# Identification and Mapping of Land degradation in Ramgarh district of Jharkhand using Multi temporal Satellite data

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## Abstract

*Land degradation takes a number of forms, including depletion of soil nutrients, salinisation, agrochemical pollution, soil erosion, vegetative degradation as a result of overgrazing and the cutting of forests for farmland leading to increase in frequency and intensity of drought in the district. All of these types of degradation cause a decline in the productive capacity of the land, reducing potential yields. Remote sensing provides an opportunity for rapid inventorying of degraded lands to generate realistic database by virtue of multi-spectral and multi-temporal capabilities. The present study is based on remote sensing data acquired from IRS-P6, LISS-III satellite data of three different seasons viz. Kharif, Rabi and summer season of year 2006 in conjunction of with Survey of India toposheet and subsequent ground truth has been used for assessment of land degradation using onscreen visual interpretation. We have examined how different remote sensing indicators work for identifying land degradation. Based on severity of degradation the area is mapped into sheet erosion, rill erosion, gully erosion, ravenous land, seasonal water logging and rock out crops. 25.80% of the area of Ramgarh district is under the category of degraded land , out of which more than 22% is severely affected by sheet erosion. The depletion of vegetation cover in the district and subsequent cultivation without proper protection measures is the reason for severe soil erosion and land degradation. The data base would enable to develop District Information System using advanced technology for periodic monitoring and development of degraded lands.*

***Key words:*** *Land degradation, IRS-P6 LISS-III, Visual interpretation*

## Introduction

Land degradation is one of the most serious global environmental issues. Over 250 million people are directly affected by desertification and some one billion

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people in over 100 countries are at risk (Adger et al., 2000). Land degradation is a composite term; it has no single readily-identifiable feature, but instead describes how one or more of the land resources (soil, water, vegetation, rocks, air, climate, relief) has changed for the worse. Land degradation is the temporary or permanent lowering of the productive capacity of land (UNEP, 1992). It includes various forms of soil degradation, adverse human impacts on water resources, deforestation and lowering of the productive capacity of range lands. Land gets degraded when it suffers from loss of its intrinsic qualities or there is a decline in its capabilities as a consequence of forces, or the product of an equation, in which both human and natural forces find a place (Blaikie and Brookfield, 1987). According to Chisholm and Dumsday (1987) land degradation is something that can result from any causative factor or a combination of factors, which reduce the physical, chemical or biological status of the land and which may restrict the land's productive capacity.

The land degradation process is generally divided into three classes: (1) physical degradation, (2) biological degradation, and (3) chemical degradation (Barrow, 1991). The assessment of land degradation requires the identification of indicators such as soil vulnerability to erosion. Generally, the assessment of the state of land degradation can be carried out using the Global Assessment of Soil Deterioration (GLASOD) method (Oldeman et al., 1991). Hoosbeek et al. (1997) recommended a qualitative method to classify soil degradation using remote sensing data. Though conventional soil surveys provide information on land degradation, they are quite expensive and time-consuming and require large man power. Spaceborne Remote Sensing is one of the state-of-the-art technologies being used for the study and management of natural resources because it facilitates synoptic view of terrain features, repetitive coverage of the same area at regular time intervals, and the amenability of data to computer analysis, thus, covers large area, consumes less time and is less expensive than ground surveys involving less man power.

Agricultural production in Ramgarh district is charactarised by mono cropping practices with only 14.5% of the net sown area being irrigated; 61% of the agricultural land holding belongs to small and marginal farmers which have contributed to poor level of mechanised farm operations in the district. Agriculture is mainly rainfed; the major crops cultivated are paddy, wheat, maize and vegetables. Situation in the district has worsened in the recent times due to land degradation. It is important to check land degradation and encourage sustainable agricultural practices in the district.

Quantification of a spatial extent during a particular time period is the first step in monitoring the progress of land degradation. Remote sensing data are handy for land degradation assessment and monitoring these periodically in time and space domain using multi temporal datasets in India (Venkataratnam and Rao, 1977; Venkataratnam, 1989; Rao et al., 1991; Venkataratnam and Ravisankar, 1992; NRSA, 1995). Most importantly, it helps to identify features and their conditions in inaccessible areas like that of Tons river catchment.

It is essential to bring about a balance between economic development and environmental conservation. Needless to mention, up-to-date information on the state of natural resources is essential for planning the sustainable development of mountain regions.

## Study Area

The study area (Figure 1) Ramgarh exists between latitude 23°25' to 23°58' N and 85°12' to 85°53' E. The general climate of the area is tropical with maximum annual temperature between 37.7°C to 44.3°C and minimum temperature between 3°C to 14°C. The area receives normal rainfall between 1102 mm to 1472 mm with significant seasonal variation.


**Figure 1: Location of Ramgarh district of Jharkhand**

The area is drained by Damodar river with Nalkari river as its main tributary. Forest covers are mainly in the hilly terrains of the study area. Most of the forests are of deciduous type. Some are also of evergreen type. Agricultural lands are located in the plain area i.e. in the central part of the study area. The land use in the area is governed by mining activity and its concomitant effect on land. The land cover dominates by urban residential and industrial build up lands correspond to mining operations and related industries whereas forests dominates over the hilly terrain reflecting the natural climatic setting of the region.

## Methodology & Data used

The methodology used to obtain and evaluate information on the status of degraded land in the basin was based on Resourcesat-1, LISS-III images of three seasons viz. Rabi, Kharif and Zaid of year 2005-06 and field investigations. The primary information for this study was obtained from the False Colour Composite (FCC) of the LISS-III satellite image of the study area. The spatial resolution of the image is 23.5 meter in first three bands. The geometrical correction of the images was made by using the ERDAS IMAGINE software, and accuracy within one pixel was achieved. Visual mode of interpretation technique based on image characteristics followed by ground verification has been employed for mapping of degraded lands. Image interpretation key was formulated based on the spectral signatures of various causative factors of different kinds of degraded lands (Table 1). The mapping legend has been made systematic and connotative. The extent and spatial distribution of different kinds of degraded lands with degree of severity under major land form and major land use in a district could be derived easily from multi temporal satellite data. The detailed methodology has been given as flowchart (Figure 2).

Image interpretation was carried out to identify the types and extent of degraded land using image interpretation keys (Table 2). The interpretation was also supported by field observations. The field study was carried out in two seasons namely Rabi and Kharif and representative soil sample were collected and have been sent for laboratory test. On the basis of the field work and results of laboratory tests, the pre interpretation was corrected. During the fieldwork the relationship between image elements and tentatively identified land degradation classes were established that were delineated during preliminary interpretation. Terrain features were also used for improving the classification accuracy (Boyed et al., 1996; Malingreau et al., 1996).

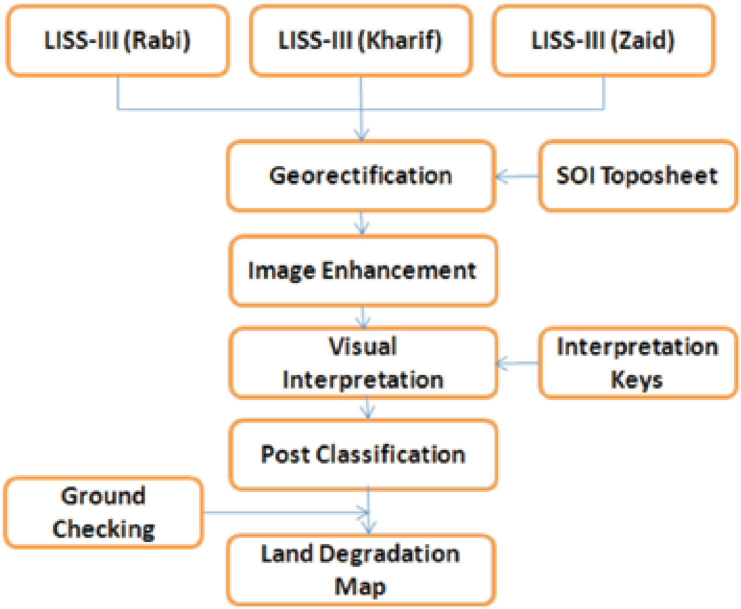



**Figure 2: Methodology Flow Chart**

**Table 1: Main visual indicators for the different types of land degradation**

| Visual Indicator | Types of Soil & Land Degradation | | | | | |
|---|---|---|---|---|---|---|
| | Water erosion | Wind erosion | Salinity or Alkalinity | Chemical degradation | Physical degradation | Biological |
| Rills | √ | x | x | x | x | x |
| Gullies | √ | x | x | x | x | x |
| Pedestals | √ | √ | x | x | x | x |
| Armour layer | √ | √ | x | x | x | x |
| Deposits of soil on gentle slopes | √ | X | x | x | x | x |
| Exposed roots or parent material | √ | √ | x | x | x | x |
| Muddy water/mudflows during and shortly after storms | √ | x | x | x | x | x |
| Sedimentation in streams and reservoirs | √ | x | x | x | x | x |

| Visual Indicator | Types of Soil & Land Degradation | | | | | |
|---|---|---|---|---|---|---|
| | Water erosion | Wind erosion | Salinity or Alkalinity | Chemical degradation | Physical degradation | Biological |
| Dust storms/clouds | x | √ | x | x | x | x |
| Sandy layer on soil surface | x | √ | x | x | x | x |
| Parallel furrows in clay soil or ripples in sandy soil | x | √ | x | x | x | x |
| Bare or barren spots | √ | √ | √ | √ | x | x |
| Efflorescence | x | x | √ | x | x | x |
| Soil particles unstable in water | x | x | √ | x | x | √ |
| pH | x | x | √ | x | x | x |
| Nutrient deficiency/ toxicity symptoms evident on plants | √ | x | x | √ | x | √ |
| Decreasing yields | √ | √ | √ | √ | √ | √ |
| Changes in vegetation species | √ | x | √ | √ | x | x |
| Plough pan | x | x | x | x | √ | x |
| Restricted rooting depth | √ | x | x | x | √ | x |
| Structural degradation, including compaction | x | x | √ | x | √ | x |
| Poor response to fertilizers | x | x | x | √ | x | √ |
| Decrease in organic matter (lighter-colored soils) | √ | x | √ | x | x | √ |
| Increased sealing, crusting and run-off; reduced soil water | x | x | √ | √ | √ | √ |
| Decrease in number of earthworms/ants and similar | x | x | x | x | x | √ |

Although not all degradation features can be detected directly from remote sensing imageries, many can be digitally enhanced (e.g. PAN sharpening and contrast stretching of the images, for mining related degradation while applying spatial filters like high pass filtering for Gullies and Ravines) and mapped. Remote sensing data substantially contribute to the mapping and monitoring of degradation features, but their use is limited by relief-controlled factors in mountainous areas causing geometric distortions and atmospheric constraints (Zinck et al., 2001). To remove the topography-induced constraints for land degradation assessment, intensity normalisation of multi-spectral data was used as a pre-processing technique for image classification of the mountainous areas (Shrestha and Zinck, 2001). By normalising the Multispectral data, possible bimodal distribution of training samples was avoided and classification errors were minimised.

Topography is an important parameter for assessing land degradation in mountainous areas. In the case of sheet erosion, slope gradient in combination with slope length controls soil susceptibility to detachment by runoff, which is dependent upon soil cohesion at saturation and the overland flow velocity.

## Results & Discussion

Visual mode of interpretation technique based on image characteristics followed by ground verification has been employed for mapping of degraded lands. Image interpretation key has been formulated based on the spectral signatures of various causative factors of different kinds of degraded lands. The extent and spatial distribution of different kinds of degraded lands with degree of severity has been mapped (Figure 3&4).

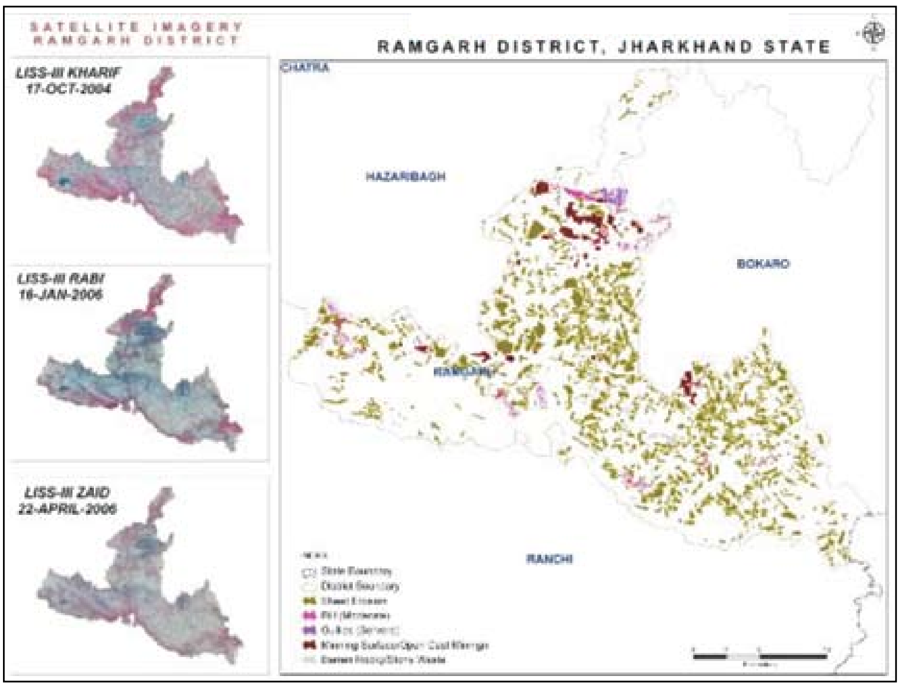
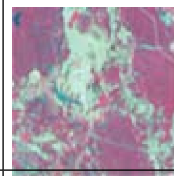
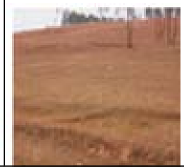
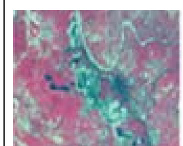
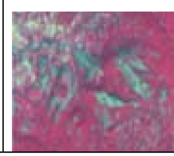
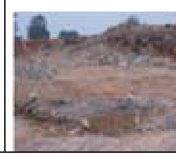



**Figure 3: Land degradation Map of Ramgarh district**

**Table 2: Visual Interpretation keys for mapping of Land Degradation in Ramgarh District of Jharkhand**

| Land degradation type | Field Indicators | Physiography | Land cover | Soil type | Appearance on Remote Sensing Data | Satellite Image of Study Area | Field photo of Study Area |
|---|---|---|---|---|---|---|---|
| **Sheet Erosion** | Muddy runoff during rainy season/Soil color is lighter than surrounding soils / Concretions/ coarse fragments on surface | Plains/ valleys / pediments with >1-3% slope class | Crop lands/ fallows/ land with / without scrub/ degraded forests. Grass cover and thick forests reduce erosion rates. Poor vegetal cover enhances erosion rate | Predominantly in soils with fine texture, low organic matter and weak structure | Slightly brighter than surrounding land of its class. Smooth to medium texture |  |  |
| **Gullies** | Well defined and permanent incised land neither cultivable nor traversable | Occurs on >5% slope lands. Starts at the lower element of slope and gradually creeps to upper slopes | Mostly land with / without scrub | Predominant in loams and associated textures | Brighter than surrounding land / gray in color depending on soil color. Mainly associated with first order streams |  |  |
| **Ravines** | Well defined and permanent incised land neither cultivable nor traversable<br>Network of deepened gullies | Associated with major streams / river network | Mostly land with / without scrub | Predominant in loams and associated textures | Medium gray to dark gray tone. Slightly coarse texture. Large to very large size & associated with stream |  |  |
| **Mining surface /open** | Associated with open cast mining and its surrounding | | Wastelands, land with / without scrub | | Shades of yellow, green, black and varies on mining stage and type of mineral explored |  |  |
| **Barren Rocky** | Contiguous rock exposure on surface or covered with stones | Hill / pediment region | Wastelands | No remarkable soil cover | Light to medium grey/yellowish white. Mainly in hilly or pediment regions |  |  |

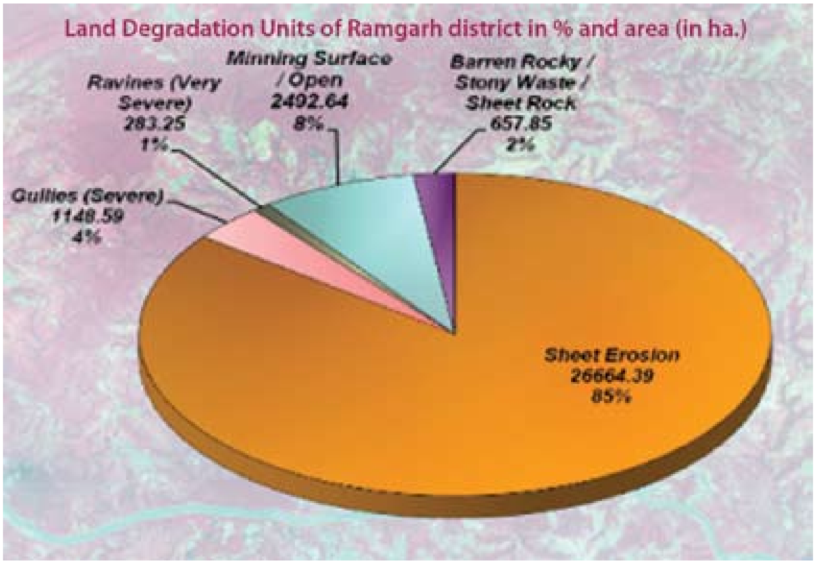



**Figure 4: Land degradation Map of Ramgarh district**

**Table 3: Degraded Land Categories**

| Name of the District | Degraded Land Categories | Total Area (in Ha) | Total Area (in %) |
|---|---|---|---|
| Ramgarh (Total Geographic area 1,21,111 Ha) | Sheet Erosion | 26664.39 | 22.02 |
| | Gully Erosion | 1148.59 | 0.95 |
| | Ravines | 283.25 | 0.23 |
| | Mining Surface/open cast mines | 2492.64 | 2.06 |
| | Barren rocky/Stony waste | 657.85 | 0.54 |
| | Total Degraded Area | 31246.73 | 25.80 |

The district Ramgarh (total geographical area is 1,21,111 ha) is showed 31246.73 ha (25.80%) is under degraded area. Out of these, the sheet erosion is 26664.39 ha (22.02%), gully erosion is 1148.59 ha (0.89%), ravines is 283.25 ha (0.35%), mining surface/open cast mines is 2492.64 ha (1.80%) and the barren rocky/Stony waste is 657.85 ha (0.54%) as shown in Table 3.

**Sheet Erosion** is a common problem resulting from loss of top soil. The soil particles are removed from the whole soil surface on a fairly uniform basis in the form of thin layers. They appear slightly brighter than the surrounding background soil colour with smooth texture. The total area of sheet erosion is 26664.39 ha, which is 85% of the total degraded land of Ramgarh district.

**Gully Erosion,** the first stage of excessive land dissection followed by their networking which leads to ravine, are commonly found in sloping lands. It appears brighter than the surrounding with coarse image texture. It is associated directly with natural stream network of the area. The erosion starts near the stream and proceeds upward along the slope. The total area of gully erosion is 1148.59 ha, which is 4% of the total degraded area.

**Ravines** are basically extensive systems of gullies developed along the river course. They are clearly visible on the Rabi data, in general. They are deep near the river and as we go away from stream/river, the depth decreases and image texture becomes smoother. The total areas of ravines are 283.25 ha, which is less than 1% of the total degraded area.

**Mining Surface/open cast mines** includes surface rocks and stone query, sand and gravel pits, brick kilns etc. Appears as discrete shades of yellowish green, black, yellow in small to medium patches. It is clearly visible in all season data. The total area of mining surface/open cast mines are 2492.64 ha, which is 8% of the total degraded area.

**Barren rocky/Stony waste** appears as irregular discrete/contiguous medium to large patches of light to medium grey/yellowish white colour on all three seasons satellite data. These are found near the hills and in the pediment portion. The total area of barren rocky/stony waste are 657.85 ha, which is 2% of the total degraded area.

## Conclusion

Land degradation hazard assessment is crucial for risk sensitive land use planning activities. Mountainous areas are frequently affected by more than one type of degradation occurring simultaneously. From the present study, it is clear that 85% of the study area is under sheet erosion. The northern part area is vulnerable to land degradation basically due to mining activities while degradation in the form of gullies and ravines can also be not neglected. This research indicates that remotely sensed data can be effectively used for identification and mapping of land degradation risks and monitoring of land degradation changes in the study area. The complexity and interplay of drivers causing land degradation vary in different sites, thus there is lack of a suitable approach to implement land degradation assessments. This paper is on a approach based on purely remote sensing techniques for mapping and monitoring of land degradation risks in a Ramgarh district. It is found that remotely sensed data have the potential to provide new insights for rapidly assessing land degradation risks in large areas. Although detailed assessments of land degradation risk results are not conducted in this paper, visual analyses of the results have indicated that the developed land degradation risk maps appear to be very reasonable and represent the real situation where land cover change increases or decreases land degradation risks.

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