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Change Detection of an Open Cast Coal Mine using Spatial analysis and ArcGIS.

Potu Vinay | Sandhi Srinivas Reddy | Bhukya Vinay | Nagireddy Anji Reddy | Pulagam Swarna Mounika | Satya Prakash*

Department of Mining Engineering, Godavari Institute of Engineering and Technology(A), JNTUK, Kakinada.
*Corresponding Author Email ID: prakashsatya@giet.ac.in

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ABSTRACT

Change Detection method identifies the change in any site on the earth with the analysis of past data. The change detection process in coal mines place a major role in finding the illegal mining operations and helps to detect the reclamation area, extended mine area, the total area of the mineral is to be extracted and land cover. This work utilizes the images from USGS to study the change detection phenomenon of a particular mining area. The LISS images hasbeen considered in this study for the optimization of results. The ArcGIS software has been used for the study of mine area. The results obtained from the software provides the optimal analysis in terms of change detection with respect to coal mine.

KEYWORDS: Change Detection, Illegal Mining, Reclamation, USGS, ArcGIS.

1. INTRODUCTION

1.1 REMOTE SENSING

Remote sensing is the most common way of finding and noticing the actual qualities of an area by estimating it's reflected and produced radiation at a far off. Remote sensing is utilized in different fields, including land surveying, topography and most geology disciplines for instance nature, hydrology, meteorology, geography, and oceanography.The Remote sensing process is shown in the figure 1.

Remote sensing is a technique for collecting, transferring, handling, and obtaining of geographic data with-out approaching the surface straight forwardly. Remote sensing innovation has unique qualities, for example, multipoint, multiband and temporal. All the while, remote sensing can gather the data of frequencies which isn't in the noticeable range, which broadens the scope of perception.

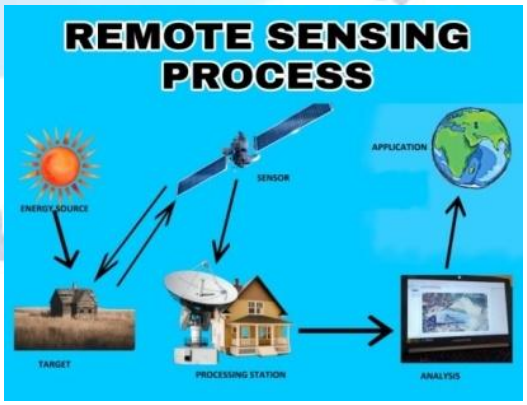

Figure 1: Remote Sensing

1.2 CHANGE DETECTION

Change detection means identifying the change of the object or any site on the earth of a particular period with the analysis of past data. The change detection of coal

mines place a major role in avoiding the illegal mining, it helps to find the area of reclamation is done, the total area of mine is extended and the total area of the mineral is extracted and also changes in land cover will be detected by comparing with the past data. Some of the applications of change detection in mining are, to find the area of the mine, to find the illegal mining, to know the amount of reclamation is done.

1.3 SATELLITE SOURCES OF IMAGE DATA

The artificial Satellites are the one of the main source to collect the images of whole globe. The various free Satellite Imagery Sources available are USGS, Sentinel Open Access Hub, Bhuvan, NASA Earthdata search, NOAA Data access Viewzx, Digital Globe Open Data Program.

1.4 COAL

Coal is a burnable black or brownish black sedimentary rock formed from accumulation of plant remains modified by chemical, biological and physical process during and after burying.It is known that the coal is originated from vegetable matter and it's development followed a ongoing change commonly designated by the peat-anthracite sequence. The series formed from the vegetable matter, peat, lignite, bituminous coal and anthracites. Chemically the main composition is carbon, oxygen and hydrogen together with minor amounts of nitrogen, sulphur and ash.

1.5 ILLEGAL MINING

Illegal Mining can be defined as the mining activities which are performed without taking the permission from the government and not having land rights, mining licenses is known as Illegal Mining.

1.6 RECLAMATION

Mine Reclamation is the process of back filling the mined area to economically usable stage or to revegetation and restoration state. The back filling is done with the overburden, boulders, sub-soil and top-soil piles, etc, after it regarding, surface stabilization and revegetation and restoration is done. The process of mine reclamation starts once mining is completed, while in some cases the Reclamation process and mining process goes on side by side.

1.7 USGS

The Abbreviation of USGS is the United States Geological Survey, The USGS was formed on March 3, 1879which is a scientific agency of the united states government. Its headquarter is located in John W. Powell National Centre, Reston, Virginia. The students can figure through intuitive guide or message search to acquire Landsat Satellite symbolism, advanced line charts, flying photographs, radar information, computerized rise model information, sentinel satellite information, some business satellite symbolism, advanced map information, land cover information and much more information.

1.8 ArcGIS

ArcGIS was launched on December 27, 1999, as of version Arc GIS 8.0. The founders are Jack Dangermond and Laura Dangermond, it was developed and maintained by Esri (Environment system research institute). In Accent it was released as ARC/INFO later it was merged into the ArcGIS desktop. ArcGIS consists of tools to create, edit maps, create databases of geographic information, produce charts, and store analyzing data. ArcGIS software is used in many areas such as Surveying, Environment sciences, City planning, Engineering, Archeology, Biology, Water management, Natural Resources Management etc. The ArcGIS desktop consists of many integrated applications such as Arc map, arc catalog, arc food box, arc sene, arc global and arc pro. At present we are using 10.8.1 version and the first version is 8.0. The ArcGIS Desktop consists of four integrated applications, such as Arcmap, Arcscene, ArcCatalog and Arcglobe.

2. REALATED WORK

Merugo and Jain [1] suggested that digital image processing and remote sensing techniques are used to find illegal mining operations.Javeed and Imran [2] studied the impact of coal mining on land use and land cover was found by using remote sensing and GIS techniques. The analysis and calculation of the area is done in the ArcGIS.Prakash and Gupta [3] utilize the remote sensing and GIS technique to find thedifferent land use like dense vegetation, water ponds, rivers, overburden dumps, and subsidence. For vegetation studies, they have used Normalized Difference Vegetation Index Image. Shilu [4] used remote sensing and GIS techniques for observing of coal refuse dumped piles for this, they have selected an area of Wangping gully of Mentougou District of Beijing, China. Dong Xia, Ba Tuan [5] used multilayer extreme learning machines and satellite images to explore and observe the surface coal mine by using satellite images.

The Open cast coal mine is selected to perform this project. The mine data have been collected from the mine and it is compared with the data of the ArcGIS analysis. By comparing, it is came to know thatwhether the mine is performed any illegal mining operations or not, change detection of Coal Mine and total area of mine is extracted.

2.1 MINE DATA

The mine was started in the year 2008, the life of the mine is 10 years, the total number of seams present in the mine is 5, the total thickness of the seam is 12.5m, the gradient of the seam is 1 in 3.0, the total land required for the mining activity is 4610000 m², the total area of excavation is 1680000 m², the maximum depth of the mine is 165 m, they have used shovel- dumper combination technology for the mining operation.

3. PROPOSED WORK

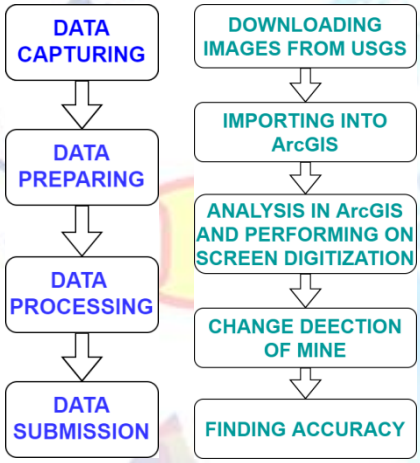

Figure 2 (a): Flowchart depicts the actual process

Figure 2 (b): Flowchart depicts the proposed process

3.1 DATA CAPTURING

To work on GIS related projects firstly it is required to collect data,thatcan be obtained by data capturing technique. The data capturing can be done with the help of satellite images.

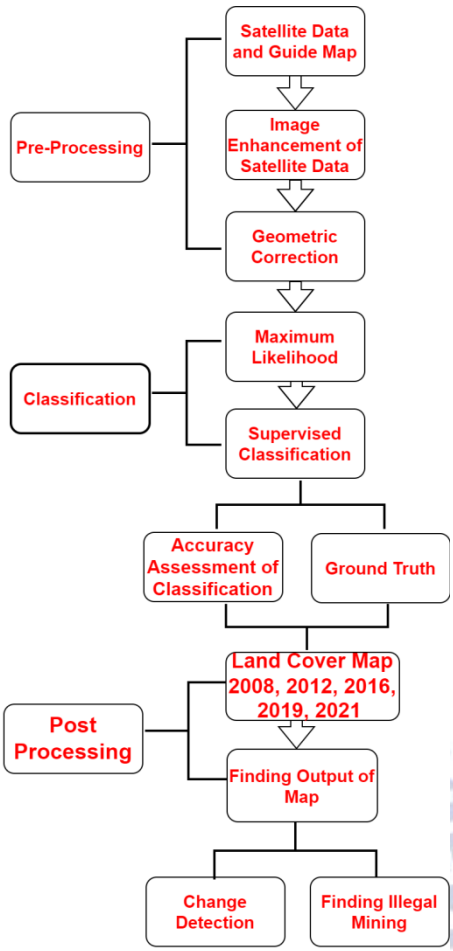

Figure 3:Flowchart represents the Data Preparing and Data Processing

4. RESULTS

Figure 4: Open Cast Coal Mine 2008

In 2008, ithavebeenobserved that how the land is present before the start of mining operations, and also the land is covered with full of vegetation. The complete land utilized until the completion of the mining operation is4608051.97 m² as on 2021.

Figure 3: Image of Open Cast Coal Mine 2012

In 2012, the total coal deposit area is 1613922.99 m², where the extraction of coal is in progress. The total overburden dumping area is 105335.06 m². The total mine area is 3948951.57 m².

Figure 4: Image of Open Cast Coal Mine 2016

In 2016 the total land used for mining operations the mine boundary area is 4548273.48m², the total coal deposit area is1613922.99 m²and the mining operation started and continues in an area of 1613922.99 m² and it is to be extracted. The area used for overburden dumping area was 1053935.06 m². In 2016 only extraction of the coal is performed and no reclamation is done.

Figure 5: Image of Open Cast Coal Mine 2019

In 2019 the total land used for mining operations and the mine boundary area is4608051.97 m². The coal deposit area in 2019 was 679938.98 m², from the image it is observed that reclamation and the extraction of a coal deposit are done simultaneously. In 2019 the total land reclaimed is 679938.98 m², and the area of the coal deposit is 679938.98 m² which is to be extracted. The total land used for the deposit of overburden is 1053935.06 m²and in that overburden dumping area 752835.33m² of vegetation is grown, after the removal of overburden from the overburden dumping area.

Figure 6: Image of Open Cast Coal Mine 2021

In 2021 the total land used for mining operations and the mine boundary area is 4608051.97 m². The coal deposit area in 2021 is 679938.98 m². In 2021 the total land reclaimed is 1136027.09 m², and the area of land to be reclaimed is 679938.98 m². The total land used for the deposit of overburden is 1053935.06 m²and in that overburden dumping area 752835.33m² of vegetation is grown, after the removal of overburden from the overburden dumping area.

Table 1: Comparing of 2008 and 2016 years Images

Description	2008	2016	Percentage of Change	Remark
Total Coal Deposit Area (m^2)	0	1613923	100	Increase
Overburden Dumping Area (m^2)	0	1052969.2	100	Increase
Reclamation (m^2)	0	0	0	No change
Total Mine Area (m^2)	0	4548273.5	100	Increase
Vegetation in Total Mine Area (m^2)	1815966	0	100	Decrease
Total Coal Deposit Area need to be Extracted(m^2)	1815966	1613923	11	Decrease

Table 2: Comparing of 2008 and 2021 years Images

Description	2008	2021	Percentage of Change	Remark
Total Coal Deposit Area (m^2)	0	4815966.1	100	Increase
Overburden Dumping Area (m^2)	0	1053935.1	100	Increase
Reclamation (m^2)	0	679938.98	100	Increase
Total Mine Area (m^2)	0	4608052	100	Increase
Vegetation in Total Mine Area (m^2)	4608052	752835.33	98.35	Decrease
Total Coal Deposit Area need to be Extracted(m^2)	1815966.1	0	100	Decrease

Table 3: Comparing of 2012 and 2019 years Images

Description	2012	2019	Percentage of Change	Remark
Total Coal Deposit Area (m^2)	1613922.99	4815966.07	66.49	Increase
Overburden Dumping Area (m^2)	105335.06	1053935.06	90.01	Increase
Reclamat1ion (m^2)	0	1136027.09	100.00	Increase
Total Mine Area (m^2)	3948951.57	4608051.97	14.30	Increase
Vegetation in Total Mine Area (m^2)	0	752835.33	100.00	Increase

From the Table 1,it is observed that Total Coal Deposit Area, Overburden Dumping Area and Total Mine Area is increased, and Vegetation in Total Mine Area and Total Coal Deposit Area need to be extracted is decreased as compared with 2008 and 2016.

From the Table 2, it is observed that Total Coal Deposit Area, Overburden Dumping Area, Reclamation, Total Mine Area and Total Coal Deposit Area need to be extracted is increased, and Vegetation in Total Mine Area is decreased as compared with 2008 and 2021.

From the Table 3, it is observed that Total Coal Deposit Area, Overburden Dumping Area, Total Mine Area,Reclamation, Vegetation in Total Mine Area and Total Coal Deposit Area need to be extracted is increased as compared with 2012 and 2019.

5. CONCLUSION

A Spatial Analysis has been considered in this study to estimate the changedetection process for an open cast coal mine. The results from this method clearly shows the changes for the years 2008, 2012, 2016, 2019 and 2021. The considered method also estimates the area of the mine related to mineral extraction, reclamation area, the area of mineral to be extracted and total land cover. Further, this study determines the illegal mining operations by compaing the data with the actual data of the mine for the said years without visiting the actual site. The cost to

perform this method is low. In this study, the accuracy of results using spatial method was found as around 98%.

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Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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