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CHANGING LAND TRAJECTORIES: A CASE STUDY FROM INDIA USING A REMOTE SENSING BASED APPROACH.

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Abstract

The change in land use land cover (LULC) pattern is the result of natural and socio-economic factors and their use by human being over time and space. Change analysis plays an important role in natural resource management and in the assessment of environmental change. Land use land cover changes over a period of 25 years have been studied with the help of remote sensing and GIS in a part of Sonbhadra district of Uttar Pradesh and Singaruli region of Madhya Pradesh. The study area situated is situated in the vicinity of Govind Ballabh Pant Sagar reservoir. The present study is focused on the changing land use practices and their implications in the study area. Land use and land cover patterns at different time viz. 1991, 2000 and 2014 were analyzed and compared using a hybrid method of classification in ERDAS Imagine version-14. Data for this purpose was sourced from remote sensing satellite imageries of LANDSAT (TM of 1991 & ETM+ of 2000 & 2014) and Survey of India (SOI) topographic sheets on 1:50000 scale. After downloading Landsat data it has been proceed and further analyzed in Arc GIS version- 10.3. In this method, a statistics of area change in agriculture, barren land and forest cover, which is governed by variation in geology and prevailing structural anomaly were calculated.

Keywords: *Land use, land cover, Landsat, ARC GIS, remote sensing, ERDAS imagine*

1. INTRODUCTION

Land Use Land cover (LULC) and human/natural modifications have mainly caused in deforestation, biodiversity loss, global warming and an increase of natural disaster flooding (Mass et. al. 2004; Zho et. al. 2004; Diwedi et. al. 2005). These environmental problems are often connected to LULC changes. The term land use describes the land, which uses for several activities of human whereas land cover states the naturally occurring land parcels like natural vegetation, water bodies, rock/soil etc. (Kumar et al. 2012; Kahlon, 2015). Therefore, available data on LULC changes can deliver critical input to decision-making of environmental management and plan the future (Prenzel, 2004; Fan et. al. 2007). Most of the developing countries of the world are facing the problem of urbanization, urban population growth and low yield of agriculture with increase the population pressure on the land (Tamilenthi and Baskaran, 2013). Urban population growth has exacerbated the demand for housing and increased the existing problems (Safarabadi et al., 2015).

Therefore, the assessment of changes in land trajectories is important to analyze the change in spatial variation with time. The development of future situations for land use and change should not only include the spatial and temporal patterns of this change but should also support in the planning and sustainable use of the resources of any country (Veldkamp and Lambin, 2001). It is vital to develop regional model and predictions of change for the area because of their vulnerability to climate change and strong human impact (Brand and Townsend, 2006).

Remote Sensing technology for acquiring the geographical data and Geographic Information System (GIS) for undertaking integrated analysis, presentation of spatial and connected attribute data is found to be much more real to known the change detection of land use land cover (Lillesand et al. 2001; Rai et. al. 2011). Multi-year datasets have been used i.e. 1991, 2000 and 2014 for the analysis of change in various spatial components. The remote sensing satellite images have been found good resources for detecting and monitoring the land use transformation (Kelarestaghi & Jeloudar, 2011). The accurate and timely LULC maps resulting from remotely sensed images are the keys for monitoring and quantifying numerous aspects of global and local climate changes, hydrology, biodiversity conservation and air pollution (Sellers et al. 1995; Bonan, 2008; Butchart et al. 2010; Schröter et al. 2010).

The land use land cover (LULC) changes information is a fundamental necessity for proper planning and utilization of the land and other natural resources and also an inventory of these resources. These changes encompass the greatest environmental concerns of human populations today, including climate change, biodiversity loss and the pollution of water, soil and air. Monitoring and mediating the negative consequences of LULC while behind the production of important resources has therefore become a major priority of researchers and policymakers around the whole world (Mishra and Rai, 2014 and 2016). Therefore, it is expected to have increasing significance in the sustainable and effective management of natural resources and environment (Sheeja et al. 2011).

Nowdays, energy is the most significant factor for the development of any country. As the economy of India is rising, the demand of coal for energy is also increasing extremely. This large dependency on coal is not sustainable for long. The study area in Sonbhadra and Singrauli region cover some of the parts of Uttar Pradesh and Madhya Pradesh. This area is considered to be South Asia’s biggest industrial area and endorsed as India’s energy capital (Fact Finding Report, Greenpeace, 2011). Due to the availability of the large coal reserves and Govind Ballabh Pant Sagar reservoir on Rihand River, it provides a suitable condition for industrial development (Areendran et al. 2013). There are numbers of establishments in the Singrauli region like Northern Coalfield Limited (NCL), National Thermal Power Company (NTPC), Jaypee Nigrie Super Thermal Power Plant, Hindalco Industries (Aditya Birla Group), Mahan Coal Limited, DB power Limited, Anpara Thermal Power Plant and many more which are posing an adverse effect on the environment. It has been evaluated that the total forested area covered by 50 major mineral producing districts in India is about 28% of country’s total forest cover (CSE 2011). The development of the area has since 1840, after the discovery of coal in Singrauli (Greenpeace, 2011). After the construction of Govind Ballabh Pant Sangar and various thermal power plants in the 1960s, the human population and settlement are increased. Therefore, the conversion of forested land into grassland and cropland was very well interpreted in the study area.

The main goal of this study is to estimate the change in the land use land cover (LULC) in Singrauli region due to industrial development. The image processing classification method has been done with the help of hybrid classification process in ERDAS Imagine version-14 software. The statistics of land parcel of different year has been generated and the accuracy assessment has also been done.

2. STUDY AREA

The study area lies in some part of Sonbhadra district of Uttar Pradesh and Singrauli district of Madhya Pradesh (Figure 1). It ranges from latitude 23°50' and 24°30' N and longitude 82°30' and 83°10' E. The total area is about 4628 Km^2 and it falls under 8 topographical sheets of Survey of India on 1:50,000 scale i.e. 63 L/11, L/12, L/15, L/16; 64 I/09, I/13 and 64 P/03, P/04. The Singrauli district was announced the 50^{th} district of Madhya Pradesh on 24 May 2008, after separation of three tehsils of the erstwhile Sidhi district: Singrauli, Deosar and Chitrangi (Areendran et al. 2013). According to the 2011 census, the Singrauli district has a population of 1,178,132.

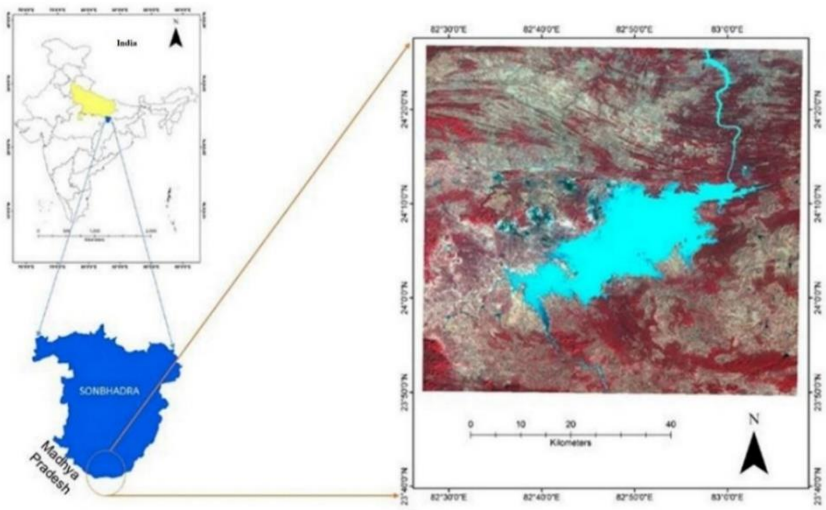

Figure 1. Location map of study area as viewed on Landsat (OLI-TRS) data of 2014.

The climate of the study area is characterized as tropical monsoonal and the temperature reaches up to 48°C during June, the atmosphere remains humid in rainy season while in January the temperature goes (Singh, 2007). Kalyan, Mayar, Matwani and Baliyanala are the four main seasonal rivers transverse through the Singrauli area (Khan et al. 2012). North flowing streams join the Bijul tributary of Son River and south-flowing streams mostly join the Kachan and Mayar tributary of Rihand reservoir (Chopra, 2011).

The Geological survey of India and the Indian Bureau of Mines had found the existence of several thick and persistent coal seams in Karharbaris, which name as Kota; from the bottom, it named as Turra and Purewa in Barakars and Jhingurdah Top and Jhingurdah Botton in the Raniganj formation. The coal of Karharbari and Barakar are composed of mainly durite, 'intermediate', and fusite, whereas the coals of Raniganj are vitrinite-rich and composed of a greater proportion of vitrite, clarite and 'intermediate' than durite and fusite. The coal of Singrauli region is similar in petrographic composition to the coals of nearest coalfields of Son valley basin (Pareek, 1970).

Collectively, the eastern part of Madhya Pradesh and the adjoining part of Sonbhadra district of Uttar Pradesh in known as Singrauli. With the construction of a dam on the Rihand river in the beginning 1950s, the development of Singrauli area has started. The main purpose of the Rihand dam was irrigation but due to the availability of coal and proper water facility, various thermal power plants have started (Areendran et al. 2013).

3. MATERIALS AND METHODOLOGY

Multi-temporal satellite imageries of LANDSAT for the period 1991, 2000 and 2014 were analyzed and compared for the present study. Survey of India (SOI) topographical sheets (1:50,000) was also used for geo-rectification (Table 1). The images were taken during the months of September (last week) and October (first week) when there is the least possibility of disturbance and noise in the atmosphere.

Table 1. List of Landsat images used in the study

Years	Satellite	Sensor	Data acquisition date	WRS Path/row
1991	Landsat 5	TM	28/10/1991	142/43
2000	Landsat 7	ETM+	26/09/2000	142/43
2014	Landsat 8	OLI TRS	25/09/2014	142/43

After acquiring the satellite data, image subsetting was carried out to extract the area being studied. This was followed by hybrid classification involving a merger of two techniques. An unsupervised classification was carried out using K-mean classifier method. Simultaneously manual interpretation was also done. This involved manual editing and correction of classes. In order to check that the whole exercise had produced dependable results, accuracy assessment was also carried out. The Kappa analysis is a discrete multivariate technique used in accuracy assessment. The result of Kappa analysis is a KHAT statistic. The value of KHAT statistic is range from +1 to -1 (Congalton and Green, 1977). The value of KHAT fall under three categories: values greater than 0.80 (>80%) shows strong agreement; between 0.40 and 0.80 (40-80%) for the moderate agreement; and values below 0.40 (<40%) represent poor agreement (Landis and Koch, 1977).

Finally, change detection matrices for consecutive time periods were generated. This was done by using two-layer matrix union thematic function in ERDAS Imagine 2014. Thematic maps were then smoothened using sieve thematic function after setting the minimum size of the cluster as three pixels. Final output maps were then generated using Arc GIS version-10.3. The land-use/land-cover categories identified were based on the classification provided by James R. Anderson (1971) which has also been adopted by NRSC (National Remote Sensing Centre), Hyderabad, India. Six main categories were identified in this study i.e. settlement area, agricultural area, forestland, scrubland, water bodies and mining area.

4. RESULT AND DISCUSSION

The land use and land cover map were prepared from each dataset of the year 1991, 2000 and 2014. In the study area, forestland, scrub land, mining area and agricultural land are dominant. The changing patterns in these classes were extracted from the classified map. Dense forest was mainly dominant at high ridges and cropland, scrubland also more in the plain and low-lying area. The industrial area is located approximately reservoir. This is due to the fact that the nearby mining area and the reservoir both fulfill the need of thermal power plant need, which requires coal and water to generate electricity.

4.1 Area changes in each class

Table 2 is showing the change in area in percentage as well as in Km^2 in different LULC classes. The forestland has gradually decreased from 1991 to 2000 by 1.74% and from 2000 to 2014 by 5.83%. The overall change in the forest is 7.57%, which shows enhanced deforestation rate in two decades.

Table 2. Area of LULC classes in different year

LULC Classes		1991	2000			2014
	Area (%)	Area (Km^2)	Area (%) (Km^2)	Area	Area (%) (Km^2)	Area
Forestland (FL)	36.36	1684.46	34.62	1604.05	28.79	1334.11
Scrub land (SC)	19.24	891.631	15.30	708.726	27.66	1281.57
Water bodies (WB)	10.63	492.358	10.18	471.658	10.19	472.207
Agriculture land (AL)	20.38	944.059	19.46	901.835	21.72	1006.35
Barren land (BL)	12.38	573.467	18.43	853.728	7.86	364.31
Mining area (MA)	0.69	31.9896	1.11	51.2109	2.31	107.199
Built up area (BA)	0.33	15.354	0.91	42.1164	1.46	67.5819

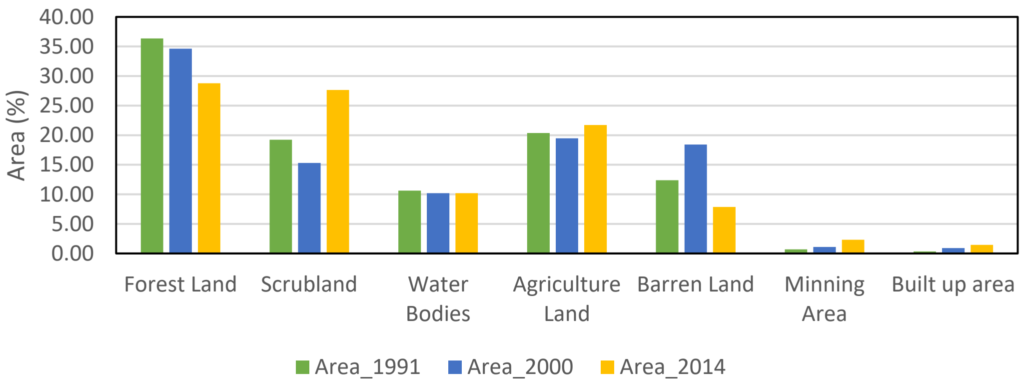

Figure 2. Change in area in percentage in different LULC classes

The mining area has increased from the year 1991 to 2014 by 1.62%. The data shows that the agriculture land built up area and scrubland also increased from 1991 to 2014, whereas, forestland and barren land decrease from 1991 to 2014. No noticeable change has been seen in water bodies (Figure 2).

4.2 Land use land cover change (1991-2000)

The matrix table (Table 3) showed the change in different LULC classes into one another for different years. The diagonal cells of the table represent the area of the particular class, which remained same in both years. Moreover, the off-diagonal value shows the area of a particular class which changed into other class.

Table 3. The transition matrix 1991-2000 (area in Km^2)

LULC Classes	1991-2000 FL	SC	WB	AL	BL	MA	BA	Total
FL	1273.77	228.31	2.37	70.69	22.11	4.92	1.88	1604.05
SC	167.88	247.67	8.49	202.30	78.15	2.38	1.85	708.73
WB	4.10	1.35	457.00	2.77	4.60	1.16	0.68	471.66
AL	78.85	273.54	1.05	372.30	174.56	0.85	0.69	901.84
BL	135.53	134.39	18.22	277.12	279.53	7.56	1.37	853.73
MA	10.62	4.17	2.88	14.43	9.25	8.96	0.90	51.21
BA	13.71	2.21	2.35	4.44	5.27	6.17	7.98	42.12
Total	**1684.46**	**891.63**	**492.36**	**944.06**	**573.47**	**31.99**	**15.35**	**4633.32**

The total area of forest in the year 1991 was 1684.46 Km^2 but in the year 2000, 1273.77 Km^2 remain as forest, 167.88 Km^2 area transformed into scrubland, 4.10 Km^2 into water bodies, 78.85 Km^2 into agricultural land, 135.53 Km^2 into barren land, 10.62 Km^2 into mining area and 13.71 Km^2 into the built up area. About 273.54 Km^2 area of scrubland was transformed into agriculture land from 1991 to 2000. It shows that the change is occurring from forest to scrubland and then to agriculture land (Figure 3).

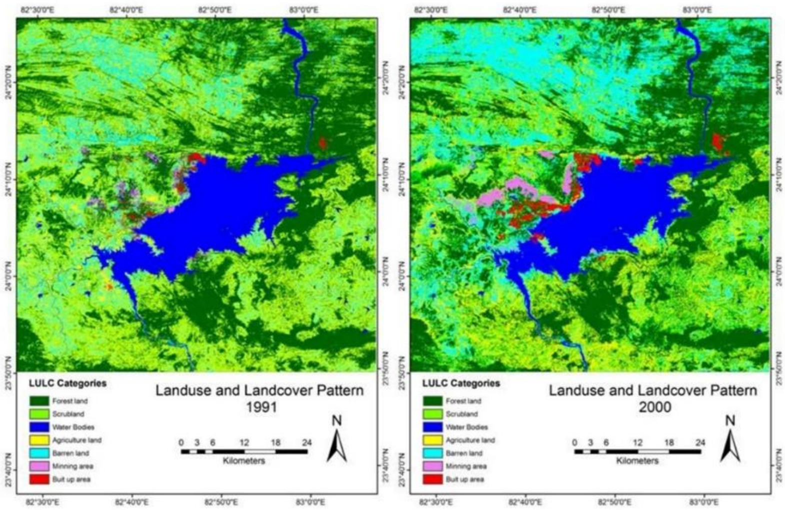

Figure 3. Land use and land cover map of 1991 and 2000.

The forest cover in 2000 has become smaller than 1991 and this is primarily due to developmental activity. The area of forest, which is transformed into mining area due to which many industries are promoted here. As a result, the demand of residence for employees and more food production are also increased. Therefore, more forestland is changing into mining, settlement and agriculture land. So, the chain is interlinked with each class, which is reflected from transition matrix data. Therefore, day by day by day the patches of natural forest are disappearing and the rate of deforestation is increasing. With the establishment of mega thermal power and coal mining project in this area during the 1980s, the rate of deforestation increased tremendously (Singh et al, 1991; Singh et al, 1997). After the discovery of large coal reserves in the 1970s, the land use practices have started to change as a result the built up and mining area have increased positively while the forested area has decreased tremendously. (Bose, 1996)

4.3 Land use land cover change (2000-2014)

The rate of deforestation from 2000 to 2014 is much higher than 1991 to 2000. The transition matrix (Table 4) shows that out of 1604.04 Km^2 forest in the year 2000, only 1004.59 Km^2 forests remained in 2014. It shows that about 40% forest has transformed into other classes. And these major classes are scrubland (288.35 Km^2), agricultural land (Km^2) and mining area (18.16). The mining area tremendously increased and it became double from 51.21 to 107.19 Km^2. The barren land has decreased from 18.43% to 7.86% because of conversion of most of the barren land into agriculture land. The agriculture land increased during 2000 to 2014. This is due to the fact that most of the scrubland and barren land are being used for agriculture purpose.

During 2000 and 2014, many industries have been established like Sasan Ultra Mega Power Project (2013), Chitrangi Power Project (2007), Mahan Coal Limited (2007) etc. Most of the industries are from the energy sector and use the coal reserves. Therefore, the rate of deforestation increased during 2000 to 2014 period.

Table 4. The transition matrix 2000-2014 (area in Km^2)

LULC Classes	2000-2014							
	FL	**SC**	**WB**	**AL**	**BL**	**MA**	**BA**	**Total**
FL	1004.59	145.80	7.63	53.10	109.50	6.39	7.09	1334.10
SC	288.35	302.79	15.37	450.42	218.60	2.87	3.18	1281.57
WB	30.39	16.05	402.04	3.32	17.71	1.36	1.33	472.21
AL	241.88	200.04	19.51	315.54	224.14	2.56	2.68	1006.35
BL	6.92	26.18	10.57	57.80	258.93	2.96	0.97	364.31
MA	18.16	10.02	12.46	14.29	13.52	33.20	5.56	107.20
BA	13.77	7.85	4.09	7.37	11.33	1.87	21.32	67.58
Total	1604.04	708.73	471.66	901.83	853.73	51.21	42.12	4633.32

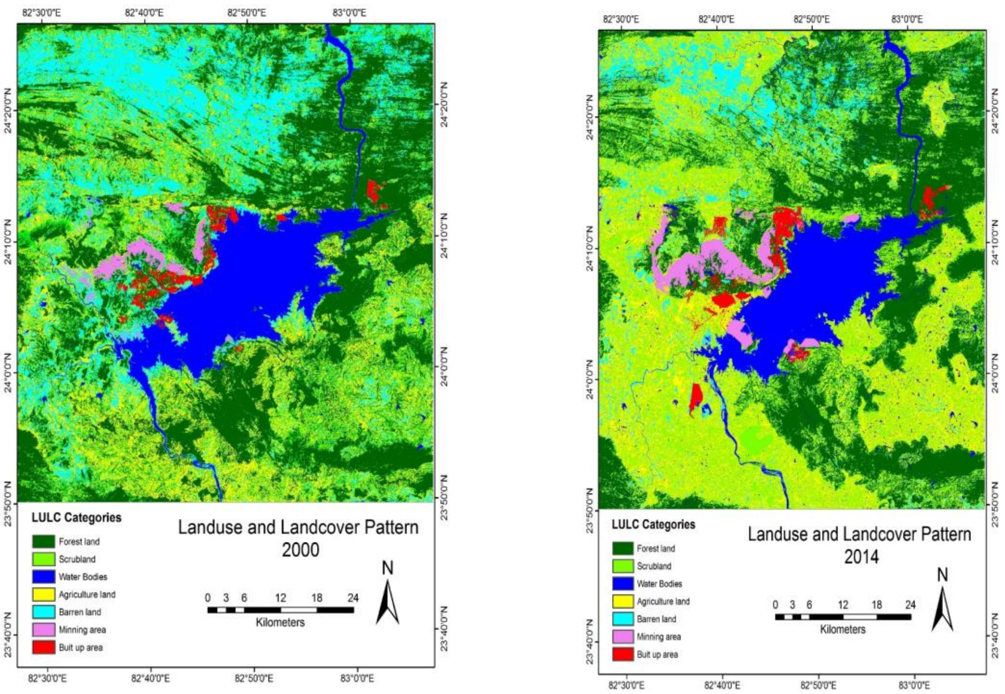

Figure 4. Land use and land cover map of 2000 and 2014.

The map shows that the mining activity is infringing the forested area. Most of the patches of forest have vanished and the agricultural area has increased during these time period. The red patches are showing settlement in 2014, some of the red patches (settlement) have increased from these time period. The light bluish color of barren land is more dominant in 2000 but in 2014, it reduced due to the conversion of barren land into agriculture land (Figure 4).

4.4 Land use land cover change (1991-2014)

The overall change from 1991 to 2014 shown in table 5. The total forest in the year 1991 was 36.36% of the total area but in 2014 it became 28.79%. Likewise, barren land decreased from 12.38 to 7.86%. The mining area has drastically changed and it increased from 31.98 Km^2 to 107.19 Km^2. It increased nearly three times within three decades. Along with this, built up area has also increased four times during these time periods (Table 6).

Table 5. Area change in percentage (1991-2014)

LULC Classes	Area (%) 1991	Area (%) 2014	Changes (+ or -)
FL	36.36	28.79	-7.56
SC	19.24	27.66	+8.42
WB	10.63	10.19	-0.43
AL	20.38	21.72	+1.34
BL	12.38	7.86	-4.51
MA	0.69	2.31	+1.62
BA	0.33	1.46	+1.13

Table 6. The transition matrix 1991-2014 (area in Km^2)

2014	1991-2014							
	FL	**SC**	**WB**	**AL**	**BL**	**MA**	**BA**	**Total**
FL	1060.36	159.43	10.38	64.33	32.44	7.14	0.01	1334.10
SC	296.19	397.67	24.00	384.39	175.45	3.87	0.00	1281.57
WB	40.10	10.88	400.86	9.04	9.32	1.96	0.06	472.21
AL	206.01	251.77	26.38	323.87	194.82	3.49	0.00	1006.35
BL	34.46	51.36	11.06	128.29	138.31	0.63	0.20	364.31
MA	23.72	15.77	14.59	23.95	17.75	10.97	0.46	107.20
BA	23.64	4.74	5.09	10.19	5.38	3.92	14.61	67.58
FL	**1684.46**	**891.63**	**492.36**	**944.06**	**573.47**	**31.99**	**15.35**	**4633.32**

4.5 Accuracy Assessment

Finally, the accuracy and Kappa statistic of the classified image checked and verified with the help of accuracy assessment method in digital image processing (Table 7). The overall accuracy of the image is 81%, 84% and 82% of the year 1991, 2000 and 2014 respectively. The value of kappa in the image is a moderate agreement for 1991 and 2014 while it is very strong agreement for the year 2000.

Table 7. Kappa and overall accuracy of all years

Year	Overall accuracy (%)	Kappa statistics
1991	81.00	0.7816
2000	84.00	0.8163
2014	82.00	0.7929

5. CONCLUSION

The study of multi-temporal satellite datasets of Sonbhadra and Singrauli Region of Uttar Pradesh and Madhya Pradesh respectively over a period of more than two decades revealed significant land trajectories in various land use land cover classes. Wherever the most of the change has found in the forest area, mining areas and settlements. Forest area has been decreased throughout the study period and mining area has increased in the same. It is because of development of many industries, which are established after 2000, so abrupt changes are seen in forestland and it loose to mining and built up area. So, it is observed that there is a strong relationship between loss of forest cover and growth in mining areas. The confusion matrix has shown that small amount of forestland is also transformed into scrubland, agriculture land, and barren land. The study shows that the forested areas are most prone to transformation and increasing human pressure on forest makes it highly vulnerable to deforestation activity in the area.

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