Imperial Journal of Interdisciplinary Research (IJIR)
Vol-2, Issue-4, 2016
ISSN: 2454-1362, http://www.onlinejournal.in

Land Use Land Cover Change Analysis of Uttara Kannada

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Abstract: *Land Use and Land Cover (LULC) changes in Uttar Kannada district during 1979 to 2013 were analysed using temporal remote sensing data with geographic information system (GIS). Main objective of the current study is to i) quantify the LULC, ii) assess LULC changes during 1979-2013, iii) assess the level of fragmentations in forest ecosystems iv) investigations of the agents of forest fragmentation. Three remotely sensed data sets, Landsat MSS (1979), Landsat TM (1999) and Landsat ETM+ (2013) i.e. for a time period of 34 years were used for the study. The ancillary data in the form of topographic maps and Google Earth were used to create the base maps of the study area. The land use of the study area was classified in to ten land use categories which include Evergreen forest, Moist deciduous forest, Dry deciduous forest, Scrub forest/Grassland, Forest plantations, Built up, Water, Crop land, Horticultural plantations and Open land. If the present rates of forest encroachment are allowed to continue, endemic species of flora and fauna will become endangered in Uttar Kannada. The land use analysis reveal a decline in evergreen forests from 57.15% (1979) to 32.52% (2013) with an increase of crop land (10.03% to 14.12%) and built up (0.94% to 3.04%). Land use change analysis showed the spurt in rate of decline of the evergreen to semi evergreen forests from 1.50% (1979-1999) to 1.88% (1999-2013).*

Keywords: *Land use land cover (LULC), remote sensing, LULC changes, fragmentation analysis, forest encroachment.*

1. INTRODUCTION

Land cover (LC) is defined as the features that are present on the earth‘s surface. Land use refers to the human induced changes for agricultural, industrial, residential or recreational purposes (Ramachandra and Bharath, 2012). Land cover changes refer to conversion and modification of vegetation, changes in biodiversity, soil quality, runoff, erosion, sedimentation and land productivity (Xiubin, 1996). Land use has been changing ever since human‘s first began to manage their environment. However, the changes that have taken place over the last 50 years have been especially important and intense as society is becoming increasingly urbanized, while natural ecosystems become deteriorated (Martinez et al., 2009). LULC changes are driven by the interaction of ecological, geographical, economic, and social factors (Zang and Huang, 2006) in the process of landscape development (Bürgi et al., 2004; Hersperger and Burgi, 2009). The interaction between biophysical and human dimensions in space and time is the main driver of Land use change. The possible impacts of land use/cover change on environment have inspired researchers to conduct research in order to understand main causes and effects of land use change (Veldkamp and Verburg, 2004).

Land use activities whether converting natural landscapes for human use or changing management practices on human dominated lands have transformed a large proportion of the Earths land surface. Due to clearing of tropical forests, practicing subsistence agriculture, increasing farmland production and expanding urban centres, the world‘s landscape is changing in inescapable ways through human actions (Foley et al., 2005). Although land-use practices vary greatly across the world, their final outcome is generally the same, the achievement of natural resources for immediate human needs, often at the expense of degrading environmental conditions.

Land use changes eliminate species locally and decline natural habitats and ecosystem functioning, affecting thus, biodiversity and provision services of ecosystem. Global biodiversity is changing at an unprecedented rate as a complex response to several human induced changes in the global environment and LULC. Land use land cover (LULC) changes are the major sources of habitat loss, ecosystem alterations and biodiversity changes in forest dominated landscapes. Habitat loss due to change in LULC dynamics is usually regarded as one of the most important factors causing the global biodiversity crisis (Setturu and

Ramachandra, 2012). Human actions are altering the terrestrial environment at unprecedented rates, magnitudes, and spatial scales. Land- cover change resulting from human land uses represents a major source and a major element of global environmental change (Turner et al., 1994, Ramachandra and Bharath, 2012). LULC change also has a significant effect on the global climate change which may include increase in mean temperature in the tropics and intensification of Indian summer monsoon. This alteration can be expected to expand montane evergreen forests into grasslands, producing a shift in grassland biome (Menon and Bawa, 1997).

Land-cover and land-use (LCLU) change analyses and projection provides a tool to assess ecosystem change and its environmental implications at various temporal and spatial scale (Lambin, 1997). Land use and Land cover (LULC) data provides useful information regarding developmental, environmental and resource planning applications at regional as well as global scale (Ramachandra et al., 2012). LULC dynamics are analysed through changes in the state of an object or phenomenon by observing it at different times. Accurate and timely detection of change in natural resources provides the basic understanding of the relationships and interactions between human and natural phenomena. Satellite Remote Sensing data, which are a useful source of information and provides timely and complete coverage of any specific area, have proven useful in assessing the natural resources and monitoring the land use or land cover changes (Satyanarayana et al., 2001). The spectral response of vegetation indices will detects changes in pixel-level vegetation conditions (Leckie et al., 2005; Wulder et al., 2005).

2. OBJECTIVES

The main aim of our present study is to understand the landscape ecology of the study area through
I. Quantification of LULC
II. Assessing LULC changes during 1979-2013
III. Assessing the level of fragmentations in forest ecosystems
IV. Investigation of the agents of forest fragmentation

3. STUDY AREA

The area of interest for our present study is Uttar Kannada (Fig 1), one of the 30 districts of Karnataka (*census 2011*) and falls in biodiversity hotspot, the Western Ghats. It lies between 74°9′ to 75°10′ E longitude 13°55′ to 15°31′ N latitude. It extends from north to south to a maximum of 180 km‘s and from east to west a maximum width of 110km‘s. It is having lush green forests ranging from evergreen to dry deciduous. The study area is considered to identify significant human interventions that have led to increased rate of forest encroachment and habitat fragmentation, deterioration of forest ecosystem and extinction of many flora & fauna species.

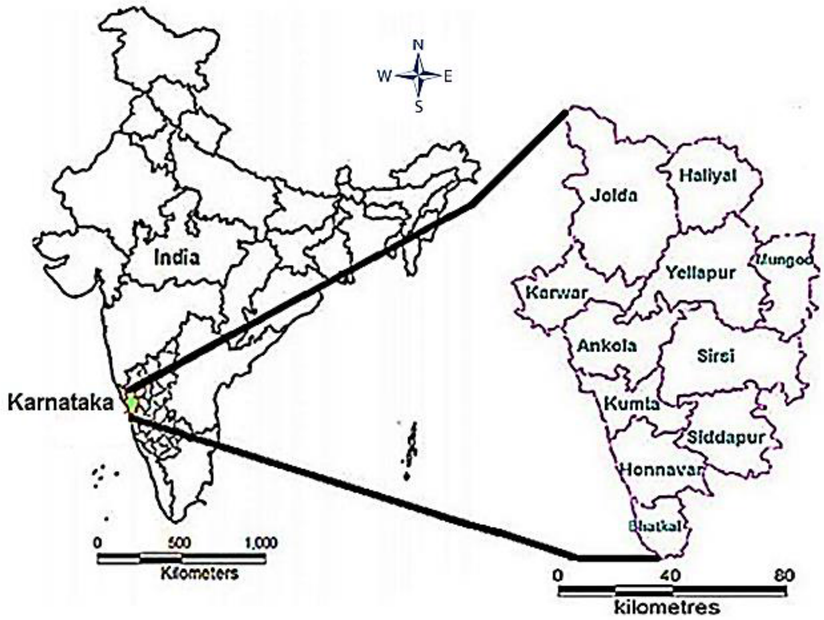

Fig 1: Study area; Uttar Kannada, Karnataka, India.

4. DATA

Remote sensing data Landsat MSS (1979), TM (1999), ETM+ (2013) acquired from public domains at *(http://glovis.usgs.gov/)* and Google Earth *(http://earth.google.com)* was used. The details of the remote sensing data are given in table 1. In addition to this the topographic maps at a scale of 1:50000 were used to provide the base map and boundary layers of the study area. These maps provide the additional information to assist the interpretation of different land use types.

Year	Satellite	Date of Acquisition	Resolution
1979	LANDSAT MSS	12/01/1979	~60m
1999	LANDSAT TM	16/02/1999	30m
2013	LANDSAT ETM+	13/01/2013	30m

Table 1: Details of Remote Sensing Data.

5. MATERIALS AND METHODS

The procedure that we have followed in our present study is shown in Fig 2.

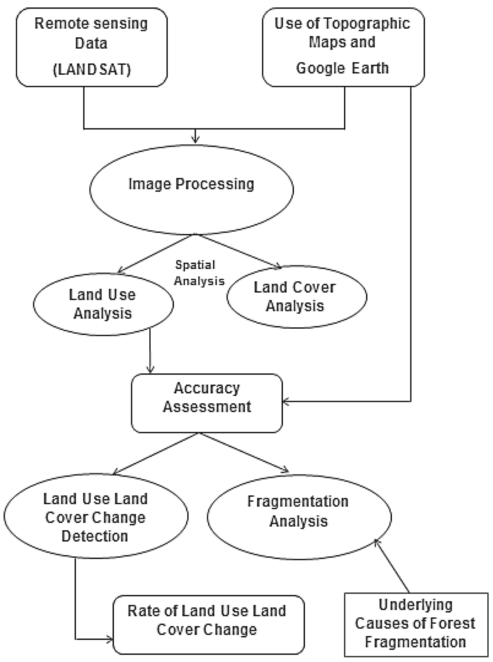

Fig 2: Flow chart of methodology followed in the study.

5.1. Pre-processing

The remote sensing data is processed to get the good insight into land use land cover analysis. The pre-processing of remote sensing data includes atmospheric correction and geometric correction inorder to enable correct area measurements, precise localization and multi-source data integration. The data obtained was geo-referenced with WGS-84 datum, rectified and cropped pertaining to the study area using Uttar Kannada boundary layer. The band correction was made using GRASS GIS *(http://grass.osgeo.org/)* in order to get the better and accurate results. The bands namely band-2 (Green), band-3 (Red) and band-4 (Near infrared) were used to produce the FCC (False Colour Composite). Google earth data was used for classification and validation.

5.2. Land Cover analysis

The normalized difference vegetation index (NDVI) is computed at temporal scale to determine the status of vegetation in Uttar Kannada. Among all techniques of land cover mapping NDVI is most widely accepted and applied. NDVI is calculated by using visible Red and NIR bands of Landsat data. The basic principle behind determining NDVI is that healthy vegetation absorbs most of the visible light that falls on it, and reflects a large portion of the near-infrared light however sparse vegetation reflects more visible light and less near-infrared light. NDVI for a given pixel always results in a number that ranges from minus one to plus one (-1 to +1). NDVI was calculated using the following equation;

$$\mathbf{NDVI = (NIR-R) / (NIR+R)}$$

5.3. Land use analysis

The false colour composite image was generated to identify distinct patches in landscape. The temporal Remote Sensing data was used for classification. The classification is based on the assumption that each land use class reflects different amount of light and in different spectral region, the properties of which are also prominent in the remotely sensed data. The land use categories used in our study are; forest (which includes evergreen, semi-evergreen, moist deciduous, dry deciduous, scrub forests-grassland and forest plantations) and non-forest (which includes built up, cropland, open land and horticultural plantations like areca-coconut plantation). Supervised classification approach was used in which the signatures/sample areas of each forest and non-forest category/land use type are taken separately from the regions clearly attributable to any of the category. These samples are called training areas. This was made possible by using the digitized topographic map layers and Google earth by which the exact signature/sample of each category can be taken. The spectral information in all spectral bands for the pixels comprising these training areas is used to recognise spectrally similar areas for each class. Thus, in a supervised classification we are first identifying the information classes, which are then used to determine the spectral classes, which represent them.

Gaussian Maximum Likelihood decision rule was used to assign an unknown pixel to its respective land use class. The maximum likelihood classifier quantitatively evaluates both the variance and covariance of the category spectral response patterns while classifying an unknown pixel. It calculates the probability of each and every pixel in the image and after evaluating the probability in each category, the pixel would be assigned to the most likely class (highest probability value) or labelled "unknown" if the probability values are all below a threshold set by the analyst.

5.4. Accuracy Assessment

Accuracy assessment evaluates the performance of classifiers. Accuracy assessment and Kappa coefficient are common measurements used to demonstrate the effectiveness of the classifications (Congalton, 1991). The inaccuracies in spectral classification are measured by a set of reference pixels. Based on the reference pixels, confusion/error matrix (also called contingency table) is generated. Error matrices compare, on a category-by category basis, the relationship between known reference data (ground truth) and the corresponding results of an automated classification. Such matrices are square, with the number of rows and columns equal to the number of categories whose classification accuracy is being assessed. From the error matrices kappa (κ) statistics, overall accuracy and producer's and user's accuracies are computed, which determine how far our classification is accurate (Lillesand & Kiefer, 2004).
Overall Accuracy = (Total number of correct pixels/ Total number of observed pixels) *100
User Accuracy = (Correct pixels/row total)*100
Producer accuracy = (Correct pixels/column total)*100

$$\hat{k} = \frac{N \sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} (x_{i+} \quad x_{+i})}{N^2 - \sum_{i=1}^{r} (x_{i+} \quad x_{+i})}$$

Where,
N = Total number of observations
r = Number of rows in matrix
Xii = Number of observations in row i and column i
Xi+ = Total number of observations in row i
X+i = Total number of observations in column i

5.5. Rate of Land use Change

The classified maps were analysed to identify the magnitude and direction of change. The compound interest formula due to its explicit biological meaning was used to assess the magnitude of the changes of various classes. It provided changes in the native land use/land cover category.
Change rate = {[Ln (At1)-Ln (At0)]/(t1-t0)}*100
Where At1 is area of class in current year, At0 is area of class in base year, t1 is current year, t0 is base year and Ln is natural logarithm.

5.6. Fragmentation Analysis

Forest fragmentation is the process whereby a large, continuous area of forest is both reduced in area and divided into two or more fragments. Fragmentation increases the number of habitat patches and decreases patch size. Sometimes, each habitat patch will be too small to sustain a local population. Species that are unable to cross the matrix will be then restricted to too small patches, reducing population sizes and the probability of their existence (Giulio et al., 2009). The decrease in the forest area and the increasing isolation between the forest patches has been the major cause of biodiversity loss.
In fragmentation analysis six fragmentation classes were considered which are; Interior (Pf=1), Patch (Pf<0.4), Transitional (0.4<Pf<0.6), Edge (Pf>0.6 and Pf-Pff>0), Perforated (Pf>0.6 and Pf-Pff<0) and Undetermined (Pf > 0.6 and Pf = Pff) where Pf is the proportion of pixels in the window that are forested and Pff is the proportion of all adjacent (cardinal directions only) pixel pairs that include at least one forest pixel, for which both pixels are forested. When Pff is larger than Pf, the implication is that forest is clumped; the probability that an immediate neighbour is also forest is greater than the average probability of forest within the window. Conversely, when Pff is smaller than Pf, the implication is that whatever is non-forest is clumped.

$$\mathbf{Pf} = \frac{\text{Number of forest pixels}}{\textit{Total number of Non-water pixels}}$$

$$\mathbf{Pff} = \frac{\text{Number of pixel pairs in cardinal direction with both pixels forest}}{\textit{Number of pixels pairs in cardinal direction with at least one pixel forest}}$$

6. RESULTS AND DISCUSSION

6.1. Spatio temporal analysis of change in land use land cover pattern of the district

Normalized Difference Vegetation Index (NDVI) was calculated at temporal scale to analyse land cover in Uttar Kannada. The computed NDVI showed that there is a shift in vegetation from 1979 to 2013. It showed that 97.24% of the area was covered by vegetation in 1979 as against 83.34% vegetation cover in 2013. On other hand the non-vegetation has shown an increase from 2.76% to 16.66% during this period (Table 2 and Fig 3 & Fig 5). Therefore it obviously reveals a decrease in the forest cover of the area (Table 3 and Fig 6).

Land use analysis was carried out at different time scales to determine the current status of forest ecosystem and the causes of transition in the land cover of the area. The analysis clearly showed a decrease in the various forest types which is most prominent in evergreen to semi-evergreen forests. The most precious evergreen forests showed a decrease in their extent from 57.15% (in 1979) to 32.52% (in 2013). The dry deciduous forests are almost at the elimination stage, which has come down to less than 1% from their extent of 2.83% in 1979. Increase in population and the rate of urbanization are mainly the causal factors of decrease in the forest cover of the area. The effect of population increase and Urbanization can be clearly seen from table 4 and Fig 4 & Fig 7 which show an increase in the built up (urbanization) and cropland land from 0.94% and 10.03% to 3.04% and 14.12% respectively during the study time period. So, most of the original forest land is lost to the construction of new houses and generating the new crop lands to support the increasing demands of the growing population. The water availability has increased in the area mainly due to construction of dams (1.8% to 2.73% during this period). The change in the land use pattern of the area is also attributed to various ongoing developmental projects in Uttar Kannada. Some portion of the forest area has also been converted to open disturbed areas either through natural calamities or anthropogenic activities which is evident from our analysis which shows an increase in the open land from 1.55% to 3.63% during the study period. Some portion of the valuable evergreen forest is lost to the horticultural plantations like areca and coconut plantation which have showed an increase from 1.68% to 4.58% during the time period from 1979 to 2013. Google earth data sets and topographic maps were used for analysing accuracy and the analysis shows that accuracy ranges from 88 to 91% (shown in table 5).

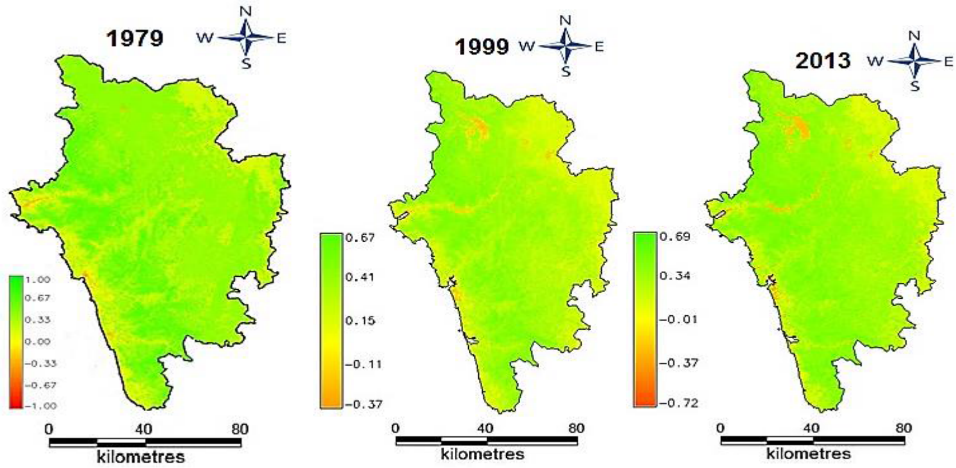

Fig 3: Land Cover Pattern in Uttar Kannada (1979-2013).

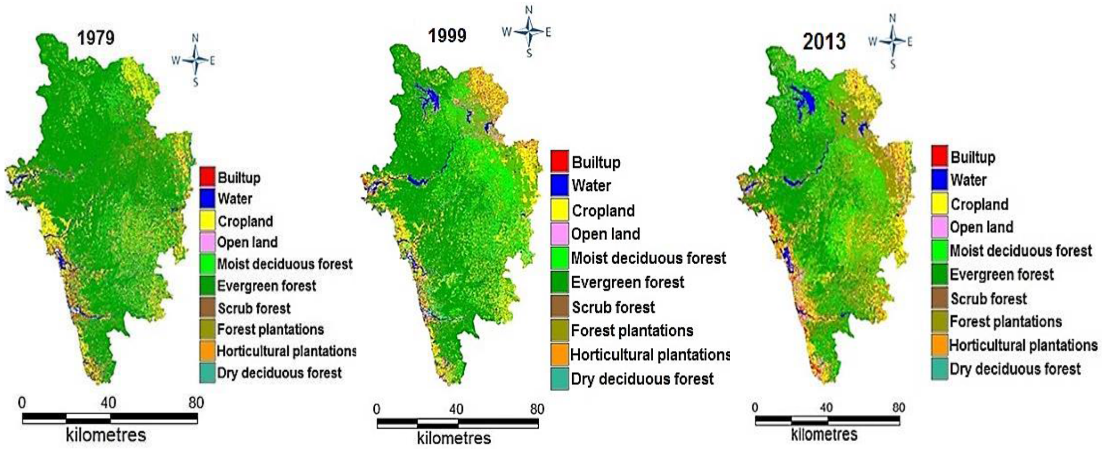

Fig 4: Land Use Pattern in Uttar Kannada (1979-2013).

Year	1979		1999		2013	
Land cover	Area					
	Ha	%	Ha	%	Ha	%
Vegetation	999880.02	97.24	960055.42	93.36	857112.73	83.34
Non vegetation	28379.98	2.76	68281.58	6.64	171340.27	16.66
Total	1028260	100	1028337	100	1028453	100

Table 2: Land Cover in Uttar Kannada (1979-2013).

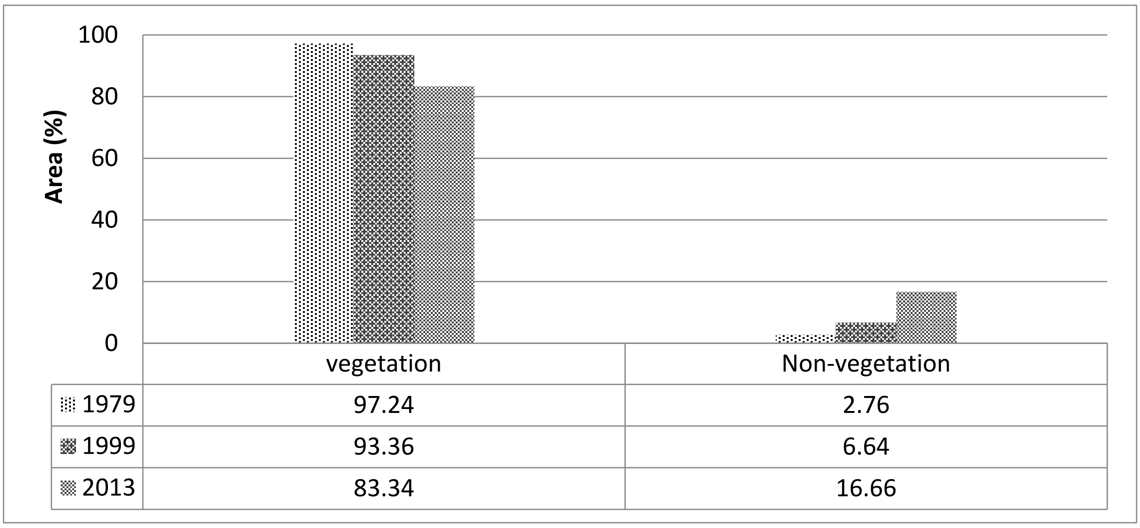

Fig 5: Temporal Change in Land Cover, Uttar Kannada (1979-2013).

Year	1979		1999		2013	
Category	Area					
	Ha	%	Ha	%	Ha	%
Forest	863641	83.99	766752	74.58	739297	71.90
Non-Forest	164617	16.01	261274	25.42	288955	28.10
Total	1028258	100.00	1028026	100.00	1028252	100.00

Table 3: Forest & Non-forest cover in Uttar Kannada (1979-2013).

Year	1979		1999		2013	
	Area					
Category	Ha	%	Ha	%	Ha	%
Built up	9716	0.94	23117	2.25	31306	3.04
Water	18519	1.80	28891	2.81	28050	2.73
Crop land	103120	10.03	141382	13.75	145172	14.12
Open land	15988	1.55	21878	2.13	37309	3.63
Moist deciduous forest	104735	10.19	170573	16.59	172595	16.79
Evergreen to semi evergreen forest	587670	57.15	435350	42.35	334384	32.52
Scrub/grass lands	58920	5.73	24352	2.37	42079	4.09
Forest plantations	83208	8.09	124710	12.13	180366	17.54
Horticulture plantation	17274	1.68	46006	4.48	47118	4.58
Dry deciduous forest	29108	2.83	11767	1.14	9873	0.96
Total Area (ha)	1028258					

Table 4: Temporal change in Land Use Pattern of Uttar Kannada (1979-2013).

Year	Overall Accuracy	Kappa Value (k)
1979	88.10	0.84
1999	90.93	0.89
2013	89.13	0.86

Table 5: Accuracy assessment and Kappa Statistics.

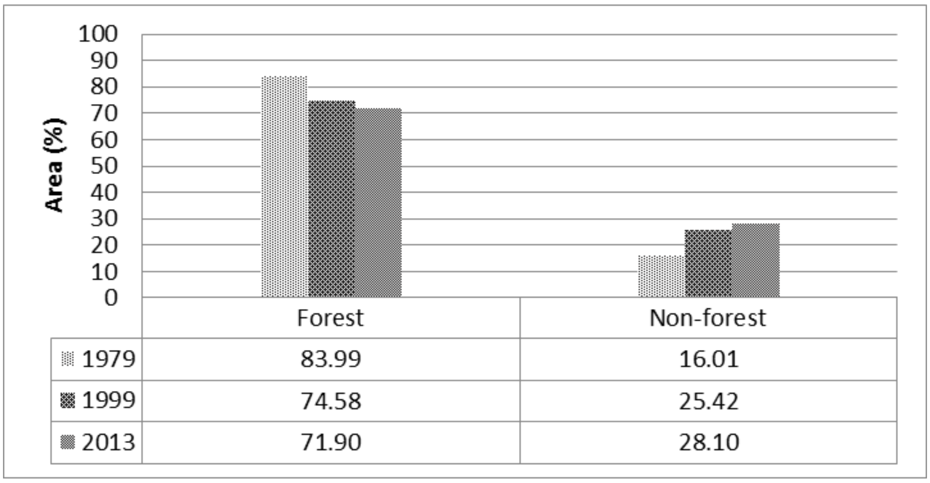

Fig 6: Forest & Non-forest cover, Uttar Kannada (1979-2013).

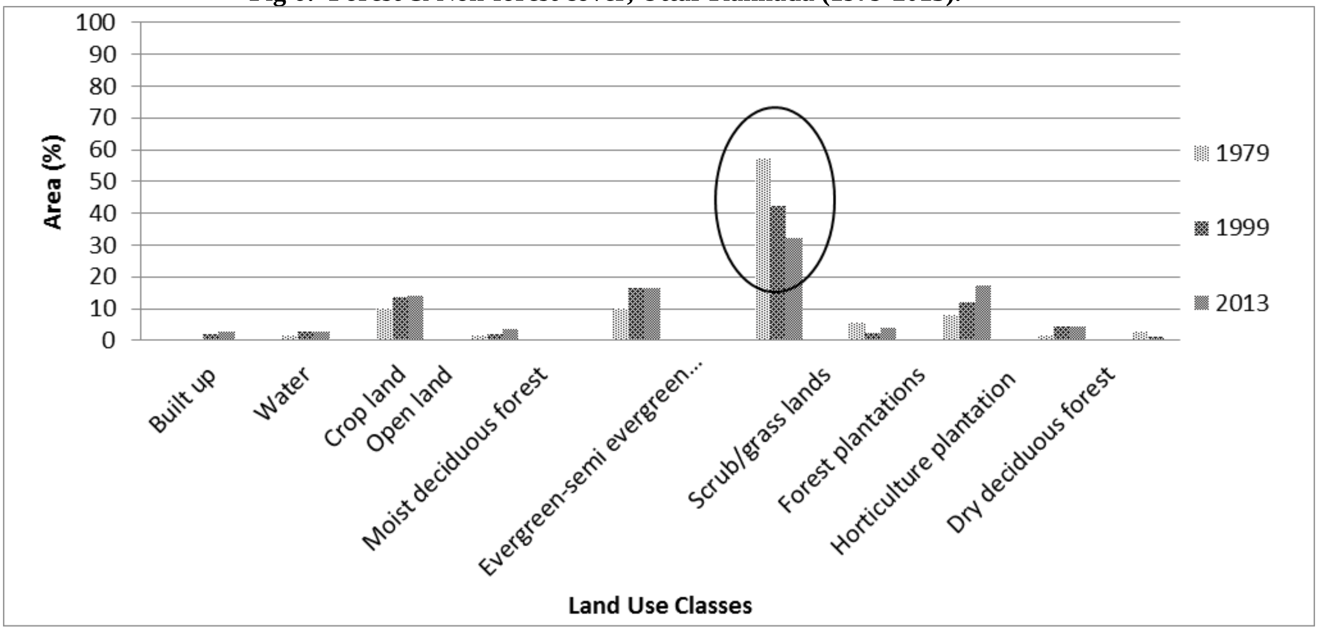

Fig 7: Temporal change in Land Use, Uttar Kannada (1979-2013).

Land use Changes

The rate of land use change in Uttar Kannada is shown in Table 6 and Fig 8 from which it is evident that there is a decrease in the forest area with a subsequent increase in the non-forest area. The increase in rate of agriculture and built up is mainly due to conversion of forest land into agriculture land and for construction of buildings (urbanization) respectively. The rate of decrease in the evergreen forest was found to rise from 1.5% during 1979-1999 to 1.88% during 1999-2013. Water was found to increase during 1979-1999 by 2.22% mainly due to construction of dams but it decreased by 0.21% during 1999-2013. The decrease in the dry deciduous forest was very high during the first time period (4.53%) as compared to second (1.25%).

Rate of Change In land use (%)		
Category	**Time period**	
	1979-1999	**1999-2013**
Built up	4.33	2.17
Water	2.22	-0.21
Crop land	1.58	0.19
Open land	1.57	3.81

Moist deciduous forest	2.44	0.08
Evergreen to semi evergreen forest	-1.50	-1.88
Scrub/grass lands	-4.42	3.91
Forest plantations	2.02	2.64
Horticulture plantation	4.90	0.17
Dry deciduous Forest	-4.53	-1.25

Table 6: Rate of change in land use categories, Uttar Kannada (1979-2013).

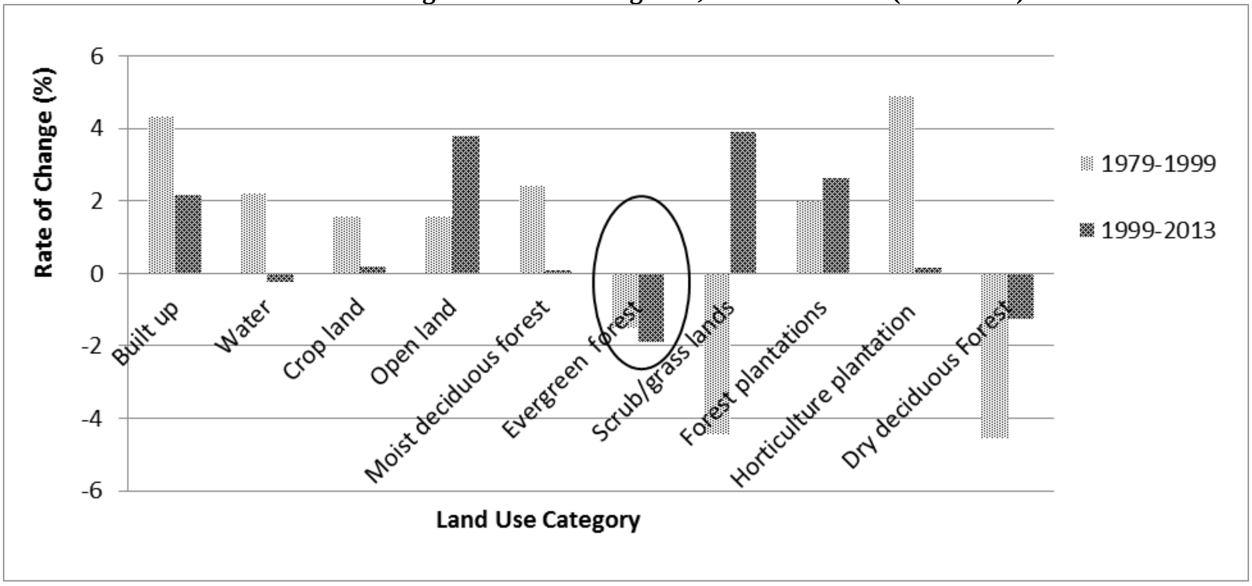

Fig 8: Rate of change in land use categories, Uttar Kannada (1979-2013).

6.2. Fragmentation analysis of the district

Temporal analysis of land use land cover of Uttar Kannada revealed large scale land cover changes in the district. To determine the level of changes, fragmentation analysis was done, which would help us in assessing the state of fragmentation and its implications. In fragmentation analysis, Pf and Pff in a fixed-area window of 3 × 3 were computed to identify forest fragmentation categories given in table 7 and Fig 9 & Fig 10.

The pattern of fragmentation was quantitatively assessed and it showed that the interior forest has decreased by 26.20% from 51.83% (in 1979) to 25.63% (in 2013). Patch forest which was only 7824 ha (i.e. 0.76%) in 1979 data has increased to 30618 ha (i.e. 2.98%) in 2013. It is also evident from this analysis that major portion of the forest has been converted into non-forest like built up, croplands, roads etc. which has increased from 24.57% to 45.75% during the time period from 1979 to 2013. This result gives us an idea regarding the present rate of deforestation.

From this analysis, it is clear that Uttar Kannada forest ecosystem in the biodiversity hotspot Western Ghats, is under the severe influence of forest fragmentation. Forest fragmentation is the main cause of biodiversity loss. Because due to fragmentation the species which were originally present in the interior of the forest are now exposed to the edges. The species confined to the interior forest conditions cannot cope up with the edge climatic conditions which are different from that of interior forest. At the edge also the threat of species loss from predators is increased as it is usually easy for the predators to reach the edges than interior of the forest. The natural disturbances like plant uprooting by wind and forest fires are common at the edges therefore increasing to the rate of biodiversity loss. Biodiversity loss by alien invasion is also common at the edges as invasive species do not face so stiff competition at edges as in the interior forest where it is difficult for them to get ample resources and sunlight to flourish. Therefore keeping in view these consequences of forest fragmentation it is necessary to take immediate action to check the present rate of forest fragmentation.

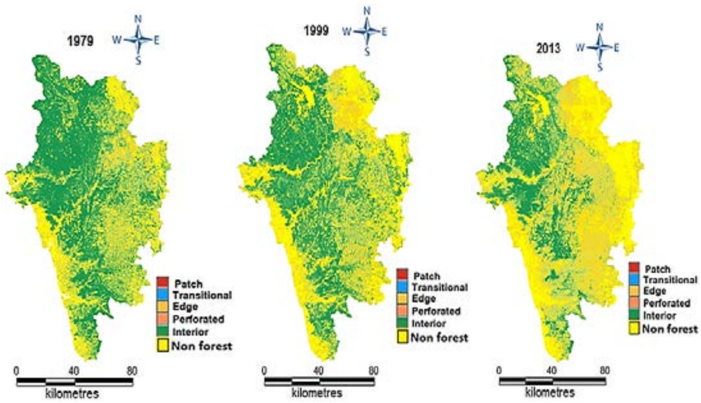

Fig 9: Forest Fragmentation, Uttar Kannada (1979-2013)

Year	1979		1999		2013	
Category	**Area**					
	Ha	**%**	**Ha**	**%**	**Ha**	**%**
Non-forest	252595	24.57	371871	36.16	470497	45.75
Patch	7824	0.76	19141	1.86	30618	2.98
Transitional	38461	3.74	42876	4.17	57434	5.58
Edge	26026	2.53	11998	1.17	8909	0.87
Perforated	170441	16.58	177842	17.29	197352	19.19
Interior	532913	51.83	404609	39.35	263643	25.63
Total	1028260	100	1028337	100	1028453	100

Table 7*:* Forest Fragmentation, Uttar Kannada (1979-2013)

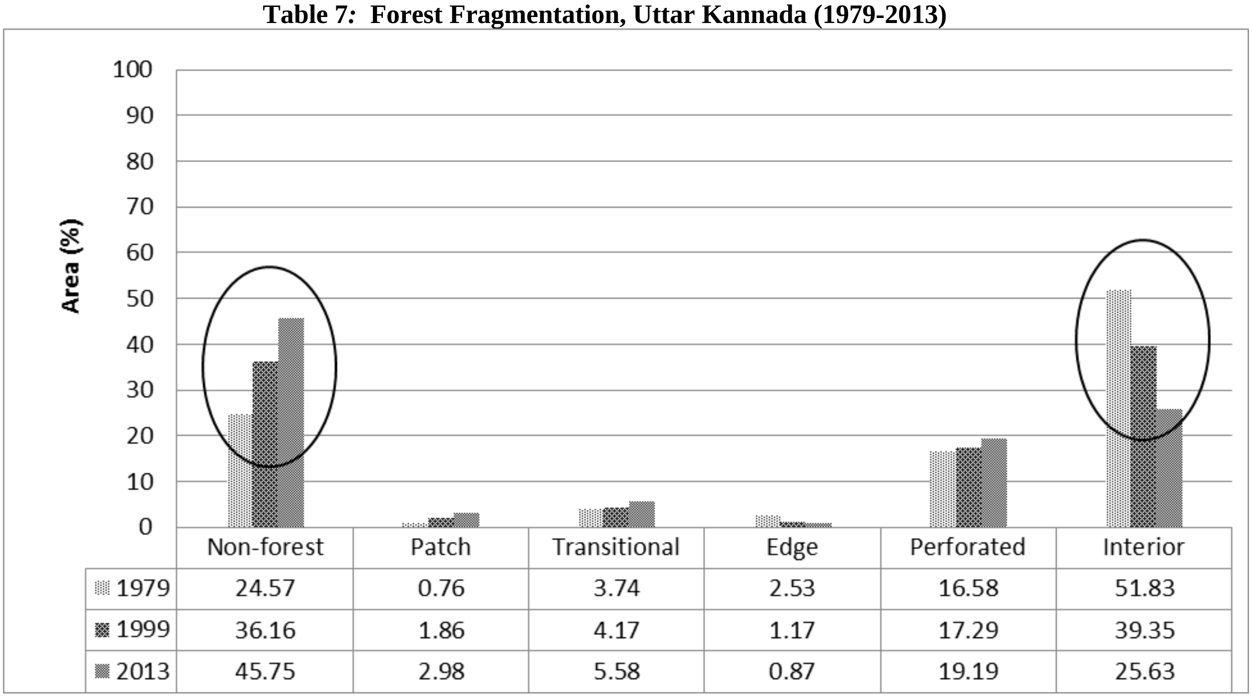

Fig 10: Percentage area of various forest classes, Uttar Kannada (1979- 2013).

6.3. Contributing factors of forest fragmentation

To identify the significant changes with respect to land use forest encroachment is considered as one of the drivers of forest fragmentation. As per Section 32 of the National Forestry and Tree Planting Act (NFTPA) of 2003, encroachment is the entry of people with their activities into forest through fragmentation. The encroachment of forest land for agricultural purposes is mainly because of relatively rich and virgin forest soils. However leaching in forest soils is much faster when reserves without permission. The entry can be deliberate or unknowingly for the purpose of grazing cattle, cultivation, settlement, construction or any other human activities (*National Forestry Authority*). At present forest encroachment is the major threat to biodiversity because it not only causes the habitat loss of species but also results in the more devastating effects exposed to the high temperatures and heavy rainfall of the tropical region and gets exhausted much faster. These factors force the encroachers to open new land annually hence they are clearing more and more forests. The forest land encroached in various forest categories in the five divisions of Uttar Kannada is shown in Table 8 & Table 9 and Fig 11 & Fig 12.

Area of forest land encroached in hectares (ha)						
Category	**Haliyal**	**Honnavar**	**Karwar**	**Sirsi**	**Yellapur**	**Total**
Acacia Plantation	4.59	402.07	45.44	159.52	3.51	615.13
Teak Plantation	14.12	144.89	44.43	25.62	0.00	229.06
Scrub forest/ Grassland	60.28	182.53	32.18	208.61	0.00	483.60
Evergreen forest	15.83	200.95	36.70	322.07	11.74	587.29
Semi-evergreen forest	15.56	513.27	31.39	450.41	22.24	1032.87
Moist deciduous forest	190.45	408.23	383.71	2475.43	290.07	3747.89
Dry deciduous forest	247.55	0.00	0.00	0.00	128.30	375.85
Total	548.39	1851.94	573.85	3641.66	455.86	7071.69

Table 8: Area encroached in different forest categories of five forest divisions of Uttar Kannada.

S. No	**Forest Division**	**Forest area (ha)**	**Percentage forest area (%)**	**Forest area encroached (ha)**	**Forest area Remaining (ha)**
1.	Haliyal	118344.56	14.18	548.39	117796.17
2.	Honnavar	140942.86	16.89	1851.94	139090.93
3.	Karwar	141958.93	17.01	573.85	141385.08
4.	Sirsi	171828.17	20.59	3641.66	168186.51
5.	Yellapur	168986.66	20.25	455.86	168530.80
6.	Dandeli wildlife sanctuary	92482.00	11.08	0.00	92482.00
	Total	834543.18	100.00	7071.69	827471.49

Table 9: Forest area encroached and remaining forest area in Uttar Kannada

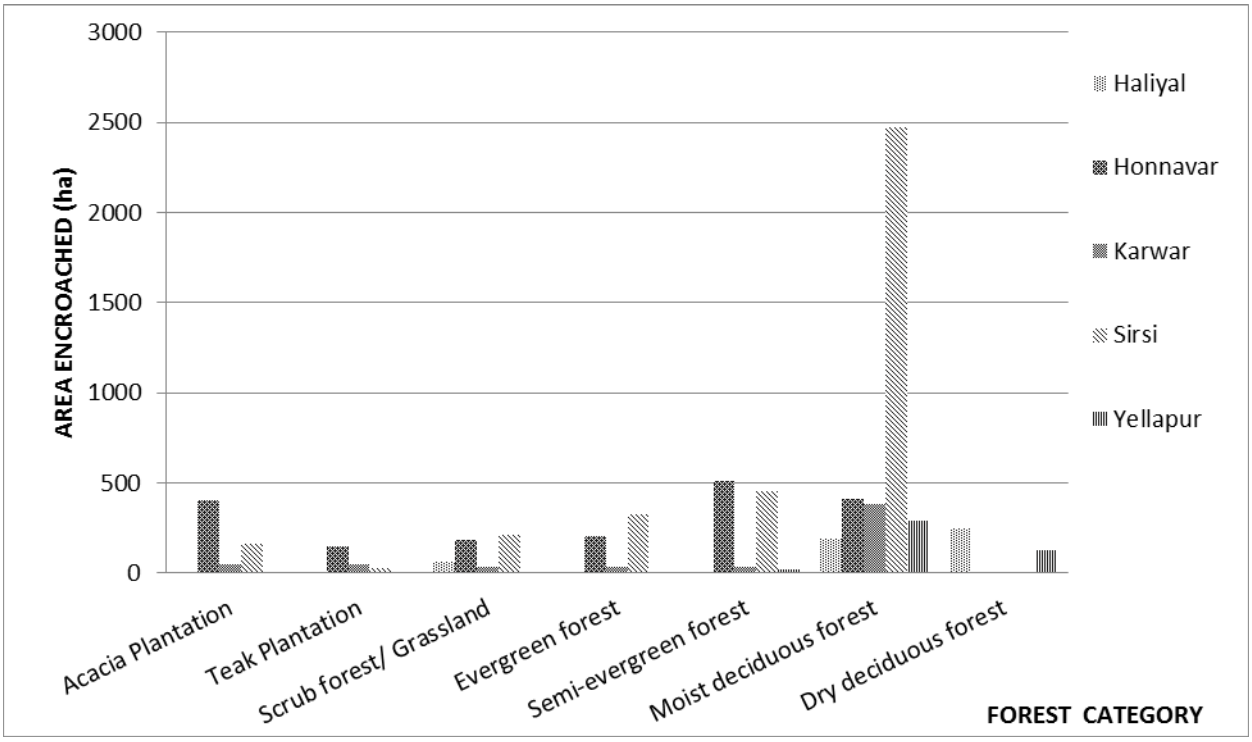

Fig 11: Encroachment in various forest categories of five forest divisions of Uttar Kannada.

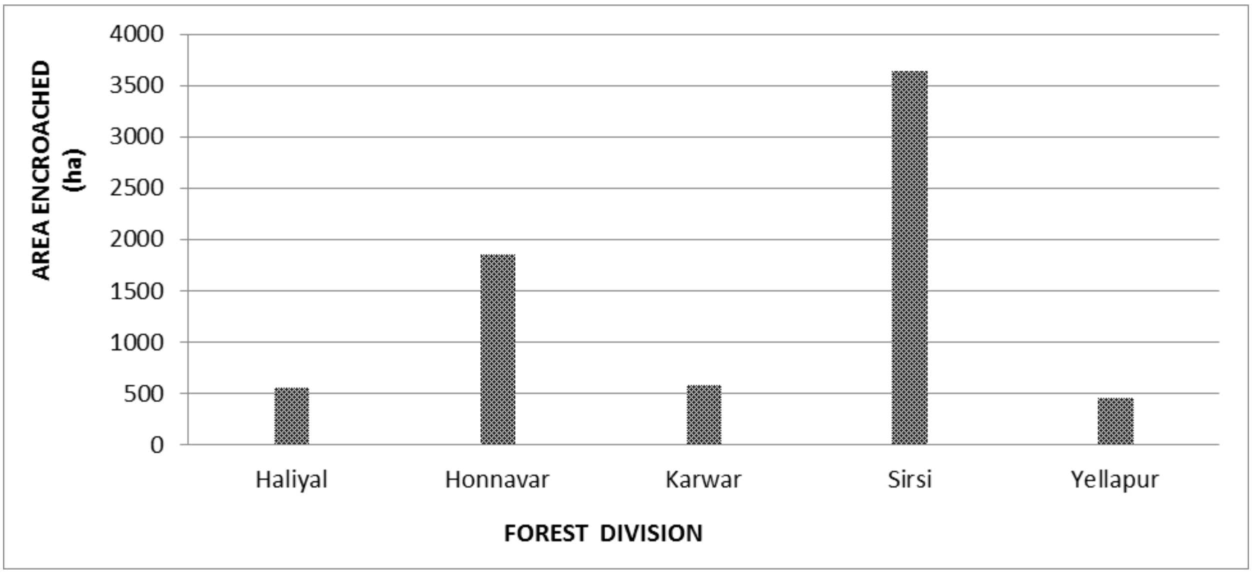

Fig 12: Forest encroachment in various divisions of Uttar Kannada.

From the above given tables and charts it is evident that the encroachment of forest land is maximum in Sirsi and Honnavar, 3641.66 and 1851.94 ha respectively. Within different forest types, Moist deciduous (3747.89ha) faces the major threat from encroachment followed by Semi evergreen (1032.87ha) and Acacia plantation (615.13ha). The encroachment is mainly an outcome of increase in population that results an increase in the needs of the people. The people living in the area have mainly used the forest land for establishing new agricultural fields, areca-coconut gardens and built ups (urbanization). The forest area in Uttar Kannada has decreased drastically from 742061.18 ha to 734989.49 ha excluding Dandeli Wildlife Sanctuary.

Forest encroachment will result in several ecological and economic effects. The ecological effects of forest encroachment will include;

- Reduction in the forest cover.
- Forest fragmentation.
- Reduction in forest biodiversity.
- Changes in vegetation type (composition and abundance)
- Curtailment of natural regeneration of the forest.
- Destruction of Ecosystems/Habitats.
- Species extinction.

The economic effects of forest encroachment will include;

- Reduction in the Total Economic Value (TEV) of the forests.
- Increases the cost of Forest Management.
- Reduction in the quality and quantity of products from forests.

If the present rate of encroachment is not controlled, it will result into more serious environmental problems and shortages of forest products. Forest encroachment affects agricultural productivity of the area due to reduction in water table, as forests have direct role in the precipitation of the region.

7. CONCLUSION

The land cover analysis of Uttar kannada revealed an increase in the non vegetation area from 2.76% (1979) to 16.66% (2013) with substantial decrease in the vegetation from 97.24% to 83.34%. The analysis of land use dynamics revealed the loss of evergreen forest from 1979 to 2013. The forest transition showed that evergreen forest cover has decreased from 57.15 % (1979) to 32.52% (2013) whereas agriculture land as well as built-up area has increased. The rate change analysis of land use showed that the rate of evergreen forest loss has increased from 1.50% (1979-1999) to 1.88% (1999-2013). It also exposed that the rate of increase in the built up and agriculture land has decreased from 4.33% & 1.58% (1979-1999) to 2.17% & 0.19% (1999-2013) respectively.

Forest fragmentation model showed that interior forest has declined from 51.83% to 25.63% (from 1979 to 2013) i.e. 26.20% of interior forest has been lost during this time period . Patch forest which was only 0.76% in 1979 has increased up to 2.98% in 2013. The analysis showed an increase in non-forest area from 24.57% to 45.75% during this time period which is of major concern as it shows the rate at which forest area is lost in the district which is directly related to biodiversity loss. Large scale land cover changes involving the conversion of forests into other land use categories are one of the primary drivers of climate changes and biodiversity loss. The study carried out on forest encroachment in this area showed that the moist deciduous forest followed by Semi evergreen to evergreen forest experience the major threat from encroachment whereas the dry deciduous forest present in only two taluks of the district namely Haliyal and Yellapur is heading towards its complete eradication. Sirsi and Honnavar taluks are the regions where there is maximum forest encroachment as compared to other taluks of the district with 3641.66 ha and1851.94 ha of forest land encroached respectively.

8. Acknowledgements

The authors are grateful to Indian Institute of Information Technology and Management Kerala (IIITM-K), Indian Institute of Science Bangalore (IISC) and particularly Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science Bangalore, India for carrying out the study on the land use land cover change analysis of Uttara Kannada.

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