ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 5, May 2017

Temporal Forest Cover Analysis of Udupi District In Karnataka Using Remote Sensing and GIS

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Abstract: **Forests all over the globe are subjected to enormous pressure resulting in deforestation and degradation due to the anthropogenic activities like urbanization and increase in cultivation. Measuring land-cover change is an essential part of sustainable conservation planning. Hence monitoring change in forest cover has become an important tool for forest management. Remote sensing offers a quick and low cost way for forest cover mapping to monitor deforestation. The objective of the study is to analyze spatial and temporal forest cover changes in Udupi district of Karnataka to understand the deforestation pattern from 1973 to 2016.The study applied supervised classification – Maximum Likelihood Algorithm in Erdas Imagine software using satellite data obtained from Landsat Multispectral Scanner (MSS), Landsat 5 Thematic Mapper(TM),Landsat 7 ETM+,IRS LISS III and Landsat 8 Operational Land Imager(OLI) for the years 1973, 1981, 1991, 2003, 2012and 2016 respectively. The area was classified into 11 land use/land cover classes' viz. agricultural land, arecanut and coconut plantation, barren land, built up land, dense forest, fallow land, grass land, other vegetation, rubber plantation, sand soil and water body. The overall accuracies obtained are 79.37%, 81.04%, 82.53%, 84.38%, 85.76% and85.76% for the years 1973, 1981, 1991, 2003, 2012 and 2016 respectively. Land use/land cover maps generated through ArcGIS indicated a significant shift from forest cover to agricultural land, plantations and urban settlement areas. The study demonstrated that monitoring of long term forest changes provides critical inputs for management of forest resources.**

Key words**: Erdas;Forest Cover; Image Classification; LULC; Satellite Imagery**

I. INTRODUCTION

Forest is a complex ecological system in which trees are dominant life forms. Besides providinghabitats for animals and livelihood for humans, forest also play a major role in greenhouse gas regulation, water supplies and regulation, soil conservation, nutrient cycling, genetic and species diversity Forests play an important role in the socio-economic scenario of any state. This role is all the more pronounced in a state like Karnataka, which isa predominantly agriculture-based rural economy.

Udupi district is known for its species diversity as the region falls in foot of Western Ghats. Rapid urbanization and agricultural expansion has become a threat to forest areas [4]. South western stretch of Western Ghats has experienced a forest decline of 25.5% in the year 1973-1995[3]. Studies shows that forest degradation has been taking place in Udupi due to the urbanization and industrial expansion [5]. Conventional ground methods of land use mapping are labor intensive, time consuming and are done relatively infrequently. Studies have shown that use of time series remote sensing data offers a quick and low cost way for analyzing forest cover change [1].Various supervised and unsupervised change detection techniques are available for land useland cover change analysis. Among that supervised method provides more classification accuracy than unsupervised classification methods [6].Among the supervised classification algorithms, maximum likelihood algorithm gives better accuracy compared to minimum distance to means and parallelepiped classification algorithms[7].

II. STUDY AREA

Udupi has a total geographical extend of 3571 sq.km which is about 1.86 % of total geographical area of Karnataka State. It lies between latitude $13^0$12' and 14^0 N and longitude of 74^0 and $75^0$15' E. Udupi is bounded by the Western Ghats on the east and Arabian Sea on the west. With the heavy rains of south west monsoon and the continuation of tropical rainforests of Western Ghats the Udupi district is environmentally important and ecologically sensitive.The area receives an average annual rainfall of 4360 mm. The area is having a coastline of more than 100km and is one of the three coastal districts of the state. The area has a total population of 1177361 as per Census 2011.Figure 1 shows the study area.

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 5, May 2017

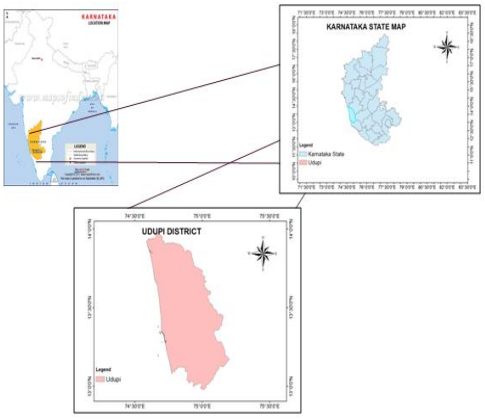

Figure 1 : Study Area

III. MATERIALS AND METHODOLOGY

A. Data Processing and Image Classification

The study was carried out using temporal satellite images of Landsat MSS (February 1973 and February 1981), Landsat TM(February 1991),Landsat ETM+(March 2003),IRS LISS III(February 2016) and Landsat 8 OLI(February 2016).The topographic map of 1977(scale 1:50000) is obtained from Survey of India and used to generate land use maps for 1973 and 1981. All the landsat images used in this study was downloaded from USGS earth explorer. The satelliteimages are radiometrically corrected using ERDAS Imagine.The False Color Composite of the area is created in order to differentiate the different features on the image based on their reflectance in each band. The chosen study area is extracted from the False Color Composite image. Supervised classification using maximum likelihood algorithm was adopted to categorize the pixels in an image into land cover classes or themes. More than 100 training samples are taken for each land cover type. These training areas are taken on the basis of high resolution images from Google Earth. Based on the visual interpretation of the area, the area is classified into 11 land use/land cover classes viz. agricultural land(AL),arecanut and coconut plantation(ACP), barren land(BR),built up land(BU),dense forest(DF),fallow land(FL),grass land(GL),other vegetation(OV),rubber plantation(RP),sand soil(SS) and water body(WB). The Maximum likelihood algorithm is used for the classification. The topographic map of 1977 was scanned and rectified using geometrically corrected image with the Erdas Imagine software.The topographic map is then compared with the classified image for the year 1973 an 1981 and the classified image is recoded which increases the accuracy. After the classification the accuracy was assessed by taking 256 samples using random sampling method.

B. Accuracy Assessment

Accuracy Assessment is a vital part to analyze the classified image result. It compares the classified image to another data source that is considered to be accurate or ground truth data. In this study ground truth data is derived using the high resolution images from the Google earth. Error matrix is created to assess the accuracy of classification. In an error matrix, the classification results are compared using information from reference site to information on a map for a number of sample areas. The Kappa statistic represents the agreement between the classified forestland cover and the observed forest.

IV. RESULTS AND DISCUSSION

A. Forest Cover change of Udupi District

The spatial distribution of forest cover in 1973 is shown in Table 1 .Forests occupied 1090.5 km2, which is about 30.53% of the district. The area under agricultural land, arecanut and coconut plantation, rubber plantation and human habitation are 299.7 km2, 321.6 km2, 20.4 km2 and 40.3 km2 respectively.i.e, these categories occupied about 8.39%, 9%, 0.57% and 1.12% respectively. The spatial distribution of forest cover in 1981 is shown in Table 1 .Forests occupied 1038.3 km2, which is about 29.07% of the district. The area under agricultural land, arecanut and coconut plantation, rubber plantation and human habitation are 337.7 km2, 358.7 km2, 20.4 km2 and 43.3 km2 respectively.i.e, these categories occupied about 9.45%, 10.04%, 0.57% and 1.21% respectively.

Table 1: Land Covers Distribution In % With Respect To Geographical Area

Class	Area in km²					
	1973	1981	1991	2003	2012	2016
AL	299.7	337.7	609.4	826.1	844.5	836.0
ACP	321.6	358.7	429.5	680.7	721.6	702.4
BR	188.1	183.3	67.5	98.2	96.3	114.1
BU	40.3	43.3	49.0	68.4	107.4	118.0
DF	1090.5	1038.3	977.6	827.9	708.8	704.3
FL	166.4	177.0	315.4	328.3	268.7	169.1
GL	19.4	19.4	29.4	18.0	16.4	16.4
OV	1326.7	1294.9	995.4	625.6	676.6	771.2
RP	20.4	20.4	21.2	23.5	56.3	62.7
SS	15.4	15.4	16.0	16.9	11.3	14.4
WB	83.0	83.0	60.9	57.9	63.7	63.0

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International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
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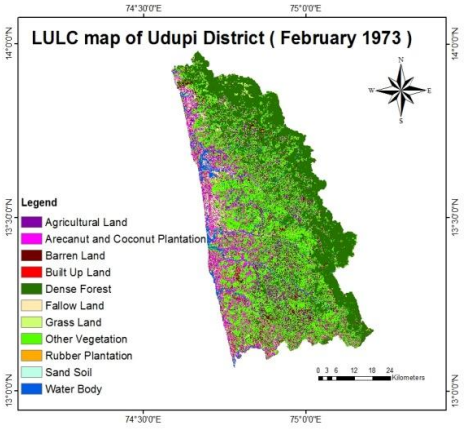

Figure 2: Classified map of Udupi District for the year 1973

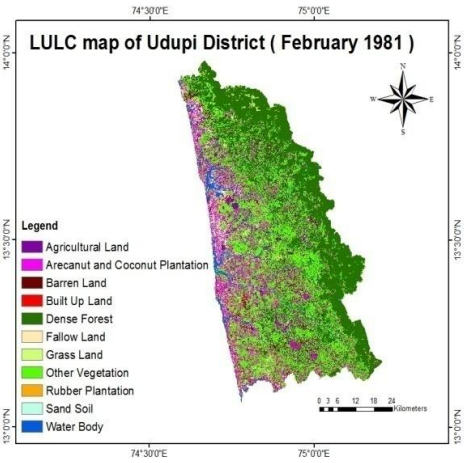

Figure 3 : Classified map of Udupi District for the year 1991

The classified mapof the area for 1973, 1981 and 1991 is shown in figure 2, figure 3 and figure 4 respectively. For the year 1991, forests occupied 977.6 km2, which is about 27.37% of the district. The area under agricultural land, arecanut and coconut plantation, rubber plantation and human habitation for 1991 are 609.4km2,429.5 km2, 21.2 km2 and 49 km2respectively.i.e, these categories occupied about 17.06%, 12.02%, 0.59% and 1.37% respectively. The classified map of area for 2003 is shown in Figure 5.Forests occupied 827.9 km2, which is about 23.18% of the district. The area under agricultural land, arecanut and coconut plantation, rubber plantation and human habitation are 826.1 km2, 680.7 km2, 23.5 km2 and 68.4 km2 respectively.i.e, these categories occupied about 23.13%,19.06%,0.65\% and 1.91% respectively.

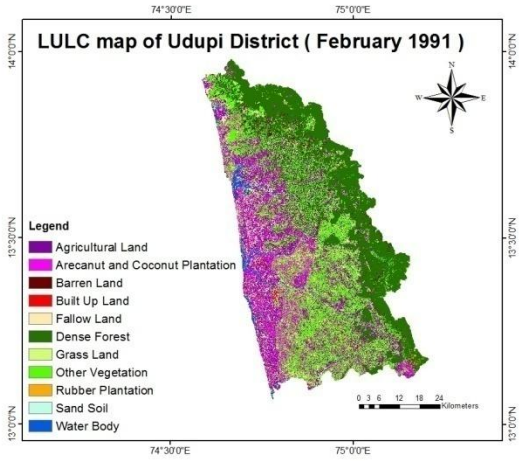

Figure 4 : Classified map of Udupi District for the year 1991

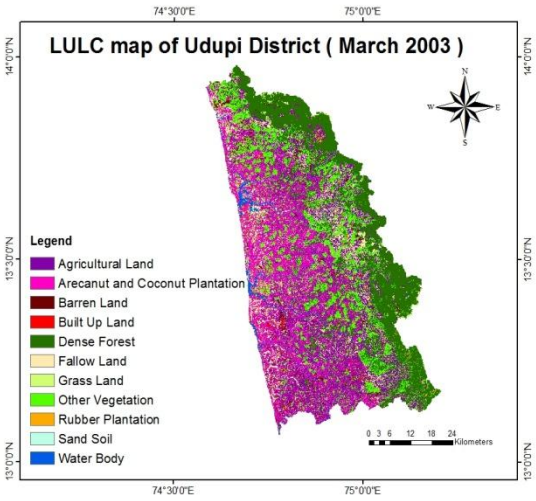

Figure 5 : Classified map of Udupi District for the year 2003

The classified map of area for 2012 is shown in Figure 6 .Forests occupied 708.8 km2, which is about 19.84% of the district. The area under agricultural land, arecanut and coconut plantation, rubber plantation and human habitation are 844.5km2,721.6 km2, 56.3 km2 and 107.4 km2 respectively.i.e, these categories occupied about 23.64%, 20.20%, 1.57% and 3% respectively.The classified map of area for the year 2016 is shown in figure 7.Forests occupied 704.3 km2, which is about 19.72% of the district. The area under agricultural land, arecanut and coconut plantation, rubber plantation and human habitation are

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
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836km2,702.4 km2, 62.7 km2 and 118 km2 respectively.i.e, these categories occupied about 23.41%, 19.67%, 1.75% and 3.3% respectively.

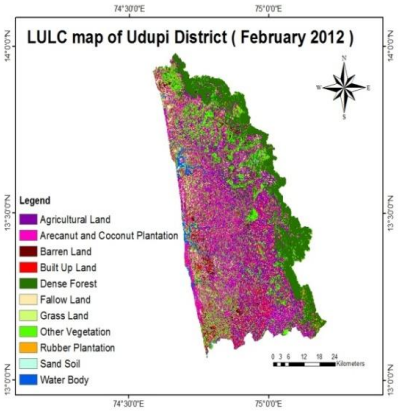

Figure 6 : Classified map of Udupi district for the year 2012

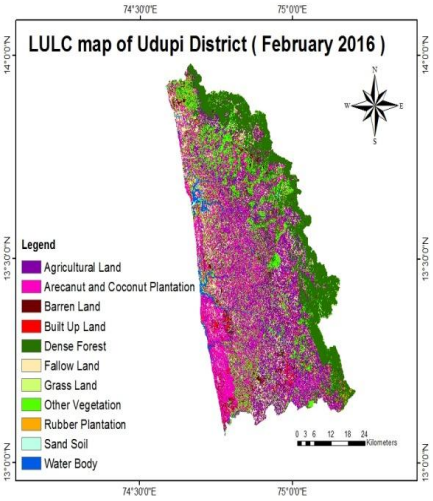

Figure 7 : Classified map of Udupi district for the year 2012

Bar chart showing the land use land covers variation of Udupi district for the years 1973, 1981,1991,2003,2012 and 2016 is shown in Figure 9.

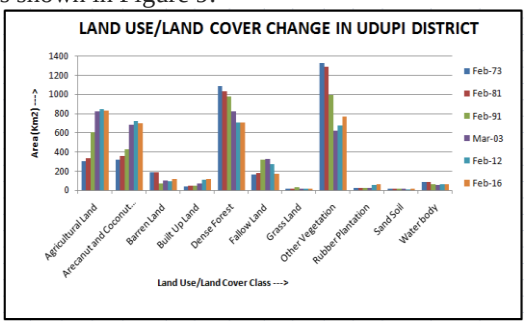

Figure 8 : Bar chart showing land use land cover variation

B. Accuracy Assessment

Accuracy assessment for the year using maximum likelihood classification is shown in Table 2. The overall accuracy obtained is 79.37 with kappa statistics of 0.7730 for the year 1973.

Table 2: Accuracy Assessment For The Year 1973

Classes	Producer's Accuracy (%)	User's Accuracy (%)	kappa
GL	83.40%	78.52	0.765
AL	70.61%	72.27	0.6942
FL	78.14	85.16	0.8352
SS	87.5	84.77	0.8329
RP	95.65	77.34	0.7555
BU	86.81	79.69	0.7784
BL	77.89	92.19	0.9125
WB	97.13	92.58	0.9187
DF	82.31	83.59	0.8192
OV	74.82	80.08	0.7793
ACP	79.47	81.64	0.7975

Producers' accuracy is calculated as the number of pixels correctly classified in a particular category as a percentage of total number of pixels actually belonging to that category. Users' accuracy tells whether a pixel classified into a given category actually represents that category on ground. The values of kappa greater than 0.80(80%) represents strong agreement; a value between 0.40 and 0.80(40% and 80%) represents moderate agreement; and a value below 0.40(40%) represents poor agreement. In the present study for the year 1973 which shows moderate agreement.

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
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Table 3: Accuracy Assessment Report For The Year 1981

Class	Producer's Accuracy(%)	User's Accuracy(%)	kappa
WB	85.87	94.92	0.9435
ACP	78.72	86.72	0.8524
FL	82.75	82.42	0.8067
BL	75.09	81.25	0.792
OV	80.43	88.28	0.8698
SS	75.72	81.64	0.7965
BU	87.02	89.06	0.8794
RP	82.86	67.97	0.6539
GL	80.41	76.95	0.7476
AL	78.66	73.44	0.7097
DF	86.27	68.75	0.6631

Table 4: Accuracy Report For The Year 1991

Classes	Producer's Accuracy (%)	User's Accuracy (%)	kappa
GL	83.40%	78.52	0.765
AL	70.61%	72.27	0.6942
FL	78.14	85.16	0.8352
SS	87.5	84.77	0.8329
RP	95.65	77.34	0.7555
BU	86.81	79.69	0.7784
BL	77.89	92.19	0.9125
WB	97.13	92.58	0.9187
DF	82.31	83.59	0.8192
OV	74.82	80.08	0.7793
ACP	79.47	81.64	0.7975

The accuracy report for the year 1981 and 1991 are shown in Table 3 and Table 4 respectively.The overall accuracy obtained is 81.04 with kappa statistics of 0.79 for the year 1981 which shows strong agreement.The overall accuracy obtained is 82.53 with kappa statistics of 0.8078 for the year 1991 which shows strong agreement.

Table 5: Accuracy Assessment For The Year 2003

Classes	Producer's Accuracy (%)	User's Accuracy (%)	kappa
GL	85.77%	84.77	0.8326
AL	69.32%	71.48	0.6853
FL	81.2	84.38	0.8275
SS	91.67	85.94	0.8463
RP	96.6	77.73	0.7598
BU	90.32	87.5	0.8629
BL	88.39	92.19	0.9137
WB	100	94.92	0.9444
DF	78.95	93.75	0.9299
OV	73.36	82.81	0.8085
ACP	79.15	72.66	0.7017

Table 6: Accuracy Report For The Year 2012

Classes	Producer's Accuracy (%)	User's Accuracy (%)	kappa
GL	90.21%	82.81	0.8125
AL	74.50%	73.05	0.7041
FL	80.8	87.11	0.8571
SS	90.95	86.33	0.8504
RP	96.65	78.91	0.7722
BU	87.16	87.5	0.8624
BL	86.45	92.91	0.9135
WB	100	95.7	0.9529
DF	81.1	92.91	0.9129
OV	76.04	85.55	0.839
ACP	84.68	82.03	0.803

The accuracy report for the year 2003 and 2012 are shown in Table 5 and Table 6 respectively.The overall accuracy obtained is 84.38 with kappa statistics of 0.828 for the year 2003 which shows strong agreement.The overall accuracy obtained is 85.76 with kappa statistics of 0.8434 for the year 2012 which shows strong agreement.

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
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Table 7: Accuracy Report For The Year 2016

Classes	Producer's Accuracy (%)	User's Accuracy (%)	kappa
GL	87.7	86.33	0.8498
AL	72.79	80.47	0.7829
FL	81.82	87.89	0.8658
SS	90.08	85.16	0.8376
RP	96.94	86.72	0.8554
BU	89.71	85.16	0.8375
BL	87.74	89.45	0.8838
WB	100	96.48	0.9615
DF	83.39	96.09	0.9564
OV	79.7	82.81	0.8102
ACP	80.18	69.53	0.6692

The accuracy report for the year 2016 is shown in Table 7.The overall accuracy obtained is 86.01 with kappa statistics of 0.84 which shows strong agreement.

V. CONCLUSIONS

From the study it can be concluded that remotely sensed data can effectively be used for forest cover mapping. Since 1973 to 1991 the rate of forest cover loss is 10.3 % in the study area and it is 38% from the year 1991 to 2016. This indicates that the degradation of the forest was more in the recent years compared to that of earlier. It is also concluded that forest has been replaced by agricultural land, built up land and other plantations.Hence monitoring of long term forest changes is essential for efficient forest management.

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