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MAPPING OF MINING AREAS IN ARAVALLI HILLS IN GURGAON, FARIDABAD & MEWAT DISTRICTS OF HARYANA USING GEO-INFORMATICS TECHNOLOGY

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Abstract

Mining is the extraction of valuable minerals or other geological materials from the earth. The Aravalli Range is the eroded stub of a range of ancient folded mountains and the sky-line of north-west India i.e. Gujarat, Rajasthan, Haryana states and Delhi union territory stretching from south-west and north-east direction. The present investigation shows that mapping of mining areas & vegetation status in Aravalli Hill (Gurgaon, Faridabad & Mewat districts of Haryana) using Cartosat-I & IRS -LISS-IV data and mapping on 1:10,000 scales. The Methodology used for mapping consists of preparation of base map, interpretation of satellite data, development of legend, ground truth collection, classification and finalization of maps in light of field information. The elevation model generated using contour information from SOI Topo maps and Cartosat-I stereo images were analyzed. The analysis clearly indicated the area of major topographical changes in the study area, which are also matching with the sites of mining area. The present study successfully completed through capability of satellite remote sensing technology in mapping the degraded lands due to the mining activity.

Keywords: Aravalli, Mining, Mapping, Topo-maps, DEM

1. Introduction

Mining is the extraction of valuable minerals or other geological materials from the earth, from an ore body, vein or (coal) seam. The term also includes the removal of soil materials recovered by mining include base metals, precious metals, iron, uranium, coal, diamonds, limestone, oil shale, rock salt and potash. Any material that can't be grown through agricultural process, or created artificially in a laboratory or factory, is usually mined. Mining in a wider sense comprises extraction of any non renewable resource (e.g., petroleum, natural gas, or even water). Mining of stone and metal has been done since pre-historic times. Modern mining processes involved prospecting for ore bodies, analysis of the profit potential of a proposed mine, extraction of the desired materials and finally reclamation of the land to prepare it for other uses once the mine is closed.

The nature of mining processes creates a potentially negative impact on the environment both during the mining operations and after the mining operations when mining is closed. This impact has led to most of the world's nations adopting regulations to moderate the negative effects of mining operations. Safety has long been a concern as well, though modern practices have improved safety in mines significantly.

Mining techniques can be divided into two common excavation types: surface mining and sub-surface (underground) mining. Surface mining is much more common.

Surface Mining (also commonly called strip mining, though this is actually only one possible form of surface mining), is a type of mining in which soil and rock overlying the mineral deposit (the overburden) are removed. It is the opposite of underground mining, in which the overlying rock is left in place, and the mineral removed through shafts or tunnels.

Abandoned Mines may be dangerous to anyone who attempts to explore them without proper knowledge and safety trainings. Old mines are often dangerous and can contain deadly gases. Standing water in mines from seepage or infiltration poses a significant hazard as the water can hide deep pits and trap gases below the water. Additionally, since weather may have eroded the earth and rock surrounding it, the entrance to an old mine in particular can be very dangerous. Old mines pits, caves, etc. are commonly hazardous simply due to the lack of oxygen in the air, a condition in mines known as blackdamp.

1.1 Need and Objectives of Study

Nearly 25 years ago a large scale mining began here for marble and granite. Due to this large scale mining the forest cover has been depleted. When a mine reaches below the underground water level, a cone of depression is formed that sacks water from the surrounding areas, drying up wells and affecting agriculture. Thus the manual drainage system and groundwater table of the entire region have been badly affected over the years. The environmental status has changed alarmingly during last four decades with ruthless destruction of forest cover over the hills followed with increase in soil erosion, sediment transportation, siltation, drying-up of lakes, dams and surface water sources, lowering of water table from 5 to 10 meters to 50 to 100 meters with increasing mining of ground water without considering recharge capacity of the ground water acquirers. So here, the present investigation has carried out in the Aravalli hills (Haryana) with the following objectives:

- Mapping of mining areas in Aravalli Hill (Gurgaon, Faridabad & Mewat districts of Haryana) using Cartosat-1 & IRS-LISS-IV MX data on 1:10,000 scale.
- To generate DEM from SOI Toposheet of 1:50,000 scale.
- To assess present vegetation status in the study area.

2. Literature

H. Pande, A.K. Sen and R.D. Garg (2011) have studied the open cast mining areas using Cartosat-1 in Jharia coal fields using the ERDAS 9.1 version with an objective of mapping the topographical changes induced due to open cast mining activity in Jharia coal fields. The elevation models generated using contours information and spot heights from SOI Topo maps and Cartosat-1 stereo images were analyzed. They clearly indicated the areas of major topographical changes in the study area, which are also matching with the sites of open cast mining. The results of the study were compared with published data about open cast mine areas about open cast mining areas within Jharia Coal Field. When compared with the topographical change areas, it is exhibited that the areas taken out by this technique are matching the areas of open cast mines with 89% confidence level. And thus the results obtained were in concurrence with existing map.

Surender Singh Chauhan (2010) has conducted a case study of Bijolia mining area in Rajasthan, India in order to evaluate scientifically the effect of mining on environment. Bijolia is one of the largest mining areas of Rajasthan, where large scale mining commenced nearly three decades ago. Satellite remote sensing data have been used during this study as the time varying properties of imageries provide valuable basis for discrimination. The study area covers about 61.7 km^2 which covers parts of Bhilwara, Bundi and Chittorgarh districts of Rajasthan and Mandsaur district of Madhya Pradesh. The mining activity in Bijolia has progressively increased from 1971 when it covered only0.84 km^2 which increased to 12.045 km^2 in 1984 and further to 30.839 km^2 in 1991.The mining activity in Bijolia has progressively increased from 1971 when it covered only 0.84 km^2 which increased to 12.045 km^2 in 1984 and further to 30.839 km^2 in 1991. Similarly, land under agriculture has decreased from 350.919 km^2 (56.875%) in 1971 to 323.970 km^2 (52.507%) in 1984 and further to 308.101 km^2 (49.935%) in 1991. Some of these lands have gone undermining whereas a major part of it has become wasteland which has increased from 17.256 km^2 (2.796%) in 1971 to 87.146 km^2 (14.157%) in 1984and further to 133.711 km^2 (21.671%) in May, 1991. This amounts to an increase of 116.455 km^2 in just 20 years. Thus, wasteland has increased by 675 per cent. Of the 30.839 km2covered by mining activity in 1991, about 8 km^2 lies in forest area, 14 km^2 in agricultural land and only 8 km^2 in wasteland. In 20 years time nearly 30 km2 of land has been directly destroyed by mining activity.

Corey R. Froese and Shilong Mei (2008) have identified the coal mine collapse pits subsidence hazard area in Turtle Mountain of the vicinity of the Frank Slide, Alberta, Canada through remote sensing techniques. Light Detection and Ranging (LiDAR) and space borne Interferometric Synthetic Aperture Radar (InSAR) data was analysed, and generated the DEM in the study area. The results have showed that the ground surface above Frank Mine has been settling at an annual rate of up to 3.15 mm, relative to the reference area. An average change of up to 3.2 mm per year, relative to the reference area was also observed overlying the footprint of the abandoned Bellevue underground mine to the east. For both of these mines, the local municipality does not currently have ground monitoring in place but acknowledges that surface collapse associated with mine subsidence is a regular occurrence that is identified and mitigated on a case-by case basis.

The Digital Elevation Models (K. Jacobsen, 2003) play a fundamental role in mapping. The digital description of the three dimensional surface is important for several applications. Today the most often used photogrammetric product are orthoimages generated by means of a single image and a DEM. The very high resolution space sensors are mainly operating in a single image mode; stereo pairs are not taken very often. The existing and not classified world wide DEMs usually do not have a sufficient accuracy and reliability for more precise applications or they may be too expensive. Digital Elevation Models (DEMs) are required for several tasks like generation of orthoimages; flood planning, erosion control and agriculture, generation of contour lines, visibility check, 3D-views and spots heights.

Lausch, A. & Biedermann, F. (2000) have conducted a study on the temporal change in the Lignite Mining Region South of Leipzig using GIS and Landscape Metrics. Multi date SPOT - XS sensor image data of years 1990, 1994 & 1996 were used to study the temporal analysis of the mining impact on the environment and with special reference to wetlands of that area. The study shows that not just a landscape metrics but also a set of metric is suitable for quantitatively capturing and describing the dynamics of biotope and landscape structures of the opencast mining landscape. The proportions and changes of important biotope and land usage elements of the southern region whereas as increase in size was ascertained for the use classes woods, deciduous forest and water in the period 1990-2020, a sharp reduction in the class of open land with no vegetation (opencast mining areas) was predicted.

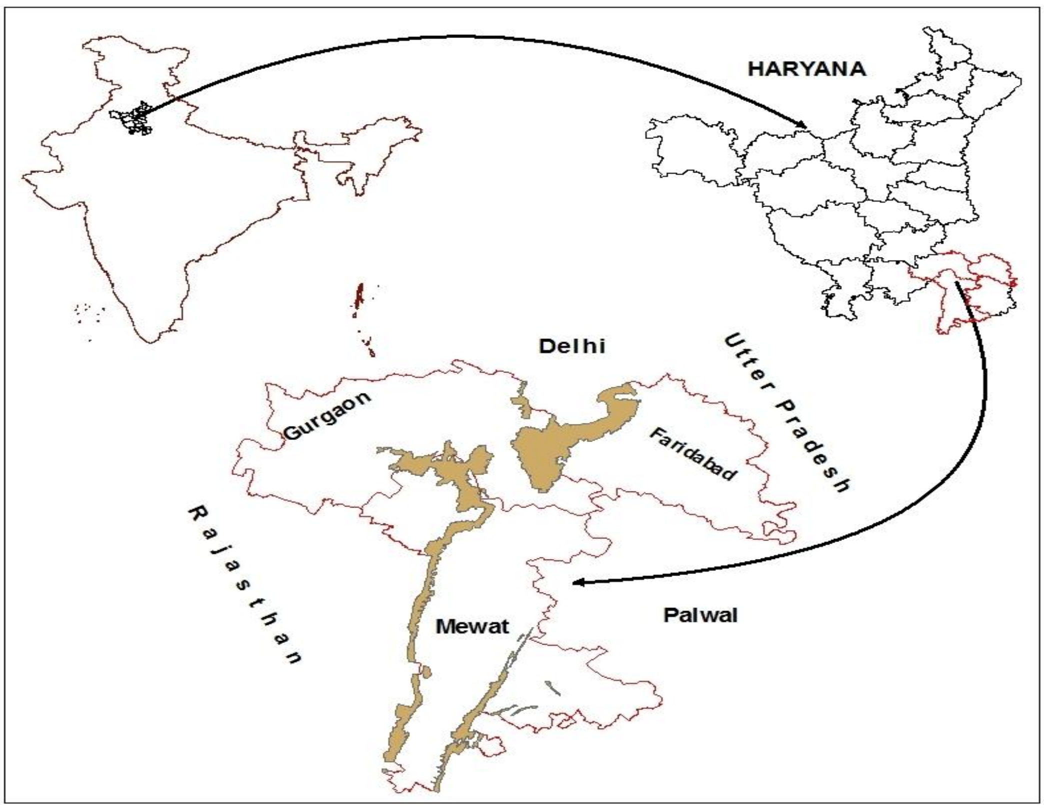
3. Materials and Methods

3.1 Study Area

Study area is Aravalli hills of three districts which are situated on south eastern part of Haryana state (Gurgaon, Faridabad, and Mewat districts). The study area lies between 27° 39’ 11” N to 28° 29’ 39’’ N latitude and 76° 52’ 50’’ E to 77° 10’ 20’’ E longitude. It is bordered by Delhi State, Rajasthan State, Palwal district and Utter Pradesh state. The total study area is about 40,429 hectors.

3.2 Technologies Used in the Research

GIS and remote sensing technique is basically used for the present study to identify the various categories like ERDAS Imaging 9.1 (Used for Digital Image Processing), Arc GIS 9.3 (Visual Interpretation, Digitization and compose the Map), GARMIN GPS-72 Model for ground truth information and Google Chrome and Internet Explorer 9.1 for Web Browser.



Map 1. Showing the Location of the Study Area

3.3 Used Data

- A high resolution panchromatic stereo images of Cartosat-I satellite with a spatial resolution of 2.5 m acquiring the images of 20 Feb. & 12Dec. 2008, 21 Aug., 28 Sep. & 21 Dec., 2009.
- Multi- temporal geo-rectified satellite images of LISS- VI acquiring of 16 March & 27 May, 2008, 29 Dec., 2009, 10 Jan., 2010 with 5.8 m resolution.
- SOI Topo-sheets used of 1:50,000 scale. Topo-sheets No. 44J/01, 44J/12, 44J/16, 44K/01, 44K/02, 44L/03, 44L/07, 44L/10, 44L/14, 44M/03, 44M/10, 44M/14, 44N/11, 44N/15, 54E/04.

3.4 Methodology

The Methodology adopted for mapping consists of preparation of base map, interpretation of satellite data, development of legend, ground truth collection, classification and finalization of maps in light of field information. The digital model is used for final analysis in the study.

3.4.1 Digital Analysis

The methodology essentially is based on on-screen digitization using standard image interpretation keys like tone, texture, size, pattern, association etc. The image interpretation keys provide a critical reference base for advanced interpretation. In on-screen interpretation the imagery is displayed onto a computer screen (normally as FCC) and intended classes are delineated based on image interpretation elements, ancillary and legacy data. Resultant output from this was in vector format, which supports complex GIS analysis and has smaller file size. On-screen interpretation has carried out using satellite data and modified after the ground truth verification. This approach enables easy updating of the features.

3.4.2 Classification Scheme

The classification scheme was developed for extracting information from the satellite data. The classification system broadly consisted of following categories:

1. Abandoned mine pits
2. Abandoned mine pits with water
3. Fairly thick vegetation
4. Sparse vegetation
5. Degraded area
6. Dry lake area
7. Lake with water
8. Vegetation in lake
9. Recreational area
10. Golf course
11. Farm houses
12. Settlements

3.4.3 Final Map Generation

The mining areas map needs to be finalized in the light of ground observations, interpretation keys, and available ancillary data set. Once the maps are finalized they need to be checked for topological and labeling errors. For mapping units having more than one problem, the associated problems need to give the mapping symbol in a separate attribute column. Map is composed using the major mining problem. Final map is composed from base map with project name (title), legend, scale bar, north arrow, latitude & longitude and year of publication.

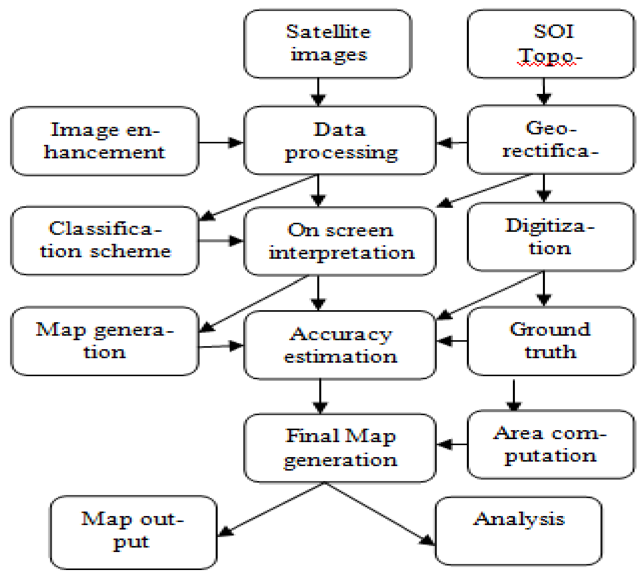


Figure 1. Showing Methodology Adopted for the Identification of Various Categories in the Study Area.

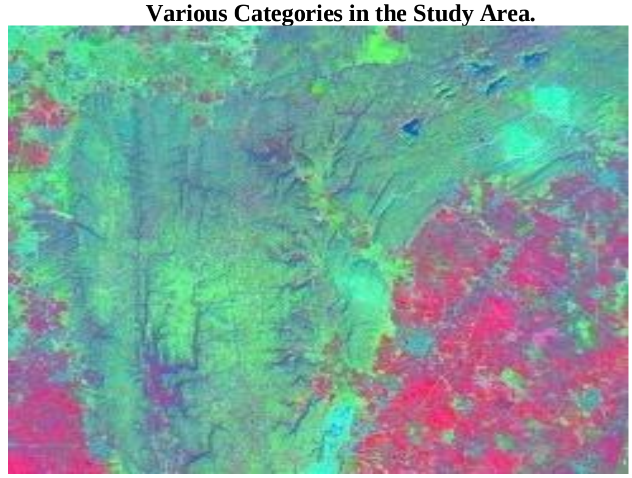


Figure 2. Resolution Merged Image (Cartosat-1 & LISS IV)

3.4.4 Resolution Merged Image

Resolution merge is the process of merging of the high resolution panchromatic image & multispectral image. Then generate an output image that is a resolution merge image. Panchromatic image has I band and multispectral image has multiple band. The resolution merge satellite image can interpret of the objects in better form than PAN image & multispectral image. The resolution merge will be better useful in the vegetation related studies. See figure 2 for Resolution merge.

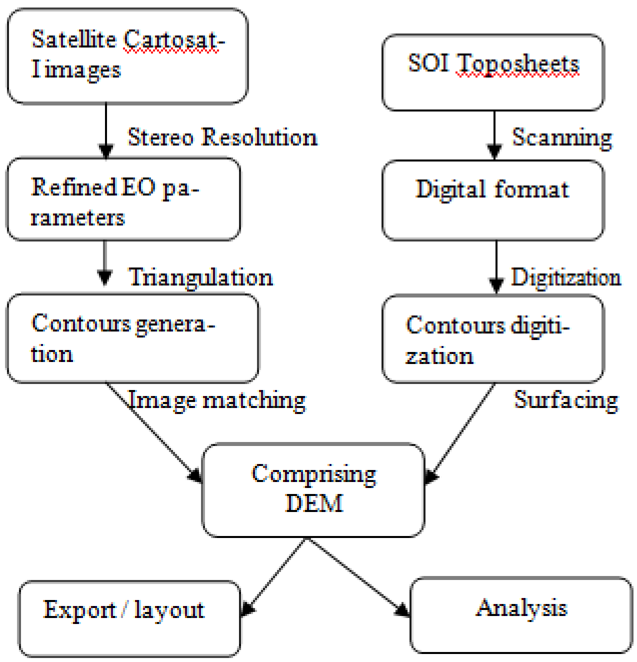


Figure 3. Showing the Methodology for DEM Generation of the Study Area.

4. Results

In the present investigation, with the image interpretation techniques, on the merged data products on Cartosat-1 and IRS LISS – IV data, the following mining categories were identified, viz.

- ⇨ Abandoned Mine Pits and
- ⇨ Abandoned Mine Pits with water

Apart from these two categories, various other land features such as lake area, (dried lake and lake filled with water), vegetation in the lake area, golf course, farm houses, an attempt has been made to quantify the vegetation status in the study area. The following classes of vegetation categories were identified:

- ⇨ Fairly thick vegetation,
- ⇨ Sparse vegetation and
- ⇨ Degraded area

Table 1. Showing the Spatial Distribution of Various Categories in Study Area

S. No	Description of Categories	Area in (hectors)	Area in %
1	Abandoned Mine Pits	4175	10.33
2	Abandoned Mine Pits with Water	256	0.63
3	Fairly Thick Vegetation	2523	6.24
4	Sparse Vegetation	4092	10.12
5	Degraded Area	6242	15.44
6	Dry Lake Area	144	0.36
7	Vegetation in Lake	400	0.99
8	Recreational Area	229	0.57
9	Golf Course	224	0.56
10	Farm House	19	0.05
11	Lake with Water	9	0.02
12	Settlements	114	0.28
13	Total Area of Aravalli Hill	40,429	100

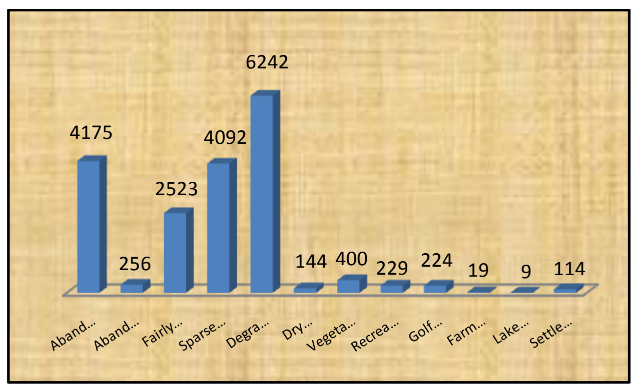


Figure 4. Spatial Distribution of Various Categories in Study Area

Table-1 & figure 4 show the spatial distribution of various categories in the study area. Total study area is 40,429 hectors, out of which the abandoned mines is 4,175 (10.33%) hectors. Abandoned mine filled with water is 256 (0.63%) hectors. Fairly thick vegetation is 2,523 (6.24%) hectors. Sparse vegetation is 4,092 (10.12%) hectors. Degraded area is 6,242 (15.44%) hectors. Dry lake area is about 144 (0.36%) hectors. Vegetation in Lake area is 400 (0.99) hectors. Area of Recreational is 229 (0.57%) hectors. Area covered by Golf course is 224 (0.56%) hectors. Area covered by farm house is 19 (0.05%) hectors. Lake with water area is 9 (0.02%) hectors. Settlements area is 114 (0.28%) hectors.

4.1 Description of the Various Categories

The general description of the various categories and their respective interpretation details were as follows:

Abandoned Mining Pits where the mining activities occurred and at present they are lying vacant. These patches occur as whitish grey in Cartosat-1 image and bright in FCC image (depending upon moisture content) irregular to regular in shape on the satellite image.

Abandoned Mining Pits with Water where the mining activities once occurred. After the rain fall the water got accumulated in these abandoned pits. These patches occur as dark in color in Cartosat-1 (PAN image) and light blue to dark blue in FFC image, depending on the depth of water, shape of the water body and associated with abandoned mine pits.

Degraded Area is the barren type area, without vegetation, moisture and construction, these areas appears light in Cartosat-1 image and bright to light in FFC image (depending upon the nature of the land).

Vegetated Areas in the lakes, they appears as gray to gray dark in Cartosat-1 image and red to dark red in FCC image (depending upon the intensity of vegetation), irregular / regular in shape and moisture.

Golf Course Area is the recreational area constructed near by the industrial estates. These areas appear as gray light in Cartosat-1 image and bright to red in FFC image (depending on the intensity of vegetation in the campus).

Form House is the area marked was the construction occurred on the Aravalli Hills. These patches occurs as bright to gray dark in Cartosat-1 image and light to red in FFC image (depending upon the intensity of vegetation, nature of construction and shape).

Settlements are the living area and constructed by man. These areas appears in light color in Cartosat-1 image and bright in FCC image (depending upon the constructed materials, shape).

4.2 District Wise Results

4.2.1 Gurgaon District

Gurgaon district has the total area of 1, 18,736 hectors, out of which, the Aravalli hills occupies an area of 11,256 (9.48%) hectors. The analysis of Cartosat-1 & LISS-IV data reveals that, an area of 491 (4.36%) hectors is under the category of abandoned mine pits, while an area of 16 (0.14%) hectors were reported to be under abandoned mines with water. An area of 972 hectors of land is reported to be under fairly thick vegetation category which was calculated to be 8.63%. Sparse vegetation covers area of 1,602 (14.24%) hectors. An area of 1,121 (9.96%) hectors was reported to be under degraded area. An area of 114 (1.01%) hectors was reported to be under Dry lake area. Vegetation in Lake Category covers area of 345 (3.07%) hectors. An area of 41 (0.37%) hectors occupies of recreational, golf course covers area of land of 137 (1.22%) hectors and settlements area is 32 (0.29%) hectors with reference to total geographical area.

4.2.2 Faridabad District

The spatial distribution of various mining categories in total AOI area of Aravalli Hill in Faridabad district which is 9,208 hectors. The analysis of Cartosat-1 & LISS-IV data reveals that, an area of 1,514 (16.44%) hectors is under the category of abandoned mine pits, while an area of 227 (2.46%) hectors were reported to be under abandoned mines filled with water. An area of 573 hectors of land is reported to be under fairly thick vegetation category (6.23%). Sparse vegetation covers an area of 315 (3.43%) hectors. An area of 941 (10.21%) hectors was reported to be under degraded area. Dry lake area accounts the area of 30 (0.33%) hectors, while vegetation in Lake Category covers an area of 55 (0.60%) hectors. An area of 164 (1.79%) hectors occupied under recreational class and settlements were found to be under is 30 (0.33%) hectors with reference to total geographical area (TGA).

4.2.3 Mewat District

The spatial distribution of various mining categories in total AOI area of Aravalli hills in Mewat district which is 19,965 (12.08 %) hectors. The analysis of Cartosat-1 & LISS-IV data reveals that, an area of 2,170 (10.87%) hectors is under the category of abandoned mine pits, while an area of 13 (0.07%) hectors were reported to be under abandoned mines filled with water. An area of 978 (4.90%) hectors covers fairly thick vegetation. Sparse vegetation covers area of 2,175 (10.90%) hectors. An area of 4,180 (20.94%) hectors was reported to be under degraded area. While recreational area occupies an area of 24 (0.12%) hectors. A golf course covers an area of 87(0.44%) hectors and 17 (0.09%) hectors was reported to be under farm house and settlements areas found to be 30 (0.33%) hectors with reference to total geographical area.

In the virtual GIS module of ERDAS IMAGINE 9.1 a virtual 3-D view was created to highlight the subsidence areas.

Clearly shows large voids in the topography in and around the area. The difference map was generated which highlighted the abandoned mining areas as compared to 1973-74 topography. The results of the study were compared with published data about abandoned mining in Aravalli Hills.

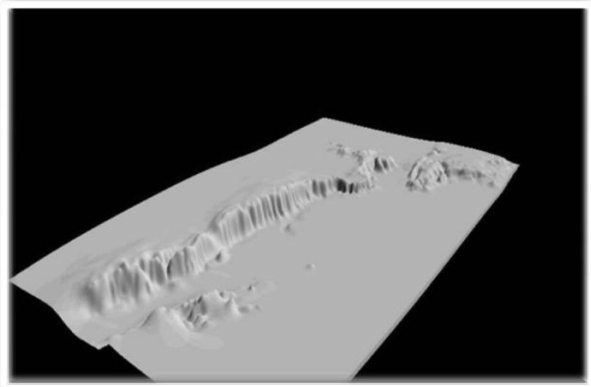


Figure 5. Showing Virtual 3D Model of the Subsidence Area.

Conclusion

The present study successfully demonstrated the capability of satellite remote sensing technology in mapping the degraded lands due to the mining activity. The high resolution satellite data is used in the study, which is more helpful in identification of smaller mining areas. The digital elevation model is used for better understanding the mining areas and dump pits.

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