



Application of Geospatial Technology for Landscape Monitoring in and around Mangampeta barytes Mine, Andra Pradesh India

M. Prasad^{1*}, M. Ramakrishna Reddy¹ and V. Sunitha²

¹Department of Earth sciences, Yogi Vemana University, Kadapa, A.P, India -516005

²Department of Geology, Yogi Vemana University, Kadapa, A.P, India -516005

Email: mannalaprasad@gmail.com

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Abstract

Mining is a nation building activity need to be encouraged, conserved and monitored. A successful mining requires a series of events like geological studies, mineral exploration, mining plans preparation, environment impact studies and successful execution of the mine. Landscape dynamic study in a mining area, is an important component in mining plans and during extraction as well. Application of geospatial technologies in the recent times is providing a sound base in quicker and accurate means change detection, continuous monitoring and environmental impact assessment of a mine over conventional methods. Mangampeta barytes is one of the world famous barytes deposits of its kind in terms of origin, quantity and quality as well. Here extensive, rapid and continuous mining activity is going on by opencast mining method, where landscape studies are of utmost importance due to removal of huge amounts of Overburden. The present study confer the Geospatial techniques utilized for the classification of various Land use and land cover (LULC) classes on satellite imagery and recognition of spatio-temporal changes in land use patterns for betterment of the society. LISS-IV satellite data is used for monitoring these changes in landscape. LULC maps were generated and analyzed for the years 2005, 2009, 2012 and 2015 using Arc GIS 10.3 software. Results revealed that the mining activity has drastically distorted the natural landscape in and around the barytes mine. This is due to removal of overburden and ore, transportation and tailing and stock yards, establishment of pulverizing mills, and barium manufacturing units around Mangampeta took place by resulting conversion of fertile agricultural lands and plantations into mining /industrial areas which needs to be monitored and conserved.

Introduction

The global need to balance ever growing energy needs have an adverse effect on the landscape, ecology and environment, particularly developing nations like India which needs steady economic growth, which in turn lead to over exploitation mine waters is don of natural resources by mining, deforestation, agricultural expansion and urbanization to meet the escalating human needs (Areendran, *et al.*, 2013). At present, landscape dynamic studies have become an essential apprehension, which in turn is an indicator for change in the environment and ecology of the whole world (Ruiz-Luna and Berlanga-Robles, 2003; Garai and Narayana, 2018). The mining industry holds significant contributions to the Indian economy (Mehta, 2002; Tripathy *et al.*, 2012, Mondal *et al.*, 2014). Advancement in mining equipment and technology lead to hasty changes in landscape, ecology and hydrology of the particular region (Turner and Ruscher, 2004; Singh, 2007). A sustainable mining activity requires uninterrupted monitoring, recognizing the long-standing impacts of mining on the environment as well as landscape, (Gupta, 2015). Unplanned mining of minerals causes is a serious threat to the environment, which results in deforestation, soil erosion at a large scale reduction of land, water and air pollution, in biodiversity (UNESCO, 1985). Hence, the change in landscape in and around the mining area needs a time series monitoring. Thus data available on LULC changes can offer critical input to decision-making of environmental management and planning the future (Prenzel, 2004; Fan *et al.*, 2007).

The Proterozoic Cuddapah Basin is storehouse of about 90% of the known barytes reserves in India and around 25% of the world. Mangampeta barytes is the single largest deposit in the world of its kind (Neelakantam, 1987; Sunitha, *et al.*, 2015) with 70 million tons(MT) of barytes, which is estimated to have an initial reserve of 37 MT with a cut-off grade of specific gravity 4.2 or higher (Clark *et al.*, 2004). Geologically the study area consists Cumbum shale and Bairenkonda quartzite formations of Nallamalai group of Cuddapah Super group (B.K Nagaraja Rao, 1987). It is an unique deposit in terms of mineralogy, origin, occurrence, quantity and quality of barytes (Neelakantam, 1987). It is being operated by open cast mining method by the Andhra Pradesh Mineral Development Corporation Ltd., (APMDC), since 1976. When there was not much environmental concern and environmental regulations on mining sector, which lead to uncontrolled and unplanned mining in terms of removal of overburden and selecting the dump yards for millions of tones of overburden. Mangampeta Barytes Mine being an open pit mine, it has been producing the overburden since 1970's till to date, resulting in huge amounts of waste rock files. It's serving barytes for about 172 pulverizing mills and 28 barium chemical industries around the mine (APMDC, 2016). However previous researchers worked in this area confined to conventional studies like origin of the ore body, geology, geochemistry, hydrogeology (Neelakantam, 1987; Nagaraju, 2006; Shalini, 2015), biogeochemistry of Mangampeta barytes deposit (Raghu, 2007). Hence, there is lack of literature/ studies on landscape, LULC pattern and its impact on the environment and society, which is an essential as hydrogeology and geochemistry. A study of the change

over a period of a decade (2005 - 2015) will certainly help in assessing the impact of the mining operation and also in understanding future probable disturbance to the landscape and ecology in case of enhanced mining operation.

A systematic multidisciplinary approach of mapping and monitoring the impacts caused by the mining activities is essential to understand the nature and extent of these hazardous events in an area (Woldai, 2001). Geospatial technology plays a vital role in environmental monitoring and reclamation of mining areas of different time periods and for remote areas (Parks *et al.*, 1987; Rathore and Wright, 1993; Singh *et al.*, 1997; Schmidt and Glaeser, 1998; Mouflis *et al.*, 2008; Koruyan *et al.*, 2012; Senthil Kumar *et al.*, 2013). Further, provides a broad-spectrum of innovative and cost effective solution for environmental monitoring (Chigbu and Onukaogu, 2013). Recently, spatial data became an essential source of information in decision making, which leads to better interpretation and conclusions in natural resource monitoring as well as conservation activities (Philipson and Lindell, 2003; Navalgund *et al.*, 2007). The present study is intended to illustrate the significance of geospatial technology in efficient environmental monitoring, in and around Mangampeta barytes mine (during 2005-2015) and to assess the current position of the natural resources and their relationship with the surrounding environment.

Study area

The barytes deposit located within Mangampeta village, Obulavaripalle Revenue Mandal, in southern part of YSR District of the Andhra Pradesh State of southern India. Area has chosen for study as buffer zone of 10 km around the mine location 14° 01' 00" North latitude and 79° 19' 00" of the East longitudes covering an area of 314 km². Administratively the study area covers an area from parts of the Obulavaripalle, Koduru, Chitveli, Pullampeta revenue mandals as shown in the figure 1. The study area proposed boundary lies in Survey of India topographic sheets # 57N/04, 57N/08, 57O/01 and 57O/5 on 1:50,000 scale.

Physiography and climate

Among the major physiographic divisions of Andhra Pradesh, the study area covers an interior uplands and plains encompassing Rayalaseema region and forms a part of the peninsular shield in India. Though the area receives rainfall from both monsoons (Northeast and Southwest), geographically it is a part of rain shadow region of Andhra Pradesh. The annual normal rainfall of the district is 750 mm (CGWB, 2013). The district receives 70% rainfall between June to September, and the rest of 20% during October to December, and remaining 10% during the remaining months. The nearest rain gauge is located in the premises of Tahsildar office situated in Obulavaripalle the Mandal head quarter, which is 9 kms away from the Mine. The successively deficit nature of the rainfall tends to put intense stress on groundwater in the region. May is the hottest month

with a mean temperature of 45⁰ C and January with a mean temperature of 25⁰ C is warm. The overall climate is dry except during the South-west monsoon season (June-October). The maximum and minimum elevations of the study area are 1087m and 101m with reference to mean sea level (MSL) respectively. The North-west, South-East and North-east part of the study area is covered by massive structural hills, ridges and valleys. North-west trending Gunjanavagu River, flowing through Kammavaripalli, Nagavaram, Vaddepalle, Malaimarpuram is the main tributary to the Cheyyeru River (Janardhanraju, *et al.*, 2007).

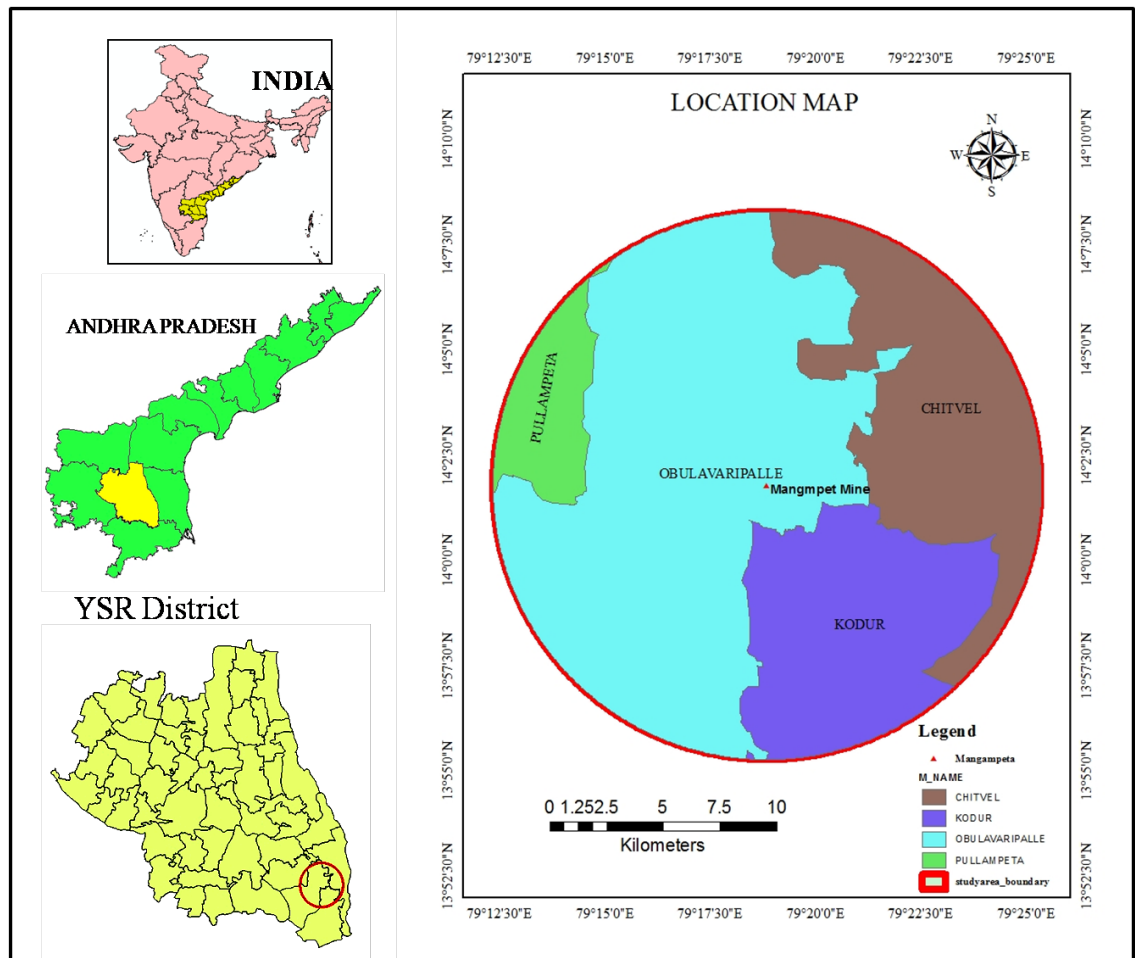


Figure1 Location map of the Study area

Demography: As of 2011 Census, the Obularipalle Revenue Mandal has 15 settlements, among those one is census town and 14 are revenue villages. Mangampeta is the only urban settlement, categorized as Census town (CT) in the Mandal. Mangampeta

population is (CT) 5175 according to census 2011. Among them males are 2750 and females are 2425 living in 1171 houses (www.onefivemaps.com).

Irrigation: Most of the cultivation in the study area is under dry conditions as there are no perennial rivers, streams or tanks and the existing ones depend on rainfall. Tube wells are the major source of irrigation followed by canals and tanks. Major crop types are banana, mango, lime, papaya, betel leaf and paddy. Kodur (well known as Railway Koduru) is a nearby town to the study area which is a "Valley of Fruit Farms". It is also called South California due to its vast fruit farms and greenery around the Kodur town ([https://wiki2.org/en/Railway Koduru](https://wiki2.org/en/Railway_Koduru)). With increasing uncertainty of the canal irrigated projects, due to poor river flows, there has been a steady increase in the share of the tube well irrigated area over the years and the share of open wells has declined due to fall in ground water table which is of foremost environmental concern. Mandal wise dynamic groundwater resources assessment of the YSR district reveals that the study area falls in Semi-critical Zone (CGWB, 2013).

Natural Vegetation: The study area contains some large and important forests, among them is Palakonda hill range which is in the systematic conservancy of Madras Forest Act of 1882 (District gazetteer). Those forests have given different names and listed in the reserved forest classification by the Survey of India Topographical sheets. There are five reserve forests with in the 10 Km radius of the study area. Koduru Extension RF is at a distance of 7.2 Km in northeast direction and Chitvel extension RF is at a distance of 7.5 Km in north direction, Maharajapuram block RF is at a distance of 6.8 km in northeast direction, Seshachalam extension RF is at a distance of 7.9 km in southwest direction and Tunakonda RF is at a distance of 8.5 km in south direction.

Geomorphology: The geomorphic landforms in the study area are broadly divided into three categories namely structural landforms, denudational landforms and fluvial landforms based on the geomorphic expression, slope factor, relief, depth of weathering and surface cover with soil or vegetation. The major geomorphic units of the study area are residual hill, pediment, inter montane valley, pediplain, denudational hills, structural hill or linear ridges, valley fills and stream channels and flood plains.

Method and Material

Open cast mining can be better monitored with the aid of geospatial technology. An appropriate data set and processing techniques with successful utilization of Geospatial data for natural resources management and environmental monitoring will provide precise and fruitful results. Hence, selection of the Remote sensing data was done after the reviewing the Remote sensing principles; type of imagery, sensor characteristics, and fundamental limitations that apply to all remotely sensed data and data types used by different applicants in their studies.

Data acquisition and pre processing: High resolution Indian Remote sensing Satellite (IRS) Linear Imaging Self Scanner (LISS) IV data with spatial resolution of 5.8 meters, is acquired from the National Remote Sensing Centre. LISS IV (P6 & RESOURCE SAT) temporal satellite data for the years 2005, 2009, 2012 and 2015 were collected. The survey of India (SOI) toposheets 57 N/8 & 57 O/5 of 1:50,000 scale were used along with collateral data, as well as other supporting data like geological maps and published literature. Visual interpretation and digital classification are two major tools for getting land use/land cover information from satellite imagery in preparation of base map and thematic maps. The study was carried out in three phases. In the first phase satellite and collateral data were collected and Digital Image Processing and Enhancement was employed in ERDAS Imagine Software. The enhanced imagery projected to UTM WGS 84 projection, clipped to Area of Interest (AOI) i.e., Study boundary, thematic maps on LU/LC prepared based on the visual interpretation in Arc GIS 10.3 Platform, while in the second phase, detailed field works were conducted for ground truth in the doubtful areas regarding the first phase mapping of LU/LC Classes and changes were incorporated after the ground verification. The third phase included database creation and geospatial evaluation of the landscape changes. LULC maps were prepared for the years 2005, 2009, 2012 and 2015 in Arc GIS 10.3 software. Further change detection analysis is also carried out to emphasize the mining effect on the land use and land cover and their impacts on the environment.

The LU/LC categorization for present study is envisaged based on the classification scheme developed by National Remote Sensing Centre (NRSC, 2006). The modification in the categories at sublevel is done keeping in view the area under investigation. The LU/LC maps depicting nine LU/LC classes were prepared for the four periods viz. 2005, 2009, 2012 and 2015 (Figures 2-5) and development, analysis is carried out to compare the land cover type. The area covered under each of the classes and the changes in area is given in Table:1 and Figure: 6 as well as each class change in percentage during 2005-2015 (Figure: 7). It was found that higher ridge areas are mainly covered by dense or open forests while scrub land are found in the low lying areas. The plains and the lowlands are dominated by cropland plantation and scrub/ fallow land. Built up areas are well distributed in the entire area, most of them occurring in the vicinity of agricultural lands. After obtaining detailed LU/LC information the attribute data of land use, land cover of the study area is generated and compared with regards to various features that indicated significant changes.

Results

A brief description of the image characteristics of the land use/land cover, as given in the classification with the use of land use maps for the years 2005, 2009, 2012 and 2015 is described below.

Table: 1 LULC areas in Sq. Km and percentages for the years - 2005, 2009, 2012 & 2015.

LULC class / Description	2005		2009		2012		2015	
	Area in Sq.Km	Area in %	Area in Sq.Km	Area in %	Area in Sq.Km	Area in %	Area in Sq.Km	Area in %
Crop land	116.56	37.11	121.76	38.76	130.31	41.48	124.82	39.74
Agriculture plantation	47.82	15.22	53.22	16.94	59.73	19.02	63.14	20.10
Settlements	9.3	2.96	9.31	2.96	9.73	3.10	10.57	3.36
Mining / industrial	3.49	1.11	3.74	1.19	5.82	1.85	7.93	2.52
Forest	40.96	13.04	40.91	13.02	40.85	13.00	40.79	12.99
Canal	0	0.00	0.21	0.07	0.25	0.08	0.27	0.09
Reservoir / Tanks	17.89	5.70	18.31	5.83	18.31	5.83	18.31	5.83
River / Stream / Drain	7.61	2.42	7.61	2.42	7.61	2.42	7.3	2.32
Scrub land Open	69.76	22.21	58.32	18.57	40.19	12.79	39.67	12.63
Transportation	0.73	0.23	0.73	0.23	1.32	0.42	1.32	0.42
Grand Total	314.12	100.00	314.12	100.00	314.12	100.00	314.12	100.00

Agricultural land

It is defined as the land primarily used for farming and for production of food, fiber, and other commercial and horticultural crops. It includes land under crops (irrigated and fallow land) plantations etc.

Cropland: In the present study crop land is the major LULC class, which occupies majority of the study area covered with crop lands. Crop area was 37.11 percent (116.56 Km²) in 2005, increased to 38.76 percent (121.76 Km²) in 2009, 41.48 percent (130.31 Km²) in 2012, but it decreased to 39.74 percent (124.82 Km²) in 2015; this decline may be due to the increase of plantations. Overall net change from 2005 to 2015 is 16.27 Km² of the total project area and it is mostly converted from Scrub lands in to agricultural lands in the southern and north eastern parts of the study area

Plantations: In the present study area mango, banana citrus, coconut and papaya are prominent. Agricultural plantation was 15.22 percent (47.82 Km²) during the year 2005, increased to 16.94 percent (53.22 Km²) in 2009, 19.02 percent (59.73 Km²) in 2012 and again increased 20.10 percent (63.14 Km²) in 2015. On the whole, this class shows an increasing trend from 2005 to 2015. The net change is 15.32 Km² of the total project area and it was coming mostly from agricultural lands and Scrub lands converted in to plantations and orchards in which they were developed all along the Gunjanavagu river and scrub lands near Kodur- Chitvel reserved forest (south eastern parts of the study area). Kodur is the region which produces good quality of mangos and banana of export quality.

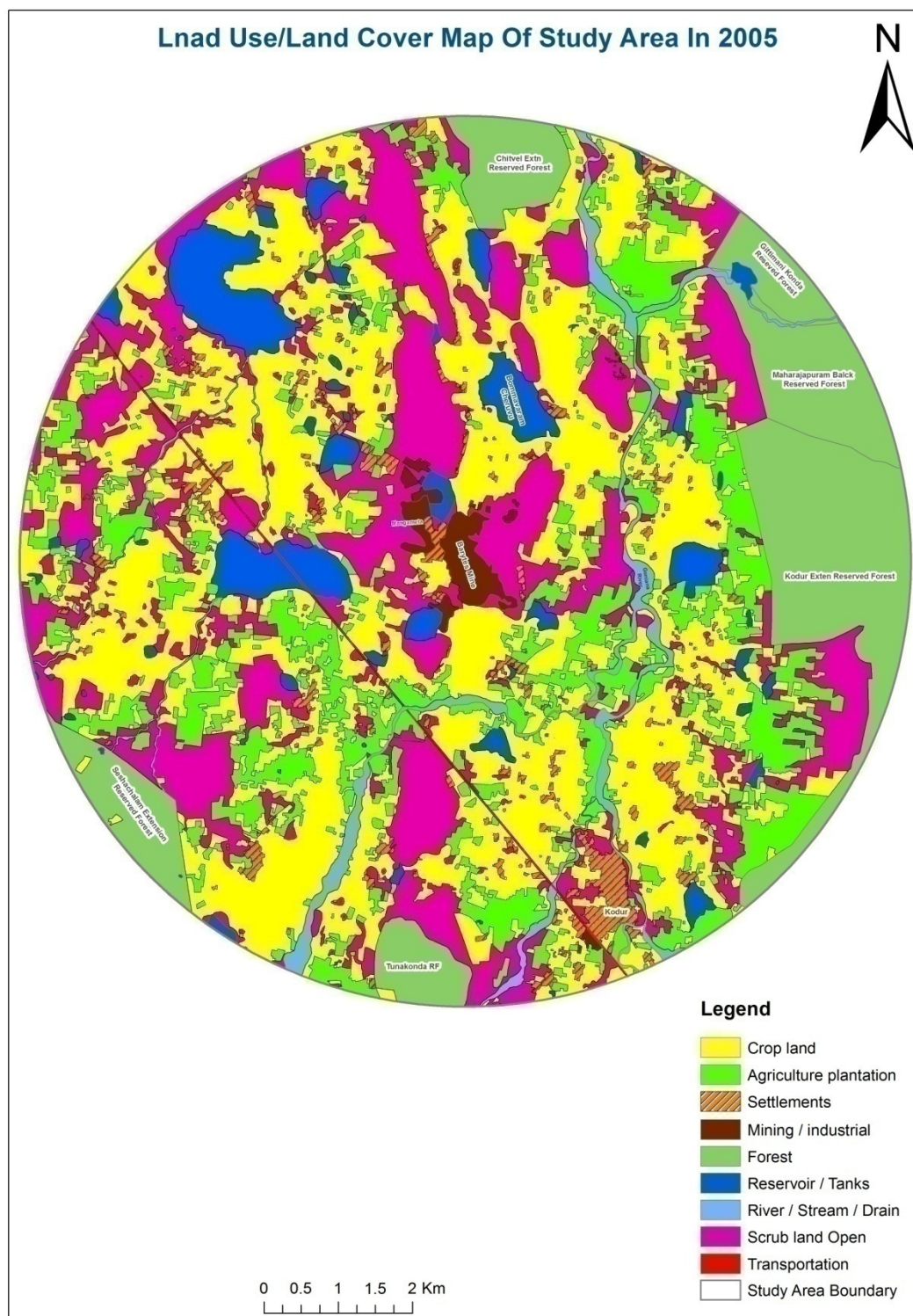


Figure 2 LULC Map of the Mangampeta barytes mine area for the year 2005.

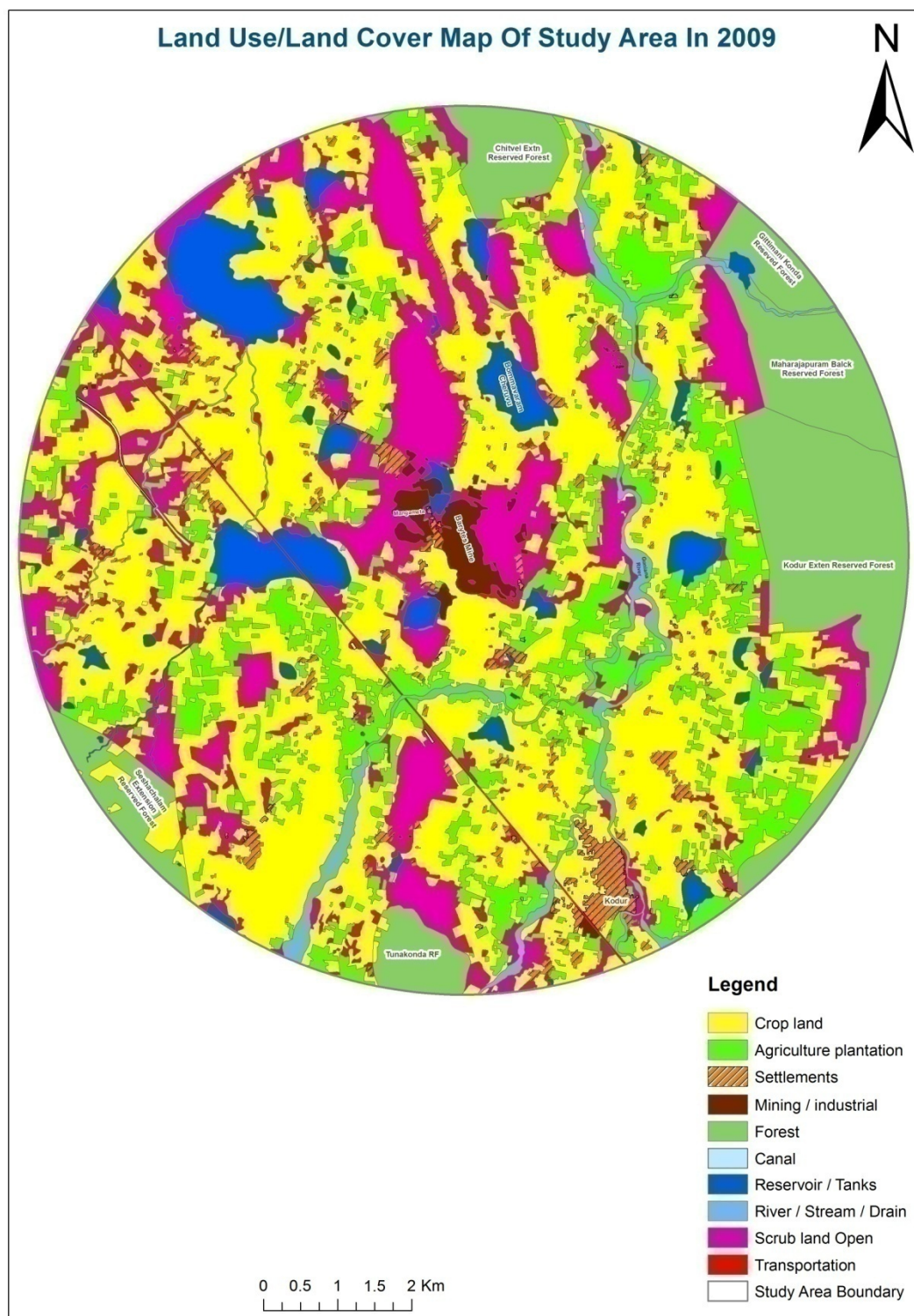


Figure 3 LULC Map of the Mangampeta barytes mine area for the year 2009.

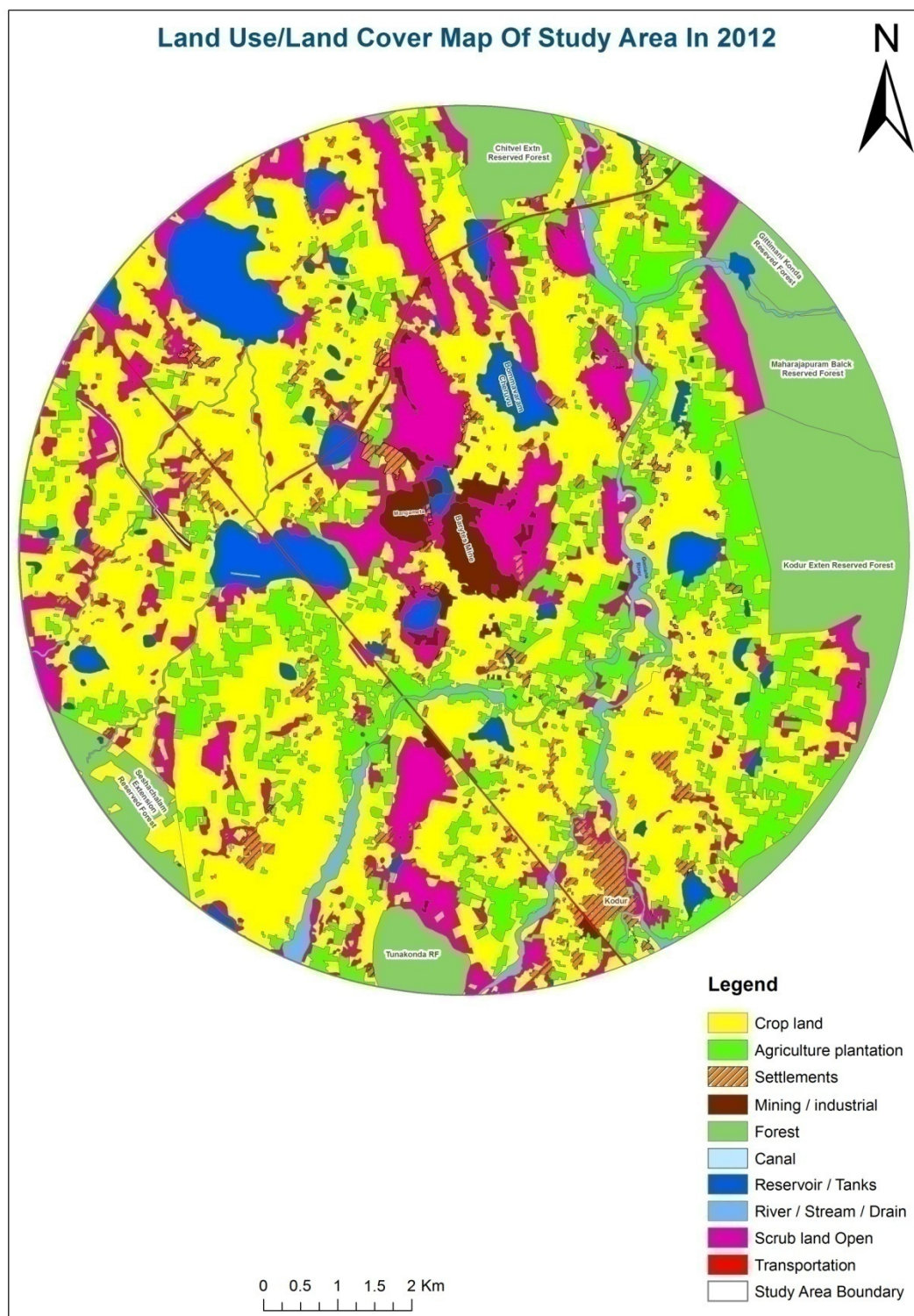


Figure 4 LULC Map of the Mangampeta barytes mine area for the year 2012.

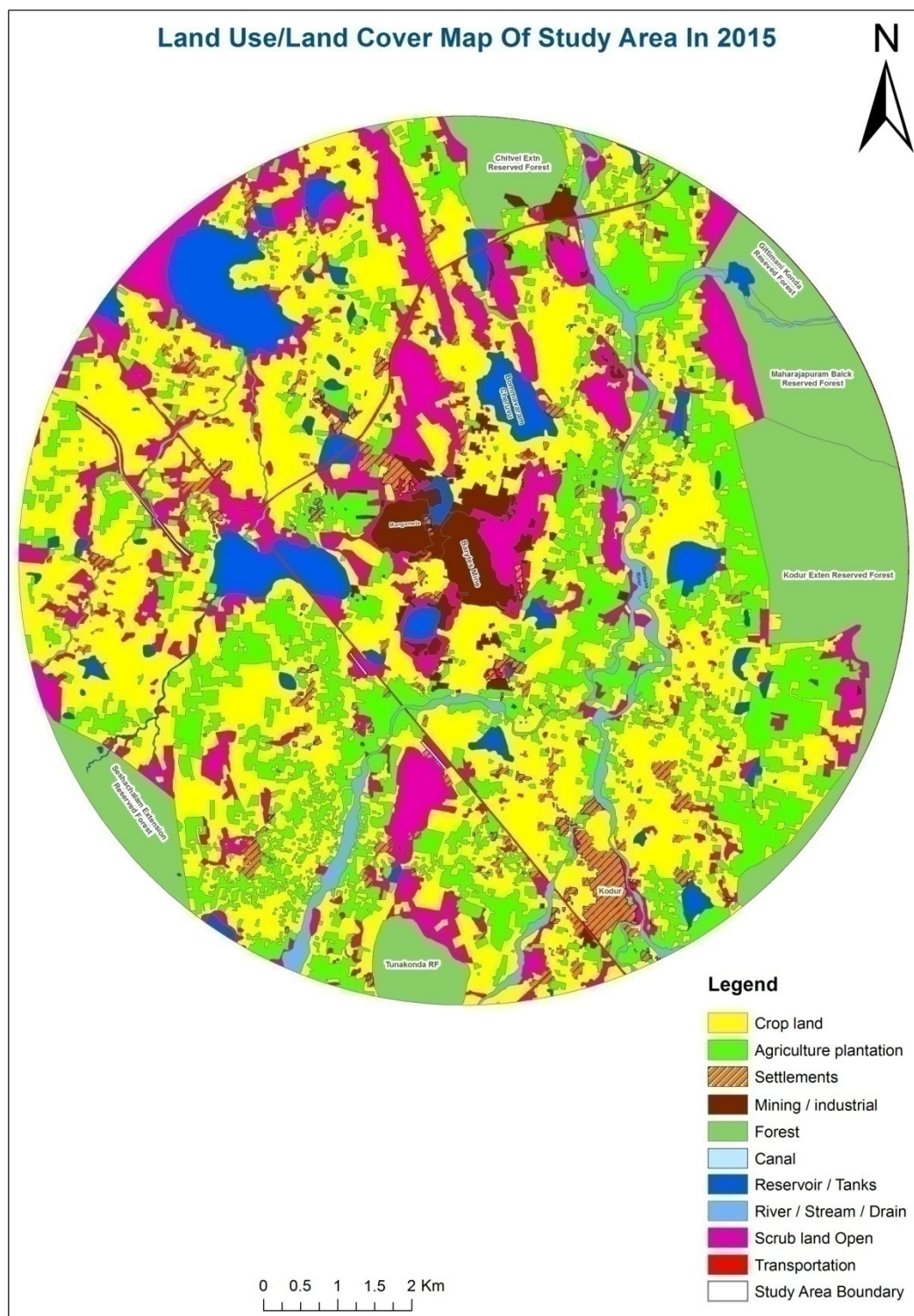


Figure 5 LULC Map of the Mangampeta barytes mine area for the year 2015.

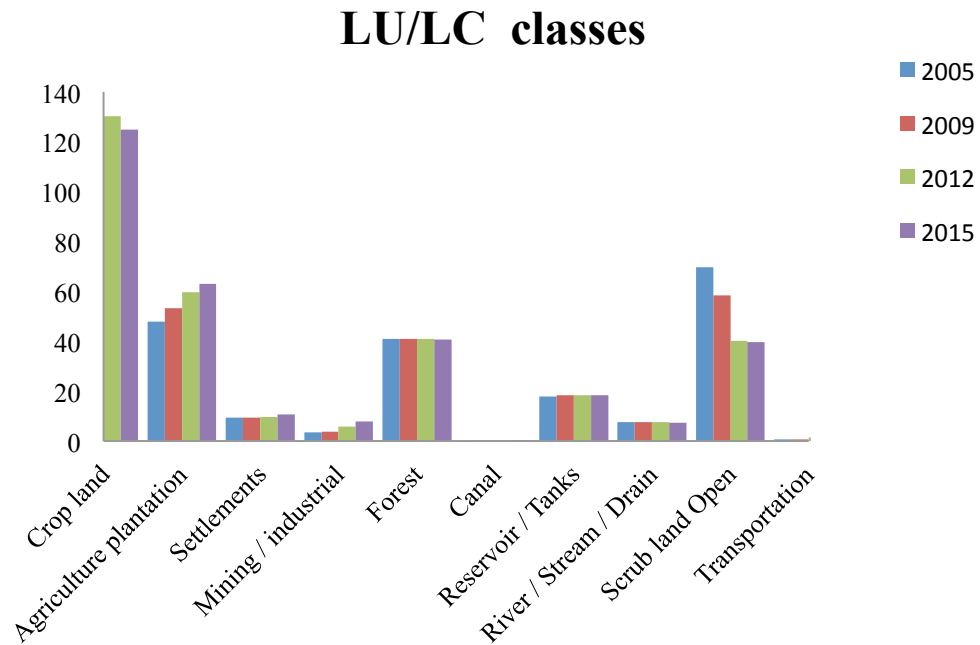


Figure 6 Showing the individual LULC classes area for the years - 2005, 2009, 2012 & 2015.

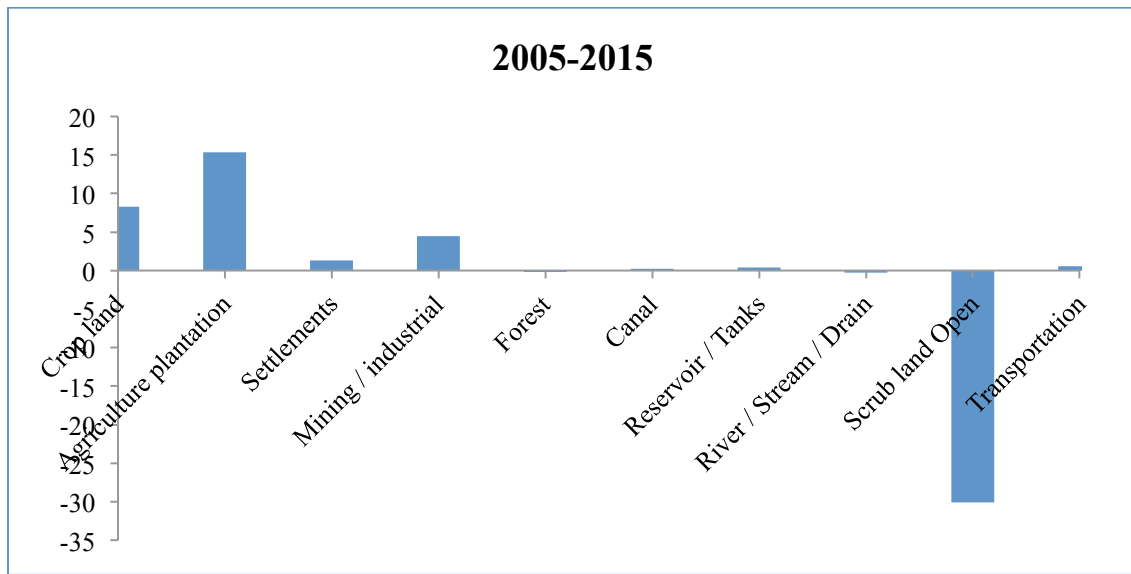


Figure 7 LU/LC change in percentage during 2005-2015.

Settlements/ Built-Up Land

The major changes in this class observed in the surroundings of Mangampeta and Kodur areas study area mainly falls in the rural area significant change in settlements as follows. This class was 2.96 percent (9.3 Km^2) in 2005 there was no considerable change during 2005-2009 in this class, but was increased to 3.10 percent (9.73 Km^2) in 2012, and 3.36 percent (10.57 Km^2) in 2015. The overall growth of settlements from 2005 to 2015 was 1.27 Km^2 which is minimal when compare to other classes. Reason for this the study area mainly covered by rural area.

Transportation

A new railway line from Obulavaripalle to Nellore which links to the Krishnapatnam Sea port is another major change after mining and canal developments. Transportation along with minor diversions/modifications is also observed. The railway construction is taken up in 2012 and 2015 and is shown in imagery hence there is no remarkable change up to 2009 with 0.23 percent (0.73 Km^2). Further this class extended to 0.42 percent (1.32 Km^2) in 2012 and 2015.

Mining / Industrial

This is the chief component in the present area which is highly dynamic and has positive growth rate. This class was exponentially developed due to intensive mining, continuous removal of overburden from the mine (Plate 1). The mining activity was expanded to northwestern part of the mine it may be due to the availability of land for dumping the overburden as well as the ore body and milling processes (Figure 9). Further, there was no scope to expand the dumping sites other than the north - north western side due to land use pattern with high value of agricultural croplands and eastern and southern sides covered by built-up land, overburden dump yards, pulverizing mills (Mangampeta administrative offices, tailing tanks and rehabilitated village in the northern side.)

The mining/ industrial area has amplified to 3.49 to 3.74 Km^2 (0.3% of the total area 314.12 Km^2) during 2005-2009, whereas it is increased 3.74 - 5.82 Km^2 (0.46 % of the total area) during 2009-2012. From 2012- 2015 this area expanded $5.82 - 7.93 \text{ Km}^2$ (0.26%). Hence it is clear that a net increase during 2005-2015 from 3.74 - 7.93 Km^2 , the mining / industrial area was expanded 4.19 Km^2 .

Forest

This is an area within the notified boundary bearing an association chiefly of trees and other vegetation types capable of producing timber and other forest produce. Majority of the forestlands in the study comes under reserved forest category which is

conserved by forest department under the law, hence there is no much change in the forest area.

Water bodies

These are the areas with impounded water, areal in extent and often with a regulated flow of water. It comprises rivers/streams, natural lakes and creeks beside manmade reservoirs / lakes/ tank/canals.

River/Stream/ Drain: In the present study area, an N-S trending Gunjanavagu river flowing through Kammavaripalli, Nagavaram, Vaddepalle, Malaimarpuram is the main tributary to the Cheyyeru River. it is observed that Rivers / Streams covered 2.42 percent (7.61Km^2) land in 2005, In this class there was no change up to 2012, but it was decreased to 2.32 percent (7.3 Km^2) in 2015. Overall net change from 2005 to 2015 is 0.1 Km^2 .

Reservoir/Tank: Orampadu, Korlakunta and Govindampalle tanks are major tanks in the study area. This class was 5.70 percent (17.89 Km^2) in 2005, increased to 5.83 percent (18.31Km^2) in 2009 this is due to the development of pulverizing plants near the mine and there was no significant change up to 2015 with overall net change from 2005 to 2015 is 0.42Km^2 ; this may be due to the fluctuations in rainfall and discharge of groundwater from the study area.

Canal: Canals are inland waterways used for irrigation and sometimes for navigation. This class identified in western part of the study area where a canal is made, which is under progress. Changes are clearly captured by the temporal data and are neatly mapped. There is no trace of canal in the year 2005, but it is clearly identified on image for the year 2009 with 0.07 percent (0.21 Km^2), 2012 with 0.08 percent (0.25 Km^2) and 2015 with 0.09 percent (0.27 Km^2). Even though this class occupies smallest area among all classes, it is an important change that took place during the study which not present earlier.

Scrub land

In the present study scrubland is the most important LULC class, which is showing a continuous decreasing trend throughout the study period from 2005-2015. Scrubland is 22.21 percent (69.76 Km^2) in 2005, decreased to 18.57 percent (58.32 Km^2) in 2009, 12.79 percent (40.19 Km^2) in 2012, and further decreased to 12.63 percent (39.67 Km^2) in 2015. Overall net change from 2005 to 2015 is 30.09 Km^2 of the total project area and it has been converted into Mining / Industrial / pulverizing mills in the central part in and around barytes mine and agricultural crop/ plantation from scrub lands converted in to agricultural lands in the south western and North eastern parts of the study area.



Figure 8 Google earth image of the Mangampeta Barytes Mine and adjacent areas (captured on 2/4/2017).

Mining Impact Assessment

Impact on Landscape: Land is one of the rich natural resources and is the major source for all living and non-living things. Mining can cause physical disturbances to the landscape such as open pits, overburden removal, ore dumping, screening and processing plants and overburden stack piles. Apart from that, it is not feasible to attain the pre mining landscape after mining which results loss of fertile soils, plant and wild life biodiversity. The open cast mining effects/affects the land use and land cover change that lead to environmental degradation. Day after day, it has increased and it's affecting the environment directly the results of land use/ land cover impact assessment is based on interpretation from satellite data and different collateral analysis. From the study of satellite image during the years of 2005, 2009, 2012 and 2015, collateral data and field verification carried out for identifying, quantifying and analyzing the spatio-temporal response of the landscape due to mining activities by the study. Those are the LULC impacts areas clearly identified by the LULC change and trend analysis. This comparative three years study has provided insights regarding the changes in land use pattern especially in the agricultural land, forestland, surface water and settlement. We found the following assessment and impact on land use and land cover.

It is observed that because of changes in land use and land cover pattern, pollution & socio-economy level has increased enormously in the surrounding area and during the

recent years it has attained the critical level. Scientific approach during mining activities has to be adopted in order to minimize the land use and land cover pattern.

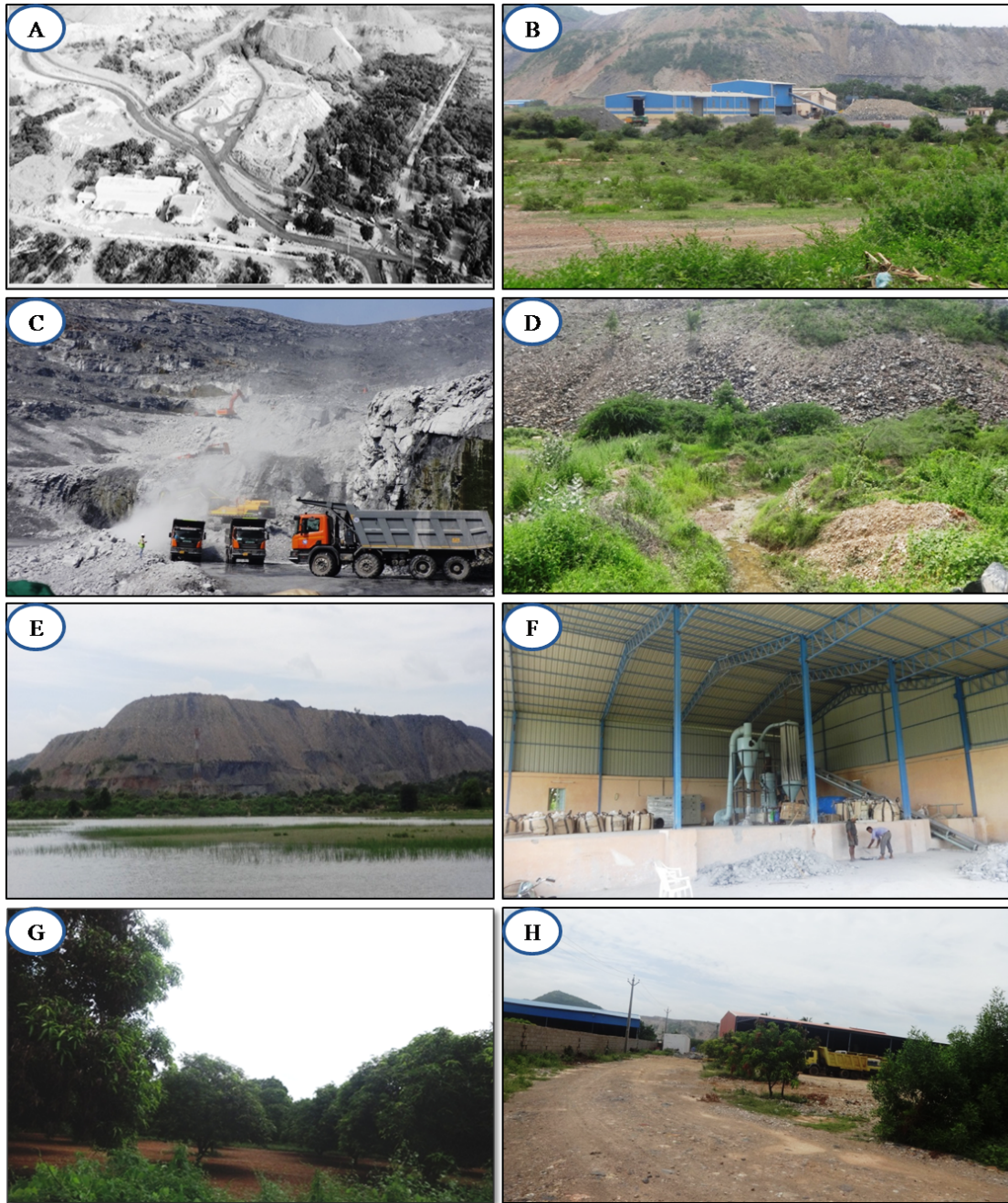


Plate:1 Showing field photographs of various land use/ land cover classes in the study area. A) Areal view of mine dumps and ore dumping yards, (Source: APMDC); B) Pulverizing mills near the mine and Overburden (back ground); C) Mining activity; D) Rain water seepage from dump; E) Govindampalle lake near the dumps; F) Pulverizing mechanism in the mill; G) Mango Plantation; H) Plantation land converted as Mill area.

Impact on Human : Human beings as individuals are an integral part of nature. In fact, the ultimate goal of all the mining and other industrial activities is to provide comfort to human beings individually. So, if any such activity causes harm to life (diseases), its purpose is defeated. In many countries, human health is, regarded as the biggest and the most valuable asset. Therefore, knowledge of the environmental impact of mining on health of individual human beings is of no less importance (Chatterjee, 1993). Mining Impacts on human health is based on the survey and data collected for assessing the water quality and prediction of the impact due to mining activities in the study area. Water quality is poor due to presence of high total dissolved solids, total hardness, sulphates and specific conductance etc. (Nagaraju *et al.*, 2006). The major impact of mining and other industrial activities on human settlements in Mangampeta are as follows: The old Mangampeta village (where the present mine was located) was rehabilitated to new village with good quality houses, roads and drain systems. Surrounding agricultural fields are converted in to industrial areas like beneficiation plants, pulverizing mills etc. Farmers of leasehold area have lost their employment and working as low scale employees and as labor in surrounding mills. The mining activity facilitated in improvement of the economic status of the people around the mine area. For local people, due to provision of more infra-structural facilities, provided by local mining industry is a boost up in the local market, which has invited people from different places to install their ancillary mills and pulverizing units in and around Mangampeta, Govindampalli, Kapupalli, Agraharam villages. Good infrastructural facilities for high school education, primary health centre and Mineral water facility is being provided by the APMDC for rehabilitated Mangampeta village.

Conclusions

Temporal change detection analysis was carried out by using the high resolution multi spectral IRS LISS- IV satellite data during the years 2005, 2009, 2012 and 2015. The output from these analyses clearly shows that the major changes in MINING/ INDUSTRIAL sector in and around the Mangampeta barytes mine by increasing 3.49 to 7.93 km² from 2005 to 2015. Establishment of 172 pulverizing mills, and 28 barium manufacturing units around Mangampeta took place by resulting in conversion of fertile agricultural lands and scrub lands in to industrial areas and plantations during 2012 to 2015. Huge amount of overburden material excavated during open cast mining is dumped in the vicinity of the mine sites. Flow of silt from overburden dumps causing degradation of land and disruption of water flow. The waste material mainly consists of weathered rock and intercalated wastes which are both toxic and nontoxic in nature by contaminates. on the whole extreme demand on land, lead to drastic shrinkage of scrublands up to 2012, thereafter agriculture lands for the establishment of mining and its associated activities were used, which is an alarming sign for conservation of agricultural lands.

To minimize or mitigate the mining impact on the landscape and ecology here are some recommendations after the detailed study. Dumping should be done in a phase wise

manner with a flat surface, overburden should be separated with specified dump yards, Tuff/ black shale should be dumped away from the tanks and stream so as to minimize the sulphide contamination in the soil, water as well as air. Further mining needs to excavate large quantities of overburden; hence it is advised to demarcate clear cut mining lease boundary and specified dumping site should be allocated to avoid lifting and removal of dumping sites (at present in the north eastern bank of the mine is having dump which needs to be removed for further mine extension). All the dumps during the course of mining operation should be protected by constructing Toe wall all along the toe of the dumps, Retention walls to check washing of silt and Plantation should be done all along the toe of the dump and tall growing species should be planted, where it acts as an acoustic barrier and also checks the dust arising from the dump, which is carried by wind convention to agricultural lands. In addition to above, additional protective measures are required, such as bunds, trenches, drains, rubble walls, embankment etc., Green belts are proposed surrounding the mining leases, waste dumps and along the permanent approach roads to the mines. Agricultural crop lands and plantation must be given first priority as so many agricultural fields are being converted as industrial areas like pulverizing mills and beneficiation plants which need to be taken care; for that it is suggested that environmental precautions are strictly followed, while giving permission for locating industrial plants.

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Authors' contribution: M. Prasad (Research Scholar), are responsible for experimental and wrote the manuscript and M. Ramakrishna Reddy (Professor). V.Sunitha (Asst. professor) helped for experiment and designs. M. Prasad is also done final editing and corresponding author of Manuscript.

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