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Satellite Image Based Land Use Land Cover Change Analysis of Ranchi District, Jharkhand

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ABSTRACT

The high rate of urbanization coupled with population growth has caused changes in land use and land cover in Ranchi, Jharkhand. Therefore, understanding and quantifying the spatio-temporal dynamics of land use and land cover changes and its driving factors is essential to put forward the right policies and monitoring mechanisms on urban growth for decision making. Thus, the objective of this study was to analyze land use and land cover changes in Ranchi area, Jharkhand by applying geospatial technology and land use change modeling. In order to achieve this, satellite data of Landsat-5,TMof1992 and Landsat-8,OLI of 2017 have been obtained and pre-processed using ArcGIS. The Maximum Likelihood Algorithm of Supervised Classification has been used to generate land use and land cover maps. For the accuracy of classified land use and land cover maps, a confusion matrix was used to derive overall accuracy and results were above the minimum and acceptable threshold level. The generated land cover maps have been run with Land Change Modeller for quantifying landuse and land cover changes, to examine land use transitions between land cover classes, to identify gain and losses of built up areas in relation to other land cover classes and to asses spatial trend of built up areas. Finally,Land Change Modeller has been run to model land use and land cover changes in Ranchi area and to predict land use changes. Generally,the results of Ranchi district of Jharkhand study have shown that there was an increased expansion of built up areas in the last 25 years from 9.69% in 1992 to 21.00% in 2017. The spatial trend of built up areas also showed that there was a growing trend in the center part relative to other directions and also increase in agriculture land from 1992 to 2017 that is28% to 37%, Forest in 1992 was about16.01% and in 2017 about 10.00% decrease in the forest areas, Barren land in 1992 was about 10.04% and the year 2017 about 8.34%, Vegetation was about 24.26 % in 1992 and in the year 2017 about 16.74 % ,Water bodies was also lit decreased in the year 1992 to 2017 there was 11.06 % to 10.02 %. Growing population pressure and its associated problems, such as the increasing demand for land and trees, poor institutional and socio-economic settings, and also unfavorable government policies, such as lack of land tenure security and poor infrastructure development, have been the major driving forces behind the LULC changes. Hence, special attention should be given to the introduction of wise land resource uses and management practices, secure land possession systems, regulated population growth, and integrated environmental rehabilitation programs. The existing tree plantation practices should be encouraged by promoting the planting of indigenous tree species, rather than eucalyptus trees, in order to enhance ecological harmony.

Keywords: *Landsat-5 TM, Landsat-8 OLI, Geospatial Technology, Land Use Change Modelling and Supervised Classification*

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INTRODUCTION

The land cover scenario is continuously undergoing changes in its structure and has been the reason of deep concern to the urban planners and decision-makers. The main contributor to the urban change is the steady increase in the urban population that mainly includes the migration from small towns and rural areas which by far is the main factor of the ever increasing land costs and slum proliferation in the urban areas and illegal occupation of government land and protected forest cover by migrants and greedy construction companies [1, 7]. One arrives at a conclusion that these changes are happening fast and the methods to curtail them or nip them in the bud are not happening which is not true at all. There is lack of awareness among people regarding new technology due to which they resort to age old methods of problem identification and irradiation that takes a lot of time and money and not to forget heavy manpower and to make all these factors work in a single smooth fashion is just another problem, there are hitches and hurdles in conventional surveys and ground truthing. By the time all the information is collected and a action plan is developed the ground reality would have changed so much that the plan does not stand any chance of success. This is one of the major problems, which most of the Government machineries and various other organizations are facing today.

Issues of land use and land cover have become increasingly important as problems of uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss off is hand wildlife habitat continue to worsen .To better understand the impact of land use change on global ecosystems, the factors affecting land use must be further examined. Growing human population exert increasing pressure on the landscape as demands multiply for resources such as food, water, shelter, and fuel. These social and economic factors often dictate how land is used regionally. Land use practices generally develop over a long period under different environmental, political, demographic, and social conditions. These conditions often vary yet have a direct impact on land use and land cover [3]**.** Examples of land use include creating parks, golf courses, urban areas, and athletic fields. Land cover refers to natural features of the surface of earth, such as vegetation cover, which may or may not been modified by humans [4]. A change in land use and land cover (LULC) may limit the availability of products and services for human populations and can have a profound impact on a region's fauna and flora, as well as on environmental and ecological health. The vast majority of land use and land cover data are acquired through interpretation of aerial photography and other similar imagery. Remotely sensed data provide the comprehensive detail needed to effectively study land use patterns. In this study remotely sensed data were used because they lend themselves to accurate land cover and land use analysis. Land cover information can be visually interpreted using evidence from aerial images, and specific objects can be seen in the context of their neighboring features [6]. In addition, according to [5] by utilizing geospatial technologies and techniques, researchers can monitor changes in land use and land cover and map areas for specific research and analysis.

Study Areas

Ranchi is located in the southern part of the Chota Nagpur plateau,which is the eastern section of the Deccan plateau.The latitude of Ranchi,Jharkhand, India is 23.344101,and the longitude is 85.309563**.** Ranchi, Jharkhand, India is located at *India* country in the *Cities* place category with the GPS coordinates of 23° 20' 38.7636'' N and 85° 18' 34.4268'' E. Ranchi has a hilly topography and its dense tropical forests a combination that produces a relatively moderate climate compared to the rest of the state. However, due to the uncontrolled deforestation, and development of the city, the average temperature has increased. Ranchi, Jharkhand, India elevation is a 644 meters height that is equal to 2,113 feet. Area is included in Topo sheet no. 73A, 73B, 73E and 73F. Ranchi has a humid subtropical climate. However, due to its position and the forests around the city, it is known for its pleasant climate. Its climate is the primary reason why Ranchi was once the summer capital of the undivided State of Bihar, Ranchi used to be a preferable hill station in the past. Temperature ranges from maximum 42 to 20°C during summer and from 25 to 0°C during winter (December to January) are the coolest months with temperature getting to freezing point in some places of the city. The annual rainfall is about 1430mm(56.34

inches).From June to September the rain fall is about 1,100mm.Ranchi is located at 23°21′N 85°20′E. The total area covered by the Ranchi municipal area is 175.12 square kilometers and the average elevation of the city is 651 m above sea level. Ranchi is located on the southern part of the Chota Nagpur plateau which forms the eastern edge of the Deccan plateau. Ranchi is referred to as the "City of Waterfalls", due to the presence of numerous large and small falls of around the close vicinity of the city. The most popular ones are Dassam Falls, Hundru Falls, Jonha Falls, Hirni Falls and Panchghagh Falls.

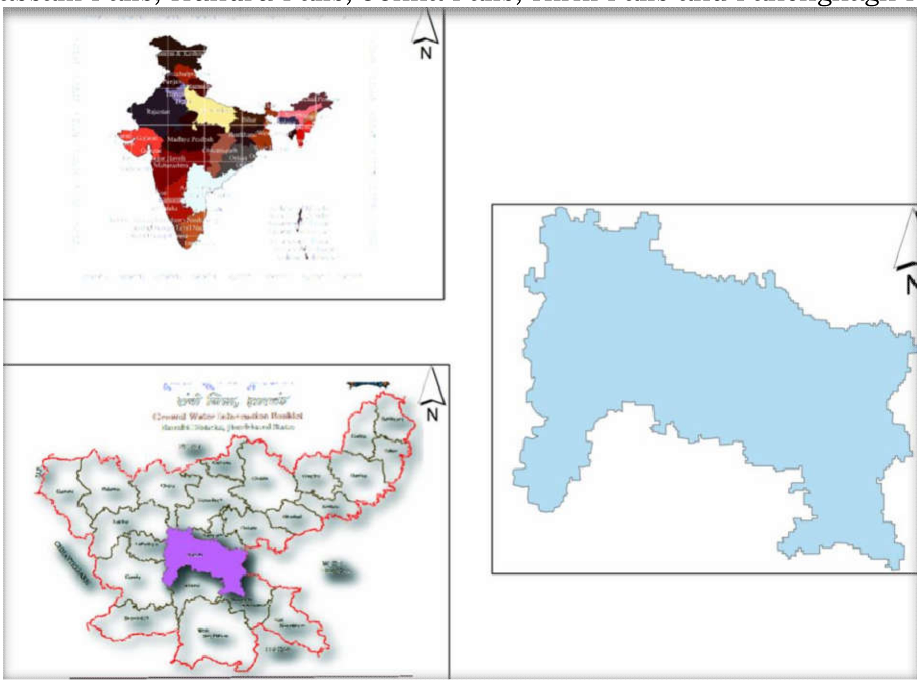


Figure1 Location map of the study area

MATERIAL AND METHODS

Database preparation

In this study Landsat imageries of TM and OLITIRS were employed and acquired in the same season and the same level of resolution for the periods 1992 & 2017.Thus, it was conducive for comparison of changes and patterns occurred in the time under discussion. The images were downloaded from the Global Land Cover Facility of the University of Maryland (GLCF,2013) and the United States Geological Survey (USGS) and spatially referenced in the Universal Transverse Mercator (UTM) projection with datum World Geodetic System (WGS) 1984 UTM. These data sets were imported in ERDAS Imagine version (Leica Geosystems, Atlanta, U.S.A.),satellite image processing software to create a false colour composite (FCC).The layer stack option in image interpreter tool box was used to generate FCCs for the study areas. The sub-setting of satellite images were performed for extracting study area from both images by taking geo-referenced out line boundary.

Land use/cover detection and analysis

To work out the land use/cover classification, supervised classification method with maximum likelihood algorithm was applied in the ERDAS Imagine Software. Maximum likelihood algorithm (MLC) is one of the most popular supervised classification methods used with remote sensing image data. This method is based on the probability that a pixel belongs to a particular class. The basic theory assumes that these probabilities are equal for all classes and that the input bands have normal distributions. However, this method needs long time of computation, relies heavily on a normal distribution of the data in each input band and tends to over-classify signatures with relatively large values in the covariance matrix. The spectral distance method calculates the spectral distance between the measurement vector for the candidate pixel and the mean vector for each signature and the equation for classifying by spectral distance is based on the equation for Euclidean distance. It requires the least computational time among other supervised methods, however, the pixels that should not be unclassified become classified, and it does not consider class variability. Ground verification was done for doubtful areas. Based on the ground truthing, the misclassified areas were corrected using recode option in ERDAS Imagine. The error matrix methods and Kappa Khat methods were used to assess the mapping accuracy.

Land use/cover change detection and analysis

For performing land use/cover change detection, a post-classification detection method was employed. A pixel-based comparison was used to produce change information on pixel basis and thus, interpret the changes more efficiently taking the advantage of "-from, -to" information. Classified image pairs of two different decade data were compared using cross-tabulation in order to determine qualitative and quantitative aspects of the changes for the periods from 1992 to 2017. A change matrix was produced with the help of ERDAS Imagine software. Quantitative a real data of the overall land use/cover changes as well as gains and losses in each category between 1992 and 2017 were then compiled.

RESULTS AND DISCUSSIONS

The results obtained through the analysis of multi-temporal satellite imageries were diagrammatically illustrated in Figs. 2–4and data are registered in Tables 1 and 2. Fig. 2depicts land use/cover status**,** Fig. 3 depicts land use/cover change in different land use categories and Fig. 4 illustrates magnitude of change in different land categories. A brief account of these results is discussed in the following paragraphs.

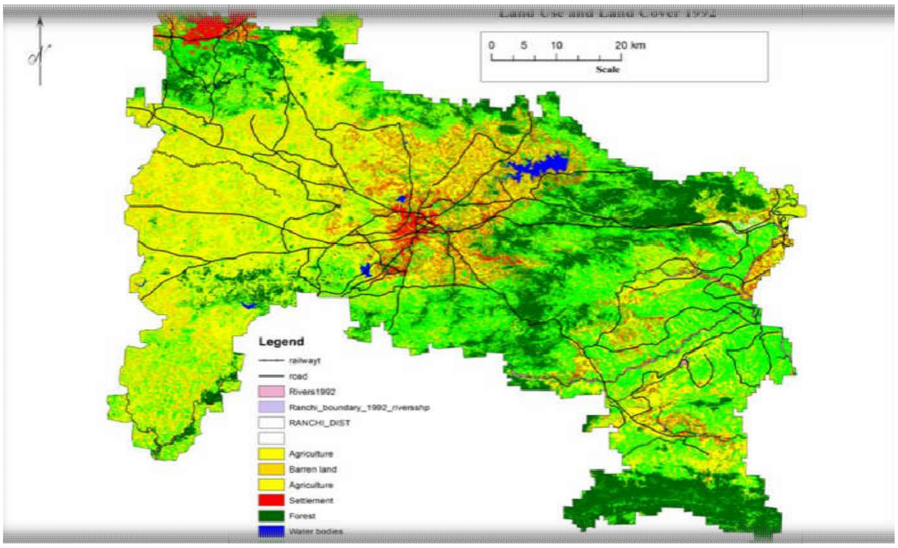
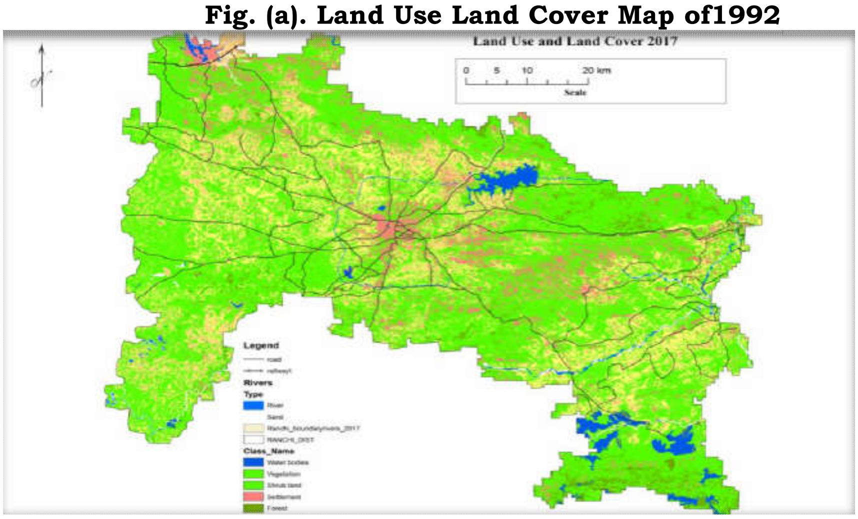
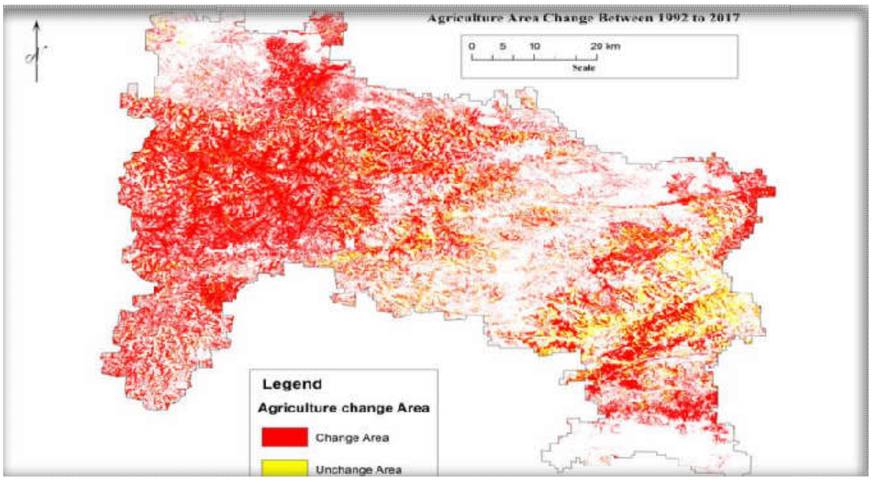


Fig. (a). Land Use Land Cover Map of1992

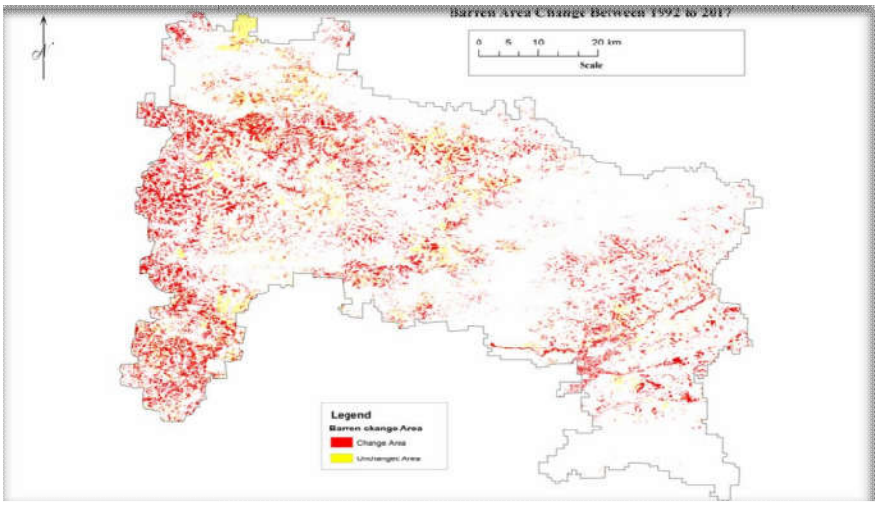


(b) Land Use Land Cover Map of2017

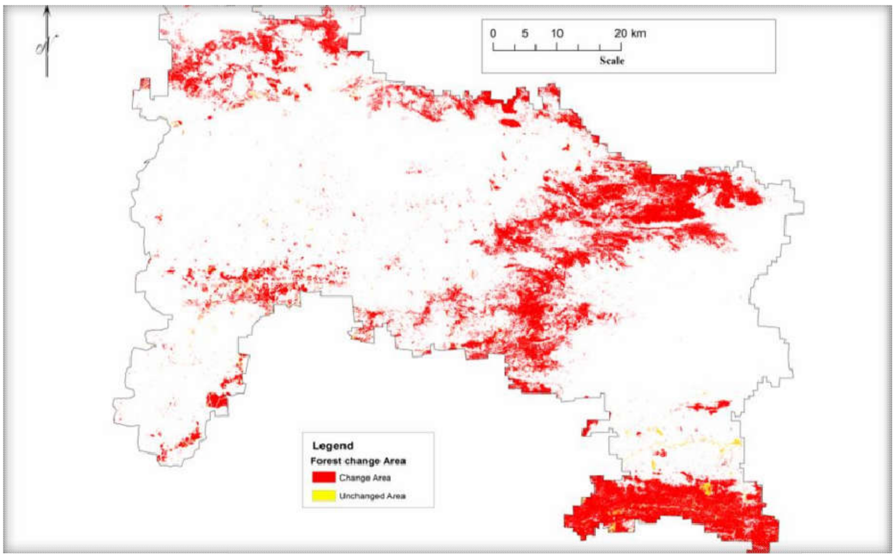
Fig 2. Land use/cover of Ranchi District; (a) in 1992, (b) in 2017 (based on Landsat Thematic Mapper Satellite Imagery).


Agriculture Area Change Between 1992 to 2017
0 5 10 20 km
Scale
Legend
Agriculture change Area
Change Area
Unchange Area

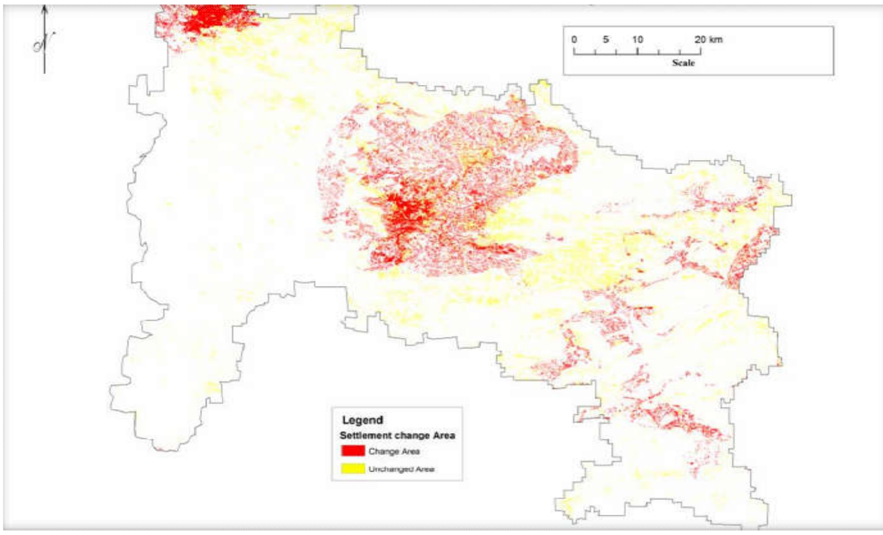
A


Barren Area Change Between 1992 to 2017
0 5 10 20 km
Scale
Legend
Barren change Area
Change Area
Unchanged Area

B


0 5 10 20 km
Scale
Legend
Forest change Area
Change Area
Unchanged Area

C.



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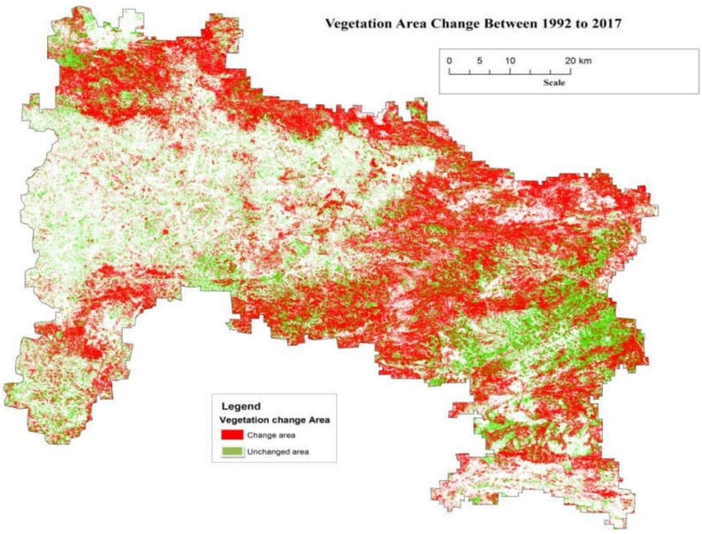
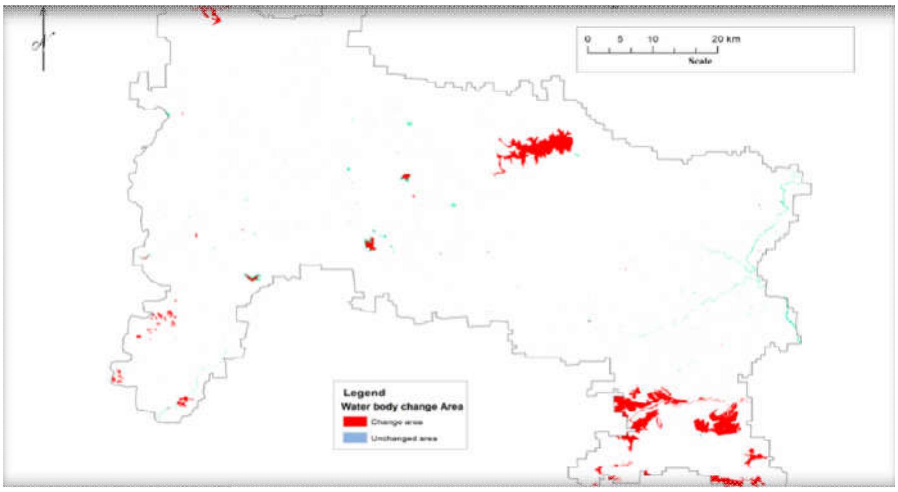


E.



F.

Figure 3. Land use/cover change in different categories during in the Ranchi district Jharkhand (1992-2017);

(a) Agriculture (b) Barren land (c) Forest area (d) Settlement area (e) Vegetation (f) Water bodies (based on Landsat Thematic Mapper Satellite Imagery).

Land use/cover status

Accuracy assessment of the land use/cover classification results obtained showed an overall accuracy of 75% for 1992 and 84.58% for 2017. The Kappa coefficients for 2017 and 1992 maps were 0.8325 and 0.8236.Fig. 2(a) depicts spatial distributional pattern of Land use/cover of the Ranchi district for the year 1992 while Fig.2(b) for the year 2017.Generally,the results of Ranchi district of Jharkhand study have shown that there was an increased expansion of built up areas in the last 25 years from 9.69% in 1992 to 21.00% in 2017. The spatial trend of built-up areas also showed that there was a growing trend in the center part relative to other directions and also increase in agriculture land from 1992 to 2017 that is 28% to 37%, Forest in 1992 was about16.01% and in 2017 about 10.00% decrease in the forest areas, Barren land in 1992 was about 10.04% and the year 2017 about 8.34%, Vegetation was about 24.26 % in 1992 and in the year 2017 about 16.74 % ,Water bodies was also lit decrease in the year 1992 to 2017 there was 11.06 % to 10.02%. Similar results were reported by [1].

Land use/cover change

Generally, agricultural areas and somehow built up areas were the most dominant land cover classes that has been observed in the study periods of1992 and 2017.The table below presents a summary of areas and percentage of land cover classes in the last 25 years.

Table: 1 - Area statistics of the land use and land cover units from 1992-2017

Land use and Land Cover Classes	1992		2017	
	Area(Sq_km)	%	Area (Sqkm)	%
Agriculture	1530.849	28%	2000	37%
Barren Land	529.6212	10.04%	448.6473	8.34%
Settlement	520.8903	9.69%	1121.15	21.00%
Forest	860.562	16.01%	143.1045	3%
Waterbody	594.83	11.06%	674.13	12.00%
Vegetation	1304.123	24.26%	900	16.74%
Rivers	17.70705	0.33%	30.3189	0.56%
River Sand	15.5879	0.29%	58.47	1.08%
Total	5374.17	100%	5374.17	100%

Table: 2 - Confusion matrix for land use and land cover map of 2017

Classified Data	Vegetation	Surface Water	River	Barren	Agriculture	Settlement	Row Total	User Accuracy
Vegetation	**2158**	610	400	00	01	01	3170	68%
Surface Water	00	**2583**	54	00	22	00	2659	97%
Rivers	84	01	**1131**	158	278	23	1675	67%
Barren	00	00	00	**4588**	191	76	4855	94.5%
Agriculture	116	00	17	00	**598**	40	771	77.5%
Settlement	00	00	06	00	00	**722**	728	99.17%
Column Total	2358	3194	1608	4746	1090	862	**13858**	
Producer Accuracy	91%	80.87%	70.3%	96.6%	54.86%	83.75%		

Table: 3- Confusion matrix for land use and land cover map of 1992

Classified Data	Vegetation	Surface Water	Rivers	Barren	Agriculture	Settlement	Row Total	User Accuracy
Vegetation	**472**	00	04	00	09	04	489	96%
Surface Water	00	**350**	140	120	00	00	610	57.37%
Rivers	30	00	**440**	00	00	00	470	93.61%
Barren	00	100	00	**1700**	20	45	1865	91%
Agriculture	00	00		00	**269**	00	269	100%
Settlement	06	00	00	00	50	**235**	291	80.75%
Column Total	508	450	584	1820	348	284	**3994**	
Producer Accuracy	92%	77%	75%	93%	77%	82%		
Over all Accuracy is - 84.41 %								

CONCLUSION

Land is non-renewable resources and has assessment of land use and land cover in temporal sequence is essential for planning and development of land and water resources. Land use and land cover changes have wide range of consequences at all spatial and temporal scales. Because of these effects and influences it has become one of the major problems for environmental change as well as natural resource management. Identifying the complex interaction between changes and its drivers over space and time is important to predict future developments, set decision making mechanisms and construct alternative scenarios. The study has been conducted by integrating GIS, remote sensing and spatial modeling tools. In order to detect and analyze changes in land cover classes, these techniques were implemented. In the first section, satellite data for the study periods of 1992, 2017 and remote sensing techniques were applied to generate land cover maps through a maximum likelihood supervised image classification algorithm. The accuracy assessment and change detection processes has also been done. The overall accuracy of land use and land cover maps generated in this study had got an acceptable value of above the minimum threshold. From the remote sensing of image classification result, the study showed that the proportion of built up areas were increased. Generally it have shown that there was an increased expansion of built up areas in the last 25 years from 9.69% in 1992 to 21.00% in 2017 The spatial trend of built up areas also showed that there was a growing trend in the center part relative to other directions and also increase in agriculture land from 1992 to 2017 that is 28% to 37%.Forest in 1992 was about16.01% and in 2017 it was about 10.00% there was decrease in the forest areas .Barren land in 1992 was about10.04% in 1992 and in the year 2017 it was about 8.34%.Vegetation was about 24.26 % in 1992 and in the year 2017 it was about 16.74 %.Water bodies was also lit increases in the year 1992 to 2017 there was 11.06 % to 10.02 %.

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