Analysis of Buffer Zones of Limestone Mines Areas using Digital Image Processing Techniques

K.S. Siva Subramanian, Abhishek Kumar Tripathi, Ramesh Kant

Abstract: The economic growth of any country crucially depends on the mining activity of that country. The mining activities require huge land for the extraction of mineral from the earth. The recent government policy imposing the systematic mapping of the land use and land cover in and around the mines. In the present study, work the analysis of land used and land covered was carried out at Malkapur limestone mines. This study discussed the brief mapping of the buffer zones buffer zones areas in by using digital image processing techniques. This research work demonstrated the changes happened in and around mines for the buffer radius of 1 km, 5 km and 10 km. In this study it was found that there were no significant changes observed in land use which intern implies that mining activities are not having any impact in land use changes. Further, in this study, not much variation was reported against the forest land and water bodies situated in and around the mines.

Keywords: Digital image processing, mines, buffer zones, Peak vector sum.

I. INTRODUCTION

Mining is one of the industrial activities which requires large land to be cleared so that the under-earth minerals can be mined efficiently. Mining operations, such as strip mining, usages of heavy earth moving machine, blasting etc., releases gasses and dust into the air. Also, the implementation of heavy machines into the land remove the top soil which leads to soil erosion and destruction of agriculture land [1]. These phenomena cause the land degradation in and around the mines. Due to these reasons, the deforestation, air pollution and land degradation are the most important problem in any mining activities. Therefore, in order to prevent the land and society around the mining industry the concept of buffer zones is introduced [2]. The buffer zones are defined as the sufficient in size to prevent the introduction of prohibited substance to adjacent land areas. The delineation of buffer zones in mining activities could help in protecting the health and well-being of the local societies and stockholders. Also, as per the recent guidelines of Ministry of Environment and Forest Government of India the mapping of every mines which are covering the radial distance of 1 km, 5 km and 10 km is mandatory. The analysis of buffer zone can be made by using the digital processing method of remote sensing technique. Remote sensing is an art of the technology which is capable of providing the detailed information about the land (object) without any physical contact with that land.

Now a days, the remote sensing technology is becoming a vital tool in mapping the large surface areas. In this technique, the data interpretation of the reflected energy from the earth surface is recorded which helps in analyzing the surface topography of that earth surface [3]. The very basic advantages of this method are that it can map the large earth surface areas. The data collected in this technique is mainly in three forms, namely, variation in acoustic wave distribution (sonar), variation in force distribution (gravity meter) and the variation in electromagnetic energy distribution (eye) [4]. These remotely gathered information through different sensors might be examined to acquire data about the items or highlights under investigation [5]. Thus, it can be defined as the process of extracting the information of the earth surface parameters using the electromagnetic radiation (EMR) of the earth surface. These electromagnetic radiation wave may be reflected or emitted from the earth surface. Whenever the electromagnetic radiation reaches to the earth surface then three energy interaction may possible such as reflection, absorption and transmission [6]. In the reflection energy interaction, the radiation is bounces off the target and is redirected by the target surface whereas the radiation is absorbed by the target surface in absorption energy interaction. Similarly, the transmission energy interaction is only possible when the radiation passes through the target surface [7]. The procedure of remote sensing can be delegated passive and active remote detecting. The passive remote sensing using sun as the source of energy and the reading solar radiations reflected from the surface are recorded for further analysis. On the other hand, in active remote sensing a kind of energy generated and sent this energy to the target surface in a manner so that the energy reflected from the surface can be recorded for further data analysis [8]. These type of remote sensing techniques is illustrated in Figure 1.
Since, the new government policies imposes a very strict rules in mapping the lease mining areas and a systematic plan view is Mandatory to full fill the rules and regulation framed by the government. In order to locate the buffer zones around considered limestone mines and provide a complete mapping information the digital processing by remote sensing techniques was adopted [10]. The complete paper consists the five sections where section I discuss the introduction of the present work and section II gives a brief glance of selected mines. The section III of this paper represents the methodology which is adopted for the preparation of land use and land cover. Section IV discuss the results and analysis of the paper which is followed by the conclusions of the paper in section V.

II. GLANCE OF THE SELECTED SITE

The Malkapur limestone mines was selected for the present research work. These mines having two contiguous mines located near Malkapur village in Tandur Mandal of Vikarabad District, Telangana State, and is situated between 17°19’50.3” N and 77° 28’ 02.7” E and 17° 20’ 32.0” N and 77° 28’ 38.8” E. The actual lease area of the selected site was about 240.733 hectares. The location of mines and study area on the map is pointed and presented in Figure 2. The photographic view of the Malkapur mines pit-I is presented in Figure 3.

III. METHODOLOGY-A FIELD STUDY

The digital image processing techniques was used as prime techniques for this research work. The land Use and land cover features can be precisely captured by digital image processing techniques. The raw satellite data will be either downloaded or purchased, and is later stacked (process termed as “Layer Stacking”), followed by clipping (subset) the required area of interest using the buffer of 10 km boundary as input unit. The boundary of the buffer has been created around lease boundary of the mine area. The data is scaled to get a coloured enhanced image. The data is further rectified in ERDAS Imagine software to obtain a geo referenced satellite data. The data is first classified using Unsupervised classification technique to get an idea about the clusters of importance, which will enable the user to understand the range of DN (digital numbers). Simultaneously field work is completed to obtain GPS points of various land use classes and this is introduced as AOI (Area of interest) to classify the data using digital techniques. About 7 different land use and land cover classes in the study area were identified and classified as per the requirement. It is also possible to use a specific colour scheme to improve the appearance of the land use map. The system of land use and land cover classification is presented in Figure 4. The area of interest in the present research work and its two-level analysis is tabulated in Table 1. In Table I, sub section of the area of interest is drawn in two analysis form which is expressed as level-I and level-II.
Table -I: Area of interest and its two-level analysis

| S.N | Area of Interest | Level-I analysis | Level-II analysis |
|-----|-----------------|------------------|------------------|
| 1   | Built – up land | Built-up land    | Urban (towns & cities) |
| 2   | Agricultural land | Crop land (i) Kharif (ii) Rabi (iii) Double cropped | Irrigated crop land Unirrigated crop land Fallow Fallow Plantation Types of plantation, casuarina, coconut, tea etc. |
| 3   | Forest | Evergreen/semi-evergreen | Dense / closed and open Forest blank Degraded forest Forest plantation Types of plantation e.g., Teak, Sal etc. |
| 4   | Wastelands | Salt affected land | Water logged land Marshy / swampy land Gullied / ravinous land Land with or without scrub Sandy area (coastal & desertic) Barren rocky/stony waste/ sheet rock areas |
| 5   | Water bodies | River / stream | Lake/reservoir/tank/canal Shifting cultivation Old / abandoned grassland / grazing land Grassland / grazing land Snow covered/glacial area Snow covered / glacial area Mining area Mining dumps |

IV. RESULTS AND DISCUSSION

The Ground truth verification of satellite data was conducted around the lease area to ascertain the land use classes as interpreted from satellite data as detailed below. These filed studies were conducted on the different various area of interest was performed in and around 10 km radius of the lease areas. The areas were surveyed at various intensity based on 1 km, 5 km and 10 km buffer with reduced no of field points. The details of field points and respective co-ordinates with field photograph is in Table 1. The data and images recorded for different area of interest was presented in Figure 5,6,7,8 and 9. These figures are presented with their respective recorded coordinates as mention in Figure 5,6,7,8 and 9. Figure 5 and 6 represents the irrigated land the harvested irrigated land. Similarly, Figure 7 and 8 are presenting the water bodies I and water bodies II respectively. Correspondingly, the Figure 9 depicts the observation of the forest area.
Fig. 9. View of forest area 17°49'69.4"N, 77°51'66.66"E

The analysis of any visible impact of current land use and land cover in and around mining areas was carried out in a very systematic manner. The majority of the area is coming under Irrigation, where most of the areas are irrigated for Rice crop, cotton and Pulses. The crops are cultivated in most of the areas in two seasons (kahrif and Rabi). Mine site is located at sufficient distance from these irrigated areas. Due to mine operations there is no impact to these irrigated areas or water bodies used for Irrigation. There are a few newly planted areas are visible in and around mining area as a requirement of Environmental balancing. The following tables II, III and IV shows current land use status. Further the obtained maps for the land used were presented in Figure 10, Figure 11 and Figure 12.

Table II: Status of land use within 1 km buffer around the lease boundary using high resolution LISS IV data

| S.N. | Class Name      | Area (Ha) |
|------|----------------|-----------|
| 1    | Mine           | 50.3624   |
| 2    | Land with Scrab| 279.2384  |
| 3    | Land without Scrab | 32.1728  |
| 4    | Plantation     | 2.57512   |
| 5    | Waterbody      | 5.197543  |
| 6    | Habitation     | 42.1345   |
| 7    | Irrigated Land | 871.4154  |
| 8    | Total          | 1283.29615|

Fig. 10. Land use and land cover classification map of the mines for lease area of 1 km

Table III: Status of land use within 5 km buffer around the lease boundary using high resolution LISS IV data

| S.N. | Class Name      | Area (Ha) |
|------|----------------|-----------|
| 1    | Mine           | 1100.383013|
| 2    | Mining Dump    | 7.202     |
| 3    | Quarry         | 145.1     |
| 4    | Quarry Dump    | 0.516     |
| 5    | Hillock        | 219.341   |
| 6    | Scrub          | 290.51    |
| 7    | Land with Scrab| 68.561    |
| 8    | Land without Scrab | 905.34   |
| 9    | Plantation     | 5.7512    |
| 10   | Waterbody      | 116.1536  |
| 11   | Habitation     | 603.2316  |
| 12   | Irrigated Land | 8198.326618|
| 13   | Total          | 11660.41603|

Fig. 11. Land use and land cover classification map of the mines for lease area of 5 km

Table IV: Status of land use within 10 km buffer around the lease boundary using high resolution LISS IV data

| S.N. | Class Name      | Area (Ha) |
|------|----------------|-----------|
| 1    | Mine           | 1173.97558|
| 2    | Mining Dump    | 7.202     |
| 3    | Quarry         | 415.50675 |
| 4    | Quarry Dump    | 0.516     |
| 5    | Hillock        | 219.341   |
| 6    | Scrub          | 571.56136 |
| 7    | Land with Scrab| 506.3126  |
| 8    | Land without Scrab | 2106.293012|
| 9    | Plantation     | 81.6235   |
| 10   | Waterbody      | 537.275318|
| 11   | Water Logged   | 14.51364  |
| 12   | Habitation     | 994.301629|
| 13   | Irrigated Land | 29937.8817|
| 14   | Forest         | 2241.729438|
| 15   | Total          | 38808.03357|
Fig. 12. Land use and land cover classification map of the mines for lease area of 10 km

Fig. 12. Land use and land cover classification map of the mines for lease area of 10 km. The current plan is to expand the existing pits. The majority of expansion is in Pit 2 and Pit 1 expansion is under progress. The expanded portion mostly falls under Waste lands of two land use types, land with scrubs and land without scrubs. The expansion is about 6.1% in Pit 2 and 2% in Pit 1. However, in Pit 1 expansion is under progress. The following table gives details of current land use status. There is a minor change of 2.4% in habitation increase near the mine site workers area and in the mine administrative area. However, there are a few habitation changes nearby villages due to normal village expansion factor.

As far as Agriculture is concerned there are not much of visible changes, however, a few areas due to individual farmers interest are kept as fallow and this leads to decrease in irrigated areas which is about 0.02%. In water body also there is no visible change. In and around the mine site there are new plantations grown increasing the plantation area by 1%. The change detection in and around of 1 km, 5 km, 10 km buffer zones are presented in the Tables V, VI and VII.

**Table-V: Observed changes in 1 km buffer zones**

| Class Name    | 2015      | 2019      | Description                                                                 | % Variation |
|---------------|-----------|-----------|------------------------------------------------------------------------------|-------------|
| Mine          | 46.82910 8 | 50.562 4  | All around the current pits                                                  | 3.733292    |
| Land with Scrub | 282.98 40 27 | 279.23 84 | All around the current pits mainly in Pit 2                                  | -3.74563    |
| Land without Scrub | 33.37 38 29 | 32.17 28  | Mainly in Pit 2                                                              | -1.20103    |
| Plantation    | 2.515191 2 | 2.5751 2  | A few random plantation are increased towards west                           | 0.059929    |
| Waterbody     | 5.237571 5  | 5.1975 43 | Marginal change due to rainfall variation                                     | -0.04003    |
| Habitatation  | 40.43566 7 | 42.13 5  | Increased after depleting a few land without scrub areas                     | 1.698833    |
| Irrigated Land| 871.9207 66 | 871.41 54 | Marginal changes due to permanent fallow lands                               | -0.50537    |
| Total         | 1283.296 159 | 1283.2 96159 |                                                                 |             |

**Table-VI: Observed changes in 5 km buffer zones**

| Class Name    | 2015      | 2019      | Description                                                                 | % Variation |
|---------------|-----------|-----------|------------------------------------------------------------------------------|-------------|
| Mine          | 1078.806875 | 1100.383013 | All around the current pits                                                  | 21.57614    |
| Mining Dump   | 7.308735  | 7.202     | All around the current pits mainly in Pit 2                                  | -0.10674    |
| Quarry        | 143.09398  | 145.1     | Mainly in Pit 2                                                              | 2.00602     |
| Quarry Dump   | 0.302652  | 0.516     | A few random plantation are increased towards west and south                 | 0.213348    |
| Hillock       | 222.361283 | 219.341   | Not much of change                                                           | -3.02082    |
| Scrub         | 292.860341 | 290.51    | Decreased marginly                                                           | -2.35034    |
| Land with Scrub | 67.9657115 | 68.561 | Marginal changes due to permanent fallow lands                              | 0.595285    |
| Land without Scrub | 932.577477 | 905.34 | Decreased substantially upto 2.5 % due to mining activites                   | -27.2375    |
| Plantation    | 5.278468  | 5.7512    | Minor increase                                                               | 0.472732    |
| Waterbody     | 116.934668 | 116.1536  | No change                                                                   | -0.78107    |
| Habitation    | 595.381872 | 603.2316  | Increased by 0.8 % due to surrounding village habitations                    | 7.849728    |
| Irrigated Land| 8197.543967 | 8198.326618 | No change                                                                   | 0.782651    |
| Total         | 11660.41603 | 11660.41603 |                                                                  |             |
Table VI: Observed changes in 10 km buffer zones

| Class Name        | 2015       | 2019       | Descriptions                                                                 | % Variation |
|-------------------|------------|------------|-------------------------------------------------------------------------------|-------------|
| Mine              | 1150.956454| 1173.97558 | All around the current pits                                                   | 23.01913    |
| Mining Dump       | 7.308735   | 7.202      | All around the current pits mainly in Pit 2                                   | -0.10674    |
| Quarry            | 410.403475 | 415.30675  | Mainly in Pit 2                                                              | 5.103375    |
| Quarry Dump       | 0.302652   | 0.516      | A few random plantation are increased to west and south                       | 0.213348    |
| Hillock           | 222.361283 | 219.341    | Not much of change                                                           | -3.02028    |
| Scrub             | 583.762477 | 571.56136  | Decreased marginly                                                           | -12.2011    |
| Land with Scrub   | 521.503252 | 506.3126   | Marginal changes due to permanent fallows lands                              | -15.1907    |
| Land without Scrub| 2122.293068| 2106.293012| Decreased substantially by 1.5% due to mining activities                      | -16.0001    |
| Plantation        | 77.53437   | 81.6235    | Increase by 2% due to mining environmental activities                         | 4.08913     |
| Waterbody         | 543.475358 | 537.275318 | No change                                                                    | -6.20004    |
| Water Logged      | 12.312275  | 14.51364   | Small change not a big impact                                                 | 2.201365    |
| Habitation        | 987.411629 | 994.301629 | Increased by 0.8 % due to surrounding village habitations                     | 6.89        |
| Irrigated Land    | 2993.57691 | 2993.56817 | No change                                                                    | 2.2026      |
| Forest            | 2232.729438| 2241.729438| Increased by 1%                                                               | 9           |
| Total             | 38008.03357| 38008.03357|                                                                                          |             |

From the above tabulated tables, it can be seen that there is no no impact of any change in land use due to the mining activities during the year 2019. Among all the area of interests mainly irrigated lands are not having any visible changes which can be attributed to land use change. Further, it can be observed that there is good amount of development in around the pit as part of mine development and mine expansion as per mine planning. Also, the water bodies are intact and not much changes are visible. Moreover, it was observed that there was slight change in irrigated lands where a few agricultural lands are converted into Permanent fallows and a few areas are reclaimed into Agricultural lands. However, the acreage is not changed (around 2% decrease). This is mainly due to individual farmers decision. It was also observed that the mining company has done additional plantation as a part of environmental activities.

V. CONCLUSIONS

Now a days the analysis of land use and land cover in and around the mines is becoming a very essential activities in the recent years. In this paper, the digital image processing was used for analysis the land use and land cover areas. The used digital image processing methods was purely based on the passive remote sensing techniques. In this paper, the changes occurred in and around mines was observed for the buffer radius of 1 km, 5 km and 10 km. This study clearly reveals that there was not much of changes in land use which intern implies that mining activities are not having any impact in land use changes. Similarly, there was no visible changes observed in the water bodies of the surrounding mines areas. However, there was a slight decrease in the acreage of 2% was reported which was mainly due to the individual farmers decision. Further, the good number of green plantations was observed which were planted by the mining company as the part of the environmental activities.

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