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ENVIRONMENTAL IMPACT ASSESSMENT OF LAND USE PLANING AROUND THE LEASED LIMESTONE MINE USING REMOTE SENSING TECHNIQUES

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ABSTRACT

Mining activities and the waste products produced can have significant impact on the surrounding environment - ranging from localized surface and ground water contamination to the damaging effects of airborne pollutants on the regional ecosystem. The long term monitoring of environmental impacts requires a cost effective method to characterize land cover and land cover changes over time. As per the guidelines of Ministry of Environment and Forest, Govt. of India, it is mandatory to study and analyze the impacts of mining on its surroundings. The use of remote sensing technology to generate reliable land cover maps is a valuable asset to completing environmental assessments over mining affected areas. In this paper, a case study has been discussed to study the land use – land cover status around 10 Km radius of open cast limestone mine area and the subsequent impacts on environmental as well as social surroundings.

Key words: Environmental impact assessment, remote sensing, land use, land cover, remote sensing

INTRODUCTION

The Limestone mining lease (ML) area lies between Latitude 24° 43' N and 24° 45' N and Longitude 74° 35' E and 74° 37' E. It is located in revenue villages Naya Kheda, Amarpura, Sawa, Sindaudi, Jorawar Singh Ka Khera, Rail Ka Amarana, Neem Ka Amarana, Bad Ka Amarana, Medi Ka Amarana, Karunda and Charlia, tehsil and District Chittorgarh in the State of Rajasthan, India. The Mining lease (ML) area is at a distance of 18 Km southwest of Chittorgarh town. It can be approached by road following National Highway No. 79 connecting Ajmer-Indore upto Shambhupura (14 Km) and then taking a diversion of 4 Km on Shambhupura-Sawa Road. The nearest railway station is Shambhupura, which is connected by Ajmer-Khandwa-Ratlam (Metre Gauge) line of Western Railway (WR).

Climate and rainfall

Climate of the region may be classified as generally dry and is characterized by extremes. The area observes maximum temperature of 45 °C in May-June and minimum temperature of 3 °C in January. Average annual rainfall recorded in the area is 700 mm.

Physiography

The topography of the area comprises of plains and hills with the altitude ranging from 410m (above MSL) to 600m approx. (above MSL). The area surrounding the mine area is generally more or less undulating plain with gentle slope. The Limestone Mining lease (ML) area is more or less flat with gentle undulations. General slope of the area is from west to east and is drained by small seasonal nallahs (Streams) flowing across it from west to east. While the surrounding areas on the E-W periphery of the 10 Km radius comprises of hills ranging from 460m (above MSL) to 600m (above MSL). While the N-S part of the area lacks hills but some isolated hillocks are present.

Drainage basin

The area falls under Gambhir drainage basin, the river Gambhir flows from the southeast part to northeast part of the area with many seasonal tributaries. It joins River Berach in the north of Chittaurgarh town. General topography around the riverbed is more or less flat bed.

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Remote sensing studies

Systematic mapping and periodic monitoring of land use and land cover in the neighborhood of any developmental activity is one of the most important components necessary for environmental impact assessment. The remote sensing satellite plays a major role in these studies by virtue of their repetitive and synoptic coverage. In order to strengthen the baseline information on existing land use pattern, the following data for the given study area was used:

Data Used

Satellite Image Used:

IRS – P6 – LISS III Image

Path – 094, Row – 54 dated 14th May 2005

Collateral data:

Survey of India (SOI) Toposheets – 45 L/10, 45 L/9, 45 L/5 and 45 L/6 (Scale 1:50 000).

MATERIALS AND METHODS

The spatial resolution and the spectral bands in which the sensors collect the remotely sensed data are two important parameters for any land use survey. Appropriate remote sensing data were processed to investigate land use pattern through digital image processing techniques. SOI toposheets were georeferenced to superimpose on orthorectified satellite image. Mosaicing was performed for the georeferenced toposheets to form a continuous frame. A base map was generated from the mosaic of SOI toposheet comprising features such as administrative boundaries, major roads, railways and river drainage. (Fig. 1). IRS P-6 LISS III data offers spatial resolution of 23.5 m with the swath width of 141 Km. The data is collected in two visible bands namely green (0.52 – 0.59 μ), red (0.62 – 0.68 μ), infrared (0.77 – 0.86 μ) along with new feature SWIR band (1.55 – 1.70 μ) with orbital repetivity period of 24 days. The shapes, sizes and colours of several geomorphic features are visible in the IRS data. Four spectral bands provide high degree of measurability through band combinations including False Colour Composites (FCC) generation, bands ratioing, classification etc. These features of the IRS data are particularly important for better comprehension and delineation of the land use classes. Hence IRS P-6 LISS – III data has been used for land use mapping. The standard FCC is generated by assigning blue, green and red colours to visible green, visible red and near Infrared bands respectively (Fig. 2). Image processing and Orthorectification was done in Geomatica (V. 9.1) software and spatial data was created in Arc view (Ver.3.1) software. Final output maps were prepared on 1:50,000 scale.

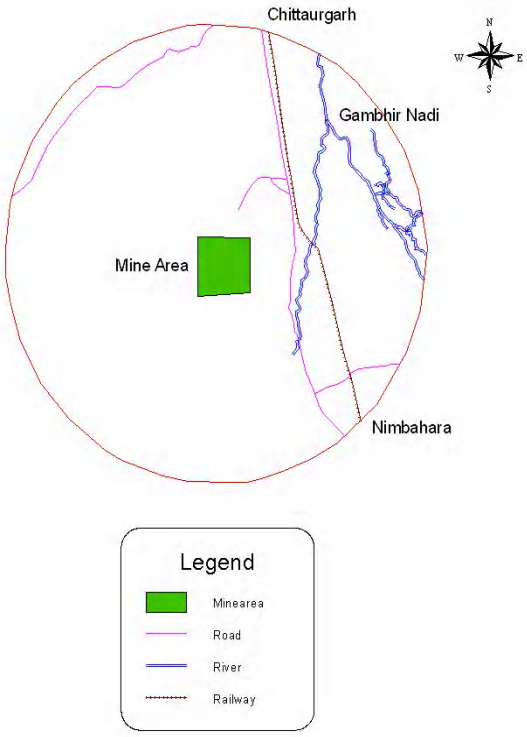
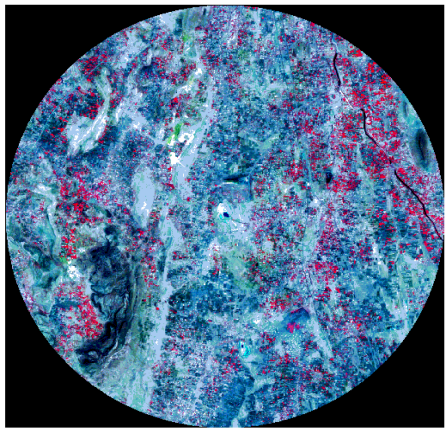


Fig. 1: Base map of study area showing 10 Km radius around limestone mine



FCC generated from LISS III image showing 10 Km radius around the study area

Fig. 2: False color composite (F.C.C) generated for study area showing 10 Km radius around limestone mine

Area of interest comprising the study area was then selected and extracted from the satellite image. Suitable image enhancements were then applied on the extracted area of interest. A visual interpretation followed by supervised classification (digital image processing approach) was adopted to classify various land use–land cover features. Several training sets/signatures for classification were collected prior to applying supervised classification. After evaluating the statistical parameters of training sets, the training areas were rectified by deleting non-congruous training sets and creating new ones. Mask of mine area within 10 Km radius was superimposed on the final output to generate area statistics for different land use categories. Classification accuracy estimation was done on the supervised classified image for further rectification. Based on this, final estimation and results for a land use – land cover features existing in the study area were derived (Fig. 3).

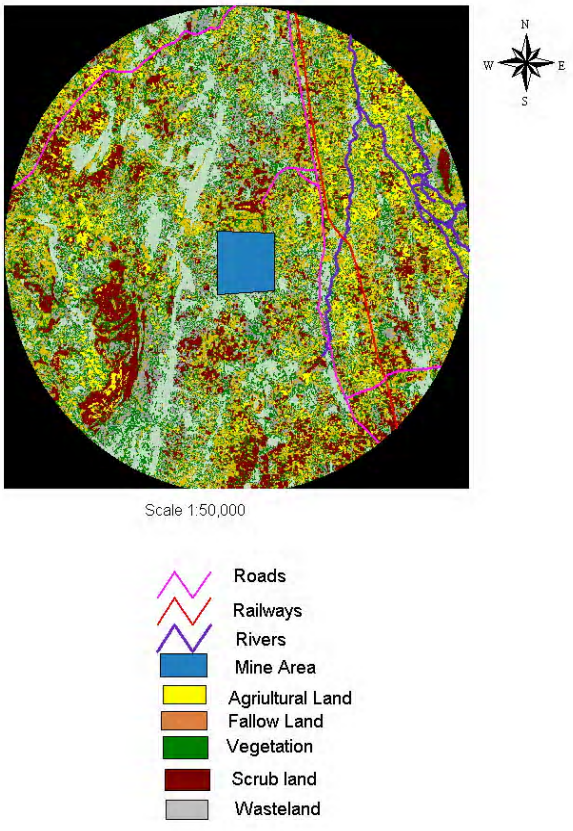


Fig. 3: Land use / Land cover classification for study area showing 10 Km radius around Limestone mine

Land use – Land cover classification

Land use refers to man's activities on land utilitarian in nature, where as land cover denotes to vegetation and artificial constructions.

The land use / land cover classification system standardized by Department of Space, Govt. of India for mapping different agro-climatic zones has been adopted for the classification. This classification has 6 major land use classes at level I and 28 at level II (Table 1). The six major classes at level I are further enunciated below:

Table 1: Land use/Land cover classification standardized by Department of Space, India

Sample No.	Level - I	Level - II
1	Built-up land	1.1 Built-up land 1.2 Road 1.3 Railway
2	Agricultural land	2.1 Crop land 2.2 Fallow (Residual) land
3	Forest	3.1 Evergreen Forest 3.2 Deciduous Forests 3.3 Degraded forests 3.4 Forest Plantations 3.5 Mangroves 3.6 Cropland in forest 3.7 Forest Blank
4	Wastelands	4.1 Salt affected land 4.2 Waterlogged land 4.3 Marshy/Swampy Land 4.4 Gullied/Ravinous Land 4.5 Land with or without scrub 4.6 Sandy Area (Coastal and Desertic) 4.7 Barren rocky/Stony waste/Sheetrock area
5	Water bodies	5.1 Rivers/streams 5.2 Lake/Reservoir 5.3 Tank/Canal
6	Others	6.1 Grassland/grazing land 6.2 Shifting Cultivation 6.3 Snow cover/Glacial area

- *Built-up land* – This comprises areas of land covered by structures
- *Agricultural land* – land used for production of food, fiber, crops and plantation
- *Forest* – This includes land such as dense or sparse evergreen forests, deciduous forests and degraded forests.
- *Wastelands* – Land having potential for development of vegetative cover but not being used due to constraints including salt affected lands, eroded land and water logged areas.

- *Water bodies* – Areas persistently covered by water such as rivers / streams, reservoirs / tanks, lakes / ponds and canals.
- *Others* - Grassland and snow covered land are included in this category
- Using the above classification system and digital analysis techniques with restricted field checks, land use / land cover distribution in the study area has been estimated.

RESULTS

The study carried out area around 10 Km radius of leased mine area indicates 26.85 % of area is under barren land/scrubland, 24.08 % is covered by vegetation (plantations) and Rocky Outcrops/ hills cover 15.17 % of the study area (Table 2). The presence of limestone mines has provided an opportunity for ancillary activity and employment to the local population.

Table 2: Land use/Land cover pattern within 10 Km radius of leased limestonemine area

Sample No.	Class	Area (%)
1	Agricultural Land / Cropland	11.00
2	Fallow Land	21.02
3	Rocky Outcrops /Scrub Land	15.17
4	Vegetation	24.08
5	Waste Land / Land without scrub	26.85
6	Water Bodies/ Rivers	1.88
Total		100.00 %

Agricultural land / Cropland and Fallow Land

Cropland (with crop) is that area with standing crop fully grown/ready for harvest as on date of satellite pass. Agricultural land/cropland use by and large is dependent on the agro-climatic conditions prevalent in the area. The area remains dry throughout the year and it receives rainfall only during retreating monsoon. The present land use/ land cover appears to have well adapted to topography, soil and rainfall pattern and the cultural practices of the people in the area. An area of 11.00 % is under this class. All those lands without standing crop and with apparent field boundary are identified as fallow land. An area of 21.02% is observed in this class.

Vegetation

Vegetation cover includes plantation done in and around the mine lease area mainly to promote the environmental condition of the area. Some of these have been done around the mine pit and are well thriving to the environmental conditions. Apart from this the class covers vegetative cover inclusive of isolated patches of scrub forests. The total extent covered by this category is 24.08 %.

Wasteland / Scrub Land / Rocky Outcrops

Wastelands are one of the most important classes in the area. Land with scrub is the land, which occupy relatively high topographic locations. The class is distributed all over the area and covers an area of 15.17 %. Land without scrub is the area with similar topography features but is devoid of any vegetative cover growth except during rainy season. One particular feature of this class is that it is subjected to severe sheet erosion with little or no soil cover. It covers an area of 26.85 %.

Water bodies

River and streams are classified as water bodies and covers an area of 1.88 %.

Socio-economic patterns

As the area is rich in limestone deposits a number of small-scale stone quarries are prevalent in the area. Quarry and quarry related activity is major source of employment. Agriculture activity is carried out in isolated patches near mine area. Most of the local people are employed in the local limestone mine.

DISCUSSION

Napiah (1997) has discussed about the use of remote sensing and GIS technology for geological and mineral prospecting with an objective of identifying the minerals using remote sensing and GIS techniques. The paper is more focused on mineral prospecting with no emphasis on the impact assessment studies of mines on people and environment. Similarly, Shanxi (2002) has also discussed about the concept behind the use of remote sensing techniques for identification of coal bed mining techniques in China. Das (2002) has emphasized on the use of remote sensing techniques for laterite/bauxite mining, the paper discusses more about the image processing techniques involved for carrying out the studies. All these papers referred for the study were based on mining applications and image processing

techniques of remote sensing with no emphasis for environmental studies. While main objective of present studies was to understand the existing land use/land cover pattern in the arid region of Rajasthan within 10 Km radius of the limestone area as per the MoEF (Ministry of Environment and Forests, Govt. of India) guidelines and understand the equivalent effect of the mine on socio-economic life of local people. The present study is having more emphasis on the environmental impact assessment aspect of the limestone mine in the typical arid zone of India. This study can be extended to further areas with similar set of conditions and environment. In short, it can be said that, Remote sensing technology can play a major role in carrying out the environmental studies and the subsequent impact assessment especially for open cast mines, which are of dynamic nature. The synoptic and temporal coverage offered by remote sensing can help in monitoring large study area along with inaccessible terrains at regular time intervals.

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