Geospatial Effect on the Mining Operation in Joda/Barbil Area of Odisha, India

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Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study aims to investigate the Geospatial effect on the extraction operation in Joda and Barbil mining areas of Keonjhar district, Odisha, India. Present work involves the topography, soil, climate, and stratigraphy investigation of the area. The acquisition of Landsat 8 TIRS (Thermal Infrared), Landsat 5 TM (Thematic Mapper), and CARTOSAT DEM data of temporal and spatial satellite images from various websites. ARC GIS and ERDAS IMAGINE 9.2 software used to find the land use and land cover images (accuracy average 90%). Normalized Difference Vegetation Index (NDVI), and Surface air Temperature (SAT) of Barbil area for 2003, 2007, 2017 and 2018 have been estimated. Comparison of the results have shown that, there is increase in built up, and mining areas whereas the agricultural land and vegetation cover are down scaled. There is constant average SAT rise of 1-2°C in all the land cover classification between 2007 and 2018. The NDVI values show conversion of sparse from dense vegetation in the area. Poor operational strategies in mines operation, like corruption, illegal mining, lack of accountability, overburden wastes/ trailing disposal, ecologic degradation, waterlogging in mine pits, and human rights violations are the root causes of environmental deterioration of the study area. It is pertinent to implement strictly, the Mines and Minerals (Development and Regulation) Amendment Act, India, 2021, regular GIS application to assess the mines volume of extraction, strict vigilance and fixation of accountability for losses of existing mines values, and afforestation/ reforestation of degraded/lost forests in Barbil area.

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Keywords: GIS studies; Illegal Mining; LU/LC; Mining areas; NDVI; SAT.

1. INTRODUCTION

The Mining/ mineral domain is well thought-out driving strength for the geological concerns, as well as geological cataclysms, ecological threats, and resource destruction Liu et al., 2015 [1]. Wang et al., (2021 [2]). The mining sectors globally is encountering unparalleled growth and cataclysm for last two to three decades. The progress in mining domain in India expedited due to rise in urbanization and industrialization. Especially the mineral and metal segment is passing through a crucial time run since last two to three years due to pandemic lockdowns and closures. Prompt efforts of the governments is addressing the issue by policy changes and the emerging markets upswing. Under the climate’s predicament and rising user’s expectations are up surging, the sector needs to meet the sustainable development goals. Environment chaos, political and social hooks are the barriers on the way of progress. The excavation, waste disposal, and transportation activities in the mining areas have made the environment of mining area as a dungeon affecting its flora, fauna and its stakeholders and aboriginals.

The mining areas throughout the globe have been assessed as 57277Km², (Maus et al., 2020 [3]) As per Ministry of Mines, Govt. annual report, 2021, India has leased mining areas, except minor minerals hydrocarbon and atomic energy (as on 31.3.2019) was 315986Ha through 3527 mines. Odisha stands as the 2nd ranked state in India contributing value wise =9% of total mineral production in the year 2015-16 as per state data 2020. The district Keonjhar having Joda and Barbil as one of the prominent mining areas in Odisha.

Improper and irregular mining in Odisha has posed threats to sustainable standards in water, air, land, forests, health and safety. The western Odisha has bountiful mineral possessions in rural locations, typically deprived of occupation, unpredictable cultivation and distracted livelihood. Mining activities has up surged jobs, with economic expansion, but imposes substantial health and other sustainable issues. From 1980, Barbil area, the mining exploration as a hub, has exceeded expectations and have lost its past green corridor serving mostly to its ethnic aboriginals.

The major iron ore potential in the Keonjhar district in Odisha. It is about 3142.70MMT, available in Joda, Mahalapat, Tiring Pahad, Sidhmath, Banspani, Thakurani, and Gandhamardan Hills etc. The minor minerals like manganese ores are accessible of quantity >20MMT at Barbil, Koida, Joda, Bhadrasahi, Kalimati etc., (DSR Keonjhar 2018 [4]).
The mining accomplishments in Barbil, Odisha is creating poor human health, agriculture, and distorting livelihood of its aboriginal people. They pose irregularities like human rights violation, illegal mining, inadequate safe water, air, and sanitation. Lack of governance, lag in complying basic indicator, corruption, poor health standards breaching social and economic obligations, Fig. 1.

As per government data the district Keonjhar has lost 104.51Km² of its mining forest areas through 64 mining projects in 38 years from 1980-2017. The indiscriminate mining and population surge has polluted dusty air, deteriorated roads, polluted portable water, mining dumps, and suffering from malnutrition (Fig. 2).

The Keonjhar district has 8303 km² total geographical area, 202 km² urban and, 8101 Km² mining/hilly area. The decennial demographic growth rate from 1971 to 81 was 16.65percentage against the Odisha State average was 19.72 percentage. The decennial growth rate during 1981-91, 1991-2001, 2001-11 were 19.95%, 16.83%, & 15.35% respectively (2011 census [5]), Fig 2.

This paper reveals the GIS works in the mining areas of Barbil, in Keonjhar, Odisha. Mining in Barbil, made the tribal group of the area, as oustees. Their access to clean air, and water are more vulnerable. People living near the mines, are under prone to waterborne diseases and fever.

1.1 Need of the Study
This study is focusing on Barbil Tehsil (22.12°N & 85.40°E) hilly mining areas of average elevation (477m), Keonjhar District, Odisha with 26 mines (21 mines in Joda and 05 mines in Barbil). The Joda & Barbil are both municipalities in the Barbil Tehsil having area of 275.5km² with 2720K population including 45% to 48% are from Scheduled Castes (SC) and Scheduled Tribes (ST). The green vegetation cover is 3097.18Km² (=33, 33%) out of 8303Km² of the district area grown over mines. The terrestrial setting of Barbil is Singhbhum (Jharkhand) in north, Thakurani Reserve Forest (RF) in east, Kolhabarpada, Tanto, Fulabadi, and Sidhamatha RF in south, and the Karo River, Balagoda,, Karo RF in west.

On date grants for number mines have been lapsed or rescind mines in Barbil and Joda areas are TISCO (some), Ardent Minerals and Metals Private Ltd, B.I.CO. Ltd. and many others. These dead mines have not only deforested the forest areas but also dumped overburdens, wastes and trailing products. Moreover, they have made a large number of ditches and ponds, which are posing health issues for the people of the area, and unfit for fisheries and plantations (Table 1), http://www.Odishaminerals.gov.in/LicenseeStatistics/CircleWiseLicenseeDetails.

Fig. 2. The decadal Population of Keonjhar District 1901 to 2011(census-2011)
Table 1. Major mines in Joda and Barbil area in force with capacity and minerals extracted

<table>
<thead>
<tr>
<th>Name of mines</th>
<th>Place</th>
<th>Quarries in Villages</th>
<th>Capacity (TPA)</th>
<th>Mineral extracted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahalapat Iron ore mining Pro.</td>
<td>OMCL</td>
<td>Eastern, western, southern, &amp; Ichinda quarry</td>
<td>70000</td>
<td>Iron</td>
</tr>
<tr>
<td>S.G.B.K. Iron &amp; Manganese Ore Mining Proj.</td>
<td>OMCL</td>
<td>Guruda, Palsa, Sijora, Tadapani, Badakalimati, Balda, and Nayagarh</td>
<td>173000</td>
<td>Iron/Manganese</td>
</tr>
<tr>
<td>Kanther Koira Mn ore mining</td>
<td>M/s P M Granite Pvt Ltd</td>
<td>Sijora, Kalimati</td>
<td>20,025</td>
<td>73.653 H; Mn, drains pollution anticipated</td>
</tr>
<tr>
<td>Joda East iron ore mine</td>
<td>Tata steel Ltd, Joda</td>
<td>Joda, Kamarjoda, Banspani, Khuntpani&amp; Baitarini R.F.,</td>
<td>22.94</td>
<td>671.093 ha Iron ore</td>
</tr>
<tr>
<td>Tiringpahar Iron and Mn. Mines</td>
<td>M/S Tata Steel LTD</td>
<td>Guruda, Palasa, Jadbahal, Khondbondh,Jalahari, Jajanga,</td>
<td>85000 (Mn) 643.71ha; Iron &amp; Mn ore</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3. Revenue generation from mining sector in Odisha from 1999-2000 to 2018-2019 (source: www.Odishaminerals.gov.in)

The Joda /Barbil area has the fifth largest deposit of iron in the world, besides manganese and Chrome ore as minor source. The ores are the major revenue generation source for the state and central Government. There are eighty Industries are mining allied (North Orissa Chamber of Commerce & Industry data) generating revenue for Odisha (Fig. 3).

Barbil town has manufacturing units like steel, Iron ore pellets, and liquid oxygen. The area is laden with dust due to mining, industrial operations and plying of mineral loaded trucks (about 7000 dumpers) in the night through the town as no bypass roads for heavy vehicles around Barbil. The dolomite mining area housed in the Saranda Hill slopes in the EGB hills in the mountainous reaches of upper Baitarani Basin with the polluted drainage channels Suna, a sub tributary of Baitarani River and south Karo (Koel Sub-Basin) (Panda et al., 2020 [6]).

1.2 Review of Literature

Revenue sector through mining activities in Odisha is ever increasing and simultaneously deteriorating the environment and socio ecological systems (Malaviya et al, 2010 [7], Panda et al, 2014 [8], Haddaway et al., 2019 [9]); Mining areas acutely pollute water, air and soil causing mainly respiratory diseases, mal nutrition, vegetation loss, and ecosystem degradation (Hota et al., 2015 [10]). Mines are susceptible to accidents, metalliferous dust and toxins exposure, fatigue and stress from the work settings, or managerial anxiety builds up that affect not only to miners but also to his family and friends (Entwistle, et al., 2019 [11], Stewart,
2020 [12]). The long-term targets of the Paris Agreement-2015 warrants prompt cessation to deforestation, encourage reforestation/afforestation at large scale particularly in industrial areas with waste dumps, water accumulation ponds, and processing structures, (Zobrist et al., 2009 [13]; Maus et al., 2020 [3]).

Mining accomplishments change their the topography of the natural resources of the mining areas, Land use / Land cover (LU/LC), environmental concerns, anastomosis of drains, soil losses, vegetation loss, waste generation, and ground water pollution. (Mathew et al, 2016 [14]; Mana et al., 2016 [15], & 2018 [16]; Garai et al., 2018 [17]. Panda et al., 2020 [6]). Comparison of statistics of GIS study results the planners and managers can make strategic plan for the deteriorating over exploited mining areas (Khan et al., 2018 [18]; Chang et al., 2021 [19]; Punia et al., 2021 [20]).

1.3 Objectives

- To investigate topographic constraints (Slope, drains, watershed)
- To investigate (LU)/(LC) changes (2003, 2009, and 2014)
- To examine climatic change impacts (SAT, NDVI, precipitation etc., (2007, and 2018) Present search will help to prepare records for the forest cover and plan for the degraded forests associated with mining dispositions. Restoring energy, agriculture, and water bodies can have safe mining activities and encourage vegetation in quarries, waste dump areas.

1.4 Topography

The study are belongs to Singhbhum carton of granite formation, and in Baitarani upland (200 to 400m above MSL) with Simlipal plateau, and Keonjhar plateau. Keonjhar plateau contains bauxite duricrust and Simlipal plateau covers Laterite formations. Joda and Barbil lies in Simlipal plateau. The Simlipal plateau has 600m to 800m uplands whereas 300 to 400m low flat terrain at above MSL sloping from north to south. https://ibm.gov.in/writeread data/files/07272015155420ORI-19.pdf

1.5 Stratigraphy

A Banded Iron Formation of volcanic, and sedimentary rock masses are encompassing the Singhbhum Granite lying in the northwestern exposure between Barsuan – Noamundi as folded into a Horseshoe synclinorium spread over area 60Km X 25Km containing minerals mainly iron, chromium, and manganese. The study area comprises of Singhbhum Granite Batholithic Complex lying as north-south elongated tract about 8000Km² made up of alternate 12 magmatic bodies of biotite-granodiorite-granite emplaced in three distinct but closely related phases of Simlipal group, and three other smaller granitic intrusion (Sengupta et al., 1997 [21]; De et al, 2021 [22]). Hematite is the chief mineral of Barbil area. The important active mines areas are housed in Thakurani, Joda east, Bolani, Sidhmith, Khandbhandha, Kasia-Barapada, Belkundi, Bolani, Gurudia, Kiribura, Dubuna, Jhbarabahal, Murga, Bamebani, Palsa, Jajang, Guali, and Uliburu. Iron content in ore bands are tough massive (64-68% Fe), laminated (62-65% Fe), lateritic (65-68% Fe), and Powered blue dust (MoEF&CC-2018 [23], DSR Keonjhar-2018 [4]). The contour, aspect and slope map of the area is in Fig. 4, Fig. 5, Fig. 6, and Fig. 7 as on 02-2021.

1.6 Principal Component Analysis

The purpose of reduce the dimensionality and accuracy improvisation of classification, the principal component analysis conducted for the satellite imageries. The terrestrial surface reflect energy at dissimilar intervals. The electromagnetic (EM) spectrum releases energy bands with various wavelengths from the blue to the mid-infrared region. The wavelengths range are 1: 0.45–0.52; 2: 0.52–0.60; 3: 0.63–0.69; 4: 0.76–0.90; 5: 1.55–1.75m; and 7:2.08–2.35μm. These ranges of wavelength store information (environment variables) in independent bands. Individual band handle the image as matrix structured. The associated pixels comprise of a digital number (DN) associated with the electromagnetic energy from a target that reflect or emit. RS gives idea of two closely spaced bands in the electromagnetic spectrum have surprising correlation, Estornell et al, 2013 [24], Erikstad et al., 2021 [25].

1.7 Data Collection and Analysis

The land sat data collected was from 02.02.2021 without cloud. The Landsat data collected are of 30m resolution. The imageries from LC08_L1TP_140045_20210202_20210306_01_T1 with data from Band source data of Cell Size (X, Y) - 30, 30, with Spatial Reference WGS_1984_UTM_Zone_45N used for aspect
contour and the shape map where in Landsat-8 considered. For Land use and land cover the steps followed are Landsat 8 collection 1 level 2 data collected from USGS earth explorer, Composite map was in produce from bands 1-7. Shape file of the study area was under insertion and the after masking out the required area.

**Fig. 4.** The aspect map of the Joda and Barbil area, Odisha

**Fig. 5.** The Contour map of the Joda Barbil area, Odisha
By using the image classification tool, the features of the area distinguished, and sampled by the training sample manager. After sampling, the similar samples were categorized and assigned names and colours. Later by help of the tool - Most Likelihood Classification, the groups were under analysis and the land use and land cover map to obtain the LU/LC map.
Climate: Mining activity has made the area very hot summer, cold winter, and dusty atmosphere. The area experiences northwesterly thunderstorm activities with a high lightening prone area. The undulated roads with large potholes, with continuous mining activities have made the climate unhealthy, suffocating and make the dwellers fatigue soon (Imran et al., 2021 [26]).

Soil of the area: The study area covers mainly laterite and lateritic soils are compact to vesicular, and at places honeycombed, composed mainly of a mixture of oxides of iron and aluminum. These soils are less fertile as permeable, acidic and are poor in nitrogen, phosphorus, potassium and calcium.

Flora and Fauna: The gorgeous flora & fauna adorns the mines area and houses wild elephants, Tigers, sambhar, etc. adjoining forest areas. The area is ironic in forest resources with large forest areas such as Thakurani, Ulliburu, and Saranda Reserve Forests. They are dense forest and hilly region (Behera et al., 2015 [28]).

![Graph showing average high and low temperature of Joda area](image1)

**Fig. 8.** The averaged high and low temperature of Joda area (GOO Masterplan -2030 [27]) The mean monthly temperature of the study with high and low temperatures are 30.77°C and 19.29°C respectively (Fig 8). The average annual rainfall is about 1378mm (Fig. 9)

![Graph showing average monthly rainfall of Joda in mm](image2)

**Fig. 9.** Mean monthly Average rainfall of Barbil the year (GOO Masterplan -2030)
2. METHODS AND METHODOLOGY

The present study involves the mining area changes, management of Barbil Tehsil area using Geospatial detection method for strategic planning to protect forest vegetation, existing agriculture setup from further deterioration in the mines area. The methodologies applied are collection of images and data from the USGS websites (open source) like SRTM and CARTO DEM (30 m spatial resolution). The images are georeferenced and further used for terrain, and drainage pattern analysis using slope, elevation etc. of Joda and Barbil. The geographical features like contour and datum further abstracted for the analysis.

Satellite imageries and data (LISS III and LISS IV) is in use for the intended mining area management, and change detection through various imageries (multi spectral) collected from NRSC “Bhuban” website and NIRD & PR lab. Image classification for the LULC at 6 years interval on LISS data is the focus of the study. Landsat 8 TIRS (Thermal Infrared) and, Landsat 5 TM (Thematic Mapper). These data, collected from the USGS websites are of use in Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST).

The GIS method is opted for comparison of the environmental losses that has occurred due to mining activities in Joda and Barbil area. The various steps involved are getting the map from the satellite imagery and the hard copy map to feature class.

2.1 Sat-Data Used

Present study uses Landsat 5, 8 and CARTOSAT DEM data of acquisition on various temporal and spatial resolutions various satellite imageries used in the study and LISS data, collected from NRSC Bhuban website and NIRD & PR lab (Table 2).

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Resolution (Spatial)</th>
<th>Sat-Data used</th>
<th>Acquisition date</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>30.00m</td>
<td>CARTO DEM</td>
<td>23-1-2016</td>
</tr>
<tr>
<td>II</td>
<td>23.00m</td>
<td>LISS III</td>
<td>10-05-2016</td>
</tr>
<tr>
<td>III</td>
<td>5.80m</td>
<td>LISS IV</td>
<td>February 2003, June 2009</td>
</tr>
<tr>
<td>IV</td>
<td>30.00m</td>
<td>Landsat 5</td>
<td>22 – 01-2007</td>
</tr>
<tr>
<td>V</td>
<td>30.00m</td>
<td>Landsat 8</td>
<td>15 – 12-2018</td>
</tr>
</tbody>
</table>
2.2 Software Used

Software are used in the study are ArcGIS 10.1 (GIS software of ESRI, USA), is a platform for designing managing, solution to create by using geographical maps, geographic data compile, and analyze mapped information using boundary as shape file, classification to find Isohyet and Isopleth maps. ERDAS Imagine 9.2 (remote sensing (RS) application software) is image-processing software.

2.3 Land Use and Land Cover (LULC) Changes

Hasty vicissitudes in the LULC of an area have turn out to be a major environmental distress in recent times (Imran et al., 2021 [26], Li X., 2021 [29]). This has commanded untenable development with the drop of green corridor along with variations in local climate and creation of urban heat islands (UHI’s) (Guha et al., 2017 [30]). Land use are in use for the analysis of environmental processes and problems. In present study for LULC classification, LISS data are in use. The multiple year of LISS data are in use for LULC classification, like LISS III, IV (2003, 2009, and 2014). These multispectral data submit for supervised classification using ERDAS 2014 Image Processing software (Kayet et al., 2016 [31]).

2.4 Supervised Classification

The collected RS data was geo-referenced and properly clipped assigning to the study area. The LULC classification made by ERDAS 2014 image processing software by supervised classification techniques. The supervised classification involves development of spectral signatures in some definite location or training sites in the imagery. The vector layer related to different polygons overlaying for various LU types digitized over the raster section. The training locations help ERDAS to grow spectral signatures for the outlined locations. The classification of images executed with the (MLA), Maximum Likelihood algorithms. Presently the land use categories are water body, agriculture land, grassland, built up land, mining area and forest.

2.5 Land Use and Land Cover

Maximum Likelihood classifier is a supervised classification technique. When classifying an unknown pixel, that evaluates both variance and covariance of the spectral response pattern.

![LULC Classification of Year 2003](image)

Fig. 11. LULC classification Joda area of LISS IV in the year 2003, (LISS III data)
Fig. 12. LULC classification Joda area of LISS IV in the year 2009, (LISS III data)

Fig. 13. LULC classification Joda area of LISS IV in the year 2013, (LISS III data)

Table 3. Class statistics of each land use class from 2003 to 2013 of single watershed area

<table>
<thead>
<tr>
<th>Class</th>
<th>2003</th>
<th>2009</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation</td>
<td>141507054</td>
<td>132955943</td>
<td>110446690</td>
</tr>
<tr>
<td>Crop land</td>
<td>60236030</td>
<td>53440760</td>
<td>46612965</td>
</tr>
<tr>
<td>Built up land</td>
<td>57035927</td>
<td>72313523</td>
<td>84567395</td>
</tr>
<tr>
<td>Mining area</td>
<td>44707156</td>
<td>46063650</td>
<td>59803042</td>
</tr>
<tr>
<td>Waterbody</td>
<td>14705880</td>
<td>13415353</td>
<td>16800557</td>
</tr>
</tbody>
</table>
Fig. 14. The various land use and land cover in Joda/Barbil areas 2003, 2009 and 2013

The LULC under Table 3 & Fig. 11, Fig. 12, and Fig. 13 shows the vegetation cover decline (including the open, dense forest and shrubs) area from 141.51 km$^2$ to 110.45Km$^2$ within the year 2003 to 2013.

This might have caused due to increase in mining area or may built up land. In Fig. 4 show classified land use and Land cover were shown using MLC techniques. All the land use land cover changes (LULCC) take place, given in table below Fig. 4.

2.6 Accuracy Assessment

The amount of accuracy depending upon the data quality is the grade of nearness of results to the ground trothing values i.e. accepted and approach the real world. The accuracy of the assessment model was to find the extent how many ground truth pixel are correctly classified. The procedure of precision valuation in thematic maps can improve land use and land cover classification by permitting unambiguous response of heterogeneity units and scale in the map.

Consistency of the supervised classification used for validating the results from the results of accuracy assessment performance on the LU/LC map. Valuation results obtained from the stratified random sampling method of classified image from the year 2003 showed a total accuracy of 93.55 with a kappa coefficient of 0.9031. The same for 2009 and 2013 of the classified images were 94% and 88.75% with kappa coefficient of 0.9103, and 0.8392. The producer’s accuracy, user’s accuracy and Kappa coefficient for different classes (Table 4).

2.7 Surface Air Temperature (SAT)

The surge in demography has demanded human settlements, rise in mining and industrial activities. The exploded urban areas due to rural migration has influenced, the surface air temperature (SAT), and upper air temperature (Connors et al., 2013 [32], Guha et al., 2020 [33], Faisal et al. 2021 [34], Nagassa et al., 2021 [35]). The township has turned up as urban heat island (UHI’s) which refers to the relative warmth of urban surfaces, and urban atmosphere. The players for the UHI’s include climate change, weather adversities, topography, and chaos in city life. The anthropogenic activities, especially in urban development, have transformed the natural landscape cover to built-up areas. The vicissitudes can have substantial consequences on native meteorological parameters (Choudhury et al., 2019 [36], Abullibdeh, A., 2021 [37]).

Satellites employed to gather information about various surficial changes like LU/LC and SAT. Landsat-8 can identify the contribution of urban settlements, UHI’s and the significances of land use change in the forest areas. Landsat-8 has two bands 10 and 11 that uses for evaluating the SAT: influence through CO$_2$ in 11 band (Nagassa et al., 2020 [35]).
Table 4. Comparison of accuracy assessment results of LULC maps (Fig. 14)

<table>
<thead>
<tr>
<th>Year</th>
<th>2003</th>
<th>2009</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water body</td>
<td>100</td>
<td>100</td>
<td>90</td>
</tr>
<tr>
<td>Built up area</td>
<td>100</td>
<td>62.02</td>
<td>100</td>
</tr>
<tr>
<td>Crop land</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Mining area</td>
<td>92.86</td>
<td>92.86</td>
<td>91.67</td>
</tr>
<tr>
<td>Vegetation</td>
<td>100</td>
<td>88.05</td>
<td>0</td>
</tr>
<tr>
<td>Overall accuracy</td>
<td>93.55%</td>
<td>94%</td>
<td>88.75%</td>
</tr>
<tr>
<td>Kappa Coefficient</td>
<td>0.9031</td>
<td>0.9103</td>
<td>0.8392</td>
</tr>
</tbody>
</table>

2.8 Surface Air Temperature (SAT)

Present study have used the Landsat-5, 2007 and the Landsat-8 of 2018 and satellite data. Images of thermal bands (band 10) for year 2018, the band six (thermal band) in year 2007 was analyzed to identify the surface air temperature. In Landsat 8, band 11 shows less temperature when compared with band 10, because band 11, being closer to powerful 15µm band of CO2 that influences atmosphere than band 10. Ground trotting of SAT data of meteorological stations tallied to assess the real-time variation. The calculation of SAT involves the following steps: (Rajeshwari et. al., 2014 [38]).

**Step (I):** The conversion from digital number (DN) to Top of Atmosphere (TOA) radiance (upper air)

\[ L_\lambda = M L Q \text{ cal} + A L \]  

Where; L_\lambda = TOA Spectrum radiance; M L= Band specific multiplicative rescaling factor; AL = Band specific additive rescaling factor; Q calories = Quantized, and calibrated standard product pixel values

**Step (II):** To convert TOA values to TOA Brightness Temperature in Kelvin T

\[ T = K_2 \ln(k_1 K_\lambda + 1) \]  

Where; T= TOA (upper air) brightness temperature; L_\lambda = TOA (upper air) spectral radiance; K_1= thermal change constant (Band specific); K_2 = Band specific thermal change constant

**Step: (III)** To convert Kelvin to Degree Celsius

\[ T^0 \text{ Celsius} = T^0 K - 273 \]  

The values obtained from bands 10 and 11 were collected from Meta data. K_1 & K_2, rescaling factor were derived using above equations (1& 2) (Rajeshwari et. al., 2014 [38]).

In the year 2007, the minimum Temperature 18.38°C, maximum Temperature 34.85°C), and during 2018 the minimum temperature 19.72 0C, and maximum Temperature 35.16°C. The temperature of sturdy area are estimated by using the wavelength of sixth band ranging from 10.4 to 12.50µm (micrometer) of the electromagnetic spectrum. The wavelength of band 10 ranges from 10.60-11.19µm, and value for 11th band ranges from 11.50-12.51µm (Fig. 15, & Fig. 16).

Table 5. Changes in temperature in different classes of LULC (during 2007 and 2018)

<table>
<thead>
<tr>
<th>Land cover</th>
<th>2007</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water body</td>
<td>19°C</td>
<td>22°C</td>
</tr>
<tr>
<td>Vegetation</td>
<td>20°C</td>
<td>22°C</td>
</tr>
<tr>
<td>Crop land</td>
<td>23°C</td>
<td>25°C</td>
</tr>
<tr>
<td>Built up land</td>
<td>27°C</td>
<td>28°C</td>
</tr>
<tr>
<td>Mining area</td>
<td>32°C</td>
<td>34°C</td>
</tr>
</tbody>
</table>

The SAT is well distributed (Fig. 15, & Fig. 16), and the minimum 18.38°C, and maximum 34.85°C temperature was recorded for the Barbil mining area in the year 2007 and of 19.72°C (minimum), and maximum temperature of 35.16°C in the year 2017 is observed (Table 5).

2.9 Normalized Difference Vegetation Index

Normalized Difference Vegetation Index, the NDVI compute greenly vegetation by determining
the changes between near infrared (that reflects vegetation strongly) and red light (that vegetation absorbs). NDVI always ranges from -1 to +1. NDVI used to estimate crop yields, pasture performance, etc. Luxuriant flora absorbs a lion’s share of the spectra of visible light that is incident on it, and reflects a major part of the near infrared light. Unhealthy or sparse vegetation reflects light that is more visible and less near infrared light. The NDVI statistics utilizes by concentrating on the bands of the satellites, those are sensitive to vegetation data (near infrared and red). The bigger the difference point to higher vegetation.

Fig. 15. Land surface temperature Map for the Year 2007 (Min Temperature 18.38°C, Maximum Temperature 34.85°C)

Fig. 16. Land surface temperature Map for the Year 2018 (Min Temperature 19.72°C, Maximum Temperature 35.16°C)
2.10 Estimation of NDVI

Present study, uses Landsat images of different years 2007 and 2018 for NDVI estimation. Classification for the change in forest cover, mining area, cropland and watershed ranging for a period of 11 years. The variations were examined by using three types of datasets separately and generated maps for the five classes i.e., lacustrine areas, built up land, mining area, vegetation and cropland. There had been dense forests during 2003, but the forest cover became sparse in the years 2007, and 2018, which has been under consideration for comparison Fig. 6 (A), and Fig. 6B.

The NDVI using the visible and near infrared region can reflect the greenness, and the amount and thickness of vegetation can be obtained. Greenly vegetation absorbs major share of the visible light that hits and reflects a large portion of the NIR. Poor and sparse vegetation reflects more visible but less NIR light.

\[
NDVI = \frac{NIR - RED}{NIR + RED}
\]  

Where: NIR = Reflectance in near infrared Band, and RED=Reflectance in Red Band.

In the present study, Fig. 17 and Fig. 18 clearly infers the NDVI variation over the Barbil watershed. The NDVI values varying between - 1 to + 1 has been segregated as - 1 to 0 (water bodies), 0.2 to 0.4 (sparse open forest), and 0.4 to 0.8 (scrubs, and light vegetation), and built up area 0.8 to 1 as dense vegetation. The pixels considered in the NDVI images of all class are in (Table 6).

<table>
<thead>
<tr>
<th>Classes</th>
<th>NDVI Values (-1 to +1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Bodies</td>
<td>-1 to 0.06</td>
</tr>
<tr>
<td>Built up &amp; light vegetation</td>
<td>0.06 to 0.13</td>
</tr>
<tr>
<td>Mining Area</td>
<td>0.16 to 0.3</td>
</tr>
<tr>
<td>Heavy vegetation</td>
<td>0.3 to 0.4</td>
</tr>
</tbody>
</table>

NDVI are helpful to differentiate the Land use and Land cover type in the area of study in order to study the co-relation with Land surface temperature variation in the selected lacustrine area. The loss of vegetation is because of increase in mining activity and increase in built up area.

Fig. 17. NDVI Map of Joda Barbil area for the Year 2007
Fig. 18. NDVI Map of Joda Barbil area for the Year 2018

2.11 Co-relation between SAT and NDVI

In the Figs. 15 & 16, 17, 18, clearly shows a strongly -ve correlation between SAT and NDVI within the Watershed. The SAT and greenly vegetation depends on the variations of rainfall in the rainy season of the year and the +ve correlation between NDVI and SAT found in the warm months from May to October (Sun and Means, 2007). The correlation between SAT and NDVI indicate that Barbil has turned out as drought prone area due to reduction in forest cover.

3. DISCUSSION

Odisha state shares from the country’s production of some minerals are Iolite, and Chromite 100%, 70.95% of Bauxite, 59.64% of Iron Ore, and 39.28% of Graphite, Manganese Ore of 18.51%, and Limestone of (1.57%) as per Annual report of Ministry mines, Government of India 2020-2021.

The sectors that mining area lagging are illegal mining which collapse the mining regulation stipulations. The Consequences are due to deficiency in Governance, failing to track basic norms and agreement with the indicators. The tendering procedure, evaluation, identification of mining volume, production figures, and clashes of interest, and accusations of corruption are the focusing factors in the mines management in the area. Before leasing the mines, it is essential to have the environment impact assessment considering the human right and aboriginal tribes health, ecology and livelihood concerns. The portable water, ground water, irrigation and water supply to the mines area needs attention. The usual threats, violence, protests, responses, inevitable scandals in the area needs responsive action and management.

Last two to three decades there is collapse in mining sector management. There is poor operational strategies in mines, which has age-old criticisms, and complaints against corruption, lack of accountability for losses in wastes, environmental degradation, waterlogging in open cast mine pits, regular seizures, and human rights violations. It is essential to frame regulations, regular seizures, GIS application to assess volume of excavations, to have strict vigilance of existing mines, and afforestation, reforestation of degraded/lost forests in Barbil area.
The mines and minerals (development, and regulation) amendment act (1957) have superseded by the Mines and Minerals (Development and Regulation) Amendment Act, 2021 in India for judicious management of the mines and its associated natural resources. The Act can regulates the mining sector as:

a) Removal of imposition on end-use minerals,
b) Use/ reuse of minerals by captive mine,
c) Auction of mineral concessions (except coal & atomic minerals) as per Govt. norms,
d) Rights of certain existing concession holders,
e) Allocation of mines with expired leases,
f) Extension of leases to government companies,
g) Conditions for lapse of mining lease, and
h) Non-exclusive reconnaissance permit.

Strict implementation of the act, the mining areas can reduce/reuse wastes, stagnant ponds, and save the environment, (MoL&J-2021 [39]).

The effect is that the mining growth needs support by cost-benefit analysis, Environmental Impact Assessment (EIA), and appropriate regulation not complying to MMDR Act, 1957 but asper Mineral Laws (Amendment) Act, 2020 inter alia, can maintain sustained and transparent mineral production, https://thewire.in/environment/odisha-mining-tribals-access-to-air-water

4. CONCLUSION

The mines area management of land, forests and water resource (Surface and underground) is a growing concern worldwide. The impacts of over exploitation, illegal mining, mines area land management, trailing deposit put grave concerns and is inviting climate variation, deteriorating water quality, and quantity has developed a number of simulation models. Improving infrastructure facilities like afforestation/ reforestation, water quality improvement, reuse of trailing, and saving the agriculture are the prime concern for effective mines area management.

From GIS studies for LULC of Barbil area, it is inferred that the due to excessive lease, illegal mining, and population surge there constant increase in mine area and built up areas in and around Barbil Tehsil at the cost of forests and agricultural land since 2003 onwards. The SAT and NDVI studies shows that there is average temperature rise in the area due mining activities and infrastructural development. Before leasing a mine, it is imperative to have EIA studies, provisions for non-violation of the human rights and aboriginal tribe's safety, health, ecology and livelihood concerns. The portable water, ground water, irrigation and water supply to the mines area needs attention along with strict implementation of the Mines and Minerals (Development and Regulation) Amendment Act, 2021.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. In addition, the producing company rather funded by personal efforts of the authors but not funded by anybody for the research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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