). On the basis of the information obtained by the identification of the physical characteristics from the RS data and their verification in the field, the major land use categories as shown in figure 3 were identified and mapped. Large part of the study area (512563 ha), is mainly covered by Agriculture, which occupies 83.17 per cent of the total area. Built Up occupies 13508 ha which is 2.19 per cent of the area. Water bodies occupy

an area of 9352 ha which contributes 1.52 per cent of the geographical area of the district.

Forest is defined as all land bearing vegetative association dominated by trees of any size, capable of producing wood or other forest products and exerting an influence on climate or water regimes or providing shelter for wild life and live stock. Under the forest category four sub-classes were identified and mapped viz., open (9033 ha), dense (5766 ha), scrub (4364 ha), blank forest (2534 ha). Wastelands are those lands, which are currently unutilized or underutilized and can be brought under vegetation cover/ cultivation with reasonable efforts. In this category, three sub-classes in the area namely gullied land (935 ha), land with scrub (56227 ha) and without scrub (1964 ha) were derived from the imagery.

Soils of Study area

With regard to soil classification of M.P. it is classified into 5 orders, 7 suborders, 11 great

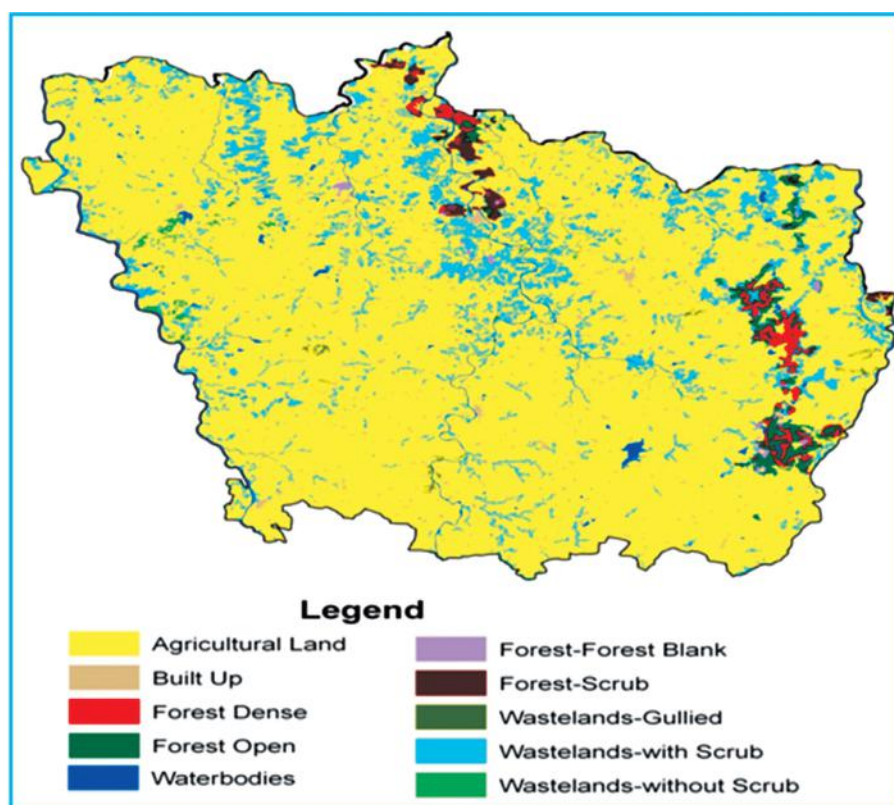


Fig. 3. Land use /cover map

groups, 26 subgroups and 130 families. The Inceptisols are predominant, covering 48%; followed by Entisols and Alfisols 10% each, Vertisols 21% and Mollisols <1% of the total geographical area of Madhya Pradesh (Tamgadge *et al.*, 1996). In the present study, (1:50,000) soil map prepared in the Natural Resources Information System (NRIS) project were used. The major part of the study area is covered by Vertisols (black cotton soil) (218470 ha) The Inceptisols covering (210543 ha), and remaining part is with Entisols (174477 ha).

Slope of Study Area

In this study, SRTM resolution (90m) data can be freely downloaded from internet website. The major part of the area is having 0-3 slope per cent. However, variations in the slope (0 to 100 per cent) was made to group the entire area into six slope classes i.e., 0-3, 3-5, 5-15, 15-30, 30-50 and > 50 per cent. The areas having slope 0-3 and 3-5 per cent were assigned moderate in erosion and the areas, which were having slope >5 per cent were considered as severe in view of the erosion. Soil loss increase as slope increases but after 50% slope, soil erosion tends to decrease due to presence of dense vegetation. With the

increase in vegetation cover, average soil loss dramatically decreases.

Assessment of Soil Erosion

FCCs obtained from LISS III sensor (with 24 m spatial resolution)) was evaluated for delineation of eroded areas. It was observed that the data enabled better delineation of small units of eroded areas barren rocky/stony waste land as given below. Based on soil, slope, land use/land cover, current soil erosion status was mapped. Visual interpretation involves identification and delineation of degraded lands that are manifested on False Colour Composite (FCC). The False Color Composites are analyzed initially with the help of topographical maps, published reports and other available ancillary data; broad categories of degraded lands was delineated. The distribution of various land degradation categories delineated through visual interpretation of IRS-P6 data as shown in the Fig. 4 (a) (b) (c). Land degradation has numerous environmental, economic, social and ecological consequences. Every ecosystem on the earth is affected by some or the other form of land degradation. When land is degraded, the ecology is damaged. There can be rather serious effects in terms of soil erosion, loss of soil fertility

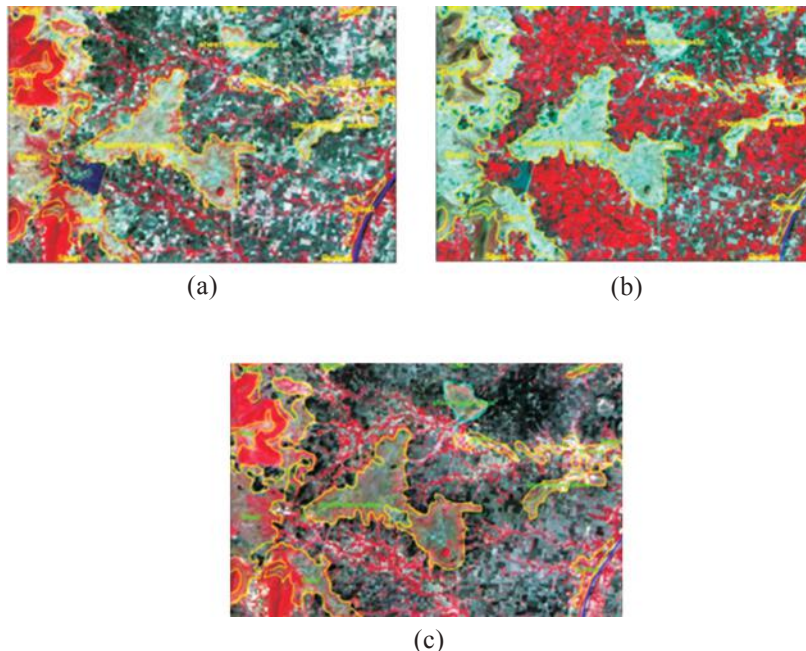


Fig. 4. (a) (b) (c): Sheet, Stony waste and gullied erosion on satellite image.

and thus reduced plant growth or crop productivity, clogging up of rivers and drainage systems, extensive floods and water shortages. Accelerated erosion adversely affects the quality of soil on site (Norton *et al.*, 1998; Lowery *et al.*, 1998; Lal, *et al.*, 1998) and its agronomic productivity (Olson *et al.*, 1998; Lal, 1998).

The eroded areas were identified distinctly on the FCC. The sheet erosion class occupied 58365 hectares followed by Gullied class 1519 hectares. The Stony Waste erosion classes were encountered in 923 hectares area.

In the present study Gullies are narrow and deep channels were developed as a result of erosion of soil by running water. They are more common on sloping surface. Figure 5 shows the soil erosion map of the site on 1:50,000 scale. Qualitative assessment and delineation and mapping of eroded lands (Dwivedi *et al.* 1997a & b; Rao *et al.* 1980) were attempted using Landsat, MSS/TM, SPOT-PLA/MLA, and IRS

LISS-I/II data. Besides, Landsat-MSS data have been used for predicting soil loss in the rangelands of Western Australia (Pickup and Chewings, 1986). Information on the extent, spatial distribution and morphometry of ravines is of paramount importance for taking up any reclamative measures. Landsat-MSS/TM data have been used for mapping ravines (Karale *et al.* 1987; Singh and Dwivedi 1989).

Creation of Digital Data Base of Degraded Lands

Though voluminous information on degraded lands in the form of maps and attributes (physical and chemical properties, geographic location, current land use, etc.) is available with various organizations, there is no organized digital data base available at the district or state level to the concerned users in M.P. Thus, a centralized digital database in a Geographic Information System (GIS) domain on degraded lands was

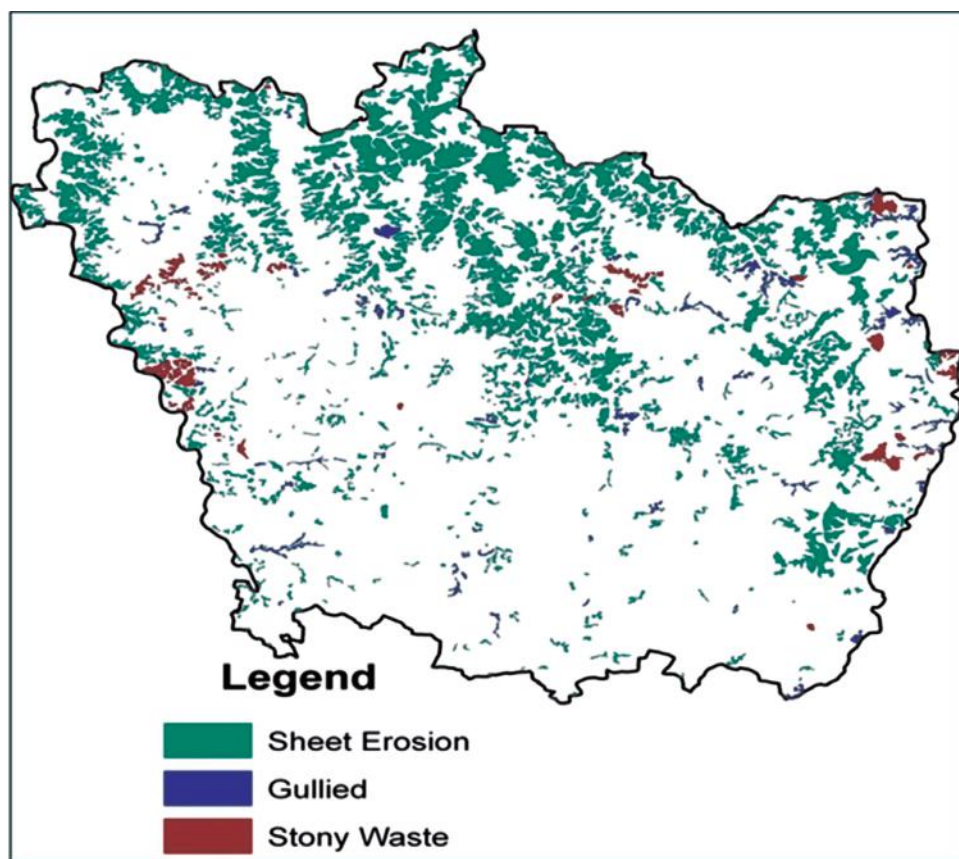


Fig. 5. Soil erosion map of the study area

developed which has related terrain parameters covering the location of the soil observation, using Global Positioning System (GPS) with adequate accuracy. It would enable studying the variations in properties of degraded lands in space and time.

Conclusions

Based on length and degree of slope from SRTM, land use /cover and soil characteristics as revealed by IRS-LISS-III data and other related ancillary data, three soil erosion categories namely sheet erosion, gullied, and stony waste was found in Rajgarh district of Madhya Pradesh. The sheet erosion occupied 58365 hectares followed by gullied 1519 hectares. The stony waste is encountered in 923 hectares area. The extent and geographical distribution of degraded lands like sheet erosion, gullied and stony waste areas can be used as an input for future planning reclamation conservation program.

IRS P-6 LISS-III remotely sensed satellite digital data has been used to classify the different land use/land covers, and Shuttle Radar Topographic Mission (SRTM) digital elevation model (DEM) data was used to draw the classified slope maps. Satellite data have become valuable tools in studying the spatial extent of degraded lands and for monitoring the changes that have taken place over a period of time due to reclamation / conservation measures. The methodologies can be used to extract precise and timely information on different aspects of degraded lands in a cost effective manner on operational basis. The methodology developed can be used for regular monitoring of degraded lands.

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