Construction of Spatial Dataset from Remote Sensing using GIS for Deforestation Study

K.R.Manjula
Associate Professor,
Dept. of MCA,
SIET, Puttur

Dr. S. Jyothi
Head (i/c),
Dept. of CSE & IT,
SPMVV, Tirupati,

S. Anand Kumar Varma
Associate Professor,
Dept. of Civil Engineering,
SIET, Puttur,

Dr.S.Vijaya Kumar Varma
Professor,
Dept. of Mathematics,
SVU, Tirupthi

ABSTRACT
The major challenges we face in the world today are overpopulation, pollution, deforestation and natural disasters. They have a critical geographic dimension and geographical component. Geographical Decision Support System is a demanding field, since enormous amount of spatial data have been collected in various applications ranging from Remote Sensing to GIS, Computer Cartography, Environmental Assessment and Planning. GIS will give the power to create maps, integrate information, visualize scenarios, solve complicated problems, present powerful ideas, and develop effective solutions. With GIS application one can open digital maps on computer, create new spatial information to add to a map, create printed maps customized to their needs and perform spatial analysis. Spatial database management systems aim to make spatial data management easier and more natural to prepare map for the users or applications such as urban planning, utilities, transportation, and remote sensing. The main aim of this paper is to prepare the digital data for the study of deforestation. This paper focuses on the data collection from various sources like NRSC, Survey of India, GLCF and NATMO etc., and prepares attribute spatial dataset for deforestation study in the study area.

General Terms
Remote Sensing, GIS and Spatial Data.

Keywords
Remote Sensing, Geographic Information System, Satellite Image, Feature Class selection.

1. INTRODUCTION
Data acquisition and storage technology progress has led to a huge amount of data stored in repositories, which grow faster. Among increasing and relevant data acquired and processed, there is a strategic segment such as satellite images, also known as Remote sensing images. The search for less expensive and more efficient ways to observe earth motivated man in developing Remote Sensing satellites [8]. The variety of spatial and spectral resolutions for a Remote Sensing images range from IKONOS 1-meter panchromatic images to the next generation of polar-metric radar imagery satellites [6]. There is a need for understanding relevant data and use it effectively and efficiently in earth analysis [8]. Although valuable information is contained in image repositories, the volume and complexity of this data makes difficult for human being to extract strategic information (knowledge) without appropriate tools [9] [8]. A vast Remote Sensing database is a collection of landscape snapshots, which supplies a single opportunity to understand how, when and where changes occurred in the world [9] [8]. According to Canada Centre for Remote Sensing (2003), Remote Sensing is the science and art of acquiring information about the Earth surface without actually being in contact with it. Remote Sensing is a field of applied sciences for information acquisition of the Earth surface through devices called Remote Sensors, which are boarded on Remote Sensing aircrafts or satellites—also called Earth observation satellites [2].

In the image acquisition process, four concepts are fundamental: spatial, spectral, radiometric and temporal resolution [4]. The spatial resolution defines the detail level of an image. The spectral resolution determines the sensor capability to define short intervals of wavelength [2]. The radiometric resolution of an imaging system describes its ability to discriminate very slight differences in energy [10]. The temporal resolution determines the necessary time for the sensor revisit a specific target and image the exact same area (Canada Centre for Remote Sensing, 2003, [10]). The huge volume of the datasets needs an efficient hardware and software infrastructure. However, still a limited capacity is available for extracting information from large remote sensing image databases. This situation has lead to a "knowledge gap" in the process of deriving information from images and digital maps (MacDonald, 2002). There are number of studies that shown the overlapping of various map to obtain the required information. The main aim of this paper is to depict the data construction and preparation process of the forest resource data in the study area.

1.1 Geography
Andhra Pradesh is the fifth largest state in India and most populous state in the south India. The state is dotted with hill ranges from the north to the south, running erratically down the middle of the country dividing it into western and eastern or coastal Andhra. In the north, there are Simhachalam and Annavaram hills, in the middle country there are the Srisailam hill ranges and in the south are the Tirumala -Tirupati hills. About 73 percent of the State's populations live in rural areas and they largely depend on agriculture for their sustenance. Agriculture is the recognized basis of the economy (Source: Principal Chief Conservator of Forest, Government of Andhra Pradesh, Hyderabad)

1.2 Land Utilization
The total geographical area of the State is 274.40 lakh hectares at the end of 1997-98. The State uses 54.4 percent of the land

within the geographical limits for cultivation. Net area sown formed 36.1 percent of the total geographical area, 22.6 percent of the total area is under forests. The details are depicted in the following table1:

Table1. Land utilization of AP
(Source: Principal Chief Conservator of Forest, Government of Andhra Pradesh, Hyderabad)

(In lakh Hectares)					
S.No.	**ITEM**	**YEAR**			
		1994-95	**1995-96**	**1996-97**	**1997-98**
1	Total Geographical Area	274.40	274.40	274.40	274.40
2	Forest	62.46	61.49	62.45	61.99
3	Barren and Uncultivable Waste	20.69	21.46	20.83	21.09
4	Land put to non Agricultural use	25.01	24.34	24.72	24.96
5	Cultivable Waste	7.79	7.84	7.22	7.52
6	Permanent Pastures and Other Grazing Lands	7.62	7.47	7.63	6.93
7	Land under Misc. Tree Crops and Groves not included in Net Area Sown	2.47	2.36	2.47	2.46
8	Other Fallow lands	17.45	16.95	15.47	16.20
9	Current Fallow lands	27.26	25.38	24.43	33.92
10	Net Area Sown	103.65	107.11	109.18	99.33

1.3 Forestry

Even today, Forests play an important role in moderating the climate, maintaining the soil mantle, improving soil fertility, purifying the air and in regulating the flow of water in rivers and streams. Andhra Pradesh has 63,814 Sq. Kms. of Forest area constituting 23.2 percent of the total geographical area of the State. Out of the total forest area of 63,814 Sq. Kms. Reserved Forest area accounted for 50,478 Sq. Kms., Protected forest forms 12,365 Sq. Kms. and the rest 971 Sq.kms are unclassified. The distribution of forest is specified in the following table2:

Table2. Region Wise Forest Area - 1997-98
(Source: Principal Chief Conservator of Forest, Government of Andhra Pradesh, Hyderabad)

S.No.	**Region**	**Land Area**	**Forest Area**	**% of Forest Area Region wise**	**% of Forest Area to land Area**
1	Coastal Andhra	92906	19563.25	30.66	21.06
2	Rayalseema	67299	15008.40	23.52	22.30
3	Telangana	114863	29242.08	45.82	25.46
	Total	275068	63813.73	100.00	23.20

2. STUDY AREA

The setting of this study spans an area of 5000 Square Kilometers and it includes the mandals of chittoor such as Thirupathi, Kalahasthi, Yerpedu, Renigunta and major portion of Kadapa Mandals such as Nandalur, Rajampet, Pullampet, Obulavari Palli, Kodur, and Nellore District mandals such as Venkatagiri, Rapur, Kaluya and Takkili. The study area boundary in lat-long is in Lower-left corner 78 deg 45 min Longitude and 13 deg 35 min Latitude. And The Upper right corner 79 deg 39 min Longitude and 14 degrees 33 min Latitude. I.e. E 79 39" to E 78 45" and N 13 35" to N 14 33". The total geographical area of the *Cuddapa* District is 15,379 sq. Kms. with 3 Revenue Divisions and 51 Mandals. Chittoor district is situated between 12-37" to 14-8" of Northern latitude and 78 –33" to 79-55" of Eastern longitude. The district is divided into three revenue divisions and 66 mandals covering 1540 Revenue villages. The total area of Chittoor is 15,152sq.kms. Nellore District, lies between 13-30' and 15-6' of the Northern latitude and 70-5' and 80-15' of the Eastern Longitude and extending over an area of 13076 Sq.Kms. Administratively the District is divided into 46 Mandals, covering three Revenue Divisions. The study area district outline is specified in the Figure 1:

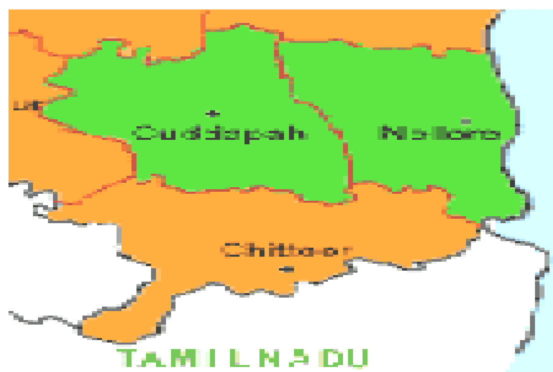


Figure 1: Map showing the District Outline containing the study area

3. AIM and OBJECTIVE

The main objectives of the study are:

1. Generation of digital dataset based on standard codification and integration with base details and to generate seamless data at Village/Mandal/Region/District levels with forest information [11].

2. Generation of report, tables and maps for the study area.

3. Report the areas with appropriate scale maps and assessment of deforestation factors report on causative.

The objective is achieved through

1. Scanning of Toposheets, Forest maps and other reference Maps.
2. Geo-referencing.
3. GIS database creation [14] [9].
    a. Natural features
    b. Transportation

   c. Mining areas
   d. Forests
   e. Other base map features
4. Attribute data linking.
5. Geometry validation and GIS creation.
6. Preparation of digital maps for the study area
7. Create forest cover map from the satellite imagery using supervised or unsupervised classification.
8. Deliverables
   a. Display of GIS data in digital format
   b. Map of the study area

4. METHODOLOGY

Spatial information on Land use / Land cover is a necessary prerequisite in planning, utilizing and management of the natural resources [12]. Recognizing the need for sustainable utilization of the natural resources, mapping of Land use / Land cover has been envisaged under the Natural Resources (NR) Census Program launched by the Department of Space, Government of India as a part of National Resource Repository (NRR). The study area is based on the secondary data, the satellite imagery which is downloaded from the Global Land cover Mapping web site and National Remote Sensing Agency and Survey of India [1].

4.1 Data products used

Satellite Data: IRS P6 LISS III 24m data of 2010 of the study area is the primary data.

Collateral Data: Survey of India topographical sheets on 1:50,000 scale, legacy data on 1:250,000, land use / land cover (AWiFs), Landsat ETM+ map of 1991 and satellite image of 2001 and 2010 data have been used as reference data[13] [11]. The details of maps are given in the Table 3:

Table3. Various Inputs used in the study

S.No	Type of Map	Resolution / Scale	Year	Source
1.	Topsheet	1:50,000	57 O/5 – 1973-79	SOI
		1:50,000	57 J/11 – 1973	SOI
		1:50,000	57 O/6 – 1973	SOI
		1:50,000	57 N/9 – 1973	SOI
2.	Landsat -7 ETM	28.5 mt	1990&2001	GLCF
3.	LISS3	Medium 250,000	05th April, 2001	NRSC
4.	P6.LISS 3 101 – 63	Medium 250,000	6th Feb, 2010	NRSC
5.	National atlas of India	-	Thematic Maps	NATMO
6.	Region and Mandal Maps	A3 Size	-	Mandal HQ

The source map samples are given in Figure 2 Figure 3 and Figure 4:

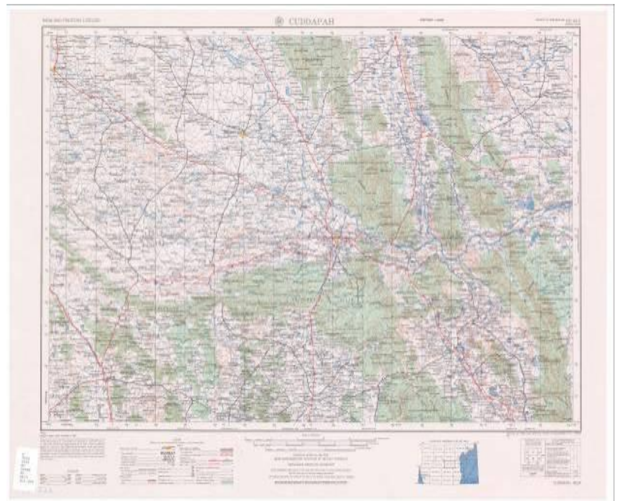


Figure2: Topography and forest area of study area is shown in the map

Figure3: Map showing the Path Row boundary of the study area

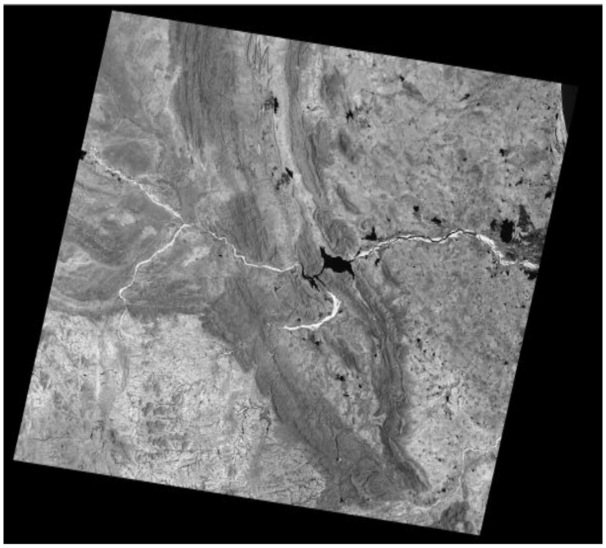


Figure4: Map showing the scene of the study area

4.2 Image classification

Preliminary interpretation of land use / land cover polygons from the satellite data sets has been carried out based on image parameters viz. tone, texture, pattern, size, shape and contextual association by using hybrid method-onscreen digitization in GIS environment combined with digital analysis[2][4][7]. Normalized Difference Vegetation Index [3] has been generated and used for forest area classification into dense/open/scrub forests [12]. Final interpretation of land use / land cover has been carried out by incorporating the ground truth [13] [11]. Neighborhood filling has been used to clean and fill the missing cell in the image while doing image classification. Edge matching of the features has been carried out to maintain the continuity of classes between adjoining sheets/districts/states. Generation of seamless geodataset at district/state level, creation of metadata, class wise area statistics are prepared [13].

We have done image classification to identify the changes in study area. Generally, Image classification refers to the task of extracting information classes from a multiband raster image [15]. The resulting raster from image classification can be used to create thematic maps. Depending on the interaction between the analyst and the computer during classification, there are two types of classification: supervised and unsupervised. The ISO Cluster Unsupervised Classification tool automatically finds the clusters in an image and outputs a classified image. The ISO Cluster Unsupervised Classification tool outputs a signature file and a classified image [7]. The output classified raster will be automatically added to Arc Map when the tool finishes. The ISO Cluster Unsupervised Classification tool optionally outputs a signature file. You can use this signature file as input to the Maximum Likelihood Classification tool to classify the input image [7]. From that classified image, we have interpreted the spatial features and their areal coverage. The feature have found out by converting them in to the geodatabase feature classes after the boundary clean process. We did the same for all the satellite bands of different decades. The intermediate and final results are derived further. The base map for the study area is shown in Figure 5:

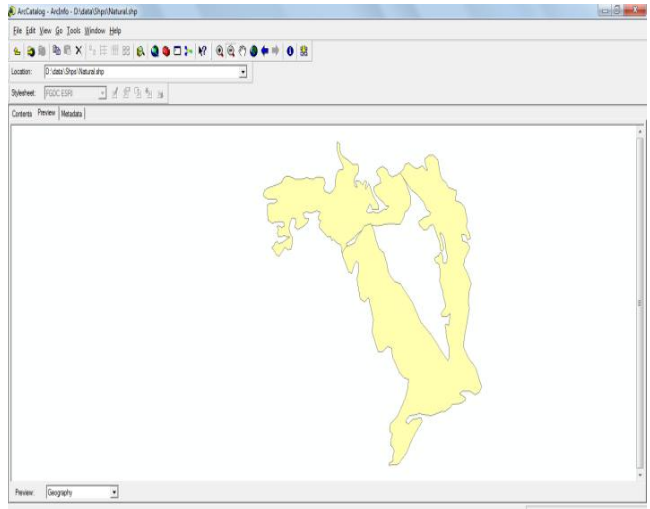


Figure 5: Outline map/Base Map of study Area

Horizontal coordinate system
Projected coordinate system n0ame:
WGS_1984_UTM_Zone_44N
Geographic coordinate system name: GCS_WGS_1984
Details
Bounding coordinates
Horizontal In decimal degrees
West: 78.743387
East: 79.657207
North: 14.559677
South: 13.599135
In projected or local coordinates
Left: 256845.000000
Right: 354735.000000
Top: 1610055.000000
Bottom: 1504515.000000
Spatial data description - Raster dataset information
Raster format: TIFF
SDTS raster type: Pixel
Number of raster bands: 1

The Classified image of the Year 1991, 2001 shown in Fiugure 6 and Figure 7 and the classifed raster properties cell information is given in table 4 and feature class information presented in table 5, table 6 and the final difference is depicted in the table 7.

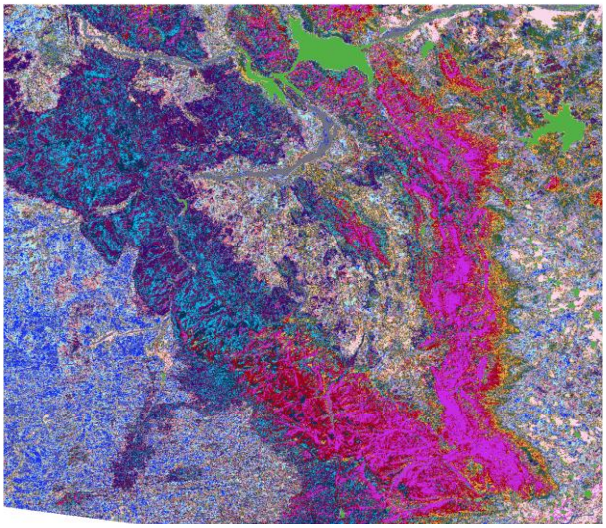


Figure 6: Classified map of 1991 for forest in the study area

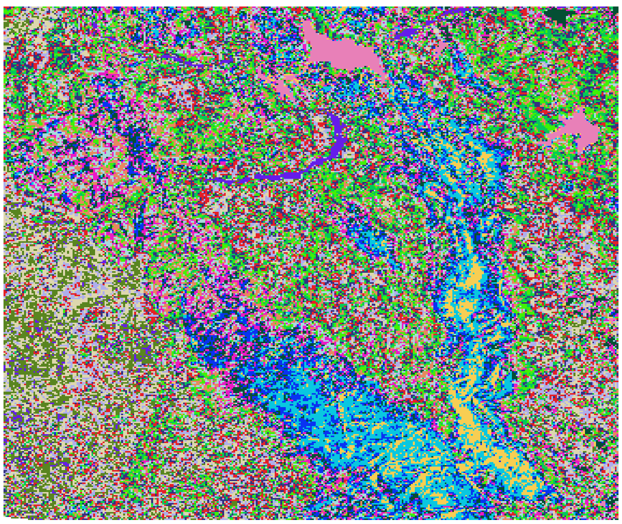
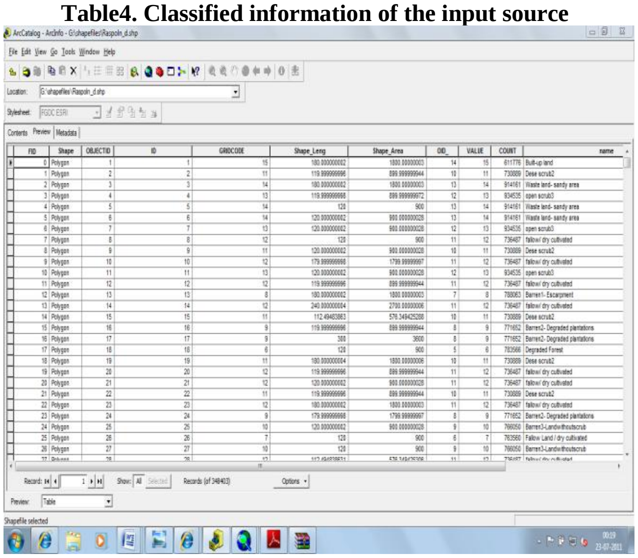


Figure 7: Classified map of 2001 for forest in the study area

Raster properties - Cell information

Table4. Classified information of the input source



ArcCatalog - ArcInfo - G:\shapefiles\Raspoln_d.shp

File Edit View Go Tools Window Help

Location: G:\shapefiles\Raspoln_d.shp

Stylesheet: FGDC ESRI

Contents Preview Metadata

FID	Shape	OBJECTID	ID	GRIDCODE	Shape_Leng	Shape_Area	OID_	VALUE	COUNT	name
0	Polygon	1	1	15	180.000000002	1800.00000003	14	15	611776	Built-up land
1	Polygon	2	2	11	119.99999996	899.99999944	10	11	730889	Dese scrub2
2	Polygon	3	3	14	180.000000002	1800.00000003	13	14	914161	Waste land- sandy area
3	Polygon	4	4	13	119.99999998	899.99999972	12	13	934535	open scrub3
4	Polygon	5	5	14	120	900	13	14	914161	Waste land- sandy area
5	Polygon	6	6	14	120.000000002	900.000000028	13	14	914161	Waste land- sandy area
6	Polygon	7	7	13	120.000000002	900.000000028	12	13	934535	open scrub3
7	Polygon	8	8	12	120	900	11	12	736487	fallow/ dry cultivated
8	Polygon	9	9	11	120.000000002	900.000000028	10	11	730889	Dese scrub2
9	Polygon	10	10	12	179.99999998	1799.9999997	11	12	736487	fallow/ dry cultivated
10	Polygon	11	11	13	120.000000002	900.000000028	12	13	934535	open scrub3
11	Polygon	12	12	12	119.99999996	899.99999944	11	12	736487	fallow/ dry cultivated
12	Polygon	13	13	8	180.000000002	1800.00000003	7	8	788063	Barren1- Escarpment
13	Polygon	14	14	12	240.000000004	2700.00000006	11	12	736487	fallow/ dry cultivated
14	Polygon	15	15	11	112.49483863	576.349425288	10	11	730889	Dese scrub2
15	Polygon	16	16	9	119.99999996	899.99999944	8	9	771652	Barren2- Degraded plantations
16	Polygon	17	17	9	300	3600	8	9	771652	Barren2- Degraded plantations
17	Polygon	18	18	6	120	900	5	6	783566	Degraded Forest
18	Polygon	19	19	11	180.000000004	1800.00000006	10	11	730889	Dese scrub2
19	Polygon	20	20	12	119.99999996	899.99999944	11	12	736487	fallow/ dry cultivated
20	Polygon	21	21	12	120.000000002	900.000000028	11	12	736487	fallow/ dry cultivated
21	Polygon	22	22	11	119.99999996	899.99999944	10	11	730889	Dese scrub2
22	Polygon	23	23	12	180.000000002	1800.00000003	11	12	736487	fallow/ dry cultivated
23	Polygon	24	24	9	179.99999998	1799.9999997	8	9	771652	Barren2- Degraded plantations
24	Polygon	25	25	10	120.000000002	900.000000028	9	10	766050	Barren3-Landwithoutscrub
25	Polygon	26	26	7	120	900	6	7	783560	Fallow Land / dry cultivated
26	Polygon	27	27	10	120	900	9	10	766050	Barren3-Landwithoutscrub

Record: 1 Show: All Selected Records (of 348403) Options

Preview: Table

Shapefile selected

Table5. Aggregated different feature class in the classified image of 1991

GRID CODE	CntGRID CODE	LU/LC classes	Total Area_Sqm
1	435	Waterbody	139133427.72038
2	6466	Dense forest	364497187.01540
3	27081	Fallow land	114238253.85840
4	38872	Open forest	708801160.53930
5	8578	Dense scrub	841660961.49500
6	55296	Agri-cultivated land	240045300.06690
7	77136	Dense scrub	585912112.76580
8	45168	Open scrub	624255010.53040
9	124983	Landwithscrub\ mine\urban mixed	289711256.18160
10	154766	Degraded forest	746961346.32100
11	89232	Degraded plantations	357364881.18190
12	167154	(foot hill) barren	685094391.71190
13	163397	Land with scrub	482101334.51070
14	124901	Land without scrub	382197752.14770
15	67461	Land with scrub	755384201.99000
16	20621	Land with scrub	597655259.44470
17	20	Land with scrub	648290190.19810
18	20621	Sandy Area	611994501.72700
19	124901	Land without scrub	594157737.29990
20	20621	Reverie sandy area	186736310.85850
21	20	Urban	18774071.46615
22	1	Mine	1691814.78456

Table6. Aggregated different feature class in the classified image of 2001

Grd Code	Cnt_G RIDCO	Name	Sum_Shape_
1	435	Water body	176117132.32197
2	6466	Dense Forest	607777749.95430
3	27081	Open Forest	848079772.63730
4	38872	Dense Scrub	454853698.81440
5	8578	Agri- Cultivated land	268003863.29790
6	55296	Degraded Forest	533037554.41840
7	77136	Fallow Land / dry cultivated	652243545.16380
8	45168	Barren1- Escarpment	678733385.86700
9	124983	barren2-degraded plantation	687631071.37920
10	154766	Barren3- land without scrub	701772738.76270
11	89232	Dense scrub2	693793063.90400
12	167154	fallow/ dry cultivated	764101748.86300

13	163397	open scrub3	1005579374.97500
14	124901	Waste land- sandy area	1101629394.50000
15	67461	Built-up land	786863248.76640
16	20621	Wasteland- Reverie sandy area	191140280.19948
17	20	Urban	35992094.77231
18	1	Mine	2793117.84041

Table7. Aggregated difference between feature classes in the classified image of 1991 and 2001

GRID CODE	Total Area Sqm	Sum_Shape	Difference
1	139133427.72	176117132.32	36983704.60
2	364497187.02	607777749.95	243280562.93
3	114238253.86	764101748.86	649863495.00
4	708801160.54	848079772.64	139278612.10
5	841660961.50	454853698.81	-386807262.68
6	240045300.07	268003863.30	27958563.23
7	585912112.77	693793063.90	107880951.14
8	624255010.53	1005579374.98	381324364.44
9	746946217.00	533037554.42	-213908662.59
10	357346296.40	687631071.38	330284774.98
11	685073479.94	678733385.87	-6340094.07
12	976171617.41	701772738.76	-274398878.64
13	611978886.16	1101629394.50	489650508.34
14	186736310.86	191140280.20	4403969.34
15	19200629.22	35992094.77	16791465.55
16	1691814.78	2793117.84	1101303.06

5. CONCLUSIONS

This basic study shows how to collect data from various sources such as land use and land cover map and forest area maps from satellite imagery and landsat images. We calculated land use and land cover and forest area changes over the years for the study area using unsupervised classification. The output thus obtained from the map is exported to the database file [9] [15] and the tables present in the paper shows clear indication for the change in the forest area and also the land use patterns. After doing, all these process which are mentioned above, we found that the individual categories show specific kind of Land use or Land Cover features on the ground. And then, we calculated their change in areas. Finally we conclude that, due to anthropogenic activity, changes such as the reduced vigor of forest vegetation, urbanization, mining etc are noticed in the study area.

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