Settlement Risk Zone Recognition Using High Resolution Satellite Data in Jharia Coal Field, Dhanbad, India

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Abstract: Coal is the most abundant fossil fuel resource present in Jharia. This is the most exploited coal field because of available metallurgical grade coal reserves. Mining in this coal field was initially in the hands of private entrepreneurs, who had limited resources and lack of desire for scientific mining. The mining method comprised of both open cast as well as underground. The open cast mining areas were not back filled, so large void is present in the form of abandoned mining. Extraction of thick seam by caving in past at shallow depth has damaged the ground surface in the form of subsidence and formation of pot holes or cracks reaching up to surface, enhancing the chances of spontaneous heating of coal seams and mine fire. This coal field is engulfed with about 70 mine fires, spread over an area of 17.32 sq. km., blocking 636 million tonnes of coking coal and 1238 million tonnes of non-coking coal. Around 34.97 sq. km. area of the Jharia Coal Field (JCF) is under subsidence. It is mentioned in JCF reconstruction program that 70% of the underground production of coal would come by caving and balance 30% by stowing and thus about 101 sq. km. underground mining area would be affected by subsidence. The other factor, which damages the land in JCF, is opencast mining and overburden dumps. Most of the built-up area is under risk zone because of mine fires activities. Mine fire and surface subsidence is the major problem in the JCF. The present study shows the settlement under risk zone using the high resolution merged data.

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1. Introduction

Mining operations involving minerals extraction from the earth's crust are having a noteworthy impact on the environment, landscape and biological communities of the earth (Down & Stocks, 1997 and Bell *et al*., 2001) and leads to ecosystem disturbance. In Jharia coal field, the coal is extracted by primitive sub-surface opencast mining method which is known as 'rat-hole' mining. A large number of researchers have used change detection procedures (Weismiller *et al*., 1977 and Yuan *et al*., 1998). Regardless of the method used, raw image differencing (Weismiller *et al*., 1977; Miller *et al*., 1978 and Williams & Stauffer, 1998), change vector analysis (Malila, 1980), image ratioing (Howarth & Wickware, 1981) and unsupervised classification change analysis (Pacific Meridian Resources, 1996).The soil layers and the underlying rock has been removed for the surface mining which eventually leads to overburden. For further processing, the ore is broken into pieces and transported and moved to crushing plants so as to get the useful product. Mining must be planned so that after mining process the dumped land can be reclaimed with useful activities like vegetation and agriculture.

JCF is probably one of the most popular area for coal mining not only in the country but also at international level due to its typical characteristics and unique status and problems. The only storehouse of prime coking coal in the country the coalfield has been witnessing mining since 1894 and is probably one of the most densely populated coal mining areas in the world. Bharat Coking Coal Limited (BCCL), Tata Iron & Steel Company (TISCO) and Indian Iron & Steel Company (IISCO) are the three mining companies operating in the coal mining activities in the 450 sq km area of the coalfield. Of the total area of the coalfield the land owned by these companies is about 50% and the remaining land is owned by various government agencies and departments and private parties. Coal mining is the prime human occupation in the coalfield and it employs about 100,000 people, which comprise of about 10% of the total population of the coalfield. In addition to coal mining there are other coal based activities, e.g., transportation, business, etc. There is hardly any coal based industry over the coal bearing area. Practically, there seems no development of the coal based industries in Dhanbad district in the last decade and a half. Out of the total proved reserves of coal in the coalfield of the order of 11.4 billion tonne only about

20-25% have been extracted or consumed by fires since inception of mining. The remaining 75% of the coal is still available.

2. Material and Methods

2.1 Study area

The JCF is one of the oldest and chief coal fields of India. It is located in the Dhanbad district of Jharkhand, between latitude 23° 39' to 23° 48' N and longitude 86° 11' to 86° 27' E. The national highway NH-2 passes diagonally through the coalfield. Jharia is a notified area and 15th largest town in the state of Jharkhand. Figure 1 showing the location of study area. The climate of the area is sub-tropical sub-humid monsoonic type with an average annual precipitation of 1700 mm of this amount; around 80% of the total precipitation is received in a period of 100 days between June and September months. The mean annual temperature of the area is 29˚C. The mean summer temperature is 28˚C and the mean winter temperature is 18˚C. The period from May to November remains wet and the remaining period dry. The JCF and its surrounding are characterized by gently undulation to a rolling topography with the overall slope towards east-south-east. The average natural slope is between 1˚ and 4˚. The relief is related to the landscape. Pediplanation appears to be the main processes of landscaping. The topography mainly bears the physiographic units which may be listed as hillocks and pediplains, monad nocks, valley-side slopes and valley flats. The elevations in the area ranges approximately 240 m in the west to 140 m in the south east near the Damodar River.

2.1 Data used and methodology

The QuickBird satellite data is used for mapping and identifying the surface features and the Survey of India (SOI) toposheet of 1:50,000 scales are used to prepare base map for study. Flow chart of methodology is shown in Figure 2.

2.2 Data collection and analysis

The high resolution data with SOI toposheet has been used to create base map and for extracting the features used for study. Various digital image-processing techniques such as supervised classification to obtain valuable information related to study and to identify the classes and features (Rani *et al*., 2011).

3. Results and Discussion

Mapping mining activities and evaluating associated environmental concerns are complicated problems because of the widespread area affected and the large size of individual mines. Monitoring and controlling these changes have been more difficult because of the outflow and time in producing consistent and up-to-date mapping. Besides, a successful monitoring approach for evaluating surface mining processes and their dynamics at a regional scale require observations with frequent temporal coverage over a long period of time to differentiate natural changes from those associated with human activities. Geographical Information System (GIS) and Remote Sensing (RS), the techniques have a distinct improvement over conventional methods/approaches to map and monitor the evolution of degraded areas. It has become a versatile tool for assessing and monitoring environmental impacts as a result of natural and manmade activities.

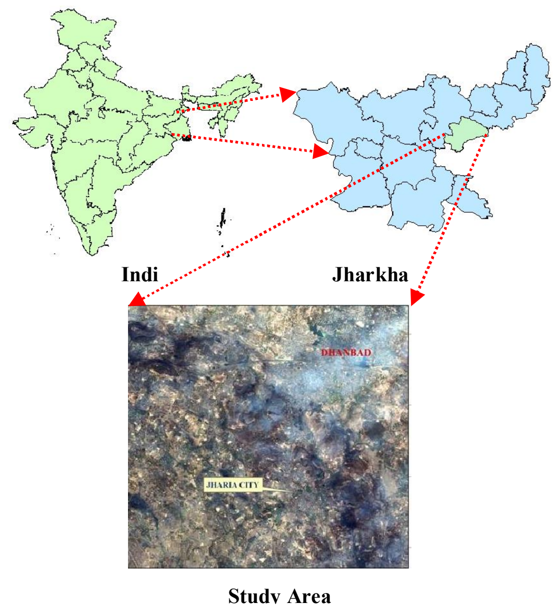

Figure 1. Location map of study site

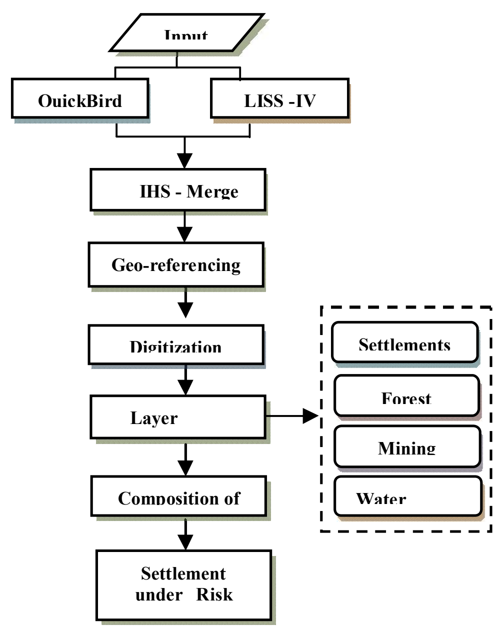

Figure 2. Methodology chart

3.1 Land use \ land cover

The entire area covers about 113.24 Sq km in JCF. The north and west part of the JCF have been severely disturbed by coal mining. Most part of the Jharia is under coal mines which are covers the 20.11 percent of the total area. Some part of the area is under cultivated and it comprises almost 20.97 percent of the total area. 24.54% area is covered by Urban built-up and rural area covers the 6.02 percent of the total area. 5.39% area is covered by forest while Brick kiln cover the2.74 % out of total. In the all over area water bodies covers the 1.71 percent. Rocky \ Barren covers the 1.34%. The rest 16.97 % is the waste land area that is not in utilization. Thus it is shows that image have diverse features. The area represents a mixed land use pattern as shown in Figure 3. A large portion of the land is covered by barren land. Generally, this land is economically unproductive and is considered as "degraded land". Wastelands are those lands, which are currently unutilized or underutilized and can be brought under vegetation cover/ cultivation with reasonable efforts. The wasteland in the area are salt affected lands, water logged land, gullied land, land with or without scrub, mining or industrial waste land and barren rocky/stony waste land. In the study area 34.61 sq km area is under built-up. This is the 30.56% of the total area. Out of this 34.61 sq km 27.79 sq km is cover by the urban which is the 24.54% of the total area and rest 6.80 sq km that is the 6.02% of the total area is cover by Rural built-up as given in the Table 1. All the built-up area is well connected by the transportation facilities. This is well connected by the railway lines. Rural and Urban built-up include residential buildings, public utilities, and other uses mainly comprised of public facility buildings, cattle sheds etc. For opencast as well as underground mining it is required to clear the surface of all the land cover and structures along with the vegetation not only in the area designated for mining purposes but also in a large area nearby which is required for making external dumps and placing associated activities. Since, in mining areas the land is taken for mining and associated activities people over there lose their livelihood. Most of the percent of this built-up area is near the coal mines. It is negatively affected by the mining activities. Most of the part is effected by the mine fires and falling in the dangerous zones. The productivity of land gets lowered due to lack of nutrients and salinity. It affects production of coal and enhances the cost of drilling and blasting in hot strata, difficulties in plying of vehicles. From the above description it is concluded that most of the built up area in Jharia coal field is highly affected by the mining and its relative activities. Its means built-up area in Jharia coal field is under risk zone. Maximum settlements found around the coal field which is most abundant risk zone in Dhandab district.

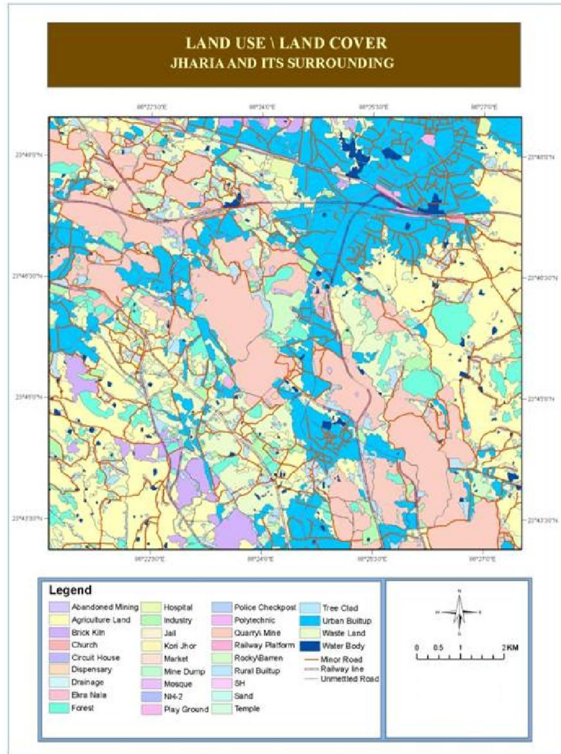

Figure 3. Land use\land cover map of study area

Table 1. Area of LU/LC

SN.	Class	Area in sq.km.	Area in %
1	Urban Built-up	27.79	24.54
2	Rural Built-up	6.82	6.02
3	Quarry\Mine	22.70	20.11
4	Agriculture land	23.75	20.97
5	Forest land	6.10	5.39
6	Water Bodies	1.94	1.71
7	Barren \ Rocky	1.51	1.34
8	Brick kiln	3.10	2.74
9	Waste land	19.22	16.97

3.2 Water resource

The entire Jharia is drained by two small streams: one is Ekra Nala drained from west to North and next is Kori Jore River itself drained from south to north as detailed in Table 2. There are several water bodies in the area. All these water bodies are not perennial so they all become dry during the hot seasons and filled during winter seasons. But all tanks, well and streams never became dry during summer season as those are located in lower area. The surface drainage pattern and its surrounding area in the coalfield have undergone a major change due to mining and other anthropogenic activities as shown in Figure 4. The water bodies are also getting affected by the unbalanced mining activities.

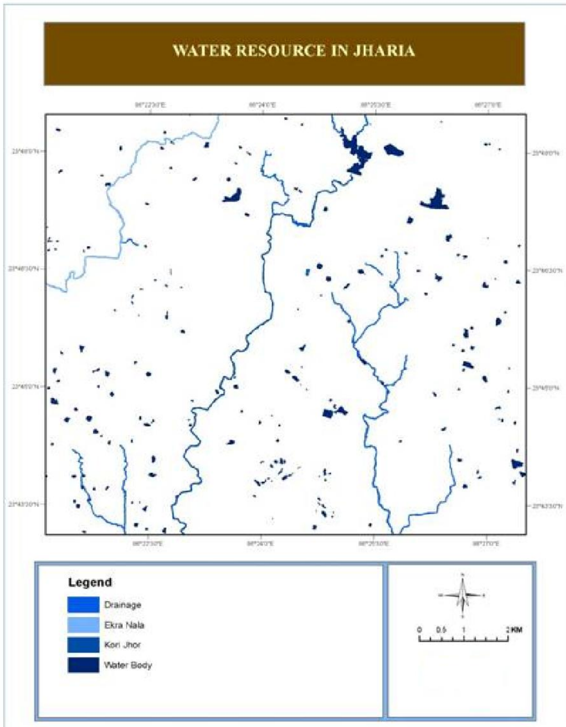

Figure 4. Water resource map

Table 2. Measures of streams

S. No.	Streams	Length in km
1	Ekra Nala	8. 80
2	Kori Jore	13.84
3	Drainage	10.20
4	Total	32.64

3.3 Agriculture and forest cover

Rice is the only major crop. Oil seeds, maize and vegetables are also cultivated, but to a significantly lesser extent. This area is further divided into different categories of crops. Kharif season crops include all the agricultural crops, which are harvested between June to October. The major kharif crops grown in the area are jowar, bajra and paddy under food grain crops and bajra and jowar as fodder crops. So far the term forest is concerns no area in the Jharia can be classified as forest. But in the settled area besides the homesteads several wild growth or planted trees can be seen of *Madhuca longifolia, Salvia divinorum, Butea frondosa, Gmelina arborea* and other trees. Thus almost all the deciduous trees are available in the Jharia but if you look all around the Jharia in a bird eye view you will feel that the village is vegetation less area as shown in Figure 5.

3.4 Coal reserve

There is a huge amount of coal reserve in JCF. This is very beneficial for the development of society. The total proved coal reserves in the coal field are about 11.4 billion tonnes out of which about 20-25% have already been exploited and consumed by the fires. Thus, about 8.55 billion tonnes of the reserves are still available as shown in Figure 6. Most of the coalfield area has been denuded of the forest cover and suffers from excessive soil erosions due to uneven mining. The mining areas should be chosen including factors like vegetation, forest settlements and soil.

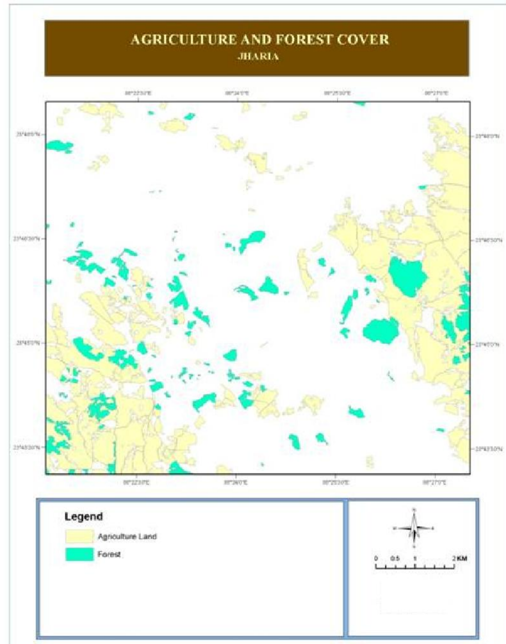

Figure 5. Agriculture and forest cover map

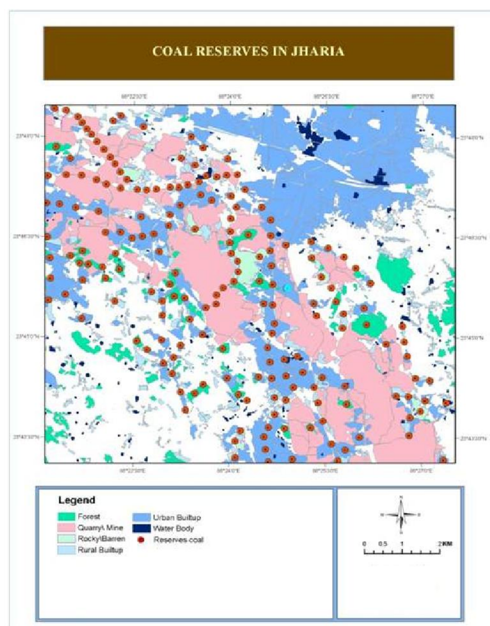

Figure 6. Coal reserves map of study area

3.5 Settlement under risk zone

The study has lead to some results as the risk zones of settlements as shown in Figure 7. These risk zones could be found by overlaying the various maps. Due to surface mining, there is danger of sliding of rocks and mine fires in the area. In the mining process, explosion is needed to remove the upper soil layer which sometimes led to release toxic gases which are dangerous to humankind. The productivity of land also lowered. The pollution due to lack of vegetation has also increased. The mining activities must be managed and then the empty land should be reclaimed or replaced by plant and agriculture activities.

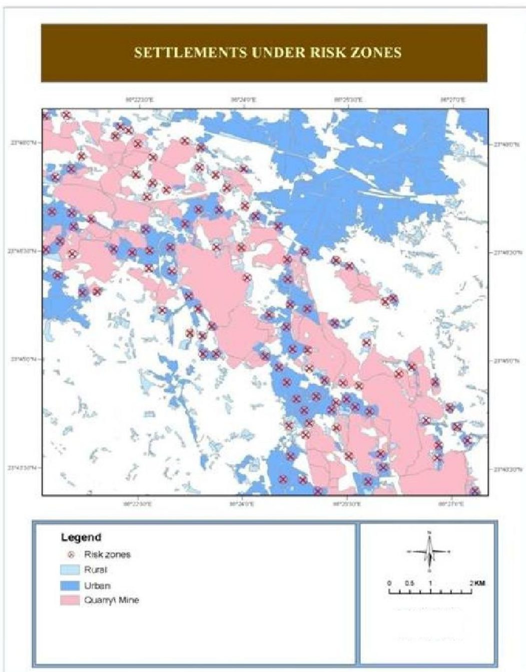

Figure 7. Settlement under risk zone map

3.6 Impacts of coal mining

The unbalanced mining activities both surface and deep mining activities lead to a major change in landuse/landcover. The vegetation is being decreased at a faster pace. The water bodies over there are also being dried or becoming unavailable. The settlement area also comes under risk zone due to explosion and mine fires. The studies shows that the land use/land cover changes of Jharia coal field of India and have reported gradual change in land cover that are having a serious danger to the vegetation present in the area due to prominent mining (Prakash and Gupta,1998).

4. Conclusion and Suggestions

From the above description it is concluded that in JCF about 20.11 percent area is covered by the coal mining. In the JCF the surface drainage pattern and its surrounding area has undergone a major change due to mining and other human activities. Mining and other social and industrial activities in the coalfield produce a huge quantity of solid wastes of different characteristics. There is a huge amount of coal reserve in JCF which is available under the built-up area, water bodies, and forest cover. Most of the built-up area is under risk zone because of mine fires activities. Mine fire and surface subsidence is the major problem in the JCF.

The production targets of the mines should be defined on the basis of the actual capacity depending upon the infrastructure and resources available. Prepare an accurate national grid surface plan of the area using the current data available from various sources. The plan should clearly indicate the locations of surface water bodies and other surface features. Prepare a disaster management plan for taking care of any disaster. Mine fire is one of the serious problems of JCF and needs serious attention. It is high time and a great challenge for the scientists, academicians, and industry people for preparing appropriate strategies and action plan for dealing with mine fires to minimize its menace. It can not only help in saving a lot of valuable coal resources which is lost due to burning, but also in reducing the adverse impacts on the environment.

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