Coal Mining Dynamics at Kuju , Bhurkunda and Khalari Coal Field Areas Over Temporal Years 1991 to 2016 using Geospatial Technology

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***Abstract*:** An attempt to study the coal mining dynamics of coal mines to the extent of percentage change in areas over the temporal years 1991, 2006 and 2016 for Kuju, Bhurkunda and Khalari coal field areas along with land use/land cover statistics were compared with transformation matrices and how remote sensing can play a vital role in detecting and monitoring coal mining activities in general along with significant role of thermal remote sensing in detecting and monitoring coal fires to prevent huge economic loss in particular were discussed in this paper.

Keywords: Land Use/land Cover, Remote Sensing, Temporal, Coal Mining

1. Introduction

The coal mining progression of coal mines were examined regarding surface region changes in coal field regions with the assistance of Coal Fields Maps and Temporal Land Use/Land Cover maps arranged from the Landsat-5 TM and Landsat-8 satellite data. Land use includes the management and reform of common habitat into fabricated condition, for example, settlements and semi-normal environments, for example, arable fields, pastures, and oversaw woods. Land utilize alludes to man's exercises and the different uses which are carried ashore though arrive covers alludes to characteristic vegetation, water bodies, shake/soil, counterfeit cover, and others observed on the land [Prakash A., et al.1998] Land cover is the physical material at the surface of the earth. Land covers incorporate grass, black-top, trees, exposed ground, water, and so forth. Earth cover is the articulation utilized by biologist Frederick Edward Clements that has its nearest current equal being vegetation [Prakash A., et al.1998]. Human exercises, particularly arrive utilize, have changed physical topographical condition enormously, the immediate aftereffect of which is the progressions of land cover. Shameful land utilize practices can antagonistically influence numerous common procedures that prompt soil disintegration, arrive corruption, natural surroundings demolition, water contamination and flooding which are frequently connected with unseemly agrarian, modern and urban land utilize hones. Land is turning into a rare asset because of populace development and industrialization. Fast development of mining exercises can likewise be credited as one reason for reduction and debasement of land. The mining of normal assets is perpetually connected with arrive utilize and arrive cover changes. Current methods of surface mining utilizing substantial gear can deliver sensational changes in arrive cover, both naturally and hydro-logically. Coal mining is the way toward separating coal starting from the earliest stage. Coal is esteemed for its vitality content, and, since the 1880s, has been generally used to create electricity power. Steel and cement industries utilize coal as a fuel for extraction of iron from press mineral and for bond generation. Coal mining has had numerous advancements over the current years, from the beginning of men burrowing, burrowing and physically removing the coal on trucks, to vast open cut and long divider mines. Mining at this scale requires the utilization of draglines, trucks, transports, water driven jacks and shearers.

2. Study area

South Karanpura Coalfield is situated in Ramgarh area of Jharkhand State, India. Karanpura Coalfield covers a zone of 195 square kilometres (75 sq. mi) and has add up to coal stores of 5,757.85 million tons. The system of coal mines on the South Karanpura coal field are claimed by Central Coalfields Limited (a backup of Coal India). There are various surface and underground mines on the South Karanpura coalfield. The South Karanpura coal mines incorporate mines in the Barka Sayal Area (Bhurkunda, Saunda, Central Saunda, Sayal, Urimari, and North Urimari/Birsa) and in the Argada Area (Gidi, Religara, Sirka, and Argada). Bhurkunda is a residential community in the Ramgarh locale of Jharkhand. Bhurkunda is found roughly 52 km north-east from Ranchi, the capital of Jharkhand. It is very much associated by Ranchi and Ramgarh. Bhurkunda is likewise known for focal coalfield constrained mines and there are numerous mines in bhurkunda, saunda-d, balkudra and numerous more places.

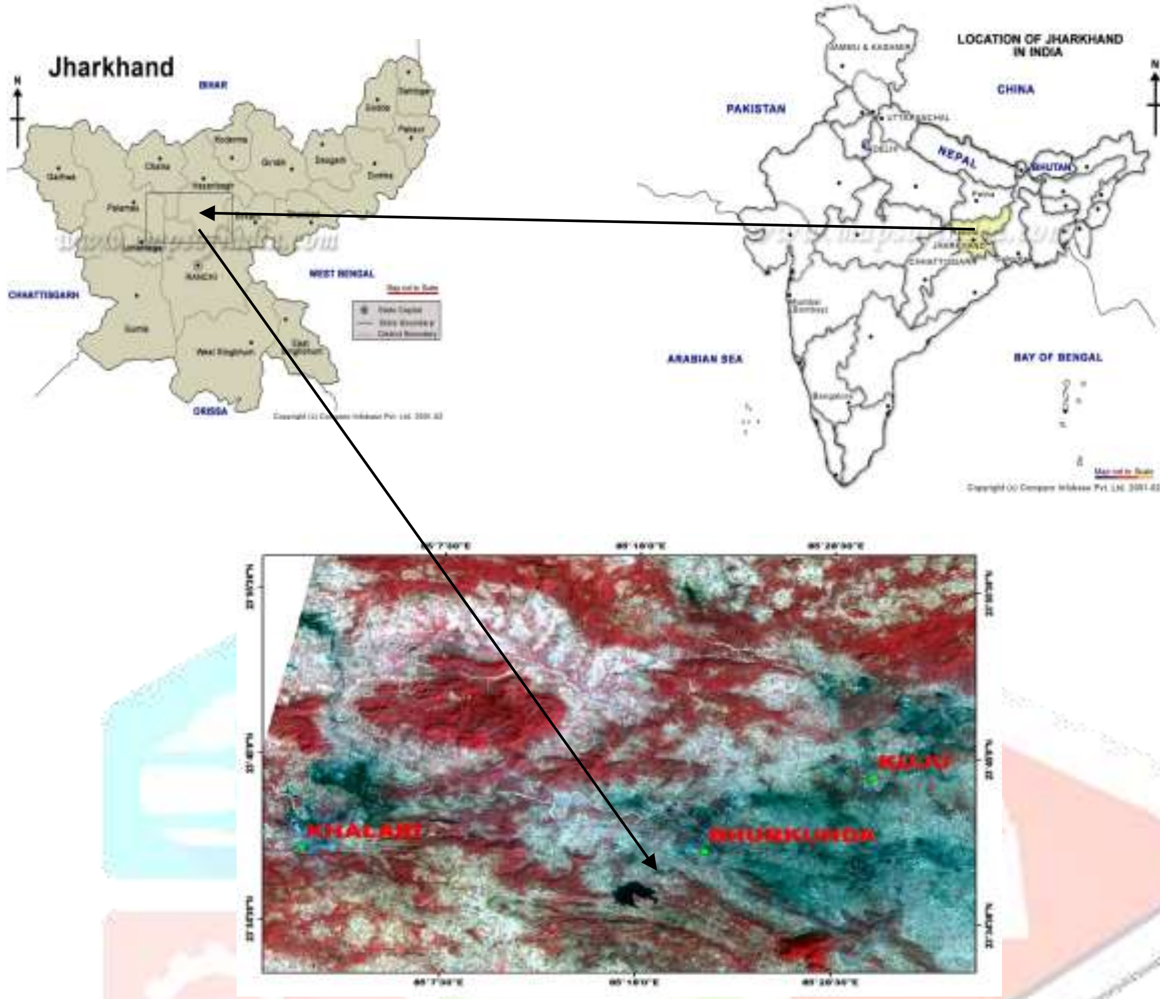

Figure 1: Location Map of the Study Area

Study area representation on Landsat 8 Satellite Image is in False Colour Composite (FCC). Dark Grey Tone represents Coal Mining Area through which the River Damodar Flows from Northwest to Southeast.

3. Methodology

The study is conducted in coalfield namely north and south karanpura Coalfields in India. Quantitative and Qualitative research which includes field survey, interviews, case-study, books and research papers related to coal mining. The research is based on both primary as well as secondary data and also secondary sources like books, journals, articles, clippings, electronic media etc. were referred. Remote sensing sensors providing multi-spectral and thermal band data of the earth-observing satellites Landsat 5 TM and 7 ETM+ along with the help of GIS- techniques were used in this research work.

In the present study, map-to-map comparison was used for land use/ land cover change detection. Temporal satellite images were used for the preparation of land use / land cover maps. Visual interpretation and image analysis techniques were used to monitor land use land cover change. Various photographic and geotechnical elements such as tone, texture, shape, size, association, drainage, landform, soil and vegetation etc. are used to identify and delineate the different land use/land cover classes. Image interpretation of satellite data followed by field validation during the year 2017 was done with reference to mapped land use – land cover categories. By using the satellite data acquired for the year 1991, 2006 and 2016, the spatial - temporal changes in the LU-LC of the region during these periods were determined. In this study the LU/LC categorization was based on LU/LC classification scheme developed by National Remote Sensing Agency. The modification in the categories at level-II was done keeping in view the coal mining activity and related land use – land cover in the area. The classification were categorized in 10 classes namely settlement, crop land, plantation, dense forest, open forest, degraded forest, scrub, barren land, river, water body in mine and coal mining area. On screen digitization technique was adopted to digitize the maps using Arc Map software (version 10.1) and further area statistics of various land use categories was calculated.

Land use land cover statistics has used to compute percentage change, trend and rate of LU/LC change between 1991-2006, 2006-2016 and 1991-2016. Maps shows area and percent LU/LC change for three periods computed for each land use land cover type. Percent change was computed by comparing the initial (before) and final (after) LU/LC areal coverage according to the following formula:

Percent LU/LC Change = (Present LU/LC area – Previous LU/LC area ÷ Previous LU/LC area) X 100.

As per the areal extent of each LU/LC type, positive values suggest an increase whereas negative values imply a decrease in areal extent. The detailed methodology adopted in the study is presented through a flow chart below.

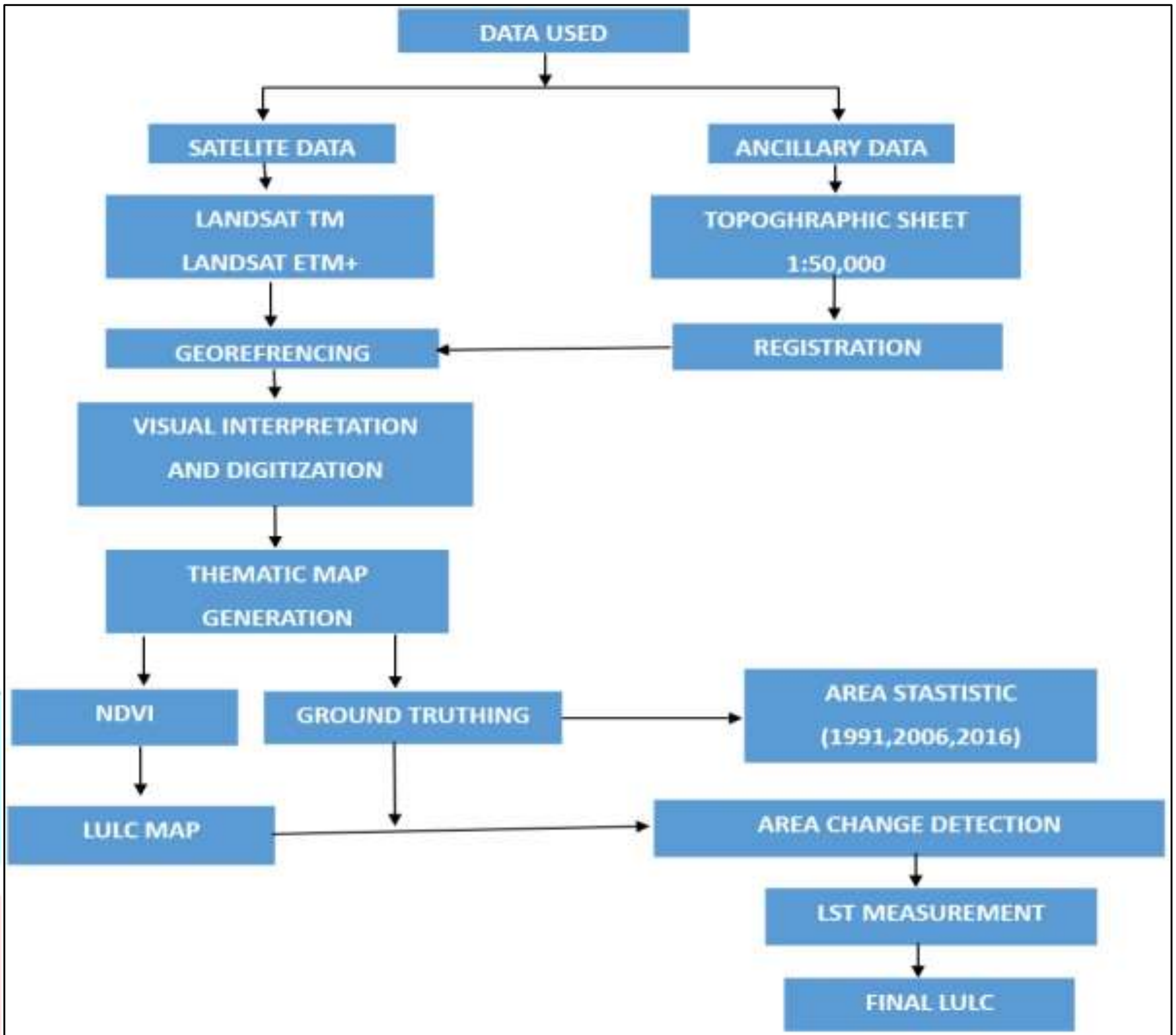

Figure 2:Flow chart showing methodology

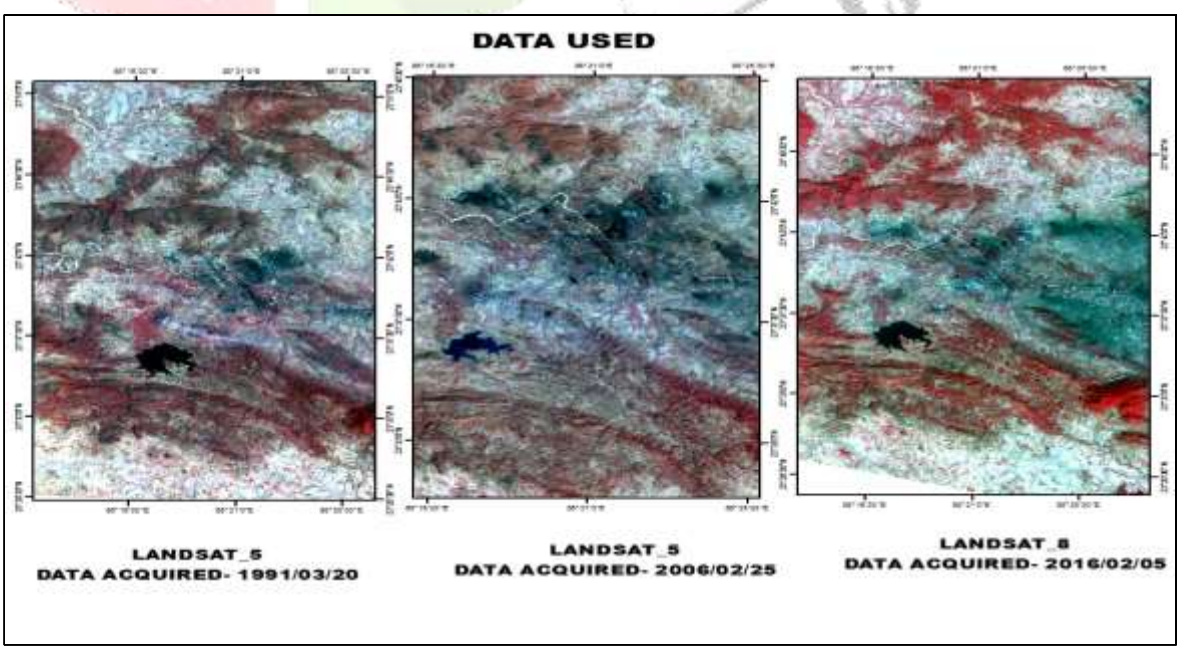

Figure 3: Satellite images downloaded from USGS Earth Explorer.

4. Results and discussion

Coal mining areas are largely located in the vicinity of Damodar River. Mining pits are interpreted on FCC by its black tone, medium to smooth texture having linear to curvilinear pattern and irregular shape whereas overburden dumps have white to light blue tone coarse to medium texture having contiguous pattern and irregular outer shape. The khalari coal mining area exhibit 18 sq. km (14.5% of total area) in 1991 to 29 sq. km (29%) in 2006 and 77 sq km. kuju coal mines exhibit 49 sq. km (24.7%) in1991, 69.8 sq. km (35.3%) in 2006 and 78.8 sq. km (39.8%) in 2016. Bhurkunda coal mines exhibits 43.5 sq. km (10.6%) in 1991, 123 sq. km (30%) in 2006 and 242 sq. km (59%) in 2016. It is interesting to note that khalari coal mining area increases during the period of 1991 (18 sq. km) to 2006 (29 sq. km) and in 2016 (77 sq. km), Kuju coal mine increases 49 sq. km in 1991 to 69.8 sq. km in 2006 and 78.8 sq. km in 2016, Bhurkunda coal mines increases 43.5 sq. km in 1991 to 123 sq. km in 2006 and 242 sq. km in 2016. In 1991 to 2006 khalari coal mines changes upto 61%, 165% in 2006 to 2016 and 327 % up to in 1991 to 2016. In 1991 to 2006 kuju changes upto 32%, 128% in 2006 to 2016 and 60% in 1991 to 2016. Bhurkunda coal mine change upto 187%, 96% in 2006 to 2016 and 456% in 1991 to 2016. Areas of abundant mines were largely converted into water bodies with in coal mine areas. The increase in coal mining area indicate increase in coal reserves in the area and increase in the coal production as large numbers of coal mines. Some mines are now abundant and filled with water. A large part of the area classified under mining area have mining dump which form large heaps of dumping materials attaining height of about 30-50 meter above ground level.

TABLE 1: AREA OF COAL MINES AND %CHANGE IN AREAS OVER THE TEMPORAL YEARS.

YEAR →	1991		2006		2016	
COAL MINES ↓	AREA in sq.km	AREA in%	AREA in sq.km	AREA in%	AREA in sq.km	AREA in %
KHALARI	18	14.5	29	23.3	77	62
KUJU	49	24.7	69.8	35.3	78.8	39.8
BHURKUNDA	43.5	10.6	123	30.1	242	59.2

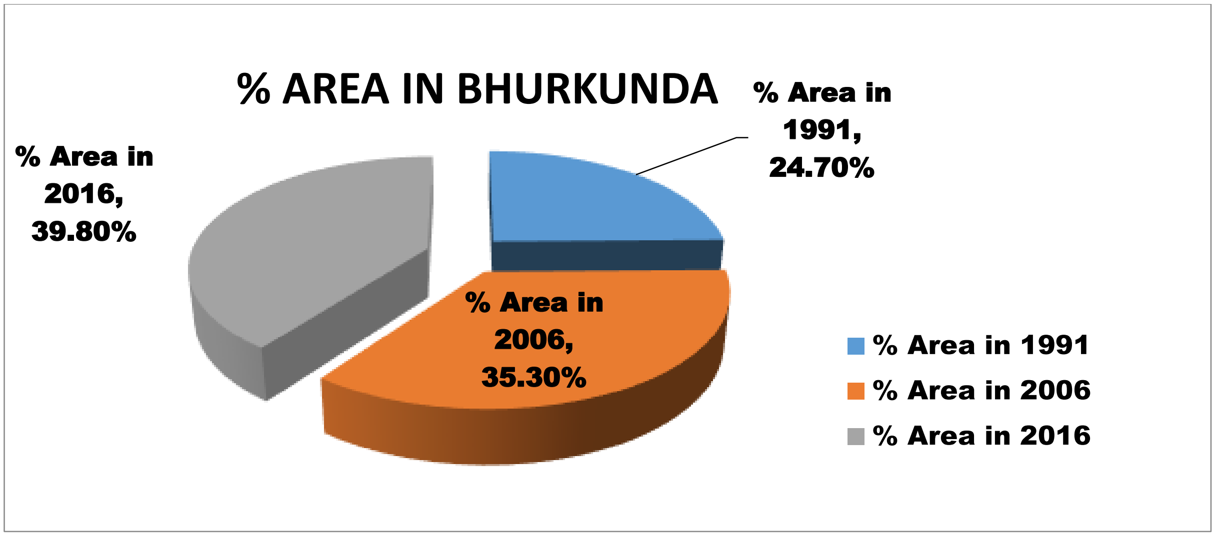

Figure 4: Pie chart shows % area in bhurkunda.

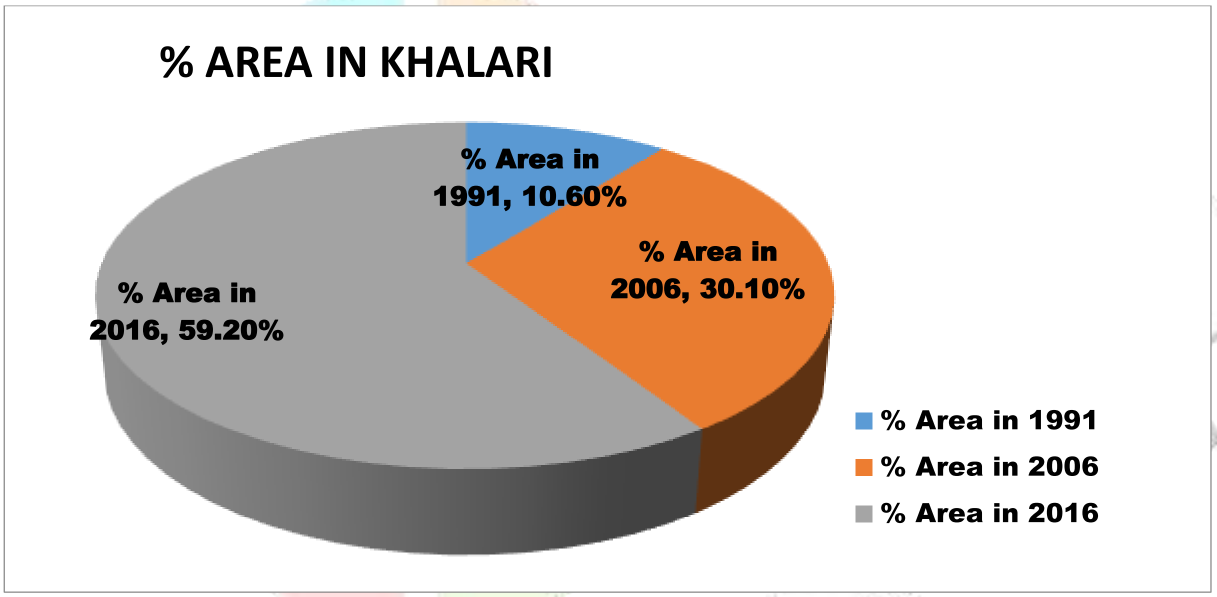

Figure 5: Pie chart shows % area in khalari.

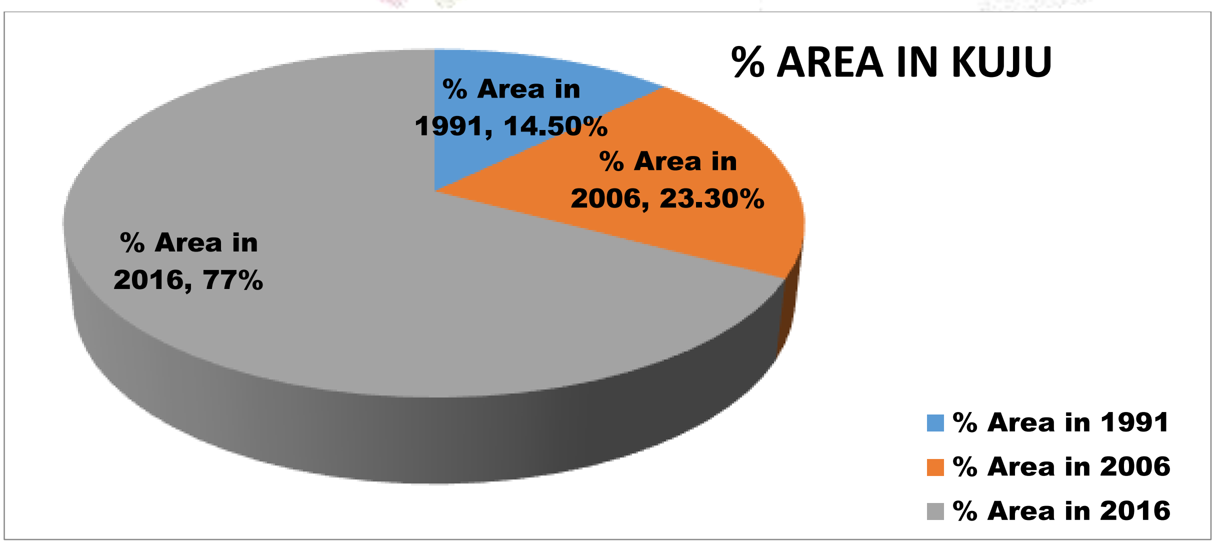

Figure 6: Pie chart shows % area in kuju

4.1 Land use/Land cover Statistics

COAL MINES →	BHURKUNDA COAL MINES AREA in sq.km		KUJU COAL MINES AREA in sq.km		KHALARI COAL MINES AREA in sq.km	
LULC FEATURES ↓	Year 1991	Year 2016	Year 1991`	Year 2016	Year 1991	Year 2016
DEGRADED	15.6	75.89	10.73	28.47	8.58	15.31
SCRUB	57.74	151.18	134.97	117.58	11.78	43.34
PLANTATION	19.50	55.29	2.55	3.79	3.43	6.51
WATER BODY WITHIN MINE	2.60	7.92	2.49	2.36	1.40	2.20
DENSE	25.08	20.91	27.03	39.88	21.93	33.52
OPEN	193.02	140.42	135.99	155.38	154.91	122.46
AGRICULTURAL LAND	100.16	121.70	44.67	36.80	24.08	36.12
SETTLEMENT	63.07	109.16	22.27	43.54	41.9	43.60
BAREN LAND	---	10.90	5.20	7.21	-----	-----
RIVER	64.82	90.48	40.58	42.20	62.0	65.23
COAL MINE	43.56	242.15	49.42	78.11	18.36	77.68
TOTAL AREA	528.89	693.37	385.90	513.12	286.37	341.50

Table 2: Land use/Land cover (LU/LC) Statistics and its Dynamics during the Study Period

Area under various categories of land use/land cover was obtained satellite image based interpretation from landsat5 data of 1991, and 2016 of landsat 8. Table 2 shows the changes in land use/land cover statistics (in Sq. km and percentage) that have taken place during each study period between 1991, 2006 and 2016. The results of the land use/land cover change statistics are also graphically represented.

4.2 Spatial Distribution of Land use / Land cover around 5 km buffer zone

Agricultural Land may be defined broadly as land used primarily for production of food and fibres. It includes land under crops (irrigated and un-irrigated, fallow, plantations etc.).In a broad sense, agricultural lands may be defined as those lands which are cultivated to produce food crops and related activities. Agricultural lands are located in the plain regions and near the peripheral zone of forests. At 5km buffer zones of bhurkunda in 1991 agricultural land is 100.16 sq. km and it increases to 121.7 sq. km in 2016. At 5 km buffer zones of kuju in 1991 agricultural land is 24.08 sq. km and it increases to 36.12 sq. km in 2016. At 5 km buffer zones of khalari in 1991 agricultural land is 44.6 sq. km and it reduces to 36.80 km in 2016.

Settlement is the land covered by settlements related to the population. The urban sprawl growth in population is generally related to decrease in cropland. At 5 km buffer zones of bhurkunda, in 1991 settlement was 63.07 sq. km and it got increased to 109.16 sq. km in 2016. At 5 km buffer zones of kuju, in 1991 agricultural land is 22.27sq.km and it increases to 43.54 sq. km in 2016. At 5 km buffer zones of khalari in 1991 agricultural land is 41.9 sq. km and it increases to 46.60 sq. km in 2016.

Plantation areas are under agricultural tree crops planted adopting agricultural management techniques. Plantation at 5km buffer zone of bhurkunda coal mines indicates that nearly 19.50 sq. km area in 1991, 55.29 sq. km area in 2016, kuju coal mines indicates that nearly 2.55 sq. km area in 1991, 2.36 sq. km area in 2016 and at khalari coal mine 3.41 sq. km in 1991, 6.51 sq. km in 2016. It was observed that there was no major changes occurred between 1991 to 2016 period but indicated an average gain of 2.75 sq. km per year in the plantation. This could be attributed illegal eloping of trees by people for fuel wood requirement indicating negative impact of population growth on natural resources

Forest refers to land with a tree canopy cover of more than 10 percent and area of more than 0.5 ha. Forests are determined both by the presence of trees and the absence of other predominant land uses within the notified forest boundaries. The trees should be able to reach a minimum height of five meter [2] within the notified forest boundaries. Forest was classified into three categories on the basis of crown density viz; dense, open and degraded. After observation of percent change analysis, it was found that maximum deforestation occurred in the vicinity of coal mining areas. Forest are divided in four categories, these are:

Open Forest reveal canopy density in between 40% to 10%. It is easily identified on FCC image by its light red - pinkish colour, smooth - medium texture, contiguous to non-contiguous pattern with irregular outline. Open forest covered an area of 193.02 sq. km in 1991 decreases 140.42sq. km in 2016 around bhurkunda coal mines and around kuju coal mines 155sq.km in 1991 open forest decreases to 135.99sq. km in 2016.Also around khalari coal mine open forest decreases from154.9 sq.km in 1991 to 122 sq.km in 2016. Due to the location of open forests in the peripheral area of dense forest, they are largely affected by human intervention for fuel wood requirement.

Barren land occupied an area of 1.95 sq. km in 1991 and 10.9 sq. km in2016. The increase in barren lands was primarily due to the loss of cultivated land as a result of the rapid increase in mining activities in the region.

Water Bodies comprises areas with surface water, either impounded in the form of ponds, lakes and reservoirs or flowing as streams, rivers, canals etc. These are seen clearly on the satellite image in blue to dark blue or cyan colour depending on the depth of water. Water bodies are categorized into river and reservoir as described below:

River represent natural course of water flowing on the land surface along a definite channel/slope regularly or intermittently towards a sea in most cases or a lake or an inland basin in desert areas or a marsh or another river. The river Damodar which traverses through central parts of the study area and flows from WNW to ESE direction is the only perennial river draining the area.

Water bodies in the coal mines are elongated water bodies measuring up to 2 km in length were located within the mining area. These water bodies are formed due to accumulation of rain water or ground water in the depression areas formed due to mining. Huge of such water bodies are situated close the coming together of river Damodar and Nalkari.

Coal mining areas are situated mostly in and around the Damodar River. Mining pits are interpreted on FCC by its black tone, medium to smooth texture having linear to curvilinear pattern and irregular shape whereas overburden dumps have white to light blue tone coarse to medium texture having contiguous pattern and irregular outer shape. The coal mining area exhibit increase over the years from 43.56 sq. km in 1991 to 242.15 sq. km in 2016. It is interesting to note that coal mining area witnessed reduction during the period of 2016 (21.09 sq. km) to 2009 (19.40 sq. km) as areas of abundant mines were largely converted into water bodies with in coal mine areas.

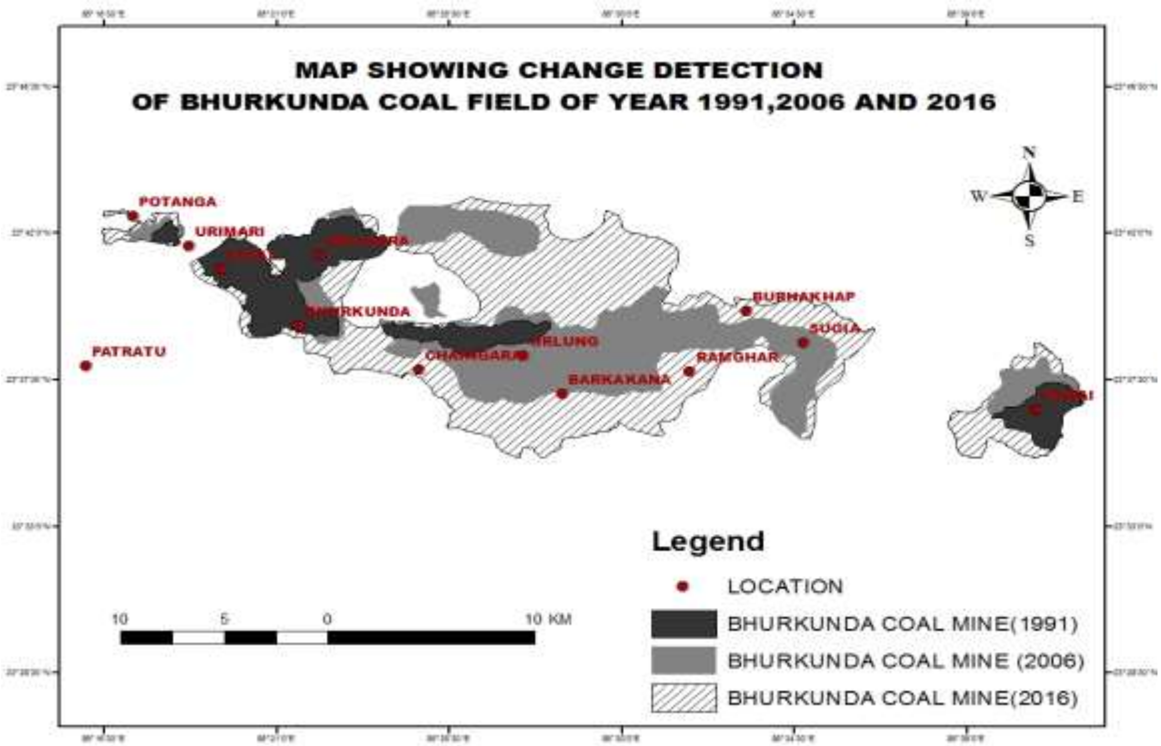

Figure 7: Map shows change detection of Bhurkunda coalfields of year 1991, 2006 and 2016

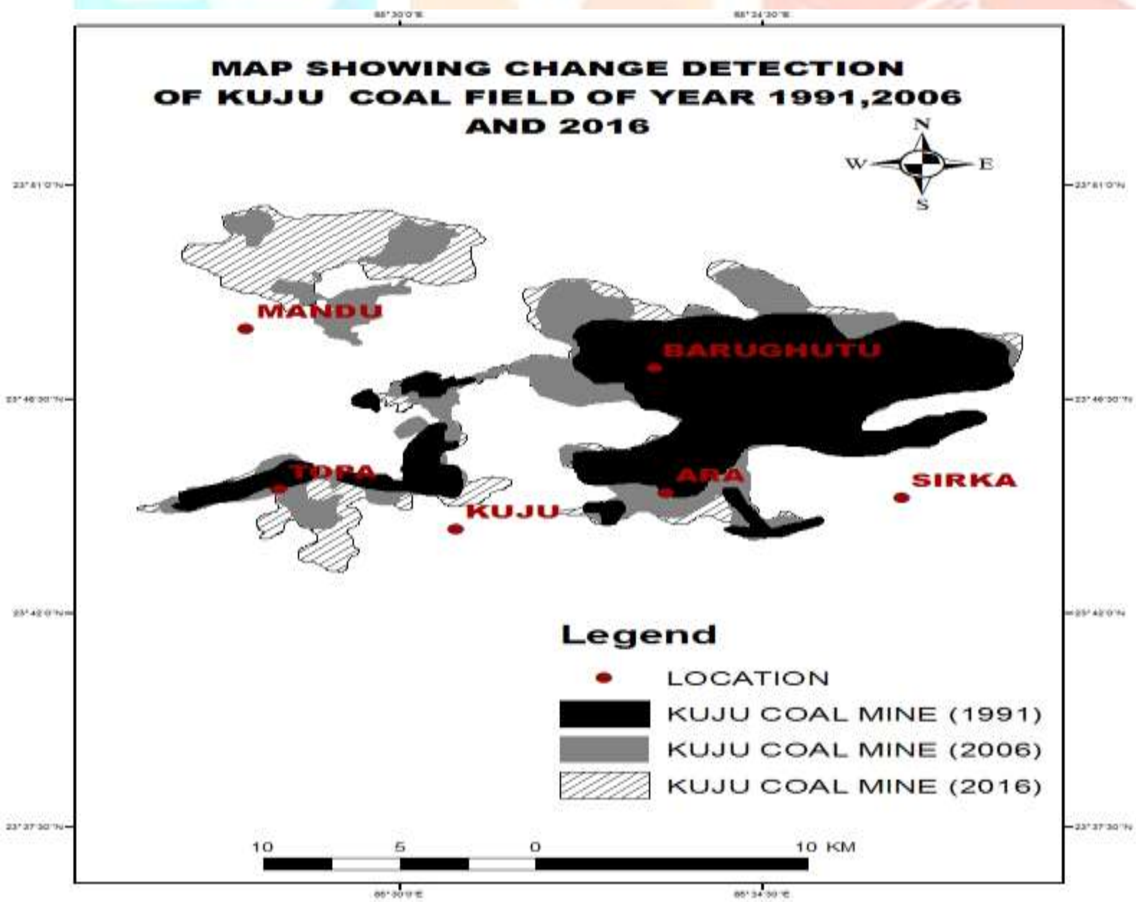

Figure 8: Map shows change detection of kuju coal fields of year 1991, 2006 and 2016

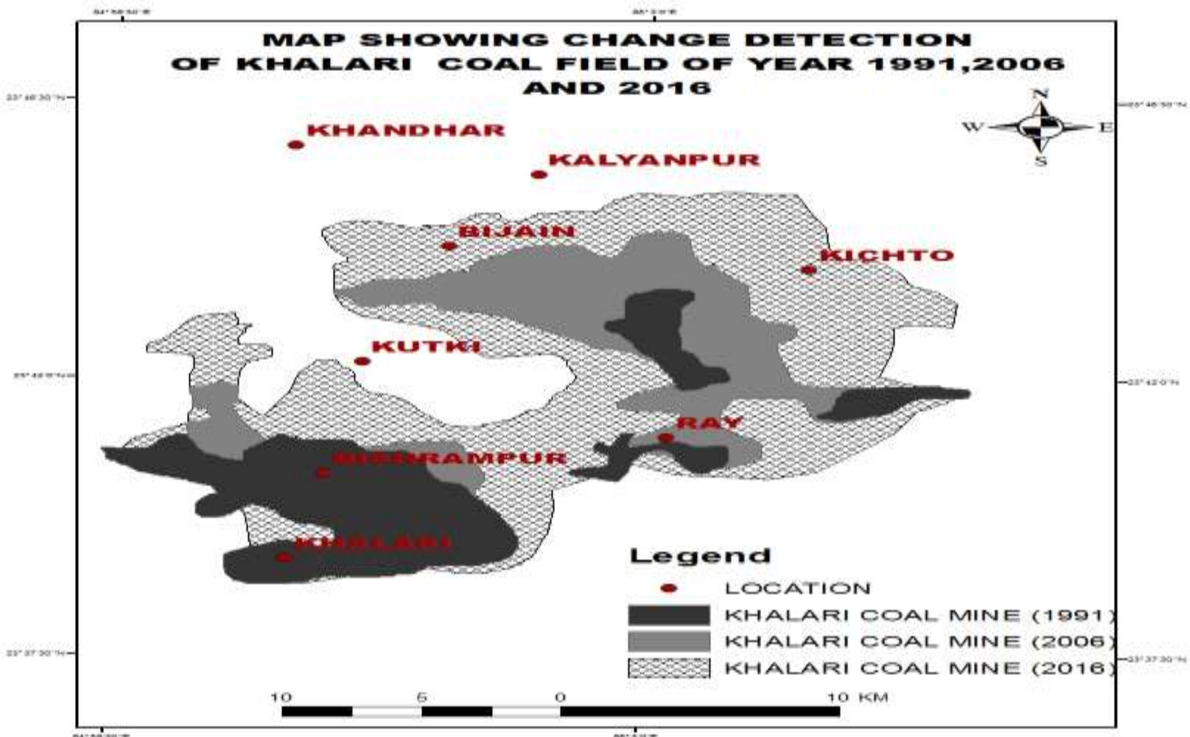

Figure 9: Map shows change detection of khalari coal fields of year 1991, 2006 and 2016

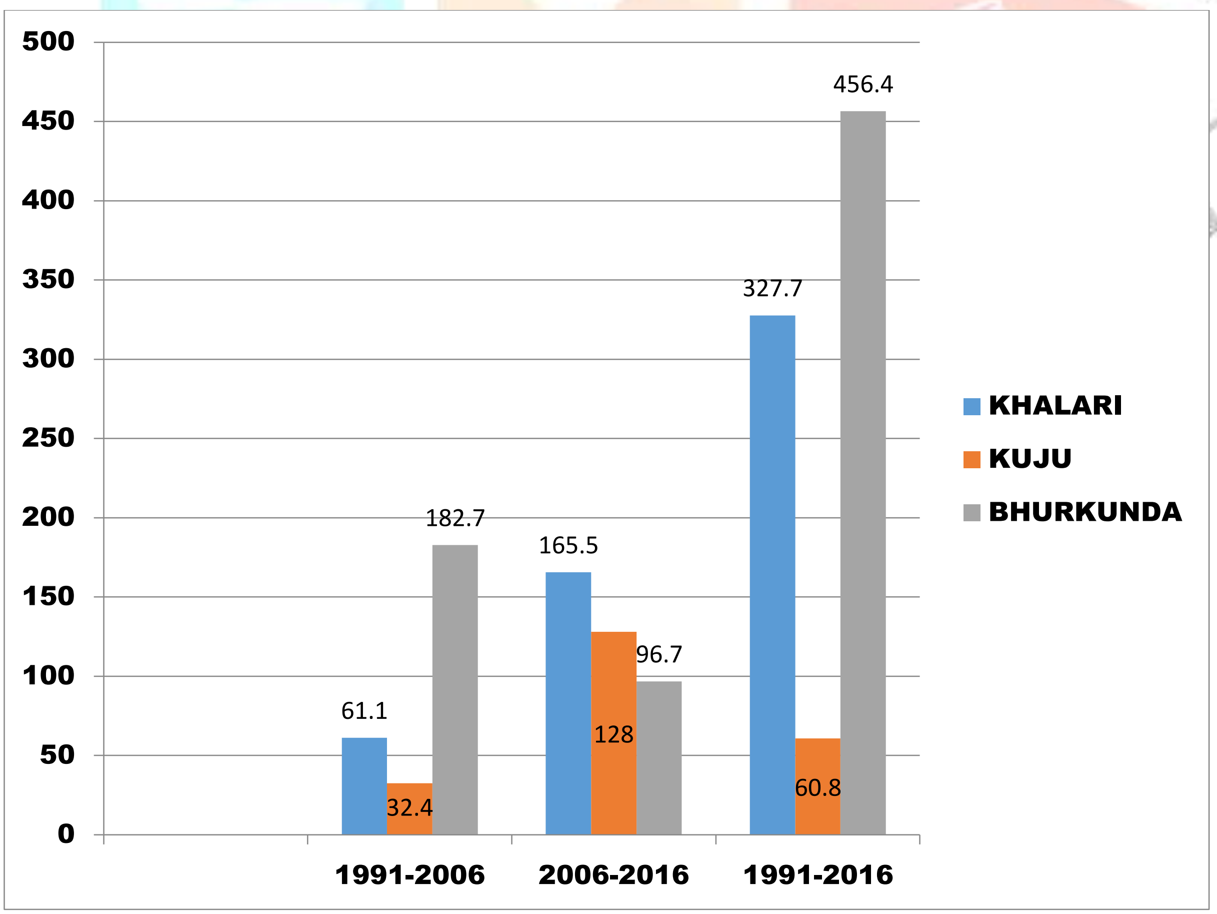

Figure 10: Graph shows Percentage Change in coal mining Areas.

5. Conclusion

Coal mining activities cause serious problems in most coal-producing countries across the globe. Their areal extents and operational frequency varies according to the local climate, terrain and social factors through prevailing mining techniques and illegal mining. The wide range impacts of coal mining activities and coal fire are largely extending from local (pollution) to global climate change. An important problem in coal fire dynamic studies is to determine the location, extent and intensity of the fires through the use of remote sensing technology.

Remote sensing can play a vital role in detecting and monitoring coal mining activities, potentially leading to the optimization of strategies for their control in minimizing economic and environmental impacts. Thermal remote sensing also plays a significant role in detecting and monitoring coal fires to prevent huge economic loss in case of any threatening environmental disaster situations.

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