Land Use Land Cover Dynamics in Indore District Using Remote Sensing and GIS

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LAND USE LAND COVER DYNAMICS IN INDORE DISTRICT USING REMOTE SENSING AND GIS

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ABSTRACT: The city/district of Indore is located on the south edge of Malwa plateau in the Madhya Pradesh state of India. The objective of this study is to follow the change in the dynamics of land use and land cover in the Indore District from 1998 to 2019. The study was conducted using the multi-spectral satellite image. It is based on the pixel-based unsupervised classification of Landsat satellite images of the year 1998, 2009, and 2019 using ArcGIS pro. The unsupervised classification of an image using Arcgis pro gives the ability to support image classification without the requirement of the training sample which reduces processing time and cost, but it has low accuracy which can be reduced by reclassification methods supervised by visual comparison of classified images with their false-color composites(FCC) image in different spectral band combinations. The results obtained showed a negative overall variation of the types of occupation of the territory of our study area. Thus, over this period, the study showed an increase in the areas of the urban agglomerations, bare mountain, and crop and/or grassland and water classes by 4.483% to 11.493%, 5.336% to 19.936%, 65.075% to 66.850%, 1.503% to 2.042% respectively, in addition, there is a decrease in the area of vegetation from 8.371% to 2.026% of the overall area. The Anthropogenic activities due to rapid urbanization, industrialization, and migration and population growth contribute substantially to this situation.

KEYWORDS:
Land use land cover dynamics; Remote sensing; unsupervised classification; Indore district; GIS; ArcGIS pro; climate change.

1. INTRODUCTION

Land and water resource degradation are the major problems in the Indian sub-continental region. The increase in the human population intensifies the utilisation of land resource that puts a significant load on the ecosystem and environment. Poor land practices and their management by concerned authorities' results in the loss of productivity, loss of organic rich matters and nitrogen enrichment on the top layers of soils which decrease the overall productivity of the crop in the region. Since the economic reformation in India dynamics of land use has changed significantly, the acceleration of urbanization and industrialization under this process has led to serious ecological destruction [1].

Indore district is one of the major districts of India in terms of population and economy in the central Indian region. It comes under India's tier-2 cities which make it one of the first cities which are going through India's "smart city mission" program. Under these programs major investment would come, expansion of urban agglomeration and transportation has to be done like metro railway and grand townships. But nothing has come without sacrifices due to this development program region is facing massive climate change, degradation of vegetation and water resources. In the past decades' not much researches has been focused in this region and only a few authors have previously highlighted the impact of population growth on the degradation of natural resources. This is why periodic monitoring and quantifying the dynamics of land use in this densely populated area is necessary.

Remote sensing (satellite) is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance from the targeted area using remote sensing satellites. The applications of satellite imagery, coupled with GIS are very diverse. Indeed, several studies have shown the importance of space tools for measuring forest cover changes, to characterize and quantify urban sprawl, to simulate and predict changes in land use [2]. Satellite images are the only available tools that allow, at relatively low cost, and in a short time, to obtain images of a large territory and to follow its evolution over time [3]. The main objective of this study is to evaluate the Spatio-temporal evolution Indore district/city and evaluate the impact of anthropogenic pressures, namely population growth and rapid urbanization in the region [4], using remote sensing technology with the help of unsupervised classification of an image using GIS platforms like ArcGIS PRO.

2. DESCRIPTION OF THE STUDY AREA

Indore district/city (study area) is found in the south edge of Malwa plateau in the Madhya Pradesh state of India. At spatial referenced location of 22.7196° N and 75.8577° E at an altitude of 550 meters above sea level, it covers an area of 3892 km^2. It is located at a distance 872 km from the national capital Delhi and 544 km from the financial capital Mumbai. The study area contains the main Indore city, "11" blocks, and "118" villages. The study area lies on a borderline between a humid subtropical climate and a tropical savanna climate in which three season were observed summer, monsoon, and winter. the study areas have a mean annual rainfall of 1062 mm, and the minimum, maximum, and an average(yearly) temperature of the area are 17.9°C, 46.5°C, and 31.9°C , also having average humidity and sunshine hours are 50%(yearly) and 2885 hours(yearly) [5]. The landscape of the study area mostly contains plane crop or/and grass fields, urban agglomeration, and Rocky/Hilly region at the south with little vegetation.

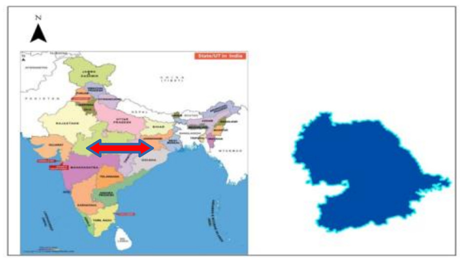

Fig.1. Location and Geometry of study area

3. RESEARCH METHODOLOGY

3.1 Data and software used

The land use land cover multi-band satellite images of the study area were obtained from the website USGS Earth Explorer "https://earthexplorer.usgs.gov/". Data sets are: Landsat 4-5 TM (Thematic Mapper) and Landsat 8 OLI(Operational Land Image) with the cloud cover less than 10%, spatial resolution of 30 m × 30 m, pixel seize 16 bit unassigned, multi-band raster image, acquisition date: 15-03-2019, 15-3-2009, 15-3-1998 with path/row no 147/044 at UTM zone 43N. The satellite images were classified with the help of pixel based unsupervised image classification wizard using ISO cluster in ArcGIS pro. Table no 1 shows the details of the data used.

ArcGIS pro. ArcGIS pro is an GIS software developed by ESRI. It is a very powerful software which can support 2d and 3d scenes for visualisation, editing, and spatial analysis including artificial intelligence. It is better than its old version ArcMap because it is a 64 bit multithread application which can allows it's user to executes multiple tools, multiple maps and tables at the same time which increase the productivity of the workflow.

Table.1. details of data used.

Year	No of images used (mosaic)	Acquisition date	Spatial resolution in meter square	No of band
1998	2	15/12/1999	30x30	6 bands
2009	1	10/11/2009	30x30	6 bands
2019	2	10/11/2019	30x30	6 bands

3.2. Method used for classification of satellite image using ArcGIS pro:

Image classification is the process of extracting information classes, such as land cover categories, from multiband remote sensing imagery. The workflow involves multiple steps to progress from pre-processing to segmentation, training sample selection, and training, classifying, and assessing accuracy. Each step may be iterative, and the process requires in-depth knowledge of the input imagery, classification schema, classification methods, expected results, and acceptable accuracy. The method used in this study for classification of image is unsupervised classification in which the outcome of the classification is determined without training samples. Pixels or segments are statistically assigned to a class based on the ISO Cluster classifier [5]. Pixels are grouped into classes based on spectral and spatial characteristics. Analyst provides the number of classes to compute, and the individual classes are identified and merged once the classification is complete. This process is basically the reverse process of supervised classification. There are further two methods for the classification of image available in unsupervised manner. In which method used is pixel based classification. In which classification is performed on a per-pixel basis, where the spectral characteristics of the individual pixel determines the class to which it is assigned. Characteristics of neighbouring pixels are not considered in the pixel-based approach. This is considered the more traditional classification method, and can result in a salt-and-pepper effect in the classified image.

3.3 methods involving Extraction of spatial data using ArcGIS pro.

3.3.1 Mosaic Raster Dataset: Mosaicking is very useful when two or more adjacent raster datasets need to be merged into one entity [6]. Multispectral satellite images of neighbourhood areas were mosaic to cover the full extent of the study area. This is carried out by using a "mosaic to new raster" tool which is made available in the "data management" toolbox in ArcGIS pro. This will requires following steps in which, first Add all the raster dataset that has to merge and then fill all the empty fields using raster properties and source properties.

NOTE: Mosaic datasets consist of three layers: boundary, footprint, and image

Illustration no 1. Image shown in fig 2(a) and fig 2(b) are input raster dataset of 2019 dataset where image shown in fig 3 is output image in which full extent of study_area_2019 is contain.

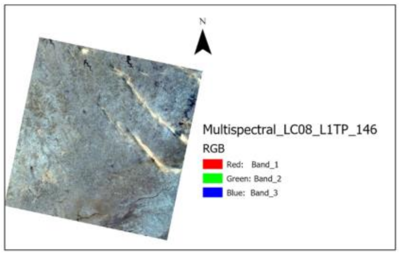

Fig.2 (A). Input Satellite image of Study Area_2019 (part 1)

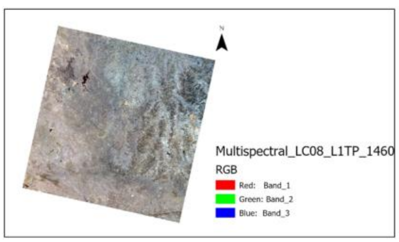

Fig.2(B).MOSAICKED of STUDY_AREA_2019 (part 2)

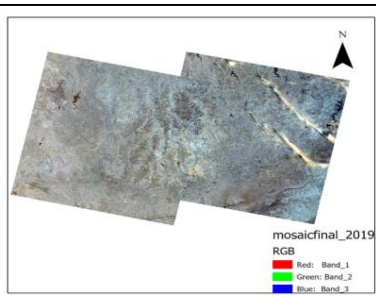

Fig.3.MOSAICKED IMAGE OF STUDY_AREA_2019

3.3.2 Clip Raster Dataset: Clipping is used to cut out a portion of the required raster dataset from an existing mosaic raster data set [7]. This is carried out by using the "clip" tool which is made available in the raster processing data management toolbox in ArcGIS pro. This tool allows the extraction of a portion of the raster dataset based on a template extent (polygon). The clip output image includes any pixels that intersect the template extent (polygon) [8]. This will requires following steps in which, first Input the Mosaicked Raster Dataset that contains Study Area then Input polygon feature (vector dataset) that will define template extent. Geometry of this input feature will we used for clipping.

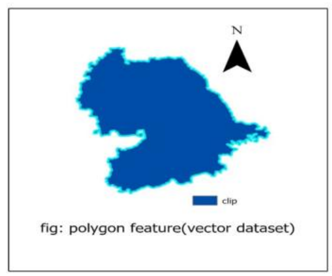

Fig.4 (A). Template extent of Study Area

Illustration no 2. Image shown in fig 3 is input mosaicked_raster_dataset_2019 and image shown in fig 4(A) is input polygon feature where fig 4(B) is final clipped image of 2019 dataset in which only study_area_2019 is contains.

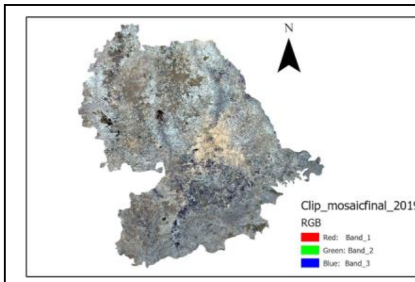

Fig.4 (B). Clipped Raster dataset (study_area_2019)

3.3.3 Unsupervised classification of image using image classification wizard:

Unsupervised pixel-based classification of image is the fastest way of image classification though it is less accurate than supervised classification but this could be minimised by reclassify the image which can clean up the errors. This is carried out by using the image classification wizard in ArcGIS pro. This process will requires following inputs such that method (supervised or unsupervised) and type (pixel based or object based) of classification, classification schema (A classification schema determines the no and the types of classes used for classification, Referenced dataset, Number classes in which raster dataset has to classified, Max no of Iteration, max no of cluster merge per iteration, Max merge distance, Max sample per cluster, and skip factor.

NOTE: UNSUPERVISED CLASSIFICATION USES ISO CLUSTER WHICH DETERMINES THE CHARACTERISTICS OF THE NATURAL GROUPING OF THE CELLS IN MULTIDIMENSIONAL ATTRIBUTE SPACE [11].

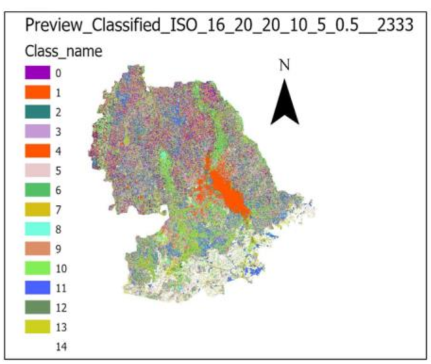

Fig.5. Classified image of study_area_2019

Illustration no 3. The classification is carried out by using pixel based unsupervised classification in which default schema (NLCD2011) is used, 15 classes were used to classify the referenced raster dataset_2019 shown in fig 4(b), Rest all the other fields were taken as default according to ISO clustering. Click on run button to get classified image of study_area_2019 shown in fig 5.

3.3.4 Reclassification of raster by visually comparing the classes with their False Color Composites (FCC) satellite image

In this process the classified raster dataset is reclassify with the help of visual comparison of classified image with their FCC image in different bands combinations which decides that which class goes to which group and the similar classes were merge together, This is carried out by using "reclassify" tool which is made available in data management toolbox. This process will requires following inputs such that the classified Raster Dataset that contains Study Area, Reclassified field (reclassified field denotes the field which is going to reclassified). Further fill the remap table to reclassify the classes working with table following parameters will we considered.

A. The table will display the class value all of them are unique integer values.

B. In Reclassification process the class_name with same integer value will be merged together. To modify table type empty cell in the table and press enter this will validate the table for new entries create a new empty row for subsequent input [9]. In which class_name with same integer value will be merge together. Further in the attribute table the merged classes will be named as water, vegetation, urban agglomerations, crop or/and grass\land, bare mountain etc according to the observation.

Illustration no 4. TO carry out reclassification process first input classified raster dataset_2019 shown in fig 5 in which class_name with same integer value will merge together, in addition following visual observation will be taken to categories classes:

A. Land use Analysis: ON comparing classified image of study_area_2019 with FCC(red = near IR, green=red, blue=blue) image of study_area_2019 shown in fug 6(A), clearly showing that class_name 04 would be urban agglomerations, class_name 14 will be mountainous region with light vegetation, class_name 10 and 06 will be vegetation. Also after deep observation it was found that class_name 11, 1,7,5,3 is crop land.

B Water analysis: On comparing classified image study_area_2019 in fig 5 with FCC(Red=Shortwaveinfrared_2, Green=Shortwaveinfrared_1, Blue=Nearinfrared) image of study_area_2019 shown in fig 6(B), clearly shows that class_name 08 would be water bodies.

After completely filling the remap table press run button to get reclassify raster dataset, further in the attribute table the merged classes will be named as water, vegetation, urban structures, crop land, mountain/unused land, and rock according to the observation output reclassify final image of study_area_2019 shown in fig 7.

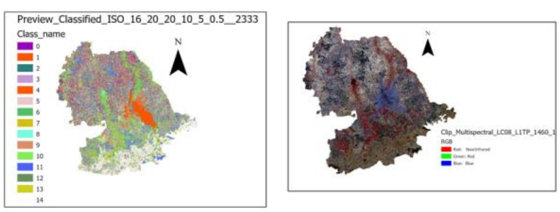

Fig 6(A): FCC image of study_area_2019 compatible for land use analysis

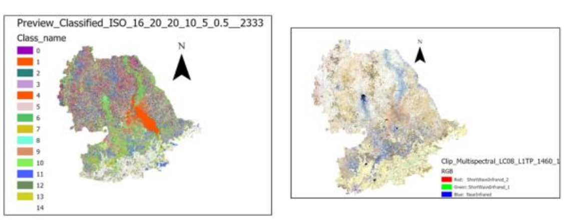

Fig.6(B). FCC image of study_area_2019 compatible for water analysis

3.3.5 Calculate fields in Attribute table using arithmetic operations in python

Attribute tables is made up of rows and columns, and all rows have the same columns. Rows are

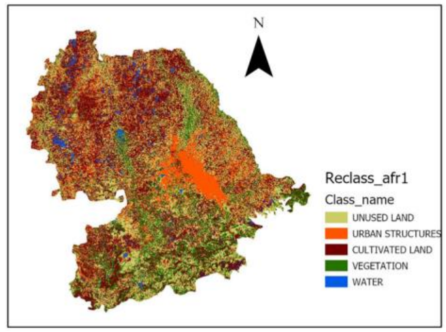

Fig.7. Reclassified final image of study_area_2019

commonly known as records, and columns are fields . Each field can store a specific type of data, such as a number, date, or piece of text . The information displayed in a table comes directly from the attribute information stored with in the geographic data [10]. This table is automatic generated by software but some arithmetic operation were required to calculate fields like total no of pixels, area covered by feature, percentage coverage by feature, This can be done by calculate field tool which uses python 3 to perform calculation, which is made available in data management toolbox.

4. RESULT AND DISCUSSION

4.1 RESULT:

4.1.1 Mapping of the land use of the city/district of Indore from 1998 to 2019

From 1998 to 2019, five classes of land use were identified. This is the vegetation class, crop and/or grassy area, urban aggregation, mountainous region without vegetation and water class. Indeed, in 1998, the vegetation class had an area of 8.37%, 5.33% for the mountainous region without vegetation, 65.07% for crops/grassland, 4.48% for the urban agglomerations and 1.50% for water. In 2009, the class size of vegetation class, mountainous region without vegetation, crop/grassland, urban agglomerations and water changed to 7.54%, 10.468%, 70.05%, 5.23% and 1.65%. At this level, there is increase in the proportion of the area of thematic classes except that of the vegetation class. In 2019, this same observation is made. The proportion of the area of the other types of occupation is increasing while that of the vegetation category has decreased and is estimated at 2.02%. The graphs in **Figure 8(a)-(c)** show the evolution of the land use classes between 1998 and 2019. They show the different changes that took place during these years in the region.

4.1.2 Dynamics of land use between 1998 and 2009

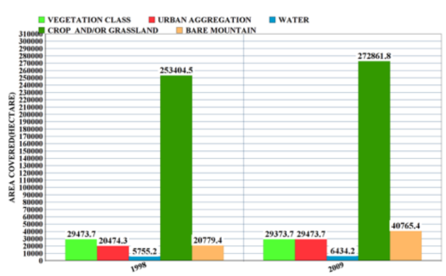

Fig.8(A). Land Cover from 1998 TO 2009

The observation of the graph in Figure 8(a) indicates a general incline in the area occupation classes except the vegetation class. Indeed, the class size of mountainous region without vegetation, crop/or grassland, urban agglomerations, vegetation class and water has increased from 20779.4 ha, 253404.5 ha, 20474.3 ha, 32695.6 ha and 5755.2 ha in 1998 to 40765.4 ha, 272861.8 ha, 29373.7 ha, 29373.7 ha and 6434.2 ha in 2009. At this level, the types of land use that have undergone more regression are the vegetation class and the urban aggregation class. The increase in the urban aggregation class and mountainous region without vegetation class, which is estimated at 20779.4 ha, 32695.4 ha in 1998 against 294793.7 ha, 40765.4 ha in 2000, was followed by a decrease in the area of the vegetation class.

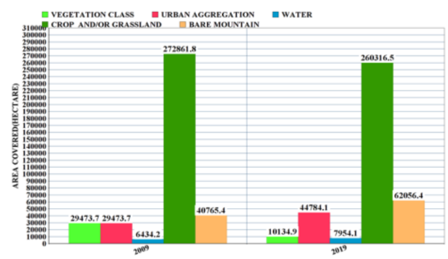

Fig.8(B). Land Cover from 2009 TO 2019

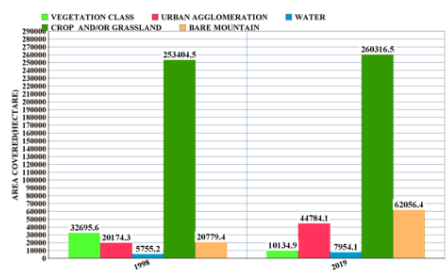

Fig.8(C). Land Cover from 1998 TO 2019

4.1.3 Dynamics of land use between 2009 and 2019:

Figure 8(b) shows that the evolutionary trend is always the same as previous periods. There is a slight decrease in the area of crop and/or grassland which goes from 272867.3 ha in 2009 to 260316.5 ha in 2019. The area of other types of land use that has inclined is 29424.3 ha, 40765.4 ha, 6434.2 ha in 2009 against 44784.1 ha, 62056.4 ha, 6954.1 ha respectively for the urban agglomerations, mountainous region without without vegetation, and water classes. This increase is still due to the decrease in the vegetation category, which decreased from from 29373.3 hectare in 2009 to 10139.4 hectare in 2019.

4.1.4 Overall change in land cover types between 1998 and 2019:

Figure 8(a) shows

the changes made between the different land cover classes between 1998 and 2019 in Indore district/city. From 1998 to 2019 the area of vegetation has increased from 20424.3 ha to 44784.1 ha, the degraded vegetation has gone from 32695.6 ha to 10134.9 ha, the area of cultivation and/or grassland has increased from 253404.3 ha to 260316.5 ha and the water class has increased from 5755.2 ha to 6954.1 ha. However, there is a significant increase in urban agglomerations class from 20424.3 ha in 1998 to 44784.1 ha in 2019. Table 1 summarizes the different transformations of the units of land use calculated in each of the five classes along with GDP and population growth between 1998 and 2019..

4.2 DISCUSSION

The method used for the production of land cover land use maps was based on pixel-based unsupervised classification using the ISO cluster. The unsupervised classification uses unsupervised machine learning with the help of different algorithms which allows it to classify image without the need of any training sample, so this method is very useful while handling larger and unstructured dataset in which processing time and cost should be low. There are further two methods are available for image classification in an unsupervised manner pixel-based and object-based. There are two methods are available for image classification in an unsupervised manner pixel base and object-based. The object-based classification is performed based on color and shape characteristics where neighbouring pixel was grouped by the process called segmentation. The result from this process more closely resembles the real world features but it becomes less accurate when classification is done over the large scale area where natural as well as man-made features were present in a complex manner, here comes the pixel-based classification where the classification is performed on the bases on digital number of involving pixels and also characteristics of neighbouring pixels are not considered during classification which allows more complex and disorganized image to be classified more accurately. The use of 5 land cover classes was sufficient to implement a landscape mapping analysis [11]. These different maps were used to follow the spatio-temporal evolution of the study area. Classification is performed on a per-pixel basis, where the Characteristics of neighbouring pixels are not considered in the pixel-based approach, so it is very important to determine and input the proper number of classes in which the Raster Dataset (study area) has to classify because ArcGIS pro uses the very typical algorithm to perform pixel-based unsupervised classification [12]. Where if the number of input class is less, then in some cases pixels which belong to one class could be merged into other class, for example, dense-forest and light vegetation could be merged into same class, as a result, it's become very difficult to differentiate them and if number of input class is excessive then one class could be broken into many classes, as a result, it's become very difficult to reclassify the classes because some of the classes were overlapped with other class/category of land cover. The classification is done by using initially 15 classes and then further reclassify them into 5 classes which gives a satisfactory result.

Table.2. Details of occupation of different land classes

	Percentage occupation		
Type of occupation	1998	2009	2010
Vegetarian	8.37	7.54	2.02
Urban agglomeration	4.48	5.23	11.49
Crop	65.07	70.05	65.80
Water bodies	1.50	1.65	2.04
Bare mountain	5.33	10 47	19.93

5. CONCLUSION

Unsupervised classification of Landsat data from satellite imagery have yielded satisfactory and very quick results, and achieved the objectives of the study. Thus, the analysis of multi-spectral Landsat images from 1998 to 2019 made it possible to follow the spatio-temporal evolution of the land use land cover of our study area . The different land cover maps made on the basis of Landsat images (using ETM+and OLI dataset) between 1998 and 2019, showed an increase in the areas of the urban agglomerations, bare mountain, crop and/or grassland and water classes, respectively, 4.48% to 11.49%, 5.33% to 19.93%, 65.07% to 66.80%, 1.50% to 2.04%. In addition, there is a decrease in the area of vegetation from 8.37% to 2.02%. It emerges from this study that anthropogenic pressures, namely population growth and rapid urbanization, mainly explain the increment and the degradation of the mountain vegetation cover and ground vegetation cover. While rapid urbanization, population growth, and lack of employment in rural area encourage massive population migration towards cities and metropolitan regions, as a result, the area covered by urban agglomerations increased especially in the last decades and this increased population need water which may be apply pressure on authorities to increase the capacity of reservoirs, as a result, the area covered by water bodies increased. Table no 2 details of occupation of different land classes.

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