IMPACT ANALYSIS OF OPEN CAST COAL MINES ON LAND USE/ LAND COVER USING REMOTE SENSING AND GIS TECHNIQUE: A CASE STUDY

ANIL Z CHITADE
Department of Civil Engineering, MANIT
Bhopal, MP, India
anilchitade@manit.ac.in
http://manit.ac.in

S K KATYAR
Department of Civil Engineering, MANIT
Bhopal, MP, India
skatiyar7@rediffmail.com
http://manit.ac.in

Abstract:
Industrialisation plays vital role in the overall development and progress of any region. Along with the development, on the same time, it has the adverse impact on environment such as air pollution, water pollution and many others.Wardha basin of Chandrapur district (M.S) has abounded with ample high quality coal minerals. This region has witnessed a lot of changes in land use/land cover (LULC) due to exploration of coal minerals and subsequently the adverse impact on environment.
This research explains the use of remote sensing (RS), Global positioning system (GPS), and GIS technology for the detection of LULC changes. In this work LULC changes have been detected using remotely sensed images during the period from 1990 to 2010, using Landsat-TM image of year 1990 and Cartosat-I image of year 2010. The above images were rectified and georeferenced using GPS data collected by point positioning mode observations.Ground truthing for the LULC classification accuracy assessment has been done using GPS instrument. Image analysis operations have been carried out using Erdas Imagine software. Various effects of coal mining activities on the Land use have been highlighted.

Keywords: LULC, Basin, Landsat-TM, Cartosat-I, Post classification.

I. Introduction:

The Chandrapur district of Maharashtra state is one of the richest districts abounds in minerals with large reserves with high grade iron ore and coal, industries and lust tropical forest. The district is famous for its sprawling coal mines and Tadoba wildlife sanctuary, which is an important Tiger destination in the country. It is also the home to several major industries and one of the biggest thermal power stations in the country. It has cement factories, Coal mines, lime stone mines, paper mills and sponge iron plants all of which are polluting activities. Mining, in general, and open cast mining in particular may lead to severe environmental degradation.

Fig 1: Due to OB Mine dump near River Course Stream Course Seems to Be Changed

Fig No.2: Vegetation Converted into artificial mountain

Fig No. 3: Dense Vegetation Converted Into Sparse vagetation and valley

Paradoxically, from an environmental point of view, coal mining is a major habitat transforming activity which has a number of detrimental environmental consequences, namely soil erosion, acid-mine drainage and increased sediment load as a result of abandoned and un-reclaimed mined lands (Parks et al.,1987).

Besides, considerable amount of solid waste piled in the form of huge overburden dumps, destruction and degradation of forest and agricultural lands, and discharge of effluents from mines into nearby water-bodies are some of the other associated problems that have adverse environmental impact. Continuous monitoring of these lands is, therefore, essential for their effective reclamation and management. However, reliable and timely information on the nature, extent, spatial distribution pattern and temporal behavior of degraded lands including land subject to mining, which is a prerequisite for their reclamation and management, is generally not available.

Mapping mining activities and evaluating associated environmental concerns are difficult problems because of the extensive area affected and the large size of individual mines. Monitoring and controlling these changes have been more difficult because of the expense and time in producing reliable and up-to-date mapping. Besides, a successful monitoring approach for evaluating surface mining processes and their dynamics at a regional scale requires observations with frequent temporal coverage over a long period of time to differentiate natural changes from those associated with human activities. In order to meet such challenges, urban planners and decision makers need to have accurate and up-to-date information.

The crucial issue is not one of reducing industrialization rather developing an understanding of environmental degradation phenomena and minimizing its impact. In this context, it is very important to investigate impact of industrialization in its environs and evaluate the available tools. Generating an environmental database for carrying out environmental impact assessment in regional context and to understand deforestation in spatial and temporal domain is a difficult task by conventional methods. Today, remote sensing data, which is synoptic, repetitive and multi temporal in nature has efficiently filled this gap. Kindred with Geographical Information System (GIS), the technique has a distinct advantage over conventional methods/approaches to map and monitor the evolution of degraded areas. It has become a versatile tool for assessing and monitoring environmental impacts as a result of natural and manmade activities (Hill et, al.1983; Wang et al. 2001; Zha et al. 2007). The technique has proved its usefulness in assessing the environmental degradation with reference to land, water, air and vegetation. It provides an excellent overview of the status of industrial areas and their impact. Earlier works have demonstrated its potential in various facets of industrial activity viz., land use change detection (Ghosh and Ghosh 1991; Prakash and Gupta 1998; Joshi et al. 2006), environmental impact (Ghosh 1989; SAC 1990; Rathore and Wright 1993; Chatterjee et al. 1994). Few of the earlier workers have also used satellite data processing for assessing the mining areas (Mamula 1978; Parks and Peterson 1987; Rathore and Wright 1993; Schmidt and Glaeser 1998).

This paper discusses the land use land cover change due to open cast coal mines in parts of wardha valley of Ballarpur region of Chandrapur area using RS and GIS techniques and organised into introduction as discussed above in part I. Part II discribed the data resources and brief about study area, part III explains the methodology for change detection followed by results in part IV and finally conclusions and discussions are made in part V.

II. Data Resources and Study area:

a. ***Data Resources***: The data used for this study purpose is listed in table No.1

Table No.1: Data resources used in Study

Sr. No.	Satellite Orbit	Date of Procurement	Path	Row	MAP
1	IRS-P5	5th April 2009	547	304	56M05NE
2	IRS-P5	5th April 2009	547	305	56M05SE
3	IRS-P5	16th March 2010	546	304	56M05NW
4	IRS-P5	16thMarch 2010	546	305	56M05NW
5	L-5 TM	26th DEC 1990	144	46	Free

b. ***Softwares Used***: Following softwares are used for study purpose

i) Erdas-Imagine v9.1

ii) MS-Office 2007

III. Study Area:

For study purpose a small piece of land having total perimeter 28920.261819 meter and total area of 23403483.637573 M^2 located between 19^{0}45’ N to 20^{0}N Latitude and 79^{0}15’E to 79^{0}.30’E longitude (parts of Toposheet No.55/M-5 as shown in Fig No.4) is taken as study area where open cast coal mines are concentrated during last 10 years. It is the parts of Ballarpur and Rajura talukas of Chandrapur district of the state of Maharashtra and shown in Fig 4.

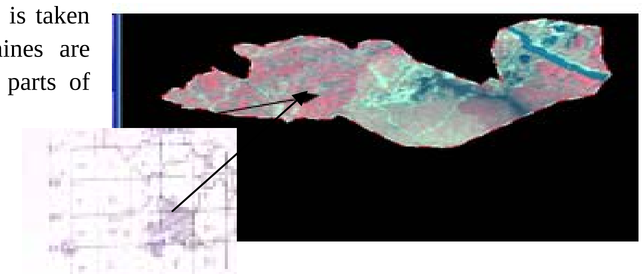


Fig No.4: Study Area in LANDSAT-TM

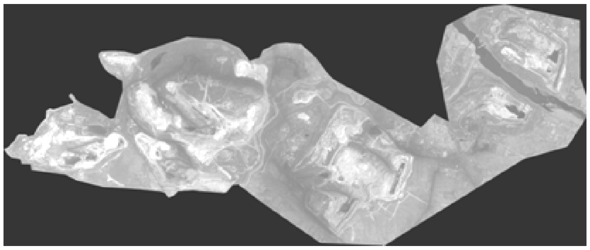


Fig No.5: Study Area on CARTOSAT-I

The study area seen on Landsat-TM and on Cartosat-I are shown in Fig No.5 and 6 respectively. Physiographically, it is situated in the Wainganga and Wardha river basin. The eastern and western boundaries of the area are well defined by the river Wardha, the tributary of Godavari. The mean maximum temperature goes up to 43°C and minimum temperature is 28°C to 29°C. According to the temperature records of 2009, the temperature of Chandrapur has crossed 49°C in the month of May. The average annual rainfall is about 1420 mm. The relative humidity is very high during monsoon season, which exceeds 70%, but after monsoon season it goes down rapidly and in summer it is only 20%.

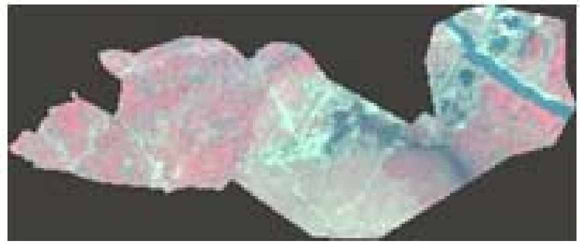


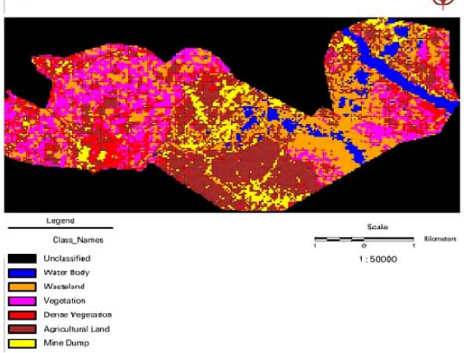
Fig No.6: Study Area on LANDSAT- TM

IV. Methodology:

The Landsat-TM image of 26th DEC 1990 and Cartsat-I image of 16 March 2010 of study area is obtained from NRSC Hyderbad A.P. Both the images preprocessed for geometrical correction and resampled in UTM projection and WGS-84 datum and WGS-84 speroid with mean RMS error of 0.36. The study area is obtained by subsetting the required area of interest. The GCPs and the ground truth sampling data are collected with GPS from the field. Both the images are then classified using unsupervised method with ISODATA cluster algorithm in ERDAS Imagine v9.1. The classified images are edited refering the ground truth data collected earlier from the field and final classified maps are prepared with assessing classification accuracy. Finally the changes in various LULC classes are obtained using post classification comparison method.

V. Results:

Fig No.7 : LULC Classification for LANDSAT-TM 1990



The classified output of Landsat-TM image is shown in Fig No.7 and for Cartosat-I image in Fig No.8.The result for overall accuracy is summerised in table No.2 and the changes taken in land use land cover classess for past 20 years in the study area are given in table No.3.

Fig No.8: LULC Classification for CARTOSAT-I 2010

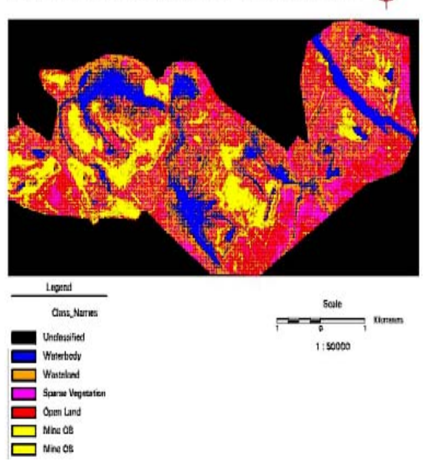


Table No.2: Overall Classification Accuracy and Kappa (K) Coefficient for Landsat-TM and CARTOSAT-I

Sr. No.	Accuracy For	Overall Accuracy	Kappa Coefficient(K)
1	Landsat-TM	95.81	0.9320
2	Cartosat-I	93.71	0.9158

Table No.3: Land use land cover classes and its change from 1990-2010

Sr No.	LULC	AREA in 1990	AREA in 2010	Change in AREA (Hectare	AREA Change in %
1	Waterbody	151.898	321.568	+169.670	+52.76
2	Mine OB	190.624	579.356	+388.732	+67.09
3	Vegetation	429.338	-	-429.338	-100
4	Sparse Vegetation	-	445.129	+445.129	+100
5	Dense Vegetation	339.633	-	-339.633	-100
6	Agricultural Land	710.593	-	-710.593	-100
7	Waste land	566.787	566.207	-0.58	-0.0058
8	Open Land	-	430.870	430.870	+100

VI. Conclusion and Discussion:

From the analysis of land use land cover classification of multitemporal satellite data it is observed that there are enormous changes especially in vegetation and agricultural area. Almost dense vegetation have been converted either into mine land or artificially created mountains of mine overburden (Fig No.1and 2). The water bodies seems to be increased from 151.898 to 321.568 but it is observed that change has occured not because of natural water surface bodies but it is due to excavation of huge quatity of material below the earth surface and spread unevenly along the study area and also gets contaminated. During the field visit, it is also observed that due to unplanned stacking of overburden material the direction of Wardha river stream has also gets changed at some places (Fig No.). Due to non availability of the exact ground truth data for 1990, some limitations for classification and accuracy assessment for landsat data has to be taken into considerations. It is observed that because of changes in vegetation, pollution level has increased enormously in the surrounding area and during the recent years it has attained the critical level.

VII. References:

[1] *Bao Nisha et al,* - Monitoring land degradation and reclamation change from ATB open-pit coal mine during 1976-2009, 978-1-4244-7739-5/10/$26.00 ©2010 IEEE.

[2] *Bernd Jahne*- Digital Image Processing, 6th Edition, Springer International Edition, pp 449-454.

[3] *Du Peijun et al*- Applications of Multi-source Remote Sensing Information to Urban Environment Monitoring in Mining Industrial Cities –Taking Xuzhou City as an Example, Urban Remote Sensing Joint Event, 2007 .

[4] *Ji Chang Dong et al,* Research Of 3s Technology Applied In Land Reclamation Of Minefield, Journal Of Coal Science and Engineering (China) Issn 1006-9097 ,Vol.14 No.4 Dec. 2008, Pp 659–662

[5] *Lei Wang*- A dissertation on investigating impacts of natural and human-induced Environmental changes on hydrological processes and Flood hazards using a gis-based hydrological/hydraulic Model and remote sensing data.

[6] *Mustafa Bolca et al*-Determination of Impact of Urbanization on Agricultural Land and Wetland Land Use in Balçovas' Delta by Remote Sensing and GIS Technique, Journal of Environ Monit Assess (2007) , pp 409–419.

[7] *Pakorn Petchprayoon- Hydrological* impacts of land use/land cover change in a large river basin in central–northern Thailand, International Journal of Climatology, and 30th March 2010.

[8] *Philip A. Townsend et al*- Changes in the extent of surface mining and reclamation in the Central Appalachians detected using a 1976–2006 Landsat time series, Journal of Remote Sensing of Environment 113 (2009), pp 62–72.

[9] *P K Joshi et al*- Assessing Areas Deforested By Coal Mining Activities Through Satellite Remote Sensing Images and Gis In Parts Of Korba, Chattisgarh, Journal Of the Indian Society Of Remote Sensing, Vol. 34, No. 4, 2006, Pp 415-421

[10] *Robert A Schowengerdt*- Textbook of Remote Sensing – Models and Methods For Remote Sensing, IInd Edition, Academic Press Elsevier, pp 357-387.

[11] *T. Darwish et al*-Environmental impact of quarries on natural resources in Lebanon, Journal of Land Degradation and Development, Issue June 2010.

[12] *V. Naydenova*, Investigating the Stream Network Changes and Landslide Processes in Open Coal Mining Areas Using Remote Sensing Methods, 1-4244-1057-6/07/$25.OO ©2007 IEEE., pp 242-247

[13] *V. N. Oparin*, On information-provided monitoring of geodynamic processes in the kuznetsk coal basin in the conditions of highly intensive sub-soil usage, journal of mining science, vol. 42, no. 5, 2006,pp 445-467.

[14] *Zubair et al* - Change Detection in Land Use and Land Cover Using Remote Sensing Data and Gis (A Case Study of Ilorin and Its Environs in Kwara State.)- A Phd Thesis.