Environmental Impacts of Coal Mining in Jharkhand using GIS

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Jharkhand

Jharkhand is one of the leading states in terms of economic growth. It is one of the richest mineral zones in the world and boasts of 40 per cent and 29 per cent of India's mineral and coal reserves respectively. Due to its large mineral reserves, mining and mineral extraction are the major industries in the state. Value of mineral production (excluding fuel minerals) during 2018-19 (up to February 2019) stood at Rs 2,313 crore (US$ 330.95 million).

A brief overview of Natural Resources in Jharkhand[1]:

Mineral	Jharkhand (in million tonnes)	India (in million tonnes)	Percentage of share in India
Coal	75,460.14	264,535.06	28.52
Iron ore (hematite)	4035.74	14,630.39	27.58
Copper ore	226.08	1394.43	16.21
Fireclay	66.80	704.76	9.47
Graphite	10.34	168.77	6.12
Bauxite	117.54	3289.81	3.57
Manganese ore	7.47	378.57	1.97
Feldspar	1.65	90.78	1.81
Dolomite	51.09	7533.10	0.67
Limestone	745.77	975,344.90	0.42
Chromite	0.74	213.06	0.34
Iron ore (magnetite)	10.26	10,619.48	0.096

Coal Advantage:

- Jharkhand is the only state in India to produce coking coal, uranium and pyrite. With 25.7% of the total iron ore (hematite) reserves, Jharkhand ranks second among the states.
- Economic advantage: It is close to the ports of Kolkata, Haldia and Paradip which helps in transportation of minerals.

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1 https://www.researchgate.net/figure/The-mineral-resources-in-Jharkhand-as-on-1st-April-2005_tbl5_284930562

Advantages of GIS in Environmental Impact Assessment

- It can visually and intuitively show environmental quality and pollution conditions.
- Combining information technologies, such as GIS, RS and GPS, EIA can realize updates and dynamic processing & visualization of data.
- Geographical position has the function of public coordinate connecting all the attributes
- GIS can manage a variety of environmental information easily and organize this information effectively to conduct environmental statistics.

Applications of GIS in EIA in the Indian Scenario:

- Land-use/land-cover analysis
- Environmental change-detection studies based on multi-temporal satellite data
- Predicting vegetation-cover loss following project implementation
- Mapping soil-erosion intensity over the project area
- Mapping environmentally/ecologically sensitive areas or hotspots
- Selecting potential sites for environmental restoration measures
- Dispersion of pollutants
- Terrain models used to estimate shadow regions, slope and aspect allocation/ siting: allocation of land for different resources.
- Preparing comprehensive thematic maps for planners, decision-makers, and environmentalists.

Some Indian projects already measuring environmental impact of Coal mining in india:
Central Database (limited/proprietary information):
http://ismenvis.nic.in/Database/Remote_Sensing_Database_9041.aspx

- Korba Region, Chhattisgarh

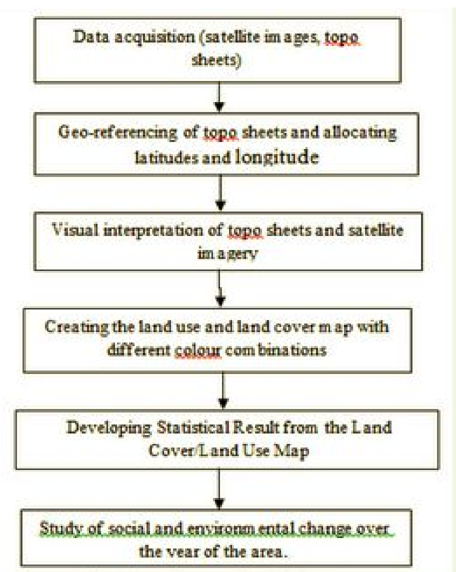

Fig. 1 Flow diagram of methodology

- Potential of Satellite Image Spectral to assess Iron Ore grades of noamundi Iron deposits
- Application of RS Data and GIS in assessing the impact of mining activities on the environment (2001)
  <document is proprietary, no DOI available either. Study is relevant however>
- **Assessment of Impact of Opencast Mine on Surrounding Forest: A Case Study from Keonjhar District of Odisha, India** (2014)
  <only abstract available> Uses temporal remote sensing data & GIS. Mainly studies forest degradation impacts of opencast mining.

Environment Monitoring Indicators used typically for mining projects

- Rainfall, vegetation, ground-level ozone, carbon dioxide, water-quality parameters, air-quality parameters, baseline land use and land cover, and soil erosion potential mapping typically.

Overview of GIS Analysis techniques used for different impact assessments:

Table 1

Indicator	Data Collection	Impact Analysis using GIS
Land-use cover (vegetation change)	Derived from some-type of overhead, remotely sensed imagery such as aerial photographs, digital satellite data, satellite image processing etc.	Change-detection approach using **Post-classification across time.** Change-correlation matrices will be the output.
Biodiversity mapping (for example, of mangrove trees, aquaculture)	Satellite sensor data used to record images	**NDVI** map at each time interval, followed by change detection. Simpson's diversity index (SDI) = measure of biodiversity.
Soil-erosion intensity	Multi-temporal remote-sensing images + environmental modelling (for predictive purposes)	Universal Soil Loss Equation = erosion model designed to predict long-term average soil losses from specific field areas.

Slope angle	Interpolated elevation data. Slope map produced from Digital Elevation Model DEM.	

A brief description of the change-detection approaches (Satapathy et al, 2008):

1. **Post-classification analysis:** is a simple method for change detection which involves the classification of each of the images independently, followed by a comparison of the corresponding pixel (thematic) labels to identify areas where change has occurred. Results can then be displayed in a change matrix or a change map. Below is a stepwise process flow that can be followed.

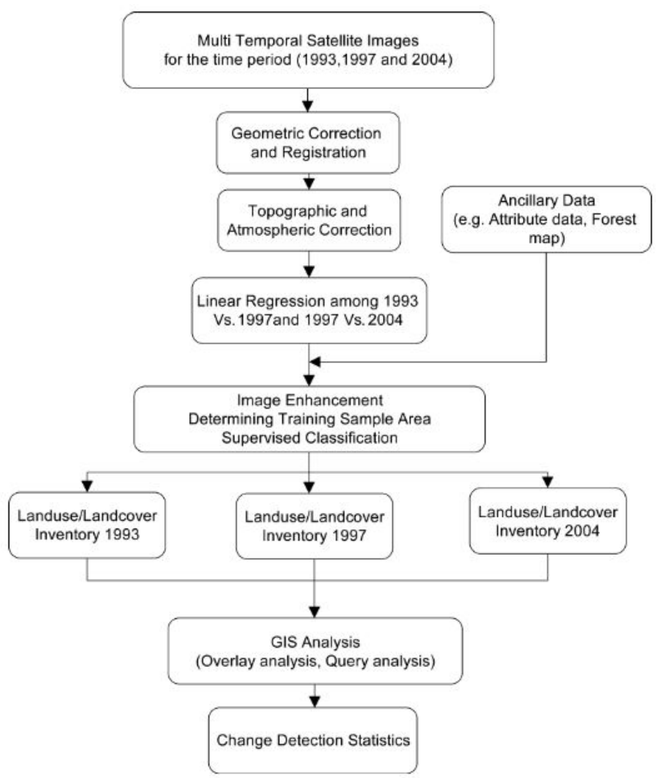

Figure 6. Flow chart for the study approach for post-classification comparison.

2. **Normalized Differential Vegetation Index** (NDVI)

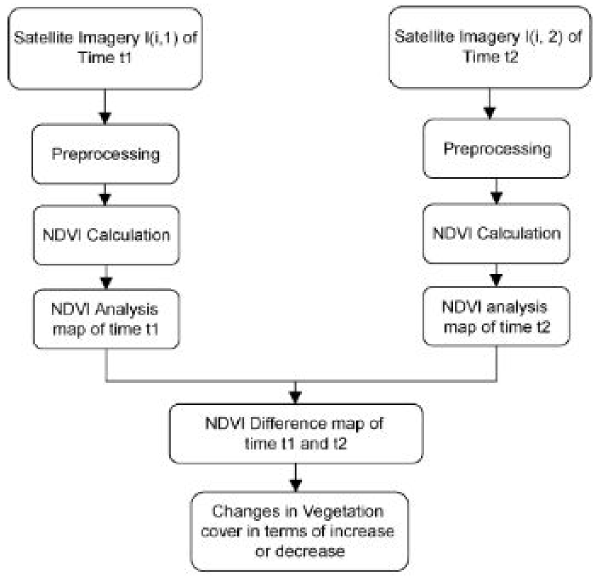

Figure 7. Flow chart for change detection using the NDVI technique.

Steps typically followed overall:

1. Developing the Base Map: scanning maps + geocoding with image processing + geo-referencing. (**graphic data)**
2. Environmental Data : **(attribute data)**
    a. Monitoring data : using GPS / remote & satellite sensing/ government data for socio-economic indicators, population etc. Some typical elements include for mining include:
3. Thematic maps: maps for each impact assessment to emphasize factor of interest. 1 attribute (temporal or non-temporal) overlaid on the graphic layer.
4. Analysis of temporal data using the techniques mentioned in Table 1 above.

Other Studies in this area:

Table 1.

Authors	**Title**	**Year**	**Purpose**
Gharehbaghi K., Scott-Young C.	GIS as a vital tool for Environmental Impact Assessment and Mitigation	2018	Studies the importance of GIS + Environmental Data Integration to improve EIA processes.

Maiti K.K., Bandyopadhyay J., Chakravarty D., Mondal S.	Application of geo-informatics for environmental health assessment (eha) on iron-ore mines area, noamundi block, jharkhand, India	2018	Noamundi iron-mine in Jharkhand. Uses NDVI index to study and analyze impacts of mining on the surrounding area. Data sourced from RS to create thematic maps for EIA.
Zhang Y., Lu W.-X., Guo J.-Y., Zhao H.-Q., Yang Q.-C., Chen M.	Geo-environmental impact assessment and management information system for the mining area, Northeast China	2015	Fuzzy logic model (T-S Fuzzy Neural Network) used to classify mining-induced damage.
Li X., Xu Z., Qiu Y., Qi J., Tang S.	Application of GIS technique in environmental impact assessment	2013	Combining GIS + Environmental Model for predicting & visualizing spread of pollutants.
Shinde V., Nandgude S.B., Singh M.	Assessment of water quality around surface coal mine in India	2013	Jharia coalfield: measures water quality. This is field research however, with water samples collected. Seasonal measurement and not in relation to mine's pre & post-construction.
Yuan Z., Shen Q.P.	Application of GIS in building environmental impact assessment in Hong Kong	2011	Model of GIS based EIA platform
Zhao X., Yan X., Jiang Y.	Integrated GIS-based prediction and impact assessment system due to mining subsidence	2010	Fuzzy logic model (Probability Integral Method, a stochastic model) used to classify mining-induced damage with input of subsidence and land-use.
Satapathy D.R., Katpatal Y.B., Wate S.R.	Application of geospatial technologies for environmental impact assessment: An Indian Scenario	2008	Provides framework for using change-detection approaches NDVI and Post-Classification Analysis.
Torresan F.E., Lorandi R.	A methodological proposal for quantifying environmental compensation through the spatial analysis of vulnerability	2008	Quantifying environmental compensation using spatial analysis of vulnerability indicators.

	indicators		
Berry P., Pistocchi A.	A multicriterial geographical approach for the environmental impact assessment of open-pit quarries	2003	
Lein J.K.	Automating the environmental impact assessment process. An implementation perspective	1998	Approaches to EIA that can be automated with GIS.
Schaller J.	GIS application in environmental planning and assessment	1992	GIS+Environmental Modelling to determine effects of river construction works, airport and highway construction.

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