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## RESEARCH ARTICLE

# A REMOTE SENSING APPROACH TO DEFINE LANDSCAPE DYNAMICS IN RANIGANJ COALFIELD AREA THROUGH TREND LINE ANALYSIS

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**ABSTRACT**

Opencast mining certainly put forwards enormous treasure and service benefits. Alongside it adversely causes widespread environmental decay especially land alteration and mutation. Therefore in recent time land use land cover changes in human influenced area have been a breakthrough for research (Steven, 1987). The researcher strives to asses and interpret the pattern of land use change due to opencast coal mining in Sodepur, Salanpur, Sripur, Satgram, Pandaveswer, Kunstoria, Kajora, Kenda, Sonepur Bazari, Bankola and Jhanjra areas of Raniganj coalfield using remotely sensed data. In order to compute the LULC changes since last five decades five spatial maps are prepared with ten distinctive classes using supervised image classification method followed by maximum likelihood algorithm in ERDAS Imagine software. To know the trend and pattern of landscape change the remotely sensed data further analyzed in Microsoft Excel. Result shows that agricultural land dominates the research area, but the area is declining from 55253.65 hectare in 1973 to 44858.6 hectare in 2015 and exhibits a negative growth rate. Contrary, urban area sharply indicates the inverse trend. The area has increased exponentially from 3552.24 hectare in 1973 to 19648.72 hectare in 2015. The patterns and trends of LULC change denotes that since 1973 the percentage of natural land use is decreasing where the man made land use is increasing.

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## INTRODUCTION

Destruction, transformation and extensive loss of various land cover during open cast mining operation are hoped. These anthropogenic changes conducted by open cast coal mining activities to land resources can be measured by assessing the LULC patterns. In Raniganj coalfield, the continuous land excavation activities were being done since 1960 for overburden and coal production purposes. Due to rapid interaction of mining aids like dragline, dumper and dozer with bare surface loss of forest, agricultural land and natural water bodies are happened. Eventually these land covers converted and transported into other land uses. Therefore it is urgent necessary to understand and compute the environmental influence of open cast coal mining on landscape pattern in and around Raniganj coalfield area. Indeed Raniganj coalfield area poses very complex land use land cover degradation scenario because of high concentration of human population, opencast mining and associated development activities (Shalaby 2007).

## MATERIALS AND METHODS

To perceive the impression of anthropogenic actions on landscapes following methods has been used

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### Remote Sensing and Other Data Sources

The satellite data were gleaned from USGS Earth Explorer portal. Five temporal satellite images were applied for preparation of LULC maps from 1973 to 2015. The visible bands, near infrared bands and middle-infrared band (1-5, 7) are utilized in this study. The thermal band is not used. Six individual topographic maps on 1:50000 scales were gathered namely 73M/1, 73M/2, 73M/5, 73M/6, 73I/13 and 73I/14 from Survey of India to built the base layer of the satellite data. Geological map, plan map and block map of individual mines is also used. Details of the satellite data are given below in Table 1.

### Data Processing

Two image enhancement techniques like contrast stretching and tail trimming were performed to improve the visual interpretability of the image. Colour space transformation like RGB to IHS function (red, green and blue to intensity, hue, and saturation) and the reverse IHS to RGB functions are applied for the year 2002 and 2010 to enhance the image information. To derive the entire research area for the year 1973 image stretching is performed using mosaic tool from data preparation tab. Entire tasks are done from spatial and spectral enhancement menu of image interpreter tab in ERDAS Imagine software.

**Table 1. Details of remote sensing satellite data**

| Year | Acquisition Date | Path/Row | Spatial Resolution | Description | Projection |
|---|---|---|---|---|---|
| 1973 | 18th & 20th March | 149/44 & 150/43 | 60 m | Landsat MSS | World Geological Survey 84/ UTM, Zone 45 |
| 1992 | 15th March | 139/44 | 30 m | Landsat 5 (TM) | |
| 2002 | 19th March | 139/44 | 30 m | Landsat 7 (TM) | |
| 2010 | 25th March | 139/44 | 30 m | Landsat 7 (TM) | |
| 2015 | 15th March | 139/44 | 30 m | Landsat 8 (ETM+) | |

## Classification Scheme

Firstly satellite images are visually interpreted. Then, signatures are selected by using AOI (area of interest) tool. To collect contiguous or similar value to the seed pixel or any accepted pixels region growing properties menu have been used. Signatures are collected from multiple areas throughout the image for a single class. Later these signatures are merged which belong to the same class and renamed after a LULC class. Signature alarm and contingency matrix utility is also used to evaluate signatures that have been created from AOI in the image. In this manner ten distinctive LULC classes are captured. After all these evaluations, supervised classification is performed with a distance file from classification tab followed by signature editor menu bar; select Classify/supervised to perform a supervised classification. The distance file can be used for post classification purposes. Option dialog is also used to define the statistical information like minimum, maximum, mean and standard deviation for the signature so that the signatures in the output thematic raster layer have this statistical information. Under parametric decision rule, Maximum likelihood is selected. Then OK is clicked in the supervised classification dialog to classify the image (Lillesand *et al*., 2004). Post classification filtering is applied from the viewer menu bar, select Raster/filtering/statistical filtering (Median filter) to remove unwanted discrete pixels from the thematic image and to producing homogeneous region permanently.

## Ground Truth and Training Data

Ground truth data has been gathered through extensive filed survey during May 2015 and December 2016 for better understanding of the LULC map. A Global Positioning System (GPS) device (Garmin) was employed across the entire study region representing all land cover classes for in-situ collection of ground truth geographic coordinates and locations; land use and land cover attributes, species information, and other general notes using stratified random sampling method. Photograph of different landscapes were also captured and linked to ground truth data. 950 random points were gathered to ensure that each class received a minimum of 30 ground truth points. The in-situ collected data was supplemented by a set of 950 points selected from the study imagery. These randomly generated points are assigned to a land cover class through a combination of expert knowledge, evaluation of spectral signatures, supervised clustering, and analysis of topographical map (Areendran *et al*., 2013). Google Earth has also been used extensively for collecting of ground truth data.

## Accuracy Assessment

The accuracy work is done in ERDAS Imagine software followed by Classification tab and accuracy assessment tool. Firstly reference pixels are randomly selected. Then accuracy is measured for each classification using a confusion matrix This matrix is placed such that class membership determined by ground truth values are along the x-axis, and class membership determined by image classification is along the y-axis. When placed this way, correct values fall along the major diagonal of the matrix. Incorrectly classified values lie in the off-diagonal areas of the matrix, such that it is apparent which class they are confused with (Congalton and Green 1999). 720 ground truth points are overlain on the land use land cover maps and the land cover value is extracted. After values are extracted a confusion matrix is generated for accuracy assessment. The confusion matrix is used for the following—

Overall Accuracy = total number of correct pixels / total number of observed pixel * 100

User Accuracy = correct pixels / row total * 100

Producer Accuracy = correct pixels/column total * 100

$$\check{K}\ (\text{Kappa}) = \frac{N \sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} (x_{i+} \quad x_{+1})}{N^2 - \sum_{i=1}^{r} (x_{i+} \quad x_{+i})}$$

Where,

N = Total number of observations
r = Number of rows in matrix
Xii = Number of observations in row i and column i
Xi+ = Total number of observations in row i
X+i = Total number of observations in column i

Field data for validation is not available for 1973, 2002 and 2010. So it is assumed that a similar accuracy is achieved using the same methods from the 2015 image (Green *et al*., 1994).

## Microsoft Excel

To show the proportion of area of different land use Pie diagram and simple bar graph are prepared in Microsoft excel using the data gathered from LULC maps. To compute the percent area and rate of land use change the below mentioned algorithms are applied —

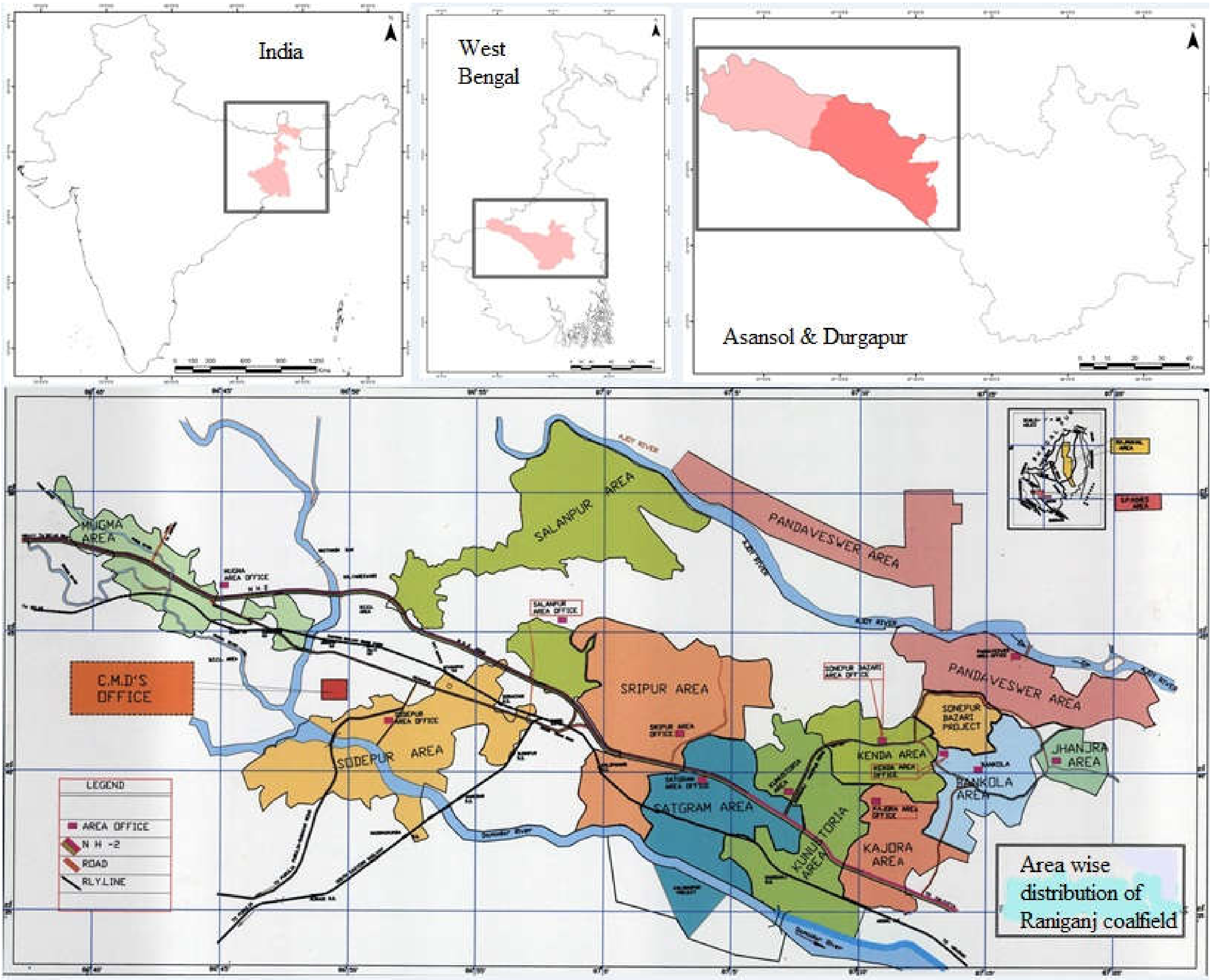
Area (%) = individual class area / total area * 100
Rate of land use change (%) = ((present LULC value – previous LULC value) / previous LULC value) * (1 / 10) * 100

Forecasting and predicting future values in excel is calculated from layout tab/trend line option. Here exponential trend line is prepared with three periods forward forecasting.

## Research Area

Raniganj coalfield is the birth place of coal mining in India is located in Burdwan district of West Bengal. About 95% of the total area of the coalfield is covered by four districts (Burdwan 71%, Birbhum 9%, Bankura 8% and Purulia 7%) of West Bengal. It is almost elliptical in shape and covers an area of about 1530 sq km. included within latitudes 23° 30ꞌ N to 23° 52ꞌ N and longitudes 86° 38ꞌ E to 87° 23ꞌ E. The coalfield has an east-west stretch of 75 km and north-south stretch of 35 km. This coalfield mainly consists 10 seams viz R-I to R-X where R – denotes to Raniganj formation and roman one is the bottom most seam whereas roman ten is the top most seam. Number of running OCP is 17 and abandoned is 21. The area presents a nearly flat topography with broad undulation. Mean elevation is 98.45m (ECL, 2015).

their areal extent from 38143.1 hectare in 1973 to 22096.8 hectare in 2015. Agricultural land dominates among all land uses, but the area is declining continuously from 55253.65 hectare in 1973 to 44858.6 hectare in 2015. River is almost at the stage of elimination, which had come down from l 4327.42 hectare in 1973 to 717.75 hectare in 2015. The areal cover of water body is minimum and also decreasing in a rapid rate from 925.82 hectare in 1973 to 712.71 hectare in 2015. According to these analysises it is clear that there was gradual decrease of dense or open forest, agricultural land, water body and river. In due course of time considerable portion of forest and agricultural land were converted into open cast quarry, construction, mining lagoon, road and fallow land. During the ground truth survey it was seen that in Satgram, Pandaveswar,




(Source: worldmapper.org & Eastern Coalfields Limited)

**Figure 1. Research area map**

## RESULTS AND DISCUSSION

In order to explore the transformation and current status of land use land cover in Raniganj coalfield area different spatial map of 1973, 1992, 2002, 2010 and 2015 is analyzed. Land use land cover is categorized into ten classes— forest, agricultural land, fallow land, river, river sand, water body, exposure, lagoon, urban and excavated land shown in figure 2, 3, 4, 5, 6 with pie diagram. Forest showed an acute decline in

Kunstoria, Kajora, Bankola, Jhanjraand Sonepur Bazari area most of the forest and agricultural land is lost due opencast miing activities including land excavation, construction of new houses and buildings, mining quarry located in the South, East and Western part of the area. Rapid growing of population and urbanization triggers the land use land cover changes.

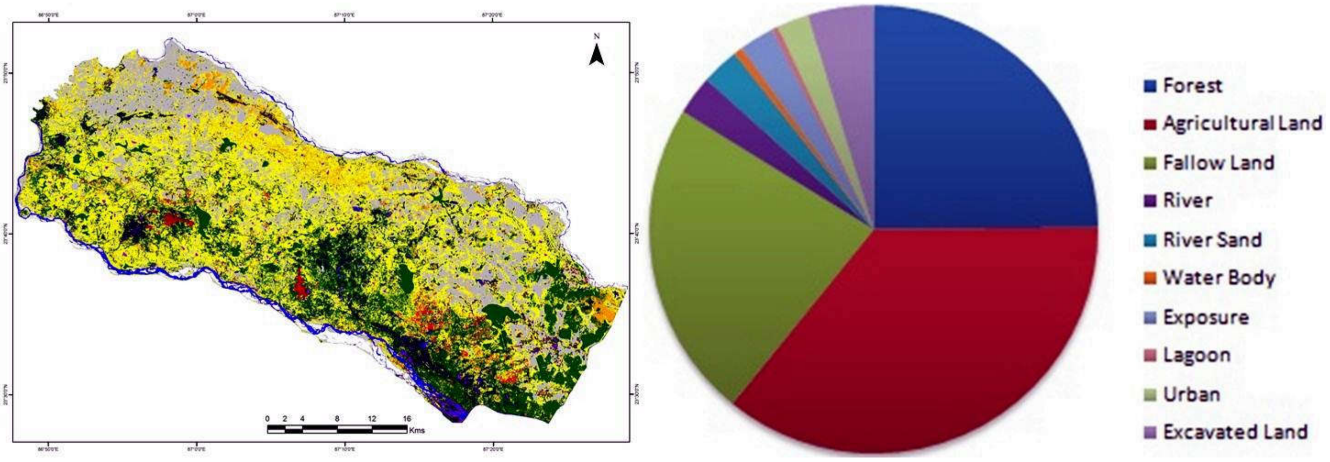



**Figure 2. Land use land cover map and pie diagram of Raniganj coalfield, 1973**

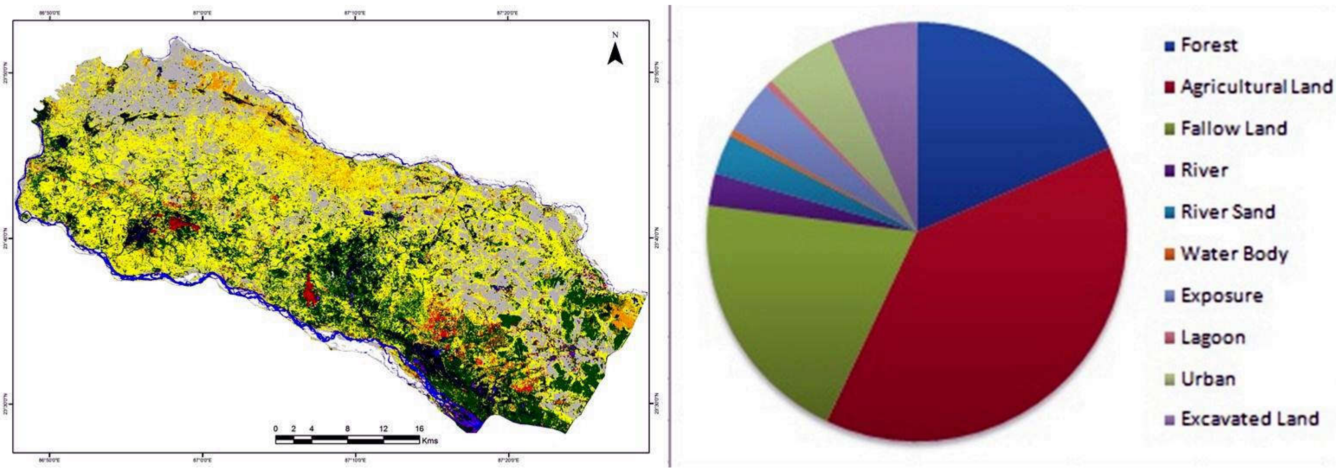



**Figure 3. Land use land cover map and pie diagram of Raniganj coalfield, 1992**

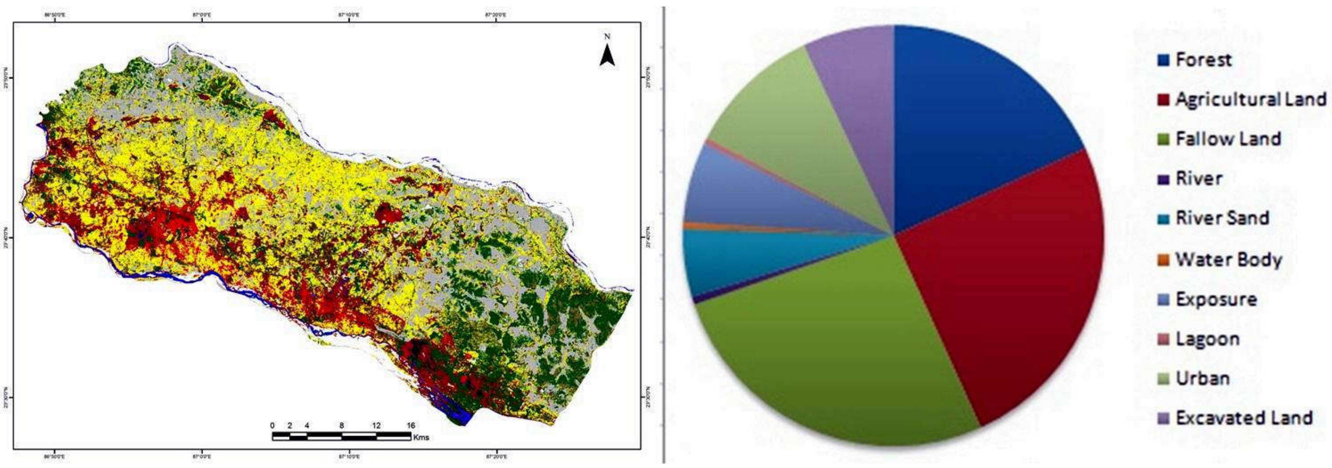



**Figure 4. Figure 3. Land use land cover map and pie diagram of Raniganj coalfield, 2002**

These factors are being accelerated due to open cast mining activities in this area. As a result there is a loss of 16046.2 hectare forest, 10394.4 hectare agriculturalland and 3609.25 hectare river land and 213.11 hectare water body. There is an increase of 10586.48 hectare fallow land, 4704.32 hectare river sand, 16095.76 hectare urban and 6499.47 hectare excavated land. Fallow land is the second largest land use of the study area which is continuously increasing from 35256.52 hectare in 1973 to 45843.2 hectare in 2015. During opencast mining virgin land is to be extracted to meet the coal. The virgin land can be either forest or agricultural land. After the abandonment of mining operation this land turned into fallow land. For instance there is a vast transformation of forest and agricultural land into fallow land located in the South East and North West parts of the research area i.e. at Purusattampur, Sripur and Dabor area. Initially this area is renowned for mining activity. Therefore it is assumed that opencast mining will be increasing decade by decade which leads to more quarry land, mining lagoon and mining exposure land. Quarry land is being created at the time of digging of land to extract both coal and overburden. When extraction and production of coal is exhausted mined areas are left abandoned, which in due course of time are covered mostly with grasses and water. Mining lagoon is that waterlogged abandoned opencast project. Contrary exposure is the reclaimed vegeted land. Dense forest, agricultural land and water body of Sodepur, Mahalaxmi, Slanpur and Sonepur Bazari area converted to excavated land or quarry or mining lagoon located in the Western, Central and southern part of the study area. Mining quarry area which increas from 7264.53 hectare in 1973 to 13764.6 hectare in 2015. Mining lagoon which also increases from 692.27 hectare in 1973 to 1678.69 hectare in 2015. Exposure land has increased from 3917.34 hectare in 1973 to 5232.68 hectare in 2015 respectively.

3552.24 hectare in 1973 to 19648.72 hetare in 2015. South, central and Western parts of this area is rapidly urbanizing. These area are Barakar, Dishergarh, Sanctoria, Panjabi more, etc. In Purusattampur, Dalmiya, Kenda and Shibpur abandoned quarry and mining overburden is converted into sparse forest, fallow land, settlement located in the eastern and South western parts of the study area of the study area. The efficiency of the remotely sensed land use land cover map is determined by its accuracy assessment using pixel based and object based combined classification method. Details results are illustrated in table 2, 3, 4, 5 and 6.

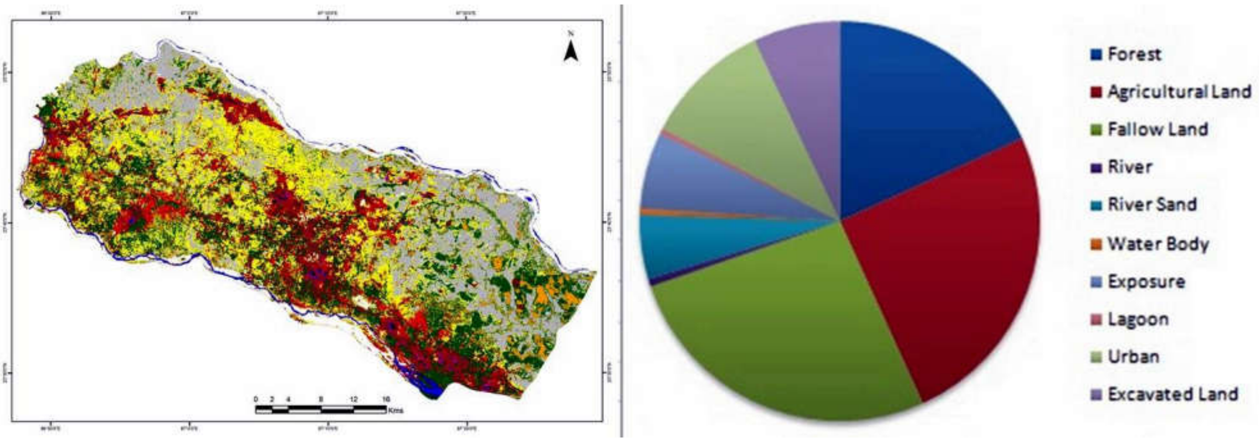



**Figure 5. Figure 3: Land use land cover map and pie diagram of Raniganj coalfield, 2010**

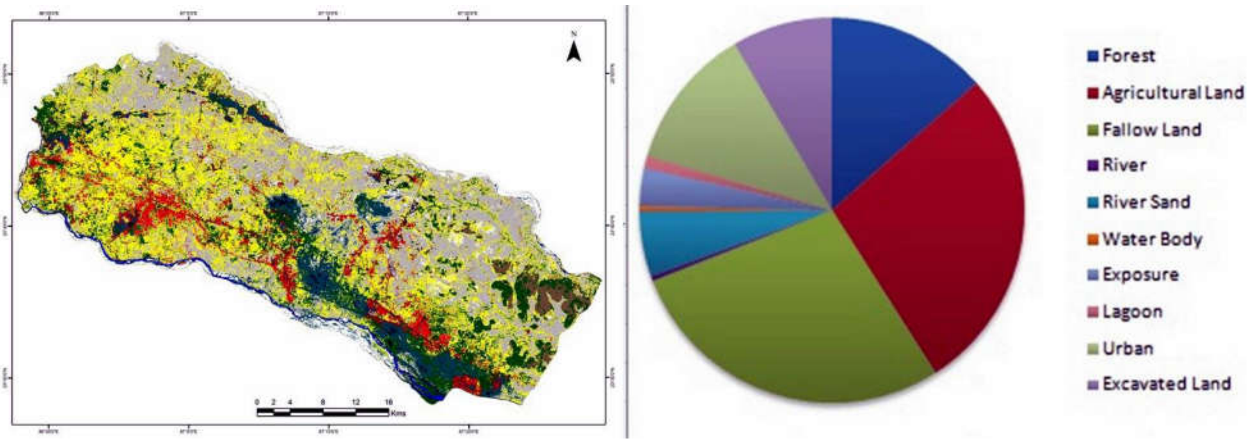



**Figure 6. Land use land cover map and pie diagram of Raniganj coalfield, 2015**

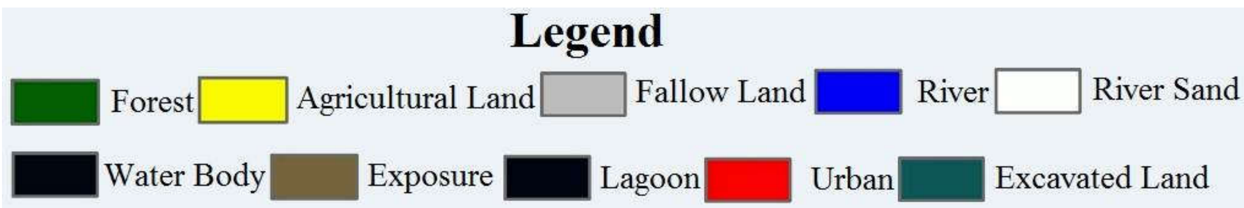



**Figure 7. Legend of land use land cover map**

River sand drastically increasded due to ceasation of river, rising population pressure, agricultural activity on river bed etc. Various segments of Damodar and Ajay river turned into river sand. It has increasded from 4165.68 hectare in 1973 to 8870.67 hectare in 2015. Durgapur and Asansol are two mighty cities of this area. These two cities are industrially advanced especially coal based industry. Therefore this area is urbanizing in a rapid rate. Urban land has increasded from

The abbreviations used for different land use are

F = Forest, AL = Agricultural Land, FL = Fallow Land, R = River, RS = River Sand, WB = Water Body, E = Exposure, L = Lagoon, U = Urban, EL = Excavated Land.

## FINDINGS

Trend and rate of land use change is computed and shown in Figure 7 and Figure 8 respectively.

**Table 2. Accuracy assessment of land use land cover map, 1973**

| | | Reference Data | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LULC Classes | F | AL | FL | R | RS | WB | E | L | U | EL | Total | Users accuracy (%) |
| Classified Data | F | 1120 | 65 | 32 | | 3 | | 21 | | | | 1241 | 90.24 |
| | AL | 15 | 1250 | 65 | 4 | 5 | 7 | 6 | | 2 | 2 | 1356 | 92.18 |
| | FL | 45 | 21 | 920 | | | 34 | | 37 | | | 1057 | 87.04 |
| | R | 11 | 12 | 5 | 480 | 9 | 102 | 10 | | | | 629 | 76.31 |
| | RS | 6 | 3 | 42 | 9 | 524 | 16 | | | 6 | | 606 | 86.47 |
| | WB | 15 | 25 | 25 | 8 | 4 | 425 | | 8 | | | 510 | 93.0 |
| | E | 18 | 30 | 3 | 6 | | 19 | 285 | | 6 | 4 | 408 | 69.85 |
| | L | 5 | 23 | | | | | 4 | 421 | 20 | | 486 | 86.63 |
| | U | | 5 | | | | | | | 1467 | | 1593 | 91.46 |
| | EL | 1235 | | | | | | | | 7 | 545 | 552 | 98.73 |
| | Total | | 1434 | 1092 | 507 | 545 | 603 | 326 | 466 | 1508 | 551 | 8408 | |
| Producer Accuracy (%) | | 90.69 | 87.17 | 84.25 | 94.67 | 96.15 | 70.48 | 87.42 | 90.34 | 97.28 | 98.91 | | |

Overall Accuracy: 88.46%

Kappa Coefficient: 0.81

**Table 3. Accuracy assessment of land use land cover map, 1992**

| | | Reference Data | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LULC Classes | F | AL | FL | R | RS | WB | E | L | U | EL | Total | Users accuracy (%) |
| Classified Data | F | 1420 | 32 | 36 | | 5 | | 23 | | | | 1516 | 93.67 |
| | AL | 21 | 1020 | 65 | 6 | 8 | 11 | 8 | | 2 | 5 | 1146 | 89.01 |
| | FL | 54 | 31 | 906 | | | 36 | | 25 | | | 1052 | 86.12 |
| | R | 2 | 15 | 5 | 610 | 9 | 98 | 21 | | | | 760 | 80.26 |
| | RS | 4 | 4 | 42 | 5 | 826 | 15 | | | 5 | | 901 | 91.68 |
| | WB | 8 | 21 | 22 | 8 | 6 | 458 | | 7 | | | 530 | 86.42 |
| | E | 20 | 36 | 5 | 6 | | 34 | 389 | | 3 | 8 | 481 | 68.61 |
| | L | 9 | 15 | | | | | 9 | 498 | 25 | | 567 | 87.83 |
| | U | | 4 | | | | | | | 1425 | | 1438 | 99.09 |
| | EL | | | | | | | | | 8 | 458 | 466 | 98.28 |
| | Total | 1538 | 1178 | 1081 | 635 | 854 | 652 | 450 | 523 | 1468 | 471 | 8850 | |
| Producer Accuracy (%) | | 92.32 | 86.59 | 86.9 | 83.81 | 96.72 | 69.60 | 86.44 | 95.22 | 97.07 | 97.24 | | |
| Overall Accuracy: 88.14% | | | | | | | | | | | | | |
| Kappa Coefficient: 0.86 | | | | | | | | | | | | | |

**Table 4. Accuracy assessment of land use land cover map, 2002**

| | | Reference Data | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LULC Classes | F | AL | FL | R | RS | WB | E | L | U | EL | Total | Users accuracy (%) |
| Classified Data | F | **1725** | 52 | 29 | | 8 | | 25 | | | | 1839 | 93.80 |
| | AL | 25 | **1230** | 50 | 10 | 12 | 4 | 3 | | 2 | 1 | 1337 | 92.00 |
| | FL | 69 | 25 | **908** | | | 32 | | 25 | | | 1059 | 85.74 |
| | R | 11 | 32 | 5 | **625** | 9 | 102 | 5 | | | | 789 | 79.21 |
| | RS | 4 | 4 | 25 | 2 | **690** | 21 | | | 3 | | 749 | 92.12 |
| | WB | 5 | 32 | 36 | 5 | 5 | **601** | | 5 | | | 689 | 87.23 |
| | E | 21 | 20 | 4 | 9 | | 36 | **385** | | 7 | 6 | 467 | 82.44 |
| | L | 36 | 15 | | | | | 7 | **469** | 36 | | 548 | 85.58 |
| | U | | 7 | | | | | | | **1355** | | 1398 | 96.92 |
| | EL | | | | | | | | | 5 | **589** | 594 | 99.16 |
| | Total | 1896 | 1417 | 1057 | 651 | 724 | 796 | 425 | 519 | 1408 | 596 | **9469** | |
| Producer Accuracy (%) | | 90.98 | 86.80 | 85.90 | 96.00 | 95.30 | 75.50 | 90.59 | 90.37 | 96.24 | 98.83 | | |
| Overall Accuracy: 90.04% | | | | | | | | | | | | | |
| Kappa Coefficient: 0.88 | | | | | | | | | | | | | |

From which it is clear that there is subsequent decrease and increase in land uses. Forest cover was 25% in 1973 but it decreased into 13.52% in 2015. Highly affected forest cover is mostly converting into fallow, agricultural, quarry. The rate of decrease in forest was found to rise from -2% during 1973 and1992 to -2.16% during 2010 and 2015. Initially from 1973 to 1992 agricultural land is increased 36.21% to 38.58% at the rate of 1% due to conversion of forest land into it. But after 1992this land use is continuously decreasing from 38.58% in 1992 to 24.89% in 2010 at a rate of -2.12%. In last five years agricultural land exhibits tiny increase 24.89% in 2010 to 27.45% in 2015 with a rate of 1.59%.

Therefore it can be said that agricultural land retains its own land and moderately affected. During 1973 to 2002 fallow land was decreased from 23.24% to 21.62%. Later fallow land is increased rapidly from 21.62% in 2002 to 28.05% in 2015 with a rate of 1.92%. Mostly forest and quarry was converted into fallow. Percentage of river area was continuously declined from 3% in 1973 to 0.43% in 2015. Most of river land was converted into river sand at a rate of -5.42% in 1992 to 2002. River sand was 3.12% in 1973 but it increased to 5.42% in 2015. River sand changed at the rate of 7.10% in 1992 to 2002 but it reduced to 1.02% in 2010 to 2015 and was transformed into crop area, river water and moist fallow area.

**Table 5. Accuracy assessment of land use land cover map, 2010**

| | Reference Data | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LULC Classes | F | AL | FL | R | RS | WB | E | L | U | EL | Total | Users accuracy (%) |
| Classified Data | F | **1654** | 59 | 36 | | 6 | | 25 | | | | 1780 | 92.92 |
| | AL | 29 | **1235** | 68 | 11 | 21 | 3 | 9 | | 8 | 13 | 1397 | 88.40 |
| | FL | 42 | 25 | **1120** | | | 24 | | 46 | | | 1257 | 89.10 |
| | R | 11 | 16 | 2 | **421** | 15 | 102 | 25 | | | | 592 | 71.24 |
| | RS | 13 | 3 | 42 | 12 | **856** | 35 | | | 12 | | 973 | 87.98 |
| | WB | 2 | 14 | 36 | 9 | 6 | **425** | | 10 | | | 502 | 84.66 |
| | E | 7 | 30 | 13 | 8 | | 36 | **285** | | 1 | 2 | 382 | 74.60 |
| | L | 13 | 29 | | | | | 8 | **589** | 20 | | 653 | 90.20 |
| | U | | 12 | | | | | | | **1426** | | 1451 | 98.28 |
| | EL | | | | | | | | | 9 | **582** | 591 | 98.48 |
| | Total | 1771 | 1423 | 1317 | 461 | 904 | 625 | 352 | 645 | 1476 | 597 | **9578** | |
| Producer Accuracy (%) | | 93.39 | 86.79 | 85.04 | 91.32 | 94.69 | 68 | 80.97 | 91.32 | 96.61 | 97.49 | | |
| Overall Accuracy: 88.424% | | | | | | | | | | | | | |
| Kappa Coefficient: 0.84 | | | | | | | | | | | | | |

**Table 6. Accuracy assessment of land use land cover map, 2015**

| | Reference Data | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LULC Classes | F | AL | FL | R | RS | WB | E | L | U | EL | Total | Users accuracy (%) |
| Classified Data | F | 1612 | 48 | 21 | | 4 | | 17 | | | | 1702 | 94.7 |
| | AL | 20 | 1180 | 57 | 5 | 7 | 8 | 5 | | 5 | 3 | 1290 | 91.5 |
| | FL | 56 | 19 | 1008 | | | 29 | | 34 | | | 1146 | 88.0 |
| | R | 9 | 20 | 3 | 523 | 9 | 124 | 10 | | | | 695 | 75.3 |
| | RS | 5 | 2 | 36 | 8 | 716 | 12 | | | 2 | | 740 | 96.8 |
| | WB | 9 | 17 | 28 | 2 | 2 | 506 | | 4 | | | 544 | 93.0 |
| | E | 13 | 35 | 7 | 4 | | 23 | 315 | | 2 | 5 | 408 | 77.2 |
| | L | 8 | 25 | | | | | 6 | 423 | 20 | | 466 | 90.8 |
| | U | | 8 | | | | | | | 1522 | | 1593 | 95.5 |
| | EL | | | | | | | | | 3 | 682 | 702 | 97.2 |
| | Total | 1732 | 1354 | 1160 | 542 | 734 | 677 | 355 | 437 | 1603 | 692 | 9286 | |
| Producer Accuracy (%) | | 93.1 | 87.1 | 86.9 | 96.5 | 97.5 | 74.7 | 88.7 | 96.8 | 94.9 | 98.6 | | |
| Overall Accuracy: 90.74% | | | | | | | | | | | | | |
| Kappa Coefficient: 0.92 | | | | | | | | | | | | | |

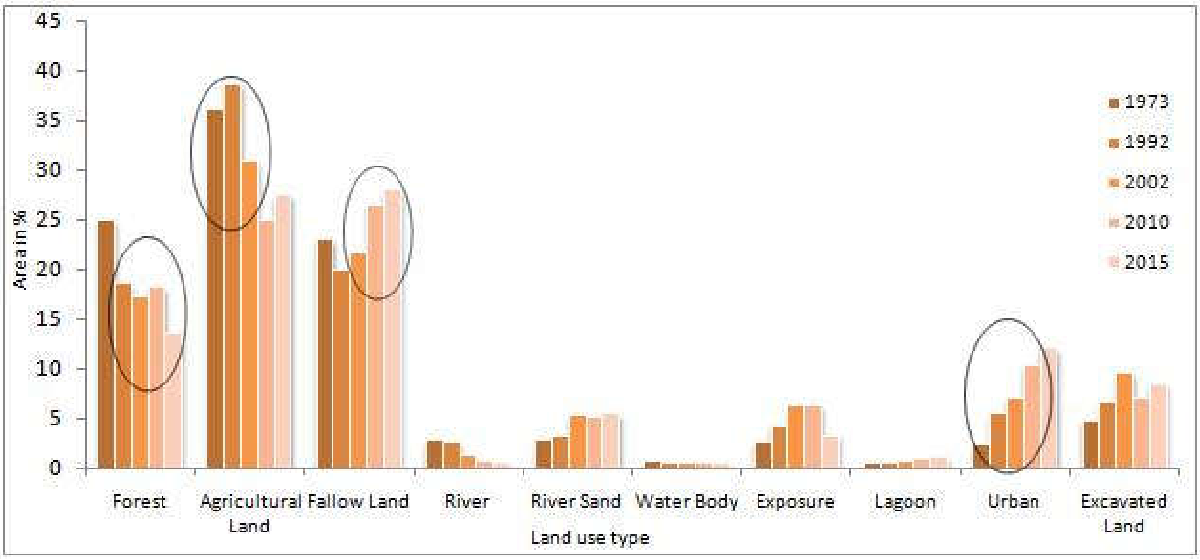



**Figure 7. Percentage area of various land use land cover, Raniganj Coalfield (1973 to 2015)**

Water body was 1.02% in 1973 and reduced into 0.43% in 2015 at the rate of -2% in 1973 to 1992. Later the rate of change has been settled about 0.52%. Exposure, lagoon and excavated land are the outcome of opencast mining and have been discussed earlier. These land uses were increasing since 1973. Exposure land was 3% in 1992 and 6.19% in 2002. After that the areal cover reduced to 3.20% in 2015. The rate of change was 7% in 1973 to 1992 and -4.53% in 2010 to 2015. Mining lagoon has increased almost 0.2% in 1973 to 1.03% in 2015. The rate of change was 3.14% in 1973 to 1992. Area of excavated land was 5.02% in 1973, it increased to 9.47% in 1992 but later it reduced to 8.42% in 2015. The rate of change was 5% in 1973 to 1992 and 2.68% in 2010 to 2015. Urban land was 2.14% in 1973 but it increased to 12.02% in 2015.

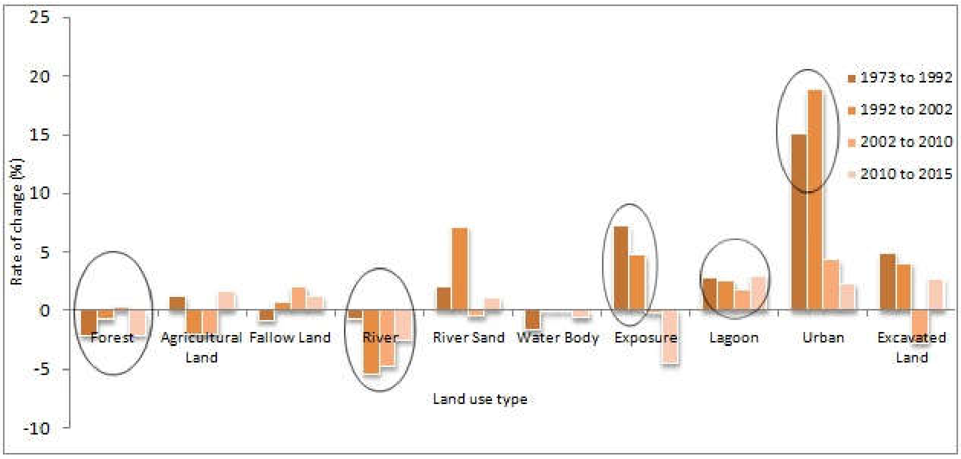



**Figure 8. Rate of change in land use categories, Raniganj Coalfield (1973 to 2015)**

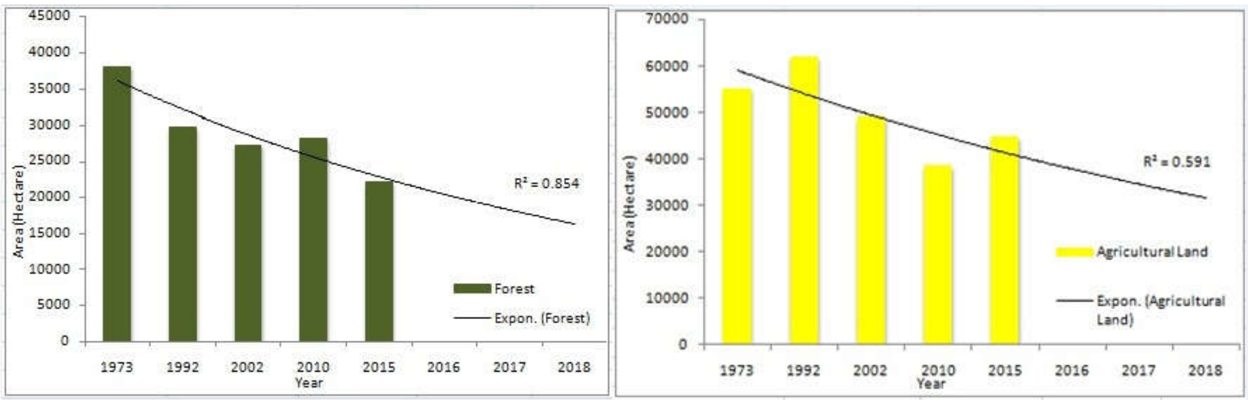



**Figure 9. Trend analysis and future prediction of forest & agricultural land, Raniganj Coalfield (1973 to 2018)**

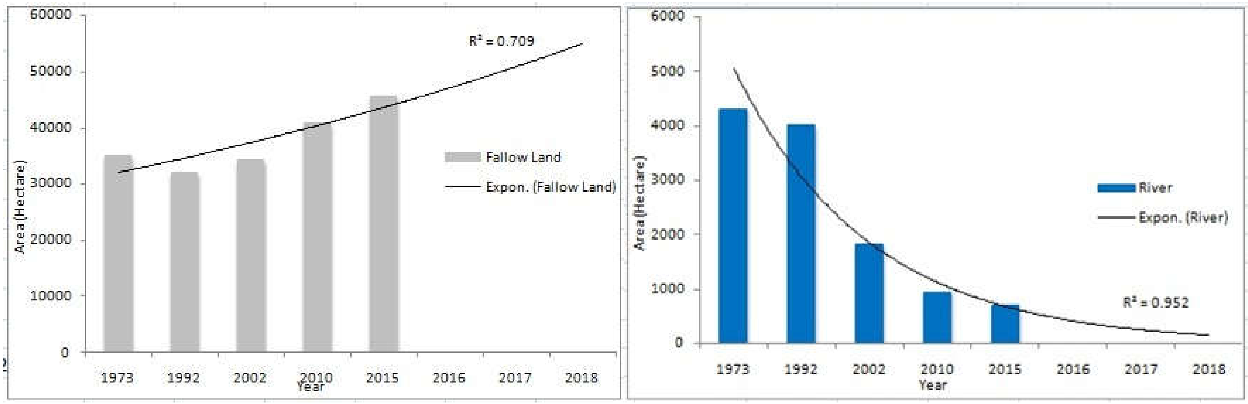



**Figure 10. Trend analysis and future prediction of fallow land & river, Raniganj Coalfield (1973 to 2018)**

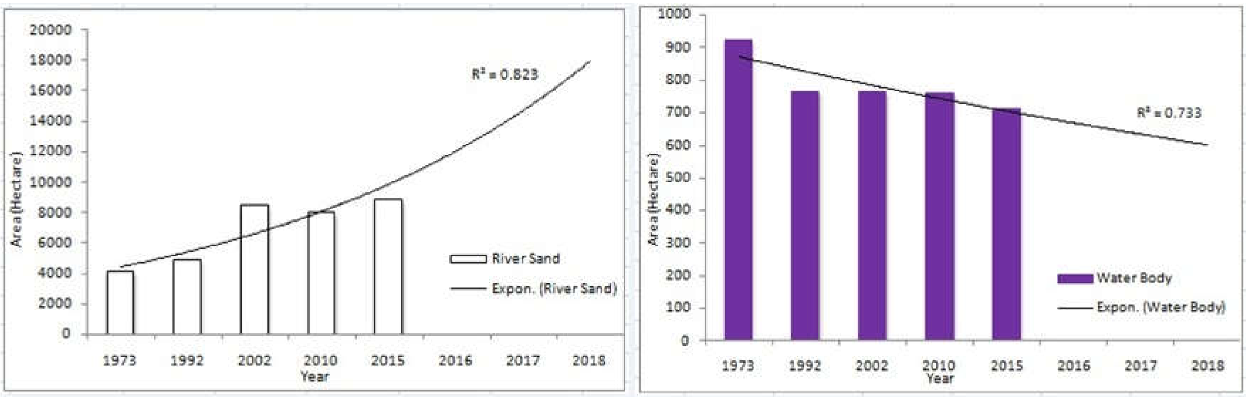



**Figure 11. Trend analysis and future prediction of river sand & water body, Raniganj Coalfield (1973 to 2018)**

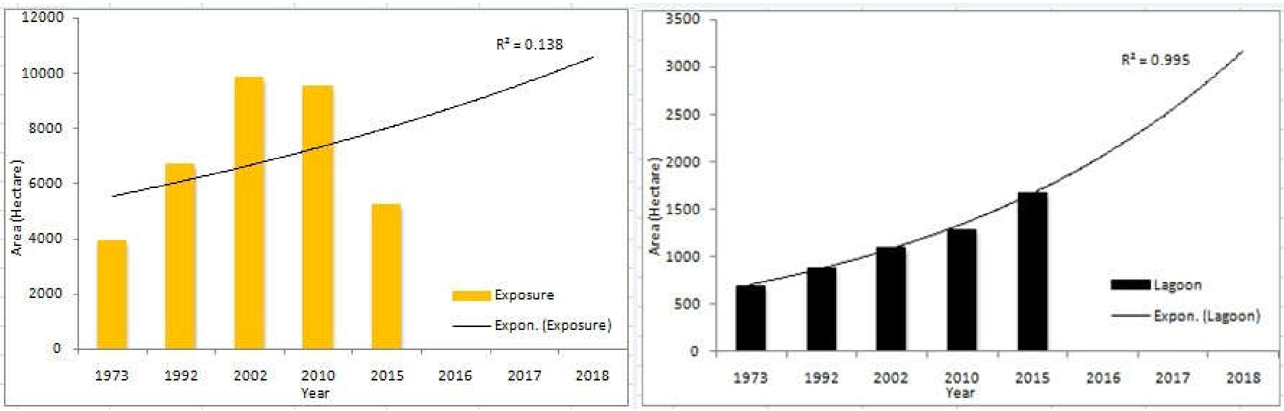



**Figure 12. Trend analysis and future prediction of exposure & lagoon, Raniganj Coalfield (1973 to 2018)**

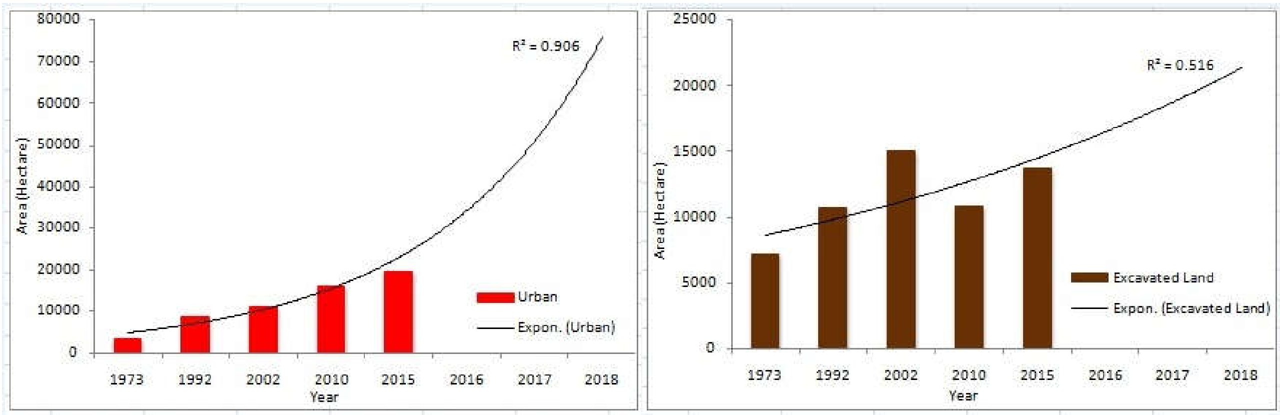



**Figure 13. Trend analysis and future prediction of urban & excavated land, Raniganj Coalfield (1973 to 2018)**

The increase rate of urbanization was mainly due to conversion of fallow land into urban and construction of buildings. The devastating rate of urbanization was 15% in 1973 to 1992 and 18.80% in 1992 to 2002. After 2002 the rate of urbanization was declined into 2.27% in 2010 to 2015. The open cast mining affects the land use and land cover of Raniganj coalfield area that causes environmental impact. Decade by decade it has been accelerated. To know these impacts in near future prediction of trends of land uses are computed using 3 periods forward forecasting algorithm with R squared value. The trend and forecasting of individual land uses in the form of exponential curve are shown in figure 9, 10, 11, 12 and 13. Test results denote that rate of reduction of forest and agricultural land will follow negative trend between 2016 and 2018. Compare to agricultural land, the forest area will be reduced more with greater rate of -2.16% in terms of the change in annual percentage. It is predicted that area of river and water body will also be reduced at the present rate. Fallow land and river sand will be increased at the rate of above 1.16% and 1.02% respectively in terms of the change in annual percentage. Exposure, lagoon and excavated areas are expected to increase slightly at their present rate. The most important forecasting is about the urban land. It is predicted that the urban area will increase significantly with greater rate of 2.26% in terms of the change in annual percentage. The increase in the urban area is mainly based on reductions in forest and agricultural land. The rate at which the urban area will increase from 2015 to 2018 is lower than during 1973 to 2002 in terms of the change in annual percentage. Highly developed economy and high human population density will also caused more urbanization. It should be remembered that the forecasting system in excel is an art not a science. Therefore the computed prediction is also just gives us a concept not actual value. From the above discussion about the trend analysis and forecasting of land use land cover in Raniganj coalfield area from 1973 to 2018 it can be said that opencast mining activity adversely affects the landscape. These adverse impressions are due to open cast mining large pits are left over, large amount of overburden material excavated during open cast mining and is dumped in the vicinity of the mine sites, flow of silt from overburden dumps causes degradation of agricultural land and crop production, degradation of forest leads to extensive loss of forest ecosystem, land instability will be increased, mine spoils affect surrounding area of mining site.

## Conclusion

Gradual change in land use land cover pattern which is associated to various running opencast mining project and developmental project in Raniganj coaal field area are bringing a cronic challenge to the landscape. The LULC analysis revealed an increase in the non forest area that is increase in man-made land use. Temporal response of the landscape has provided insights about the changes in the forest, agricultural land, fallow land, river sand, quarry and urban. From the above result and discussion it can be said indiscriminate opencast mining has disastrous to these land uses. If the rate of LULC transformation is happened with the present rate it definitely will lead to deforestation, destruction of fertile soil and more mine abandoned land. Shibpur, Pandaveswar, Damaliya and Purusattampur area are mostly affected. It is observed that because of changes in land use and land cover pattern in Raniganj coalfield area Sonepur Bazari, Khottadih, Bomjemehri and Dalurband area will be affected vastly. Large scale land cover changes involving the conversion of forests into other land use categories, mining activity, urbanization and climate change are primary drivers. In order to minimize the impression of mining activitry on landscape scientific approach during and after mining activities has to be taken like proper backfilling, storage of top soil seperately, forestation and monitoring the spol ersion from dumped overburden. Due to larger size of the study area it is very difficult to allocate the land uses adequately at small scale. Furthermore, the accuracy through visually interpreted process is not good enough. These are the limitations of this study (Rao, P. 2014).

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