4.0 RESULTS AND DISCUSSIONS

Land surface alterations due to CSF are linked with the mining at JCF. These alterations are caused due to the mining related fires associated with the subsidence and the spontaneous heating of the coal, resulting in the land use changes. These alterations cause short and long term impacts. RS and GIS are well proven effective techniques to study these changes. The software's of these techniques provide colour recoding, ratioing, transformation, principal component analysis, NDVI image generation, integration operations, layouts, etc. Hence, the RS & GIS tools have enhanced the functions of identifying and mapping of LULC and its changes.

Here, the CSF studies in JCF were conducted using RS & GIS techniques. The various land use classes, identified on the basis of the satellite imageries and the field surveys, were Dense Forest, Open Forest, Degraded forest, Coal Quarry, Advance Quarry, Mining Pit, Stock, Dump, Barren, Overburden (OB), Cultivated Land, Fallow Land, Waste land with or without shrub, Siltation, Ash, fire area, Fly ash pond, Urban, Rural, Industrial, Ponds, Water Logged Area, Open Scrub, Barren Land and Sand.

A number of image processing tools, namely ratioing, equalization, image segmentation and image transformation operations had been used with the satellite imageries for demarcating of the different LULC patterns present at JCF. A number of band combinations of the colour composites had been adopted here for the study of CSF. It had been found that FCCs of the type Standard FCC Band 321, FCC Band 421 and FCC 431 provided useful information for the vegetative LULC mapping for CSF. The NDVI images had been prepared and used for the vegetation studies. LULC maps of the selected sites

had been prepared with the satellite and the ground verification data. Studying changes in the land use pattern applying remotely sensed data was based on the comparison of the time sequential data. Change detections using satellite data allowed for the timely and consistent estimates of the changes in the LULC trends, over large areas. Time sequential surface changes that have occurred in the JCF since 1972 had been studied. Data manipulation in several steps involving pre-processing, processing and colour display had been carried out for the change detection analysis of the area under study. Statistical normalization had been carried out to facilitate data analysis. The registered and standardized images had been used for detecting LULC changes by image analysis and differencing of NDVI images. The above studies observed that the LULC pattern had changed in the JCF in the last five decades due to the increased opencast and the underground mining activities. The pixels that had earlier depicted vegetation or populated or barren were later showing opencast mining. Vegetated areas had decreased and the land surface subsidence and settlements increased due to the changes in the locations of CSF.

The K- Means and the ML algorithms or the unsupervised and the supervised processes and the image segmentation methods were used to process each pixel for the single LULC algorithm unit. The analyses of the ML classification for the MSS data, with the qualitative and quantitative techniques were applied for the coal fire demarcations. The mean vector and the covariance matrices were the inputs to the function for the estimation from the training pixels of a particular class. This information on the pixel by pixel basis was then used by the ML classifier to assign a particular class to different values obtained. A variety of LULC classes were identified in the JCF with the help of enhancement techniques, given in Table 4. The CSF monitoring and mapping in the JCF was assessed for a period of 1972 to 2017 through temporal interval with the help of LISS-MSS data. Coal seam temperature was used for the prediction and demarcation of the CSF. The coal fire zones observed in the eastern part of the JCFs were

the Lodna– Tisra–Kujama–Jiyalgarha and the Kusunda–Kenduadih zones. The most significant coal fire zone was observed at Gonudih, present in the western part of the JCF. In Tisra, Kenduadih, Nadkhurkee areas, pixel temperatures were found to be above 47°C on the calibration with the field data. The fire zone in the western part of the JCF was limited to the Dumra–Nadkhurkee– Jayramdih area. The major collieries, which showed an increase in the fire affected areas were Kusunda (0.62 km^2), Golukdih (0.23 km^2) and Lodna (0.21 km^2). In contrast, the impact of the fire had reduced considerably in collieries such as Nadkhurkee (0.27 km^2), Godhar (0.19 km^2), Benedih (0.14 km^2), Gonudih (0.26 km^2) and South Tisra (0.24km^2). The fire zone, obtained from the single band image, is illustrated in figure 76. In the present analysis, the spectral image provided the classified land use land cover for the coal seam fire areas. The optimization of the pixels by the data mining based classifications for the decision making is advantageous in CSF mapping with vegetation growth. The data mining scrutinizes the facts of coal seam fires for the advantageous requisite informations. Recode algorithms were applied to hidden patterns to obtain the class recognitions of the pixels by segmentation classifier. Decision making process derived from datasets were used to accelerate the transformation of information at the different stages. It was observed that the segmentation of the data by the ML improved the interpretations for the original images. The segmented result was validated in the field and it was found that the ML algorithm provided better segmentation processes.

RS & GIS are useful tools for differentiating and identifying various LULC classes. RS & GIS provided efficient procedure for the demarcating of the CSF upon validations from the ground data. A variety of LULC classes were identified in the JCF. It appears from the satellite data that the CSF is dominant in the lateral direction and not vertical. The digital number based system for Level- 2 land classes had been deployed for the field. This system also provided the method of presenting Level 2 LULC information. The extraction of the basic thematic

information from the land use was quite challenging with regard to classification automation and transferability. The development of a better accuracy spatial decision support system for planning was attempted here.

The opencast mining alters the topography of the area as large pits are left after mining due to inadequate reclamation measures. Field and ground investigations showed that the subsidence had left a prominent mark on the general topography of the JCF. Fires in the coalmines caused an increase in the surface temperatures. The LISS data images revealed that the high temperatures were caused due to underground CSF. This was interpreted from the drying up of the soil moisture content, reflected in NDVI zoning.

Table: 16 LULC classes and percentage of pixels (also illustrated in figure 72)

S. No	Class	Pixels	Percentage
1	Dense Forest	43106	2.15
2	Open Forest	82532	4.11
3	Open forest scrubs	81651	4.07
4	Degrade forest	54531	2.72
5	Artificial Forest	85942	4.28
6	Coal Quarry	52792	2.63
7	Advance Quarry Site	94951	4.73
8	Mining pit	82542	4.11
9	Stock	84714	4.22
10	Dump	63687	3.17
11	Barren OB	104059	5.18
12	Cultivated Land	95194	4.74
13	Fallow Land	96028	4.78
14	Waste land	89941	4.48
15	Waste land	107920	5.38
16	Siltation	71442	3.56
17	Barren Land	148202	5.27
18	Fly ash pond	94600	4.71
19	urban	76283	3.80
20	rural	64348	3.21
21	Industrial	41826	2.08
22	surface water body	50338	2.51
23	ponds	83628	4.17
24	Water logged area	105016	5.23
25	CSF	52089	2.59
Total		**2007362**	**100**

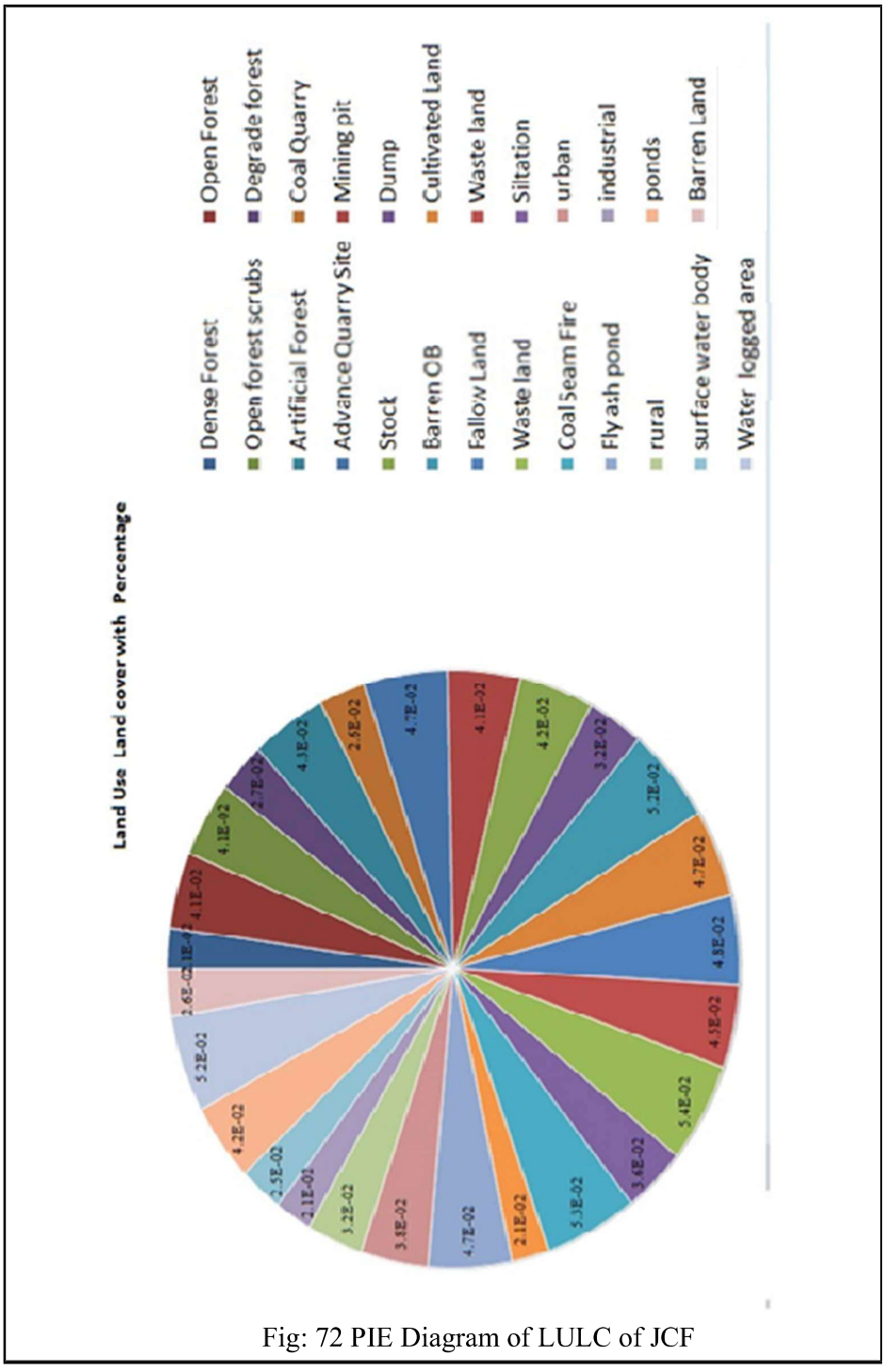

Fig: 72 PIE Diagram of LULC of JCF

4.1 CSF ADVANCEMENT

The CSF in JCF was demarcated by incorporating the inputs from the analysis of the temporal satellite data of 1972 to 2013 in ERDAS and Arc Map/ GIS software's.

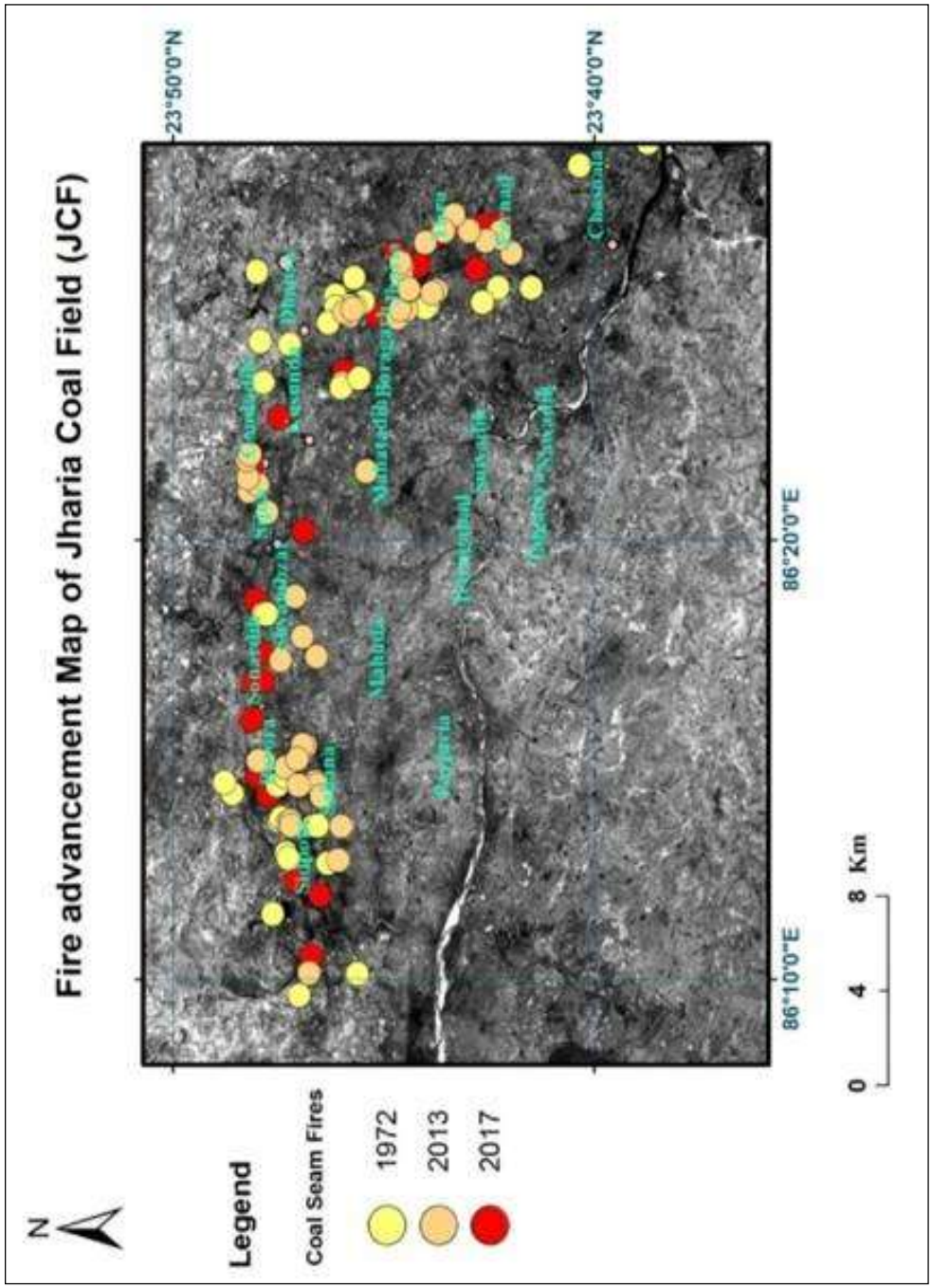

Fig: 73 Map showing CSF advancement in last 45 years in JCF

The behaviour of the fire advancement had been studied. The quantification of surface and subsurface CSF was reduced in the last decade.

The LULC maps were prepared by the simulation of the pixels values in the NDVI, Histogram Equalization and field investigations in JCF. LULC change was detected with real time field data. The following classes listed in the table below had been identified in Level – 1 and Level – 2 categories. The LULC map Fig: 69

Table : 17 Level-1 and Elaborated Level - 2 category of classes

S. No	Level -1	Level -2
1	Forest	Dense Forest
2		Open Forest
3		Degraded forest
4		Artificial(Forest)
5	Mining Area	Coal Quarry
6		Advance Quarry site
7		Mining Pit
8		Stock
9		Dump
10		Barren OB
11	Agriculture land	Cultivated Land
12		Fallow Land
13	Wasteland	Waste land with or Scrub
14		Siltation
15		Ash
16		Barren
17		Fly ash pond
18	Settlement	Urban
19		Rural
20		Industrial
21	Water Body	Ponds
22		Waterlogged Area
23		Open Scrub
24		Barren Land
25		Surface Water

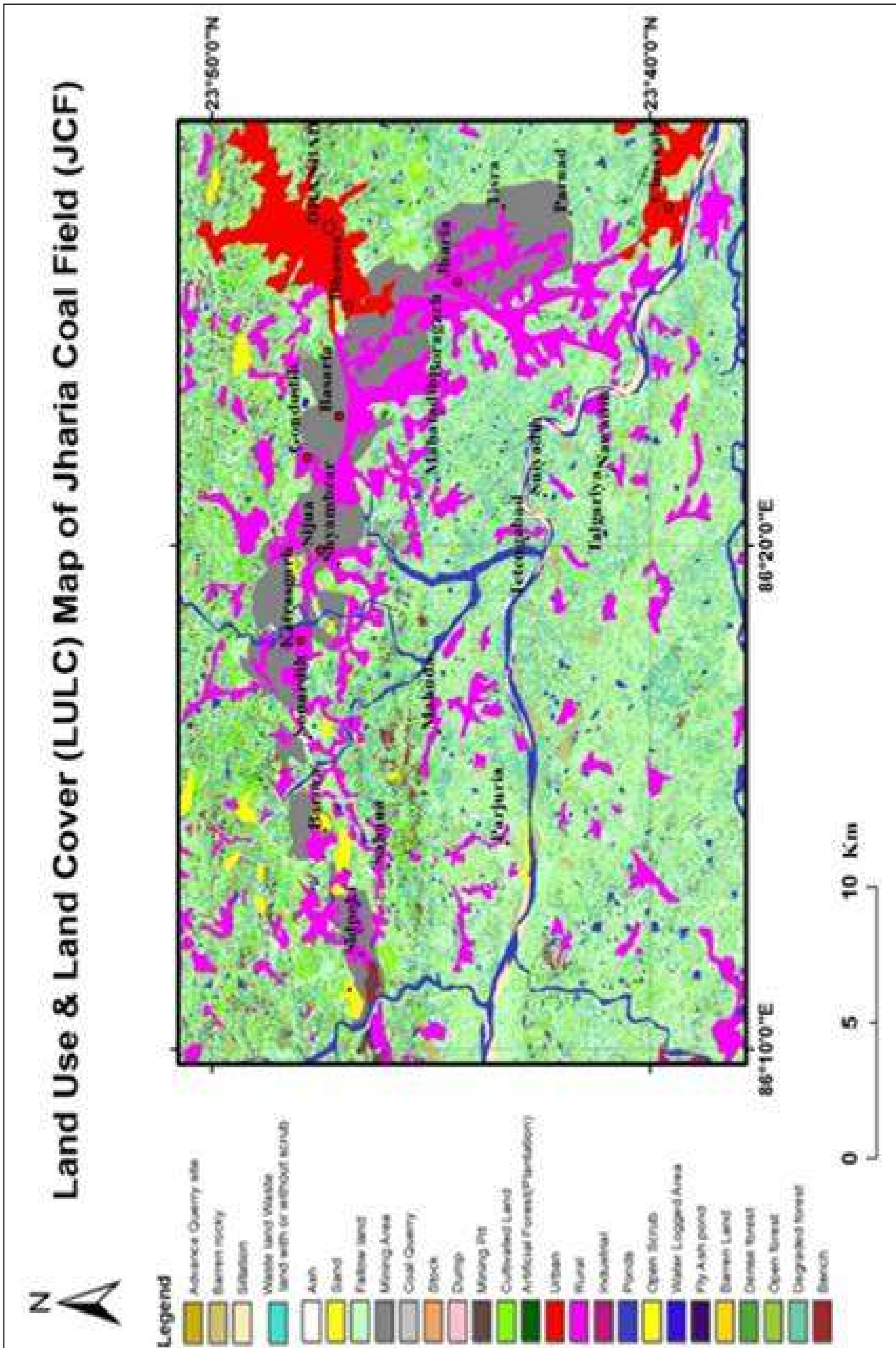

Fig: 74 LULC image after recode with reference to field data.

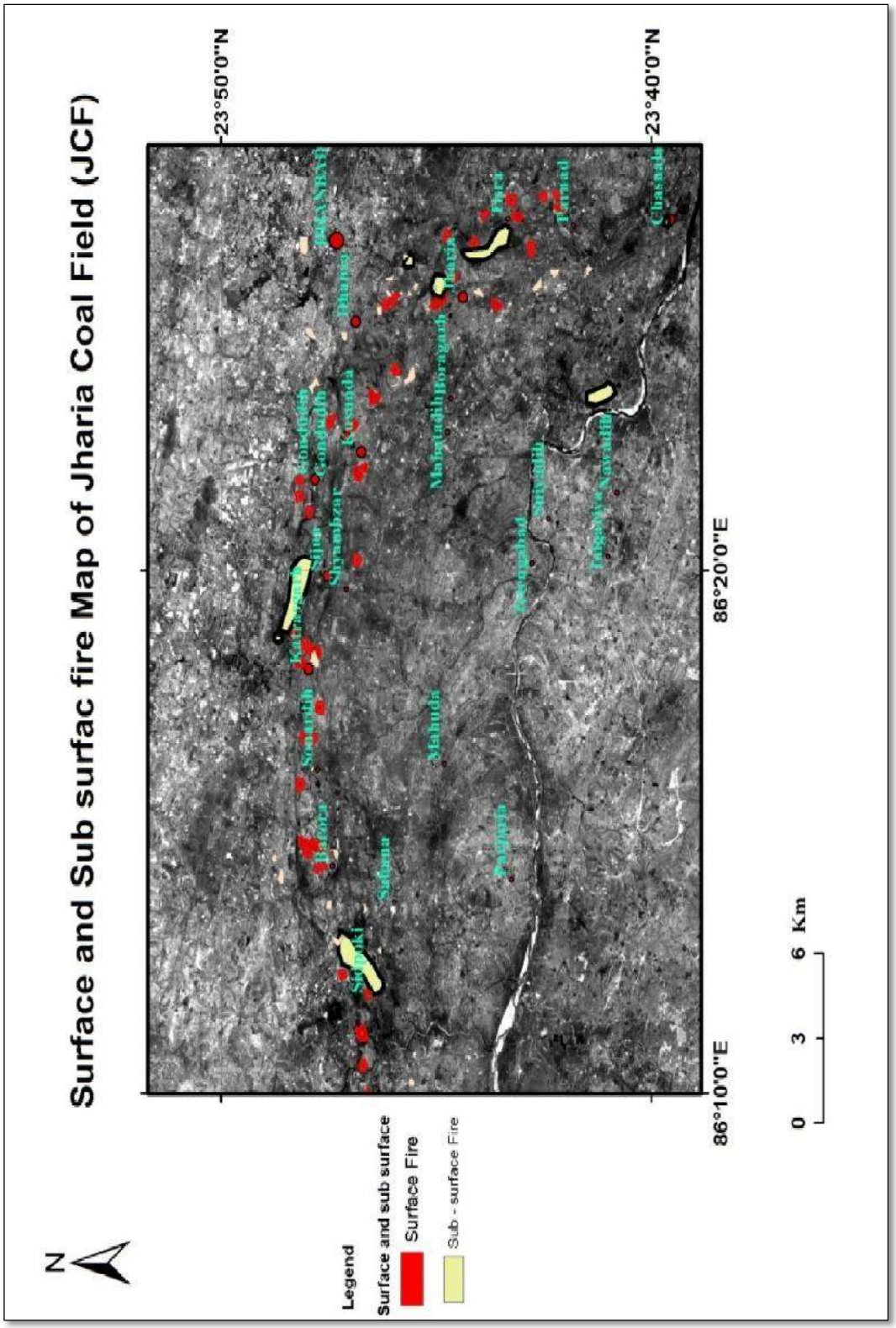

Fig: 75 Map showing surface and sub-surface CSF in JCF

The various zones of surface and subsurface fire has been demarcated and illustrated in the figure above.

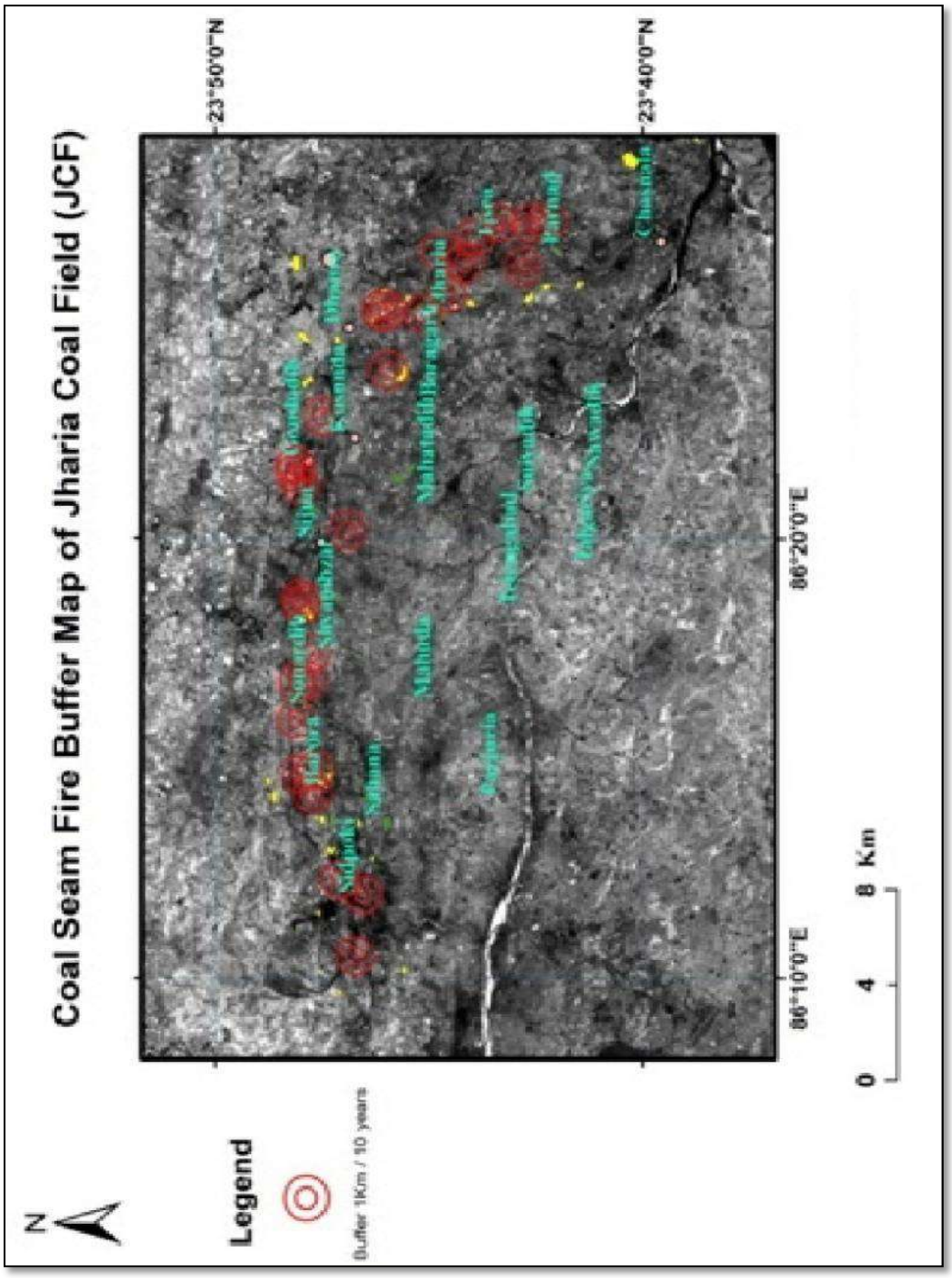

Fig: 76 Map showing buffer zone of CSF in JCF