

LAND USE CLASSIFICATION AND LAND COVER ASSESSMENT USING ACCURACY MATRIX FOR DHAMTARI DISTRICT, CHHATTISGARH, INDIA

Farhan Khan^{1,*} and Bhumika Das²

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Abstract

The land use land cover change monitoring is vital for planning, developing and managing of any region. The main aim of this study is to monitor Land use and land Cover (LULC) changes of Dhamtari district of Chhattisgarh for the periods of 1999-2004, 2004-2009, 2009-2014, and 2014-2020. Landsat-8 and Landsat-5 data were used to generate LC map. The imageries were then used for supervised classification using maximum likelihood technique to prepare LULC maps. The change map of study area is for a time period of 1999-2020. This change map shows the change of one class to other. Five major classes viz; agriculture, barren land, forest area, urban area and water bodies have been identified. The forest and agriculture class are dominant in the study area. The LULC in the study area has experienced intricate changes over past two decades. The accuracy was assessed using google imageries and field verification, 200 random points were selected to verify the LULC map. The results Shows, agriculture, Forest, Urban area have increased by 25.60% (1037.9Km²), 42.60% (1728.2Km²), 23.60% (958Km²) while barren land and water bodies have decreased by 4.80% (194.2Km²) and 3.50% (141.6Km²) respectively. The average changes occurred in each class in last two decade from 1999-2020 are agriculture land 22%, barren land 22%, Forest 38%, urban land 15%, and water bodies changes to 3%. The results from the study will help the policy makers to understand the change trend and land management in the Dhamtari District.

Keywords: Accuracy assessment, Land classification, Kappa coefficient, Land change, Chhattisgarh, Land cover

Introduction

Land plays a significant role in ecosystem; Human life depends on the ecosystem. A fundamental variable that affects and connects several parts of the human and physical environment is land cover (Foody, 2002). Land use/land cover (LULC) is now a sensitive matter of interest eternally; because of its effects on ecosystems, it is considered one of the most important environmental problems

of global importance (El-Tantawi *et al.*, 2019). Due to global change followed by urbanization the land use land cover became important for every nation and its development. The development should be directional in better way and it should not affect the present scenario. From the LULC map the proper trend can be targeted and according to the present resources i.e., roads, water, forest the area for

¹ Farhan Khan, Assistant Professor, Rungta College of engineering and Technology, Bilai. E-mail: Farhan_1991@rediffmail.com.

² Dr Bhumika Das, Associate professor, Mats University, Raipur. E-mail: drbhumika@matsuniversity.ac.in

* Corresponding author

development can be determined easily (Mashi and Shuaibu, 2017). Now a day the whole world is facing changes in ecosystem, due to increase in population, industries, vehicles etc. These changes are having adverse effect on ecosystem due to which human existence is on the verge of annihilation if the situation is not controlled. The Global Environmental Monitoring System is continuously monitoring the changes which are affecting the environment. The general changes are taking place due to the conversion of barren, forest land into urban land (Minta *et al.*, 2018; Mishra *et al.*, 2020). The land is degrading due to mixing of unwanted foreign particles resulting in decreased yield. The land can optimize using proper planning and management, this can be done using LULC Maps. In the last five decades, particularly since the 'green revolution' and also because of urbanization, humans have dramatically modified the surface of the Planet, mainly with the rapid deforestation and the transition of the natural environment into the living activity (Dutta and Guchhait, 2020; Liu and Yang, 2015).

The aim of this study is to investigate the differences between LULC of different year of Dhamtari district to determine the changes occurred and to assess the accuracy of classification using Kappa coefficient this will determine the area covered by different classes and what is the current scenario? This paper will guide the local land development authorities about the trend of development. For Dhamtari district increase in agriculture, Forest and urban land is observed.

The Paper Consisted of Introduction where all broad idea of the research is mentioned, next section consist of study area details, followed by Materials and method. Last two sections are result and discussion where the researcher has explain the research findings with factual data. Lastly Conclusion of the paper is mention with the precise research results.

Literature Review

In developing countries urbanization is increasing rapidly across the world, which causing several impact on ecological cycle from excavation till erection of structures (Dong *et al.*, 2017; Marondedze and Schütt, 2019). From last three-decade world has changed tremendously, resulting the same change in every country (Arunyawat and Shrestha, 2016; Akyürek *et al.*, 2018). The impact of changes can be seen in terms of global warming, population growth, ozone depletion, solid waste generation and many other (Aziz and Ahmed, 2017; Al-Maliki *et al.*, 2018; ALDAHWI *et al.*, 2018). This effect is degrading the land quality and disturbing the ecosystem (Akhssas *et al.*, 2020;

Bernard *et al.*, 2020). As a result of ecological mismanagement riverbanks are eroding and to manage it land use land cover monitoring is important (Chen *et al.*, 2013; Corner *et al.*, 2014; Bokaie *et al.*, 2016; Bhat *et al.*, 2017; Chirachawala *et al.*, 2020). To obtain the equilibrium state, the river is vulnerable to flooding and accumulation. Mapping the modified channel location is important for monitoring the probability of erosion and changes in the characteristics of land use/land cover, as well as for identifying the reasons for those changes (Debnath *et al.*, 2017; Liping *et al.*, 2018).

LULC is a vital element in understanding the interrelationship between anthropogenic behaviours and the environment, Managers may assess past decisions using this knowledge, as well as gain insight into the potential impacts of their present decisions before they are introduced (Dawoud *et al.*, 2016; Debnath *et al.*, 2017; Demissie *et al.*, 2017; Díaz-Díaz *et al.*, 2017; Das *et al.*, 2021). Analysis is needed on what changes occur, when and where they occur, the rates at which they occur, and the physical and social factors that drive those changes in order to explain how LULC influences and interacts with environmental processes (Fu and Weng, 2016; El-Tantawi *et al.*, 2019; Fonseka *et al.*, 2019; Ghosh *et al.*, 2019; Foody, 2002). With Continuous development the population is also increasing resulting more demand of agriculture land (Lu *et al.*, 2010; Misra and Kumar, 2020). United Nations Environment Programme (2014) reported in the world 30% of the land is used by agriculture and 10% land is used by cropland cover. In Case of Middle suleh valley, Northern Ethiopia LULC from 1985-2015 shows increase in agricultural land and settlement by 19% and 345.2% respectively (Kaichang *et al.*, 2012; Hishe *et al.*, 2019).

The coverage of ground surface, weather, vegetation, urban, water, rocks, soil or categorizing, outlining and mapping comes under land cover (Islam *et al.*, 2018; Ibrahim and Yunus, 2019; Hussain *et al.*, 2020; Kumar, 2021). It is essential for worldwide monitoring studies, resource organization and forecasting events (Imran Basha *et al.*, 2018; Misra *et al.*, 2020). QuickBird image acquired in 2005 demonstrated extensive urban expansion on the expense of the initial morphologic features in Al-Aziziyah valley. The residential areas and road networks are the major land use features occupying 39% of the entire study area. All urban expansions have occurred either over, across, or instead of the various initial morphologic features (Jelil Niang *et al.*, 2020).

LULC classification can help in different ways but the accuracy assessment is necessary to validate the classified data which is used for calculation of area covered by different classes of classified

satellite images, this assessment is done using Kappa statistics (Kindu *et al.*, 2013; Kaliraj *et al.*, 2017; Magesh and Chandrasekar, 2017). For LULC a hybrid system of classification is proposed which incorporates segmentation of images, study of GIS, and visual representation which provides overall accuracy of 83% (Mas *et al.*, 2017).

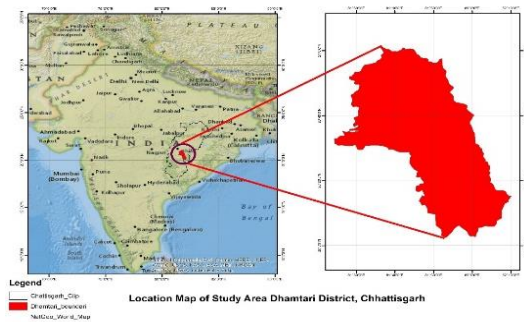


Figure 1. (a) Global location of study area (b) Study Area.

Study area

Dhamtari, it is located at the centre of Chhattisgarh which is known as fertile plains region of Chhattisgarh. The study area is geographically lying between latitude $20^{\circ} 2' 30.1884''$ N to $21^{\circ} 1' 25.1436''$ N and longitude $81^{\circ} 24' 16.8408''$ E to $82^{\circ} 10' 1.9416''$ E covering the total area of 4060.3 sq. km and altitude of 317 meters above mean sea level. As per 2001 census the total population of study area is 703569. The district's rural population is 610001, which is 86.7 % of the total population of district. Forests occupy about 52 percent of the overall geographic area. The main source of safe water is from River Mahanadi and Kharoon which is the principal rivers of study area. Figure 1. The normal average rainfall is 1,300 mm which is received by the district. Dhamtari has a tropical climate condition. The formation of rocks ranging in age from Archaean-Palaeoproterozoic to Cainozoic are exposed. The oldest rocks in the area are represented by Bengpall Group of Archaean age. Younger intrusives of Meso Proterozoic age (2000-1600 m.y.) are exposed in the southeastern part of the district. Intruding gneisses and granitoids include basic dykes of gabbroic, doleritic and basaltic composition. The area is covered in limestone, dark grey, pyritiferous and argillaceous limestone. The district is in Chhattisgarh state in central India. Lenses of intraformational conglomerate are seen in the upper part of the district. There are no economic mineral deposits of any significance.

Materials and Methods

Data source

Landsat 5 Thematic Mapper (TM) imageries of 1999, 2004, 2009 and Landsat 8 OLI/TIRS imageries of 2014 and 2020 with Spatial resolution of 30 m are used. The supervised classification of the Landsat images for different parameters of land use are performed. The imageries are Free from Cloud cover and are downloaded from United State Geological Survey (<http://earthexplorer.usgs.gov>). This Landsat data covers a time period of 21 years. Each data set consist of different bands of images ranges from 1 to 7 depending on different wavelength. The Landsat data used for this study are given in Table 1

Method

The Classification of the Study area is performed using ArcGIS 10.8. The LULC map was made using Five classes agriculture, Forest, barren, Urban, and water bodies. This classes are the important factor on which the land change depends. The particulars of land use land cover used for study is shown in Table 2.

In this study, the classification of Landsat imageries is performed using maximum likelihood method (Hishe *et al.*, 2019). The imageries are classified using supervised classification, as this technique is more accurate than unsupervised classification. The Boundary of Study area is chalk out and digital boundaries are created to use with satellite imageries. The imageries are selected with different band from one to seven (Akyürek *et al.*, 2018). These imageries are then stack together in progressive order and composite image is generated,

Table 1. Details of Landsat Data acquired for study.

Dataset	Path/row	Resolution	Date Acquired	Source
Landsat 5 Thematic Mapper (TM)	142/046	30 m	a)05-12-1999 b)18-12-2004 c)16-12-2009	USGS
Landsat 8 OLI/TIRS	142/046	30 m	a)30-12-2014 b)27-10-2020	USGS

Table 2. LULC classes and their details in the study area.

LULC class	Particulars
Agriculture	Farm land, shrubs, herbs, small plantation, gardens, Dry farm
Forest	Ever green forest, manmade forest, conserve forest
Barren	Desert, bare rock and soil, infertile land
Urban	Settlement, roads, and manmade structures
Water Bodies	Ponds, Lake, River

which is used to recognize diverse classes with ease. The Landsat imageries band combination is explained in Table 3.

These images are then classified using multiple training samples for each class. The final classified image map will be generated with complete area covered with different classes. This final image is used for analysis of result and LULC map is generated. The ArcGIS Software is used for all the geospatial analysis and for calculation of area and its percentage. Excel sheet is used. The classification is used to determine the area covered by different classes in respective years, the changes occurred during different time interval can easily be detected using these classified imageries. The complete methodology is explained using flowchart shown in Figure 2.

Final use of land use land cover map generated will be for analysis of accuracy by user and producer, which will authenticate the work of user while selection of each class and of software which has produced completely classified map. Confusion matrix is used for analysing the accuracy using Kappa coefficient. To achieve more accuracy in change result, land cover classification

should be accurately performed (Mahamud *et al.*, 2019; Mohamed and El-Raey, 2019).

Results and Discussion

Land Use Land Cover

The study area belongs to an agriculturally based region and major parts are covered by forest. The people belong to this region mainly depend on the agriculture, so it becomes essential to keep a keen watch on changes which are affecting the land and if changes are taking place, then what factor is replacing it. In the Present study Author have selected a time period of two decades i.e., year 1999 to 2020 and determined the percentage change occurred during this time. The Landsat imageries of year 1999, 2004, and 2009 are from Landsat 5 TM because latest imageries were not available, for 2014 and 2020 Landsat 8 OLI imageries are collected. Both the imageries are clear, the major difference between these imageries is the quality of captured image. The latest Landsat imageries are much clearer as compared to old.

Land use land cover for 1999 to 2020

The LULC map provides details about the independent changes occurred at each class. Occasionally the changes will be positive or negative. From the classified image of different time interval, the changes occurred are shown in Figure 3. and Table 4.

Table 3. Band combination for Landsat images.

Landsat 5 (Band used)	Landsat 8 (Band used)	Landcover Type
Band 7,4,2	Band 6,5,2	Agriculture
Band 4,5,3	Band 5,4,3	Forest
Band 3,2,1	Band 5,6,4	Barren
Band 4,3,2	Band 7,6,4	Urban
Band 3,2,1	Band 5,6,4	Water

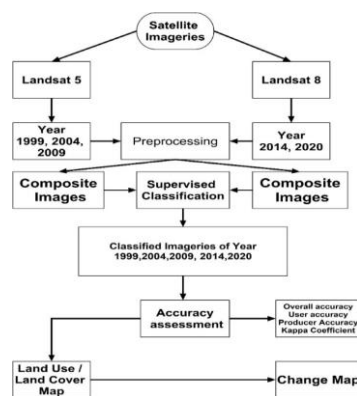


Figure 2. Flow Chart for Methodology.

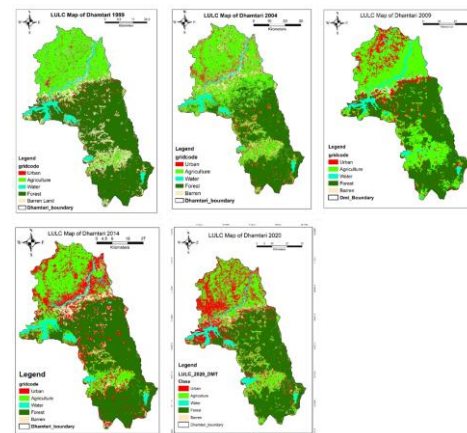


Figure 3. LULC map of dhamtari (1999-2020).

Table 4. Percentage Cover for LULC 1999-2020.

Classes (↓)/Year (→)	1999		2004		2009		2014		2020		Average % change from 1999-2020
	Area (%)	Area (km ²)	Area (%)	Area (km ²)	Area (%)	Area (km ²)	Area (%)	Area (km ²)	Area (%)	Area (km ²)	
Agriculture	19.50	790.4	33.50	1361	19.90	807.5	9.70	394.2	25.60	1037.9	22
Barren land	34	1380.5	8.40	341	27	1097.5	37.70	1530.5	4.80	194.2	22
Forest	38.70	1572.4	34.50	1401.8	37.10	1505.3	35.90	1456	42.60	1728.7	38
Urban	4.70	189.1	20.70	841.7	13.80	561.4	13.50	548.4	23.60	958	15
Water Bodies	3.10	127.9	2.80	114.8	2.20	87.9	3.20	131.2	3.50	141.6	3

Accuracy assessment

LULC map is generated using high resolution satellite imageries, the classification is performed using ArcGIS, But to validate the classified image we need to cross check all the classes. So, to perform validation random 200 points are selected for each year and this location point data is retrieve and compared between ground truth and produced images. This comparison gives the data for overall accuracy, user accuracy, and Producer Accuracy.

With the help of above statistical data the Kappa coefficient value can easily calculated and the maps can be validated. In assessment the confusion matrix is created which is a quantitative method of characterising accuracy of classified Image.

For calculating overall accuracy

$$\frac{\text{Total number of correctly classified Pixel (Diagonal)}}{\text{Total number of Reference Pixels}} \times 100$$

For User accuracy

$$\frac{\text{Number of Correctly Classified Pixels in Each Category}}{\text{Total number of Classified Pixels in that Category (Row total)}} \times 100$$

For Producer's Accuracy

$$\frac{\text{Number of Correctly Classified Pixels in Each Category}}{\text{Total number of Classified Pixels i that Category (Column total)}} \times 100$$

And Kappa coefficient can be calculated as

$$\hat{K} = \frac{M \sum_{i=j=1}^r n_{ij} - \sum_{i=j=1}^r n_i n_j}{M^2 - \sum_{i=j=1}^r n_i n_j}$$

Where:

r=number of rows in error matrix

n_{ij} =number of observations in row i, column j

n_i =total number of observations in row i

n_j =total number of observations in column j

M=total number of observations in matrix

Change map for each five year

Change map expresses purpose of the research by showing the change in each class every year by year, by calculating the change it becomes convenient for others to determine change in every class. This change map helps to keep ecosystem balanced by prohibiting the excess change in any class. So, the change map of study area is made year by year and total change map from 1999 to 2020 is generated to understand the overall change in between two decades.

The change map for different years is shown in Figure 4. respectively. The complete analytical data for change in area in sq. km. is given below tables by which the analysis of area change can be done with ease.

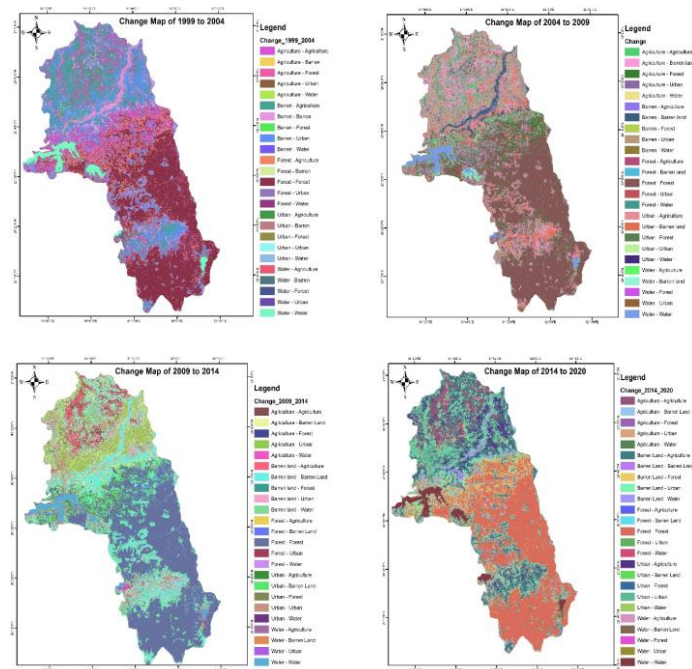


Figure 4. Change map for Different Year (1999-2020).

Discussion

Land use and land Cover (LULC)

Agriculture

The first class based on classification was agriculture land. The study area is agriculture Based area. The maximum people depend on the agriculture production for their bread and butter. For the study time period from 1999 to 2020 Different changes occurs in this area. Some agriculture land is reduced due to urban growth some area of agriculture is increased due to organic production craze. In the year 1999 the agriculture area was 19.50% then in 2004 it was 33.50% the gain of 14% occurs during this five year. Similarly, for the year 2004 to 2009 agriculture area was 19.90% with a loss of -13.60%. In next five year the agriculture area was 9.70% in 2014 but as we see from 2009 to 2014 there was a loss of -10.20% and in the year 2020 total percentage of agriculture land is 25.60% but for last five years there was gain of 15.90% in this class.

Barren land

The second class was barren land, for the period of 1999-2004, 2004-2009, 2009-2014, and 2014-2020, The Percentage area covered is 34%, 8.40%, 27%, 37.70% and 4.80% respectively and gain/loss between different time period -25.60%, 18.60%, 10.70%, and -32.90% respectively. From the loss/gain we came to know that in this class there is a loss in the area.

Forest

Forest land is the major land class covered by the study area. The coverage of land under this class for different time period are 38.70%, 34.50%, 37.10%, 35.90%, and 42.60%. The gain/loss for this area is very minimum as compared to other classes. There was a loss of -4.20% from 1999-2004, gain of 2.60% for 2004-2009, loss of -1.20% for 2009-2014, and gain of 6.70% for 2014-2020.

Urban

The percentage area covered for this class is 4.70%, 20.70%, 13.80%, 13.50%, and 23.60% respectively. Similarly, the gain/loss for urban class for a period 1999-2020 are 16%, -6.90%, -0.30%, and 10.10% respectively.

Water Bodies

The last class for LULC is water Covered Areas, As the study area is agriculture base so the water is important factor considering the area. The water covered area for different time period is (1999) 3.10%, 2.80% (2004), 2.20% (2009), 3.20% (2014), and 3.50% (2020). The gain/loss for each

time interval is -0.30% (1999-2004), -0.60% (2004-2009), 1% (2009-2014), and 0.30% (2014-2020). This class has major gain in the previous time period as observed in LULC Map.

Accuracy assessment

Every LULC classification requires the assessment for the accuracy of classification. This analysis validates the result obtained from classification of satellite imageries. For accuracy assessment the random points are taken in this study 200 random points are chosen by researchers. This ArcGIS software is used to validate this random point with reference to the google imageries. After the Validation the Overall accuracy, Producer Accuracy and user accuracy is determined which is further used to calculate Kappa coefficient as given in Table 5.

Table 5. Accuracy assessment for the year 1999-2020.

year	Overall accuracy	Kappa
1999	98%	0.98
2004	76%	0.79
2009	83%	0.84
2014	89%	0.9
2020	92%	0.93

Change Map

The Final change map is generated using old classified imageries. The total change occurred during the span of 21 years for every five year is determined. This change map helps the user to understand the changes taking place from one class to another and the trend of change can easily evaluate by this change map shown in Figure 5.

Study Findings and Implication

The study determines the changes occurred in the study area for a period of 21 years. The land changes due to urban footprint are determined. This study will help the policy makers to understand the change and to make policies for the research area for future developments based on research.

Conclusion

From the complete Study of Dhamtari LULC map, change map is generated and accuracy assessment is performed. From the LULC map total area covered in each year and total area covered by every single classes are determined. The major area covered is agriculture and forest. The remaining classes shows fluctuation in their areas. The main factor which governs the change in study area is growth of urban area. The study aim was to calculate the change for different time period i.e., 1999-2004, 2004-2009,

2009-2014, and 2014-2020. The changes are the time dependant variable. The changes from one class to other are shown in change map of every time period. Changes occurs from agriculture to forest, forest to urban, barren to water and vice versa.

The final calculation of accuracy of map is done to validate the results from different year map. This validation is important for supporting the result and justifying it. From the result of assessment, the user can know that the results should be accepted or rejected based on the accuracy percentage. Kappa coefficient is also calculated for the above classified Map.

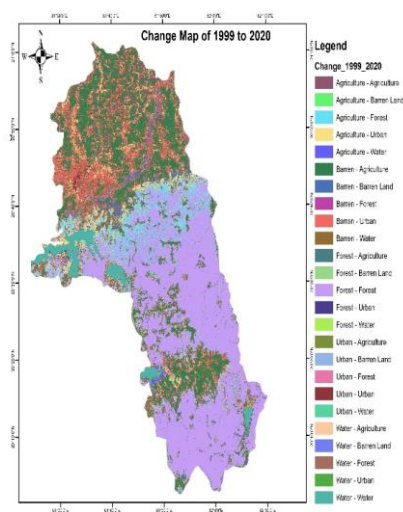


Figure 5. Change Map from 1999-2020.

Limitation of the study

The study focuses on the land change land use pattern. The study doesn't cover the temperature variation and change prediction for future research. The further extension for this research should consist of temperature variation and change modelling for study area.

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