LAND USE AND LAND COVER CHANGE DETECTION STUDY AT SUKINDA VALLEY USING REMOTE SENSING AND GIS

A THESIS SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF TECHNOLOGY

By

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DEPARTMENT OF MINING ENGINEERING
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CERTIFICATE

This is to certify that the thesis entitled **"Land use and land cover change detection study at Sukinda valley using remote sensing and GIS"** submitted by **Biswajit Majumder** in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

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ABSTRACT

Sukinda valley is known for its chromite deposit which accounts for 97 percent of the India's total chromium reserve. But the chromium found here being hexavalent in nature, possesses health risk to the people residing in the area. Therefore, it becomes indispensible to monitor the changes in the mining activities of the area and to regulate them. The present study was therefore undertaken to analyze the land cover and land use change that has taken place in Sukinda valley between 1975 and 2005 using Remote Sensing data and GIS by mapping land cover and land use. The land cover and land use study was conducted by mapping LANDSAT data of three different years (1975, 1992, 2005) with the help of ERDAS and Quantum GIS. The result of the work shows a rapid growth in mining between 1975 and 2005 at the cost of decrease in forest area.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND TO THE STUDY:

With the public as well as the private sector continuing to venture into it, the mining industry has grown and spread wide. But this industry sprawl often infringes upon productive agricultural and essential forest land, neither of which can resist nor deflect the overwhelming momentum of mining activities. This growth is an indicator of industrialization (development) and generally has a negative impact on the environmental health of a region.

Land is becoming a scarce resource due to population growth and industrialization. Rapid growth of mining activities can also be attributed as one of the reasons for decrease and degradation of land. Thus, it becomes an important task to regulate mine area for sustainable development and environmental protection. Usually, minerals occur under features such as forest area or agricultural land and thus mining activities are to be undertaken at the cost of degrading this forest or agricultural area. Therefore, it becomes indispensable to supervise such changes on the earth's surface.

The land use/land cover pattern of a region is an outcome of natural and socio – economic factors and their utilization by man in time and space. Hence, information on land use / land cover is essential for the selection, planning and implementation of land use and can be used to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population (Zubair, 2006).

Why remote sensing?

Earlier, when there was no remotely sensed data and the assistance of computers, land use/land cover change was detected with the help of tracing paper and topographic sheet. But then this method was tedious and studying large areas required lot of effort and time. Conventional ground methods of land use mapping are labor intensive, time consuming and are done less frequently. Thus, with the advent of satellite remote sensing techniques, preparing accurate land use land cover maps and monitoring changes at regular intervals of time is relatively simpler. In case of inaccessible region, the only method of obtaining required data is by applying this technique.

Today remote sensing and GIS technology has enabled ecologists and natural resources managers to acquire timely data and observe periodical changes. With multi-temporal analyses, remote sensing gives a unique perspective of how rural area evolves. The most important element for mapping land use change due to mining is the ability to discriminate between rural uses (farming, forests and water body) and quarries. "Remote sensing methods can be employed to classify types of land use in a practical, economical and repetitive fashion, over large areas." (Natural resources Canada)

Why is Sukinda chosen?

Sukinda area has attracted people from other regions of Orissa over the past years due to its large chromite ore reserves. 97% of the total proved chromite (chromium ore) reserves of the country occur in Sukinda valley. Mining activities has been practiced in the Sukinda valley since 1950 (Dhakate *et al*, 2008). The extraction of chromite has mostly been carried out by open cast and at a few places by underground mining methods. The valley is spread across Dhenkanal and Jajpur districts and is very densely populated. As a result of the population growth and rapid chromite mining, the valley has expanded very fast causing many changes in land use. The chromite ore found here is hexavalent Chromium which has adverse health effects (Occupational safety and health administration). Chromite is exported and used in the domestic market mostly for production of iron-chromium alloys (ferroalloys), which accounts for about 85% of the total chromite demand. Some chromite is also used for refractories, ceramics and preparation of chromium containing chemicals.

What is change detection study?

"Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times" (Singh, 1989). "Timely and accurate change detection of Earth's surface features provides the foundation for better understanding relationships and interactions between human and natural phenomena to better manage and use resources” (Lu *et al*., 2004).

Changes in land cover by land use do not necessarily imply degradation of the land. However, due to a shift in land use patterns, land cover changes that affects biodiversity, water and other processes that come together to affect climate and biosphere (Riebsame *et al*., 1994).

A detailed understanding of the impact of mining on changes in land use/land cover pattern has become necessary for the Sukinda valley. Therefore, present study was undertaken to analyze the extent of human-induced landscape transformation in the mining affected areas of Sukinda valley by interpreting temporal remote sensing data using geographic information system (GIS). Land cover types (dense forest, quarry, water body and open forest) were delineated in order to achieve the above objective. The areas under settlement/non-forest were also taken into consideration to know the trend due to the impact of mining activities in different time periods.

1.2 STUDY AREA:

The study area lies between latitude 21^{O} 59’ 52” to 21^{O} 6’ 31” N and longitude 85^{O} 41’ 54” to 85^{O} 59’ 15” E and is a part of famous Sukinda Valley, Jajpur district, Orissa. The drainage in the area is towards Northwest and finally join Damsal Nala flowing NE-SW and the stream is perennial in nature. In the southern part, Mahagiri Hill ranges lies with an altitude of 300 m above mean sea level, whereas Damsal Nala lies between 100 to 180 m above mean sea level. Daitari Hill ranges lies in the northern part. The average rainfall of the area is around 2400 mm/year. The location map of the study area is shown in Figure 1.1.

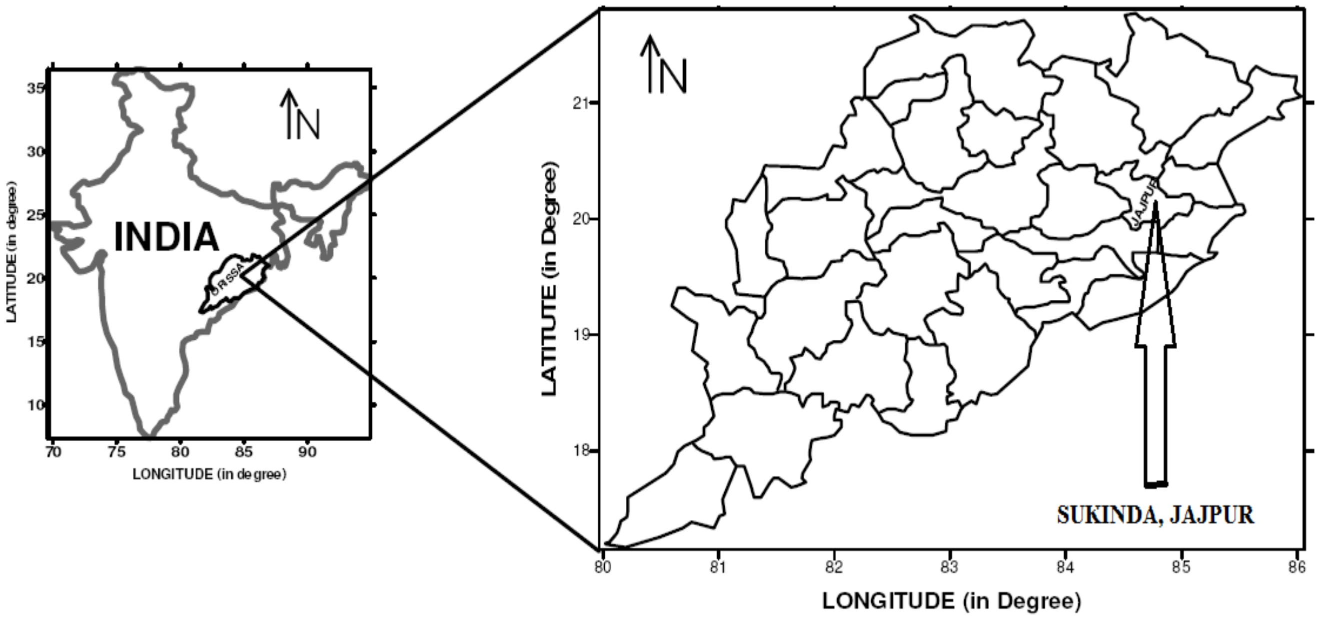

Figure 1.1: Location of the study area

1.3 DEFINITION OF TERMS:

- ***Remote sensing:***

  It is defined as any process whereby information is gathered about an object, area or phenomenon without being in contact with it. Given this rather general definition, the term has come to be associated more specifically with the gauging of interactions between earth surface materials and electromagnetic energy (Zubair, 2006). On the otherhand it is the science of acquiring, processing and analyzing information.

- ***Geographic Information system:***

  A computer assisted system for the acquisition, storage, analysis and display of geographic data.

Land use:

This is the manner in which human beings employ the land and its resources.

- ***Land cover:***

  It implies the physical or natural state of the Earth's surface.

- ***Ground Control points***

  Ground Control Point can be defined as a point on the earth surface with known location (i.e. fixed within an established co-ordinate system) which is used to geo-reference image data sources, such as remotely sensed images or scanned maps.

- ***Mosaicking***

  Mosaicking is the process of joining two geo-referenced images into one. (Tutorial on Remote Sensing Techniques Using ArcView 3.2 and ERDAS Imagine 8.4, 2001)

- **Geo-referencing**

  It is the process of establishing the correct position of an aerial photograph within a map or finding the geographical coordinates of a place name or street address. (Wikipedia)

1.4 ORGANISATION OF THESIS:

Chapter 1 gives an insight to the selection of the topic and its importance. The objectives and scope of the present work is identified in this chapter.

Chapter 2 gives a brief idea about the literature review that has been performed before undertaking the project.

Chapter 3 reviews the methodology of the process of building up the land use mapping of the study area.

Chapter 4 presents a thorough discussion on the statistical results obtained from the land cover land use map.

Chapter 5 Conclusion of the study is done in this chapter.

1.5.1 AIM OF THE STUDY:

The aim of the study is to assess the land cover and land use changes in Sukinda valley at in last three decades.

1.5.2 OBJECTIVES:

The following specific objectives will be pursued in order to achieve the aim above.

- To create a land use land cover classification scheme
- To generate statistical data on land consumption by quarries and reduction of forest area

CHAPTER 2

LITERATURE REVIEW

2.1 LITERATURE REVIEW

With the advent of the first remote sensing satellite (Landsat 1) in 1972 many land cover land use study have been undertaken. These studies were conducted in various areas including urban areas, agricultural area, mining area. For example, Singh *et al* (1997) has done detail study on the impact of coal mining and thermal power industry on land use pattern in and around Singrauli coalfields using Remote Sensing data and GIS. Database for land use was prepared for multispectral, multi-temporal data of years 1975, 1986 and 1991 of LANDSAT MSS and TM using PAMAP GIS software. The study revealed that areas mining and build up land increased from 1975 to 1991. There was substantial loss in agricultural and forest land which was due to rapid industrialization of the area.

Sarma *et al* (2005) have worked on coal mining impact on land use/land cover in Jaintia hills district of Meghalaya, India using remote sensing and GIS technique used LANDSAT data of 1975, 1987, 1999 and 2007 to conclude that there was four fold increase in mining area from 1975 to 2007 accompanied by three fold decrease in forest area. Visual interpretation technique was used for land use/land cover mapping for the different data of four years.

Another study was carried out by Anil *et al* (2010) on the impact analysis of open cast coal mines of Chandrapur district on land use land cover using remote sensing and GIS technique. The study was carried out using multi-temporal satellite data (IRS-P5 data of 2009 and 2010 and LANDSAT-5 data of 1990) to create a land use/ land cover mapping of the area; and reported a 67% increase in mine area.

Ololade *et al* (2008) have worked on land-use/cover mapping and change detection in the Rustenburg Mining Region using Landsat images was carried out using remote sensed data; Landsat MSS in 1973 (4 bands), TM 1989, 1997, 1998 (6 bands) and ETM 2002 (6 bands) and topographic maps of 1969 and 2005, used as reference base maps of the region. Standard image enhancements and registration was performed on the images. Supervised classification was performed by using maximum likelihood method. Land-use classes; woodland, grassland, cultivated land, bare soil, rivers, dams, water ponds, built-up area, tailing dams and open cast mines were identified from satellite data and field surveys. Results showed that in the last three decades open cast mines, tailing dams; mine dumps and return water ponds have increased extensively in the Rustenburg region; vegetation has undergone a general decrease; woodland and grassland have been changed to cultivated land. An expansion of the built-up area can be explained by the fact that there was increase in the development of transport networks; settlements developed over the years due to the immigration of mine workers in the area. Consequently, the landscape became highly disturbed due to increased mining and agricultural activities.

A detailed study has been done on the work of Edward *et al* (2009) on open pit gold mining and land use changes in Bogosu-Prestea area, south west Ghana. Land use change due to mining employed over a twenty year period (1986 – 2006) was analyzed within the Golden Star Resources Bogoso Prestea Limited (GSRBPL) concession. The study revealed that mining in the area increased by 12.1 % in land coverage from 1986 to 2006 with decrease in agricultural land use from 97.8% in 1986 to 82.7% in 2006. Settlements increased from 0.45 % in 1986 to 4.95 % in 2006 due to a rural – urban migration.

Another interesting work was done by Byeong-Hyeok *et al* on forest reclamation monitoring in the abandoned mine of the Samtan coal mining area located in the southern part of Jeongseon-gun, Gangwon-do, Korea. Effects of vegetation health for abandoned and forest recovered period using multi-temporal satellite datasets was analyzed. Vegetation and forest health was analyzed using NDVI mapping on the three multi-temporal Landsat 5 and 7 satellite datasets. Results from NDVI map identified the new recovered forests and hence confirmed that the natural forests are restoring their vegetation health.

A work on land cover change study of the Oil Sands Mining Development in Athabasca, Alta, Canada was carried out by Natural Resources Canada (2005). The primary impact was assessed using an information extraction method applied to two LANDSAT scenes. The study was done using two LANDSAT images of 1990 and 2001. Land cover maps shows a decrease of natural vegetation in the study area for 2001 approximately 64% relative to that of 1992.

CHAPTER 3

METHODOLOGY

3.1 METHODOLOGY

The detailed methodology adopted in this thesis to achieve the above objective is described in this chapter.

Flowchart of the broad steps followed in this work for deriving statistics of land use pattern of the area is shown in Figure 3.1.

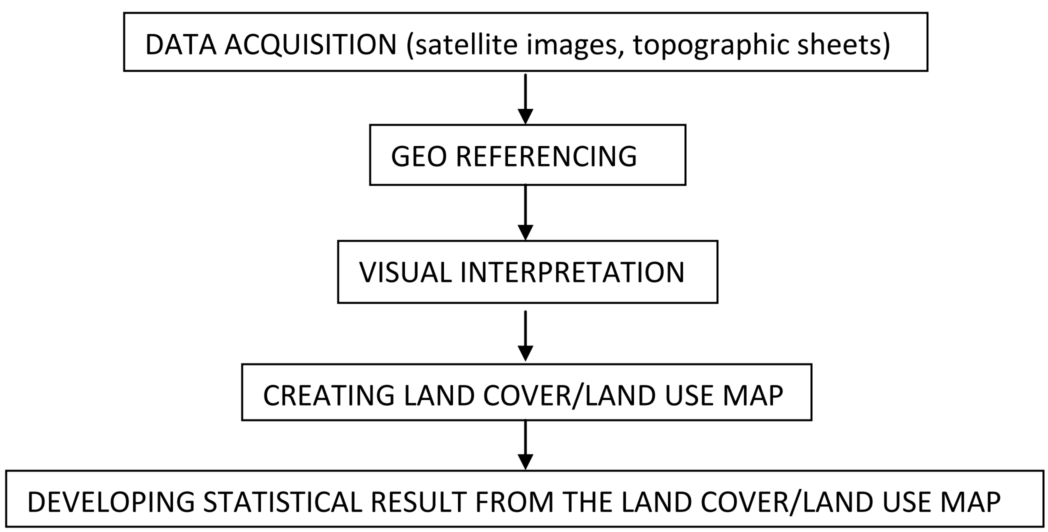

Figure 3.1: Flowchart of the methodology

3.2 DATA ACQUIRED AND SOURCE:

For the present study, multispectral, multi-temporal LANDSAT satellite data of Sukinda valley were acquired for three years namely, 1975, 1992 and 2005. All the imageries belong to the month of November. All the LANDSAT images have been taken from Global Land Cover Facility (GLCF), a NASA-funded member of the Earth Science Information Partnership at the University of Maryland. The 1975 image is a MSS image having resolution of 79 metres, while thematic mapper image of 1992 and 2005 has resolution of 30 meters. All the satellite images were brought to Universal Transverse Marcator (UTM) projection in zone 45N. Topographic sheet 73G/12 and 73G/16 were also collected for the year 1982 and 2005. Table 3.1 show the list of data acquired along with their date of production, resolution and source.

Table 3.1: Data source

Sl No.	Data type	Date production	Scale	Source
1	Landsat image (MSS)	01-11-1975	79m	Global Land Cover Facility (GLCF) www.***glcf***.*umiacs.umd.edu*
2	Landsat image (TM)	01-11-1992	30m	Global Land Cover Facility (GLCF) www.***glcf***.*umiacs.umd.edu*
3	Landsat image (TM)	01-11-2005	30m	Global Land Cover Facility (GLCF) www.***glcf***.*umiacs.umd.edu*
4	Topographic sheet (73 G/12 and 73 G/16)	1982	1:50,000	
5	Topographic sheet (73 G/9 and 73 G/13)	2010	1:50,000	

3.3 SOFTWARE USED IN THE STUDY:

Two following softwares were used for this project

1. ERDAS 8.4 – This was used for displaying images and mosaicking and geo-referencing the images.
2. Quantum GIS 1.6.0 – This was used for classification by visual interpretation and to create the land cover/ land use pattern.

3.4 MOSAICKING THE TOPOGRAPHIC SHEETS:

All the topographic sheets were first geo-referencing using ERDAS. Mosaicking was then performed on topographic sheet number 73 G/12 and 73 G/16 of 1982 so that the image after mosaicking could give a complete view of the study area. Similarly, the other two topographic sheets (number 73 G/12 and 73 G/16) of 2010 were also mosaicked together. These mosaicked images were used to overlay the satellite images.

3.5 GEO-REFERENCING THE SATELLITE IMAGERY:

All the satellite imagery was geo-referenced using the mosaicked topographic sheet as the reference image. A total of five ground control points (GCP) were chosen for each image. Table 3.2 shows the root mean square error.

Table 3.2: RMS error during geo-referencing

Sl. No	Corresponding year of image	RMS error
1	1975	0.564
2	1992	0.450
3	2005	0.212

3.6 DEVELOPMENT OF A CLASSIFICATION SCHEME

The classification scheme which gives a broad classification of the land use land cover of the study area is shown in Table 3.3.

Table 3.3: Classification scheme

Sl. No	Class
1	Dense forest
2	Quarry
3	Water body
4	Non-forest area

The definition of non-forest area as used here denotes agricultural land, settlement, open forest and barren lands.

3.7 CLASSIFICATION

Land use map for the year 1975, 1992 and 2005 have been created using Quantum GIS for land use analysis (shown in Figures. 4.1, 4.2, 4.3). The steps followed for analysis are - (a) Digitization of different classes using polygon tool, (b) displaying all the different classes in the same layer, and (c) calculating area of each class. These data of three years was analyzed and changes in land use pattern detected by creating a land use table (Table 4.1) which featured area of different classes.

3.8 LIMITATION OF THE STUDY:

The major limitation of the study is that the resolution of all the three images is not the same. The 1975 MSS image has a resolution of 79m whereas the 1992 and 2005 images which were acquired through Thematic Mapper have a resolution of 30m. Therefore, accuracy of results yielded from 1975 image is less than that from 1992 and 2005 image.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 RESULTS AND DISCUSSIONS

This chapter describes results of land cover and land use analysis of multi-temporal satellite images. The results are shown in Table 4.1.

Table 4.1: Land use land cover mapping

Land use/Land cover	**1975**		**1992**		**2005**	
	square km	%	square km	%	square km	%
Quarry	0.96	0.26	6.03	1.6	11.8	3.2
Dense forest	204	55.3	181	49.1	172.5	46.8
Water body	1.0	0.27	0.6	0.16	1.37	0.37
Non forest area	162.44	44.17	180.77	49.14	182.73	49.63
Total	368.4		368.4		368.4	

The data presented in Table 4.1 represents the area of each land use land cover category of the three different years.

During the period from 1975 to 2005 quarry area increased by 10.8 square kilometer, a percentage increase of 1125. Dense forest area saw a decrease during the same period from 204 to 172.5 square kilometer. The change in area of dense forest was the maximum when compared with all the classes. Water body increased from 1.0 to 1.37 square kilometer during the period

1975-2005. There was an increase in non-forest area which may be attributed to an increase in settlement area, barren land and deforestation activites.

The land cover land use maps of the year 1975, 1992 and 2005 are shown in Figure 4.1, 4.2 and 4.3 respectively.

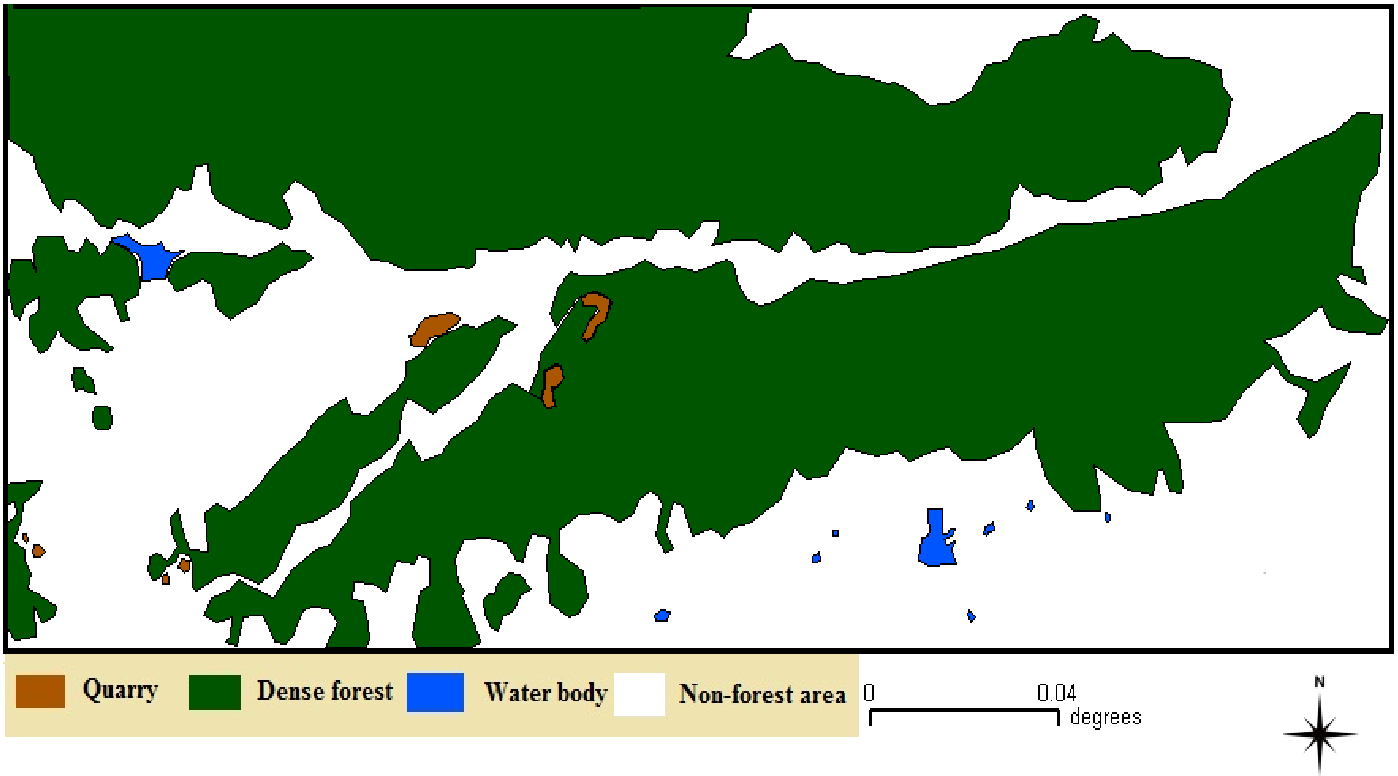

Figure 4.1: Land use land cover map of Sukinda in 1975

The 1975 map shows that most of the study area is covered by dense forest. In 1975 area occupied by quarry was only 0.96 square kilometer, 0.26 percent of the total area. Dense forest occupied 204 square kilometer, which is more than 55.3 percent of the total study area. Area of water body was 1 square kilometer, only 0.27 percent of the total study area. Non-forest area was 162.44 square kilometer which was 44.17 percent of the total area.

In 1975, quarries occupied the minimum area whereas dense forest and non-forest land percentage was the maximum.

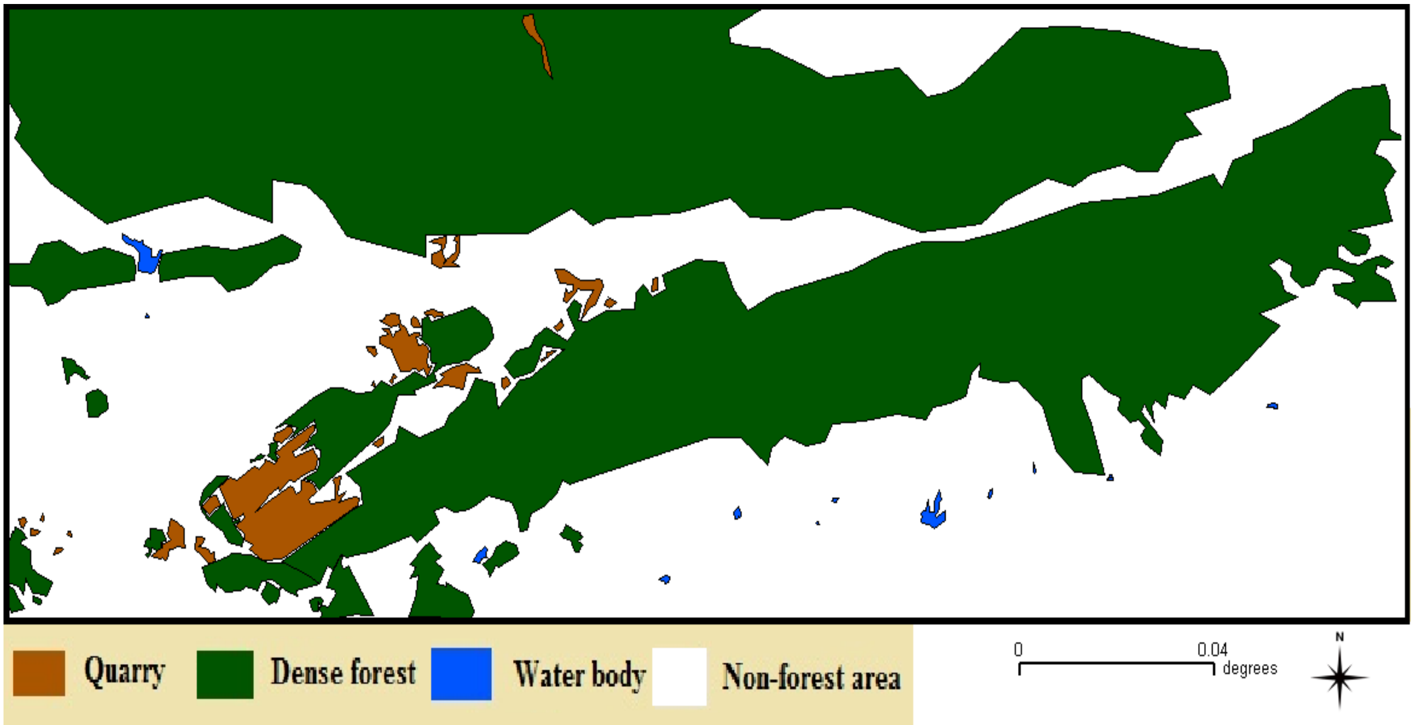

Figure 4.2: Land use land cover map of Sukinda in 1992

In 1992, land use land cover pattern has changed drastically with respect to 1975. Area under dense forest witnessed a huge percentage decrease of more than 12 percent. Area occupied by quarries increased from 0.96 square kilometer to 6.03 square kilometer. This was accompanied by a decrease in water body from 1 square kilometer to 0.6 square kilometer. In 1992, dense forest and non-forest land occupied the largest classes with total of 98% of the total class. Water body takes up the least percentage of the total class. It is estimated that almost all the decrease in dense forest area is due to the fact that forest land have been utilized for mining and related activities and also due to human pressure on forest for firewood as well as grazing of cattle in the forested area.

In 2005, area under quarry increase to 11.8 square kilometer which is more than 3 percent of the study area. There was a decrease in dense forest area from 181 square kilometer to 172.5 square kilometer. This decrease can be attributed to the increase in mining area. Water body increased from 0.6 square kilometer to 1.37 square kilometer, a threefold increase. Non-forest land increase from 180.7 to 182.7. This increase was due to increase in settlement area since migration of population took place due to increase in mining activities.

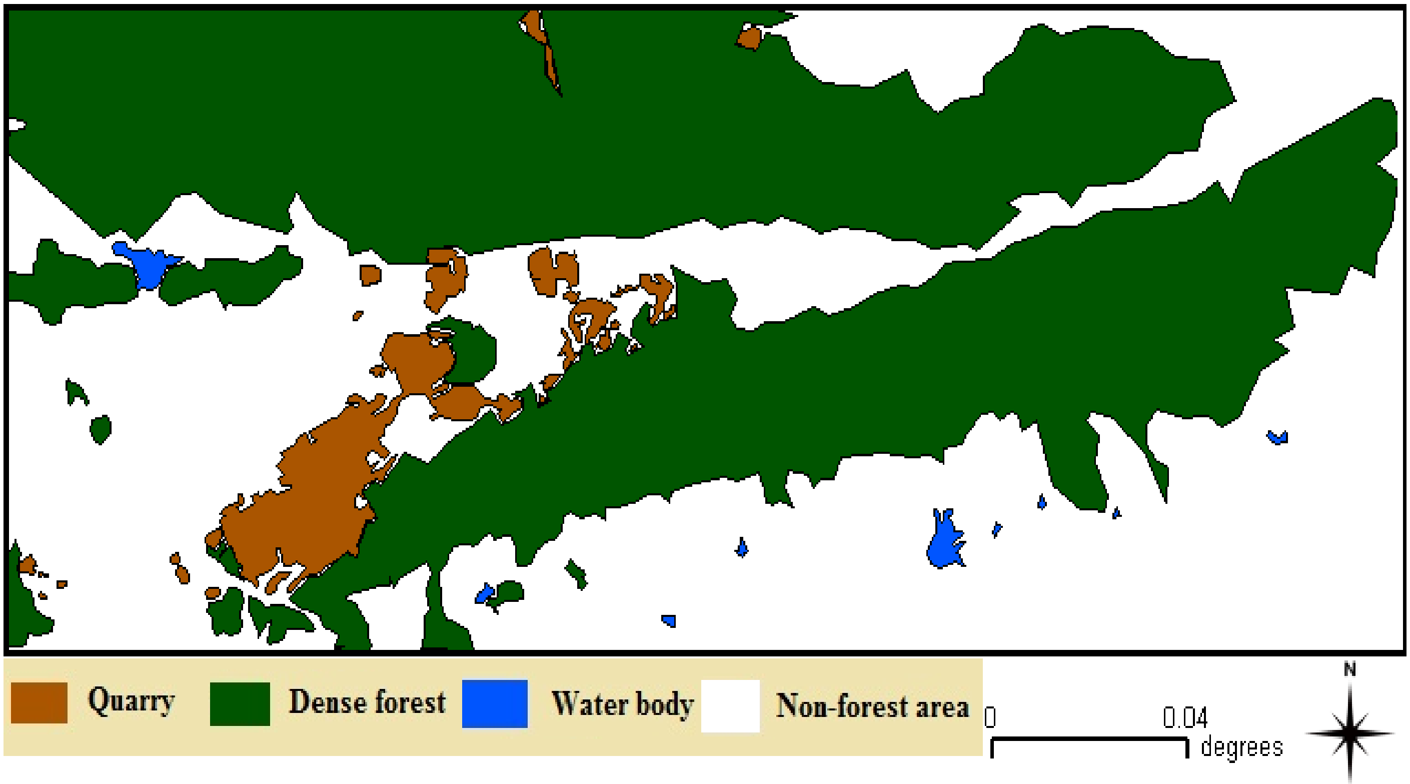

Figure 4.3: Land use land cover map of Sukinda in 2005

4.2 CHANGES IN DIFFERENT LAND USE/LAND COVER

Prakash and Gupta (1998) in their work on the land use/land cover changes of Jharia coal field of India have concluded that mining operation possess a serious threat to the vegetation. Ghosh (1998) affirmed that the mining activities lead to the change in the natural topography of the region.

With the advent of mining operation, apart from quarries, considerable portion of the dense forest was converted to non- forest area such as settlement, roads and grasslands. Most of the dense forest areas and agricultural fields were converted into mining areas. Thus the increase in mining area can be attributed to the decrease in dense forest and agricultural land. Increase in mining activities caused increase in settlement by migration of people into the area.

CHAPTER 5

CONCLUSION

The result of the work showed that there was a rapid change of quarry and dense forest during the period from 1975 to 2005. Therefore, it can be concluded that increase in mining activities is damaging to vegetation. The present study can useful to identify the vegetation areas which are under risk due to mining activity.

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