AN ASSESSMENT OF LANDUSE LAND COVER CHANGES IN ANAIMALAI TIGER RESERVE FROM 1987 TO 2017

Deivanayaki M*[1], Ezhilarasi N and Perumalsamy P*

*Ph.D. Research Scholar, Assistant professor
PG and Research Department of Zoology, Government Arts College (Autonomous),
Coimbatore – 641 018
Tamil Nadu, India

Abstract: The present study evaluates the changes in LULC pattern of Anamalai Tiger Reserve, Tamil Nadu, India. Landsat satellite imageries of different time periods, i.e. Landsat 5 and Landsat 8 were obtained from the United Nations of Geological Survey (USGS) Earth Resource Observation and Science Data Centre. Landsat 5 TM (Thematic Mapper) was used for the years 1987, 1997 and 2007 and the Landsat 8 OLI (Operational Land Imager) are used for the year 2018. The images of study area were classified into seven different classes. The results obtained from the LULC change, shows that agricultural land (21.39sq.km), grass land (0.03sq.km), open and scrub forest (327.02sq.km), settlements/Built-up land (5.20sq.km) and Tea plantation (4.95sq.km) had increased and the dense forest (-353sq.km) had decreased.

Key words – LULC changes, classification, Anamalai Tiger Reserve, GIS and Remote sensing

1. Introduction

Land use is defined as the arrangement, activities and inputs that people undertake on certain land type whereas land cover reflects bio-physical state of earth's surface (Moser, 1996). Land use changes affect key aspects of the earth's functioning, including a direct impact on global biodiversity (Sala *et al*., 2000). Information of LULC and conflicts supports the assessment of wildlife habitat and identification of current status of the study area. Now, advanced geospatial technologies have further improved the efficiency of mapping landuse and land cover type at different landscape level. Remote sensing technology and geographic information system provide an efficient method for assessing landuse issues and effective tool for landuse planning and modelling. The technique has been used extensively in the tropics for generating valuable information on the forest cover, vegetation type and landuse change (Forman, 1995). Applications of remotely sensed data made possible to study the changes in land cover in less time, at low cost with better accuracy (Kachhwaha, 1985), in association with Geographical Information System that provide suitable platform for data analysis, update and retrieval (Star *et al.*,1997; McCracker *et al.*,1998; Chillar, 2000). Thus, integration of these techniques forms a potential tool for landuse land cover and change detection.

Few research works on this LULC were done in India which includes the research work on Coimbatore forest division and adjoining villages with special references to elephant migratory route from 1990 to 2010 by Ramkumar (2014). A landscape-level assessment of Asian elephant habitat, its population and elephant-human conflict in the Anamalai hill ranges of southern Western Ghats studied by Baskaran *et al*., (2013). An assessment of present study is important to develop effective management plan with appropriate actions to manage the wildlife with respect to its ecological, economic and cultural resources and to reduce HWC through feasible mitigation measures and create harmony ensure the human wildlife co-existence. Hence, this present study has undertaken in order to understand the land use and land cover changes over time (LULC changes) in Anamalai Tiger Reserve and its fringe by using remote sensing and GIS technique for 30 years from 1987 to 2017.

2. Study area and Methods

The Anamalai Tiger Reserve (ATR) falls within the Western Ghats mountain chain of South West India, a region designated as one of twenty-five Global Biodiversity Hotspots. It extends 76° 49.3' and 77° 21.4'E and latitudes 10° 13.2' and 10° 33.3 N and encompasses an area of 958.59 Sq.km and has reserve forest and protected areas on three sides bordering with Kerala and Tamil Nadu. Climatically, the study experiences and exhibits the widest variation in annual rainfall among its different parts with maximum 50 mm to 5000 mm rainfall. The tiger reserve supports diverse habitat types. Other unique habitats like mountain grasslands, savannah and marshy grasslands are also present. Considerable extent of man-made teak plantations, invasion of exotics like eucalyptus, wattle, pines. The biota of this region is not only highly diverse, it is distinctive with over 2000 species of plants and over 600 species of vertebrates. ATR is divided into six ranges and 32 divisions, the ranges include, Manombolly, Pollachi, Ulandy, Udumalpet, Amaravathy and Valparai. The Northern boundary of the reserve opens into the plains of Pollachi and Udumalpet Taluks, it shares the boundary with human habitations, farm lands and few villages. The 10 km of these regions announced as buffer zone. (Fig.1).

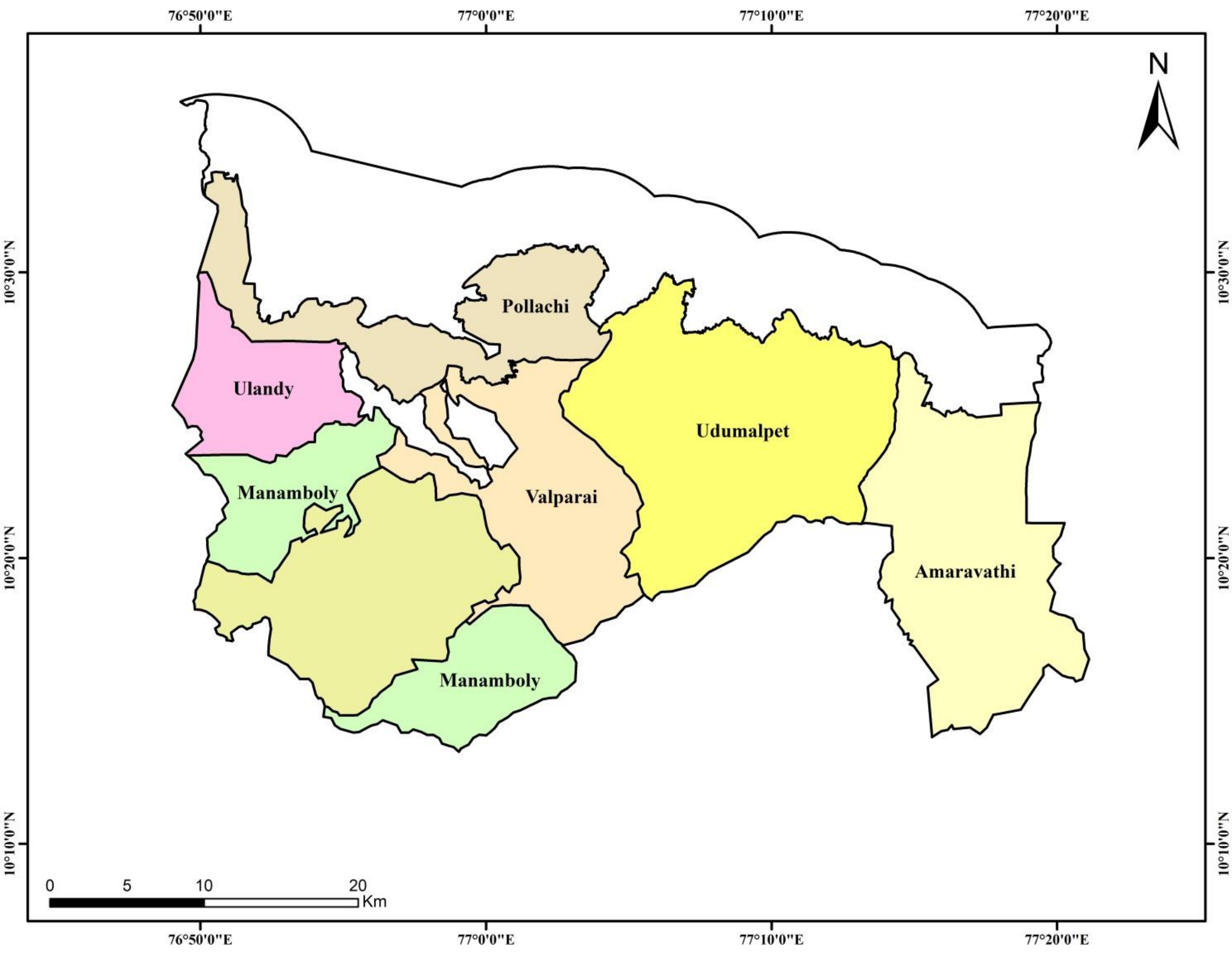

Figure 1. Map of study area with buffer zone

3. Methodology

The present work was carried out to analyse the various landuse changes in the ATR. Due to rapid urbanization, industrialization as well as agricultural expansion the landuse pattern of the study area has been affected over the years. The LULC map for the years 1987, 1997, 2007 and 2017 were prepared from Landsat data using visual interpretation techniques in ArcGIS 10.1. The classification was done based on the National Remote Sensing Centre (NRSC) classification. The area estimation was calculated in sq.kms. This was done for the entire duration for the study area. Therefore, the changes were identified for about 30 years duration.

3.1. Data and Software used

In this study, two satellite images of multi-spectral and multi-temporal satellite data namely Landsat 5 and Landsat 8 were obtained from the United Nations of Geological Survey (USGS) Earth Resource Observation and Science Data centre (http://www.usgs.gov). Landsat 5 TM (Thematic Mapper) was used for the years 1987, 1997 and 2007 and the Landsat 8 OLI (Operational Land Imager) are used for the year 2018. These images were acquired with relatively clear sky (cloud coverage less than 10%). The images were layer stacked and a False Colour Composite (FCC) was prepared from the layer stacked data using ENVI 4.8 software. The datasets are opened in ArcGIS 10.1 and by using visual interpretation techniques data are interpreted and landuse land cover classification was done. The technical specifications of the Sensors are given in Table 1 & 2.

Table 1. Technical specification of the satellite data

S.No.	Date of Acquisition	Data	Sensor Type	Entity ID	Spatial Resolution
1	19.01.1987	Landsat 5	TM (Thematic Mapper)	LT05_L1TP_144053_19870119_20170210	30 meter
2	04.06.1997	Landsat 5	TM (Thematic Mapper)	LT05_L1TP_144053_19970604_20161231	30 meter
3	27.12.2007	Landsat 5	TM (Thematic Mapper)	LT05_L1TP_144053_20071227_20170111	30 meter
4	18.01.2017	Landsat 8	OLI(Operational Land Imager)	LC08_L1TP_144053_20170118_20170311	30 meter

Table 2. Software used

Software	Function
Arc GIS 10.2	Preparation of Thematic map. Data base generation & Analysis

3.2. Land use/land cover classification

The landuse/ land cover classification was done for about 30 years duration using Landsat satellite data. A total of seven classes were classified in the study area. The LULC of agricultural land, dense forest, grass land, open/ scrub forest, settlements/built up land, tea plantation and water body (Table 3). Landuse map for the years 1987, 1997, 2007 and 2017 have been created using ArcGIS 10.1 software for landuse change analysis. The classification was done based on the classification formulated by National Remote Sensing Centre (NRSC). By using visual interpretation technique digitization of different features has been done using the polygon tool in ArcGIS software. After the digitization the polygons are grouped based on the classes using the dissolve option. Finally, area calculation was done. This technique is followed for all the corresponding years. The steps followed for the analysis are; (Fig 2).

Table 3. Classification scheme adopted for this study

S.NO	Land use/Land cover classes	LULC class components
1	Agricultural Land	The land used for farming and for food production and other commercial and horticultural crops and fallow land
2	Dense Forest	It is an area bearing an association predominantly of trees and other vegetation types
3	Grass Land	Grazing land/Dense /degraded
4	Open and Scrub Forest	Moist and dry scrub area
5	Settlements / Built up Land	It is defined as an area of human habitation developed due to non-agricultural use and that which has a cover of buildings, transport, communication utilities in association with water, vegetation and empty lands.
6	Tea Plantation	Tea plantation
7	Water Body	Ponds, Rivers, Reservoirs, Streams etc.

Digitization of different classes using polygon tool

- Grouping using dissolve option
- Area calculation

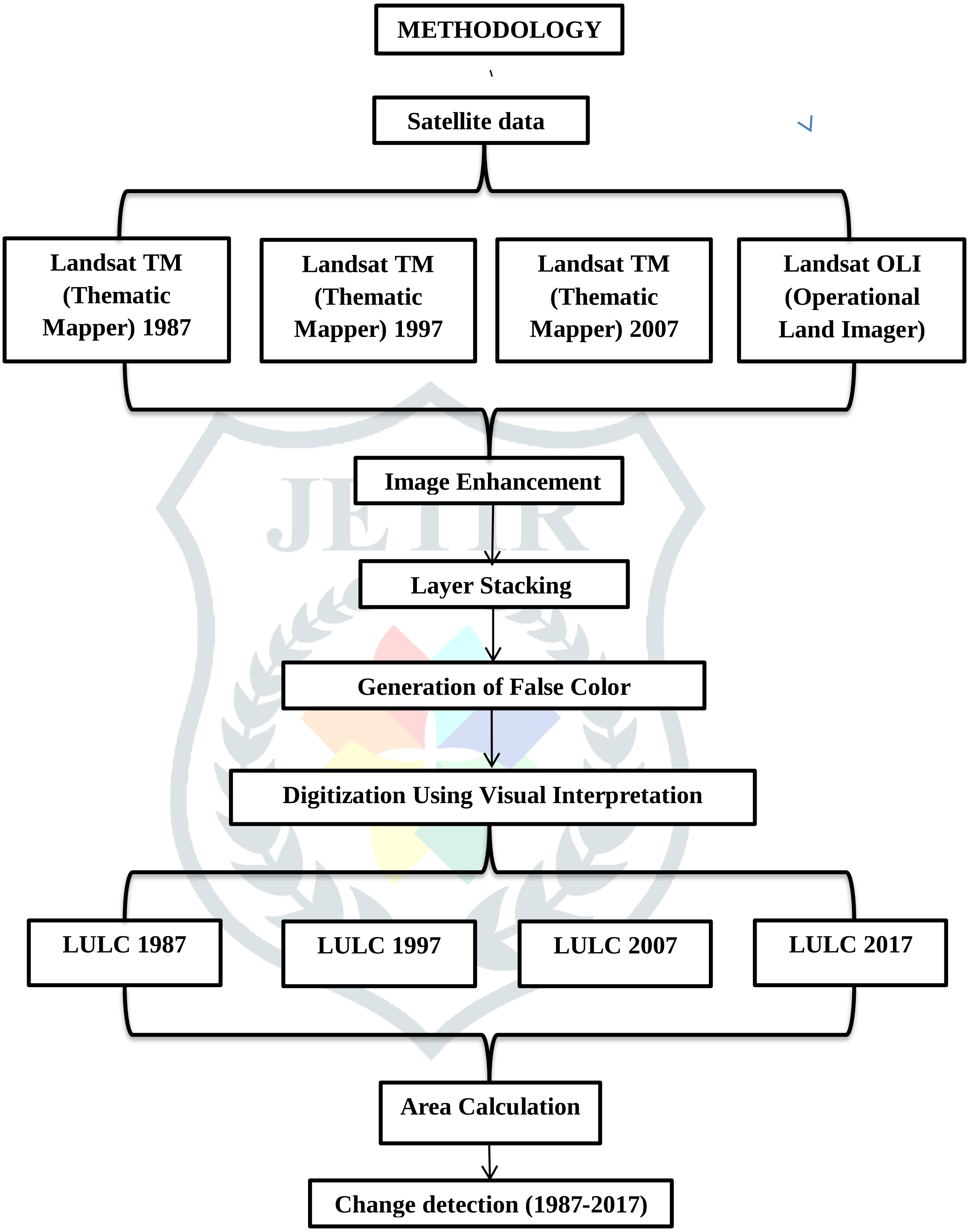

Figure 2. Methodology flowchart for LULC Change detection

4. Result and discussion

Land use/cover status

Change detection analysis is performed not only to detect changes that have occurred, but also to identify the nature of those changes and to determine the areal extent and spatial pattern of those changes. The changes in LULC were identified for 30 years. The results from the classification and the various changes between 1987 and 2017 in LULC were described below.

4.1. LULC 1987

The landuse land cover map for the year 1987 (Fig.3) was prepared from Landsat 5 TM satellite data. In 1987, most of the area in ATR covered by dense forest. The result from area calculation shows that dense forest occupied about 55.32 % of the total study area which was followed by the agricultural land about 24.95%. The scrub or open forest covers about 16.68%. Therefore about 97 % of the study area has only three features such as dense forest, agricultural land and scrub forest. Following this, the water body, settlements, grass land and tea plantation was presented. The areal coverage of these categories are 2.17%, 0.26%, 0.17% and 0.15% respectively. The areal coverage of the LULC features was shown in Table 4.

Table 4. Table shows the areal coverage of LULC classes in 1987

LULC type	Sq.km	Percentage (%)
Agricultural Land	337.807	24.95
Dense Forest	749.027	55.32
Grass Land	2.328	0.17
Open and Scrub Forest	225.81	16.68
Settlements / Built up Land	3.586	0.26
Tea Plantation	2.04	0.15
Water Body	29.431	2.17

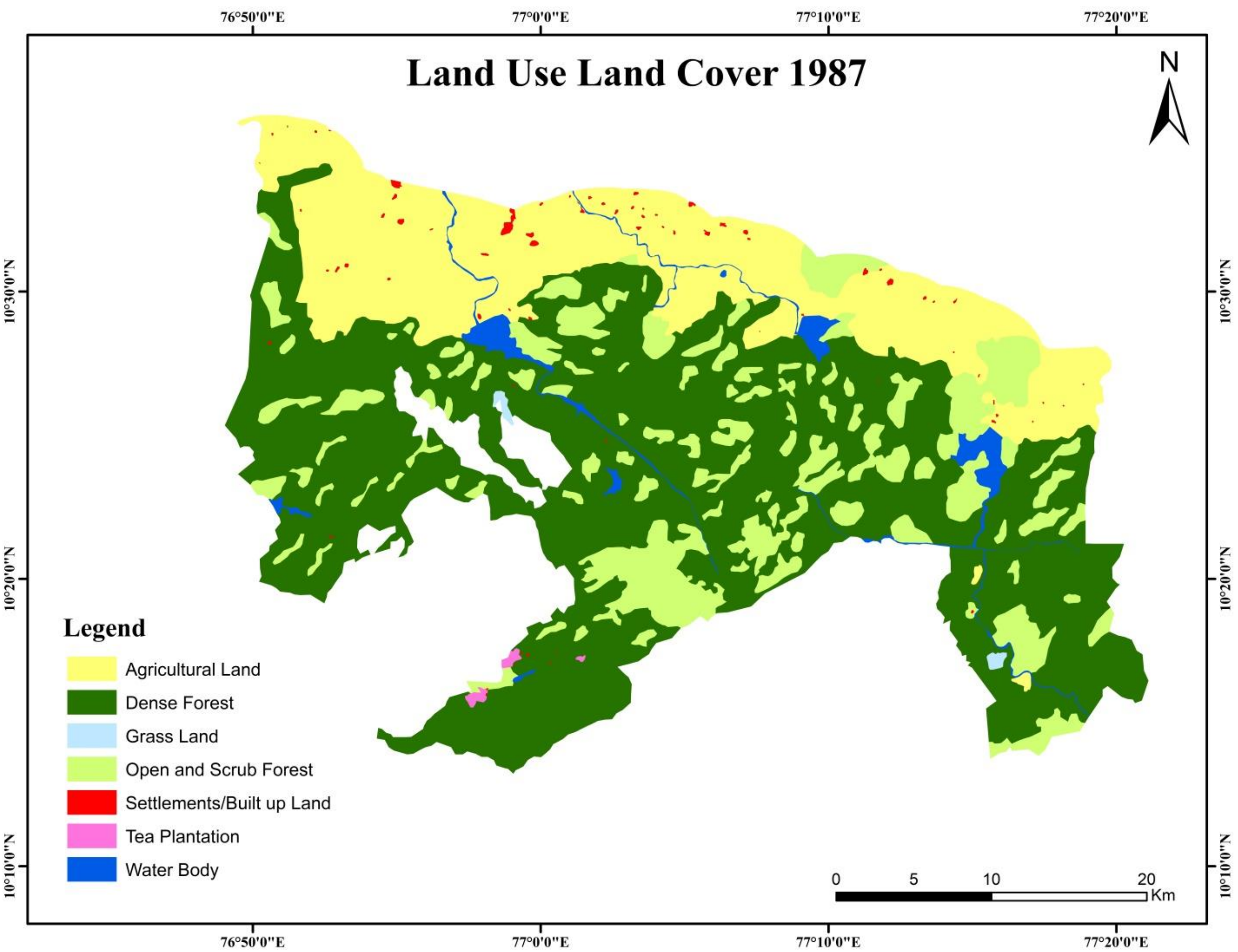

Figure 3. Map shows the LULC of 1987

4.2. LULC 1997

In the year1987, most of the area in ATR covered by dense forest (Fig 4). The result from area calculation for 1997 shows that dense forest occupied about 50 % of the total study area which was followed by the agricultural land about 26.29%. The scrub or open forest covers about 20.21%. From this result, we can understand that dense forest had decreased an there is an increase in agricultural land and scrub forest. Following this, the water body covers about 2%, tea plantation 0.36%, settlements covers about 0.11% and grass land covers 0.11 % of the total study area. The areal coverage of the LULC features were shown in Table 5.

Table 5. Table shows the areal coverage of LULC classes in 1997

LULC type	Sq.km	Percentage (%)
Agricultural Land	356.00	26.29
Dense Forest	679.22	50.16
Grass Land	1.55	0.11
Open and Scrub Forest	273.67	20.21
Settlements / Built up Land	4.54	0.33
Tea Plantation	4.83	0.36
Water Body	29.55	2.18

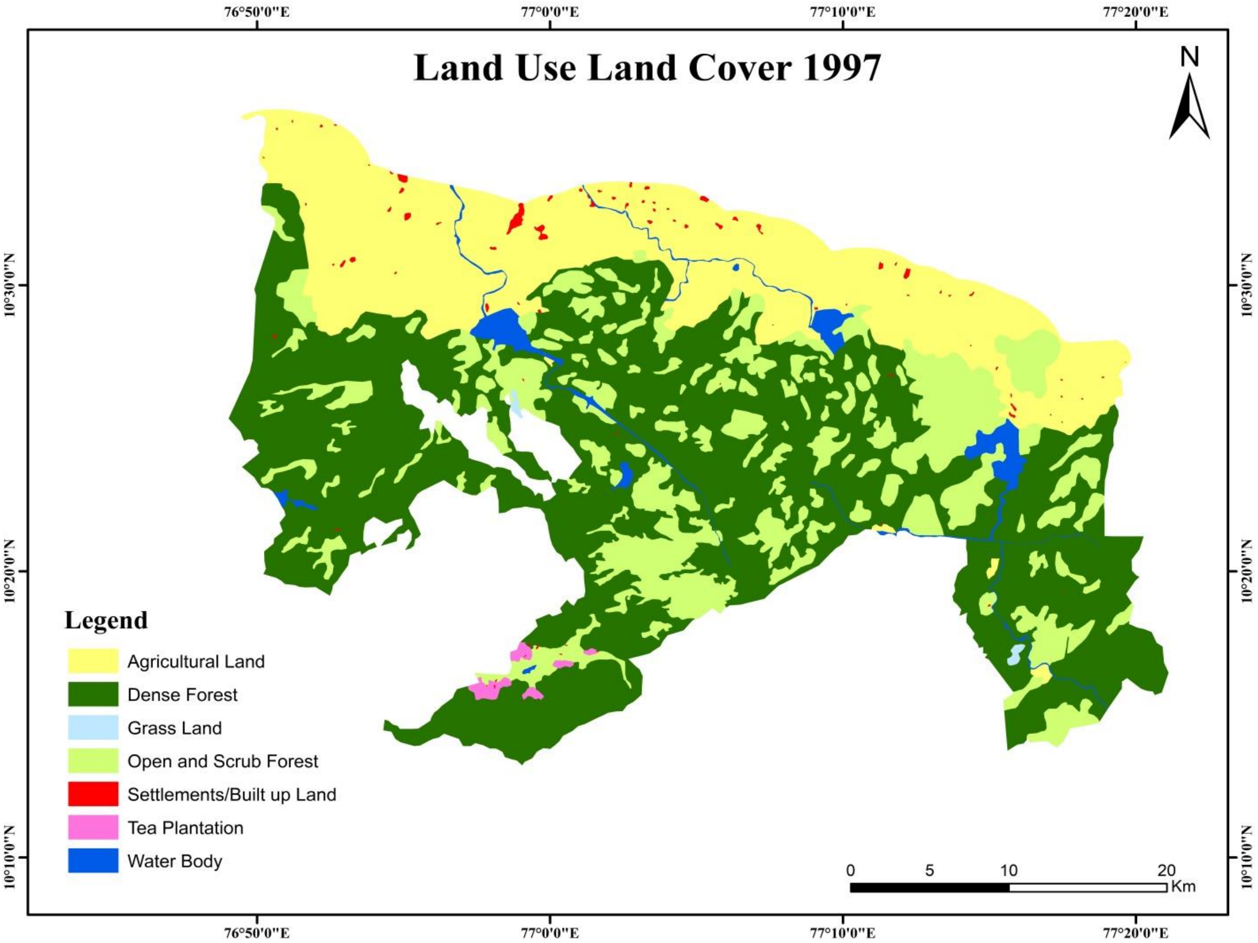

Figure 4. Map shows the LULC of 1997

4.3. LULC 2007

This map was prepared from Landsat 5 TM satellite data. In 2007 seven categories of land use classes were classified (Fig 5). The results shows that dense forest land covered about 43.24 %, agricultural land covers 26.29%, open or the scrub forest has 26.82% of the total area, water body covers 2.71%, grass land covers about 0.07%, settlements are 0.50% and plantation has 0.41% of the total area. The bar diagram and table 6 below gives us an insight about the variation in areal coverage. (Fig 6).

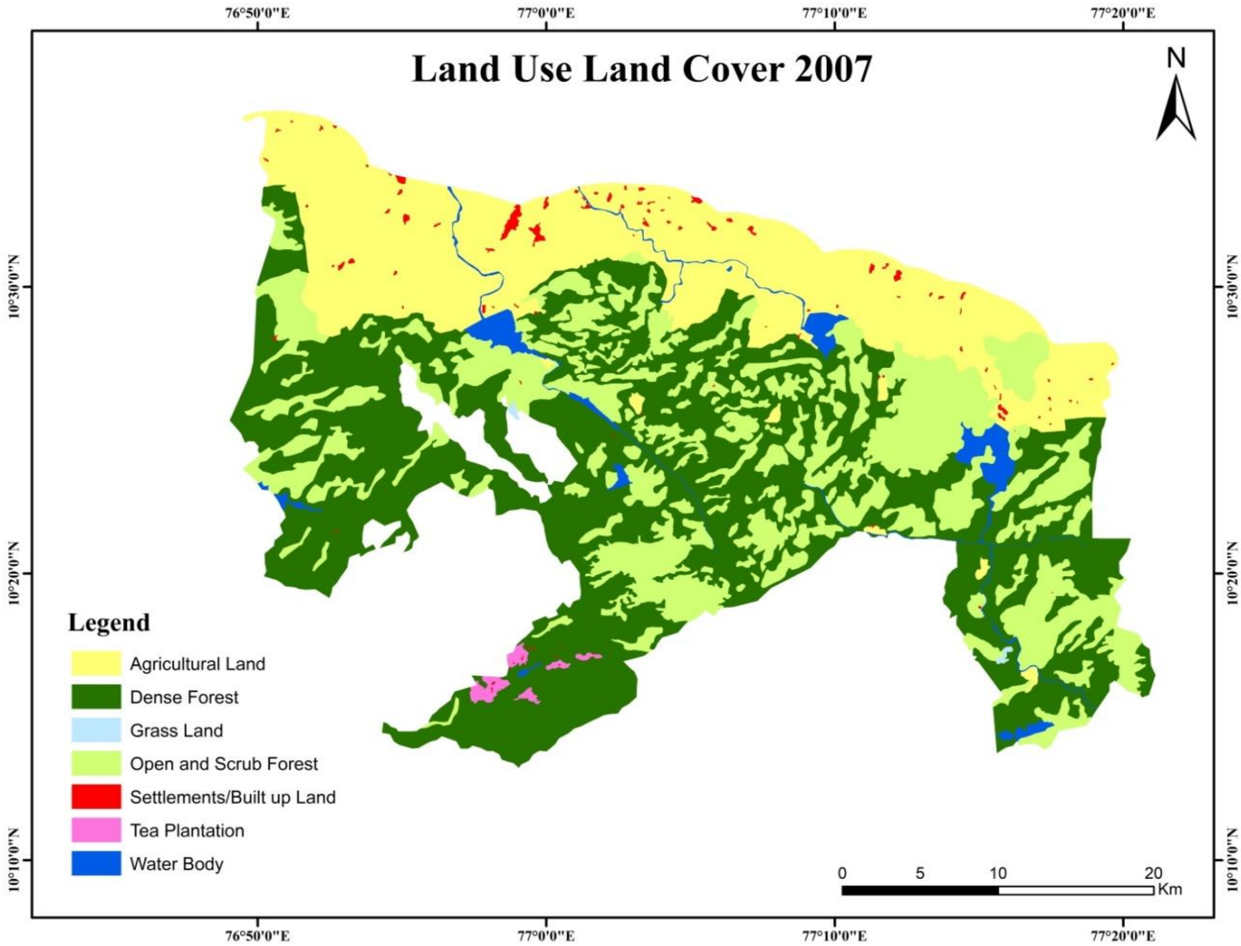

Figure 5. Map shows the LULC of 2007

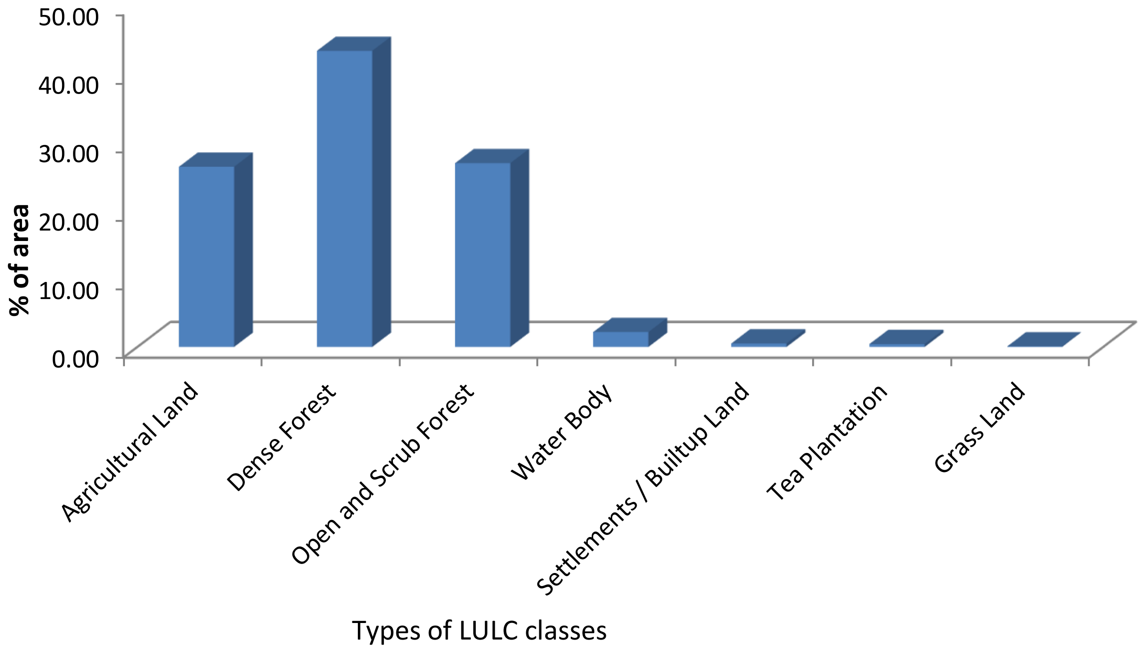

Figure 6. Percentage of area of LULC in 2007

Table 6. The rate of change of LULC for three decades in ATR and its buffer

LULC classes	Rate of change (Area in sq.km)			
	1987-1997	1997-2007	2007-2017	1987-2017
Agricultural Land	18.20	0.01	3.18	21.39
Dense Forest	-69.80	-93.74	-190.20	-353.74
Grass Land	-0.77	-0.55	1.36	0.03
Open and Scrub Forest	47.86	89.52	189.64	327.02
Settlements / Built up Land	0.95	2.22	2.03	5.20
Tea Plantation	2.79	0.77	1.39	4.95
Water Body	0.12	-0.22	-0.38	-0.48

4.4. LULC 2017

Similar to the above three years LULC map for the year 2017 (Fig 7 &8) was prepared from the Landsat data. During this period, most of the area in the study area was covered by forest land and agricultural land. In this, dense forest covers about 29.19%, the open forest covers 40.83%, and agricultural land covers 26.53%. Among these three categories, the open/ scrub forest occupies most of the area. The water bodies, settlements, plantation and grass land covers only a small extent. The areal coverage of water bodies is 2.14%.

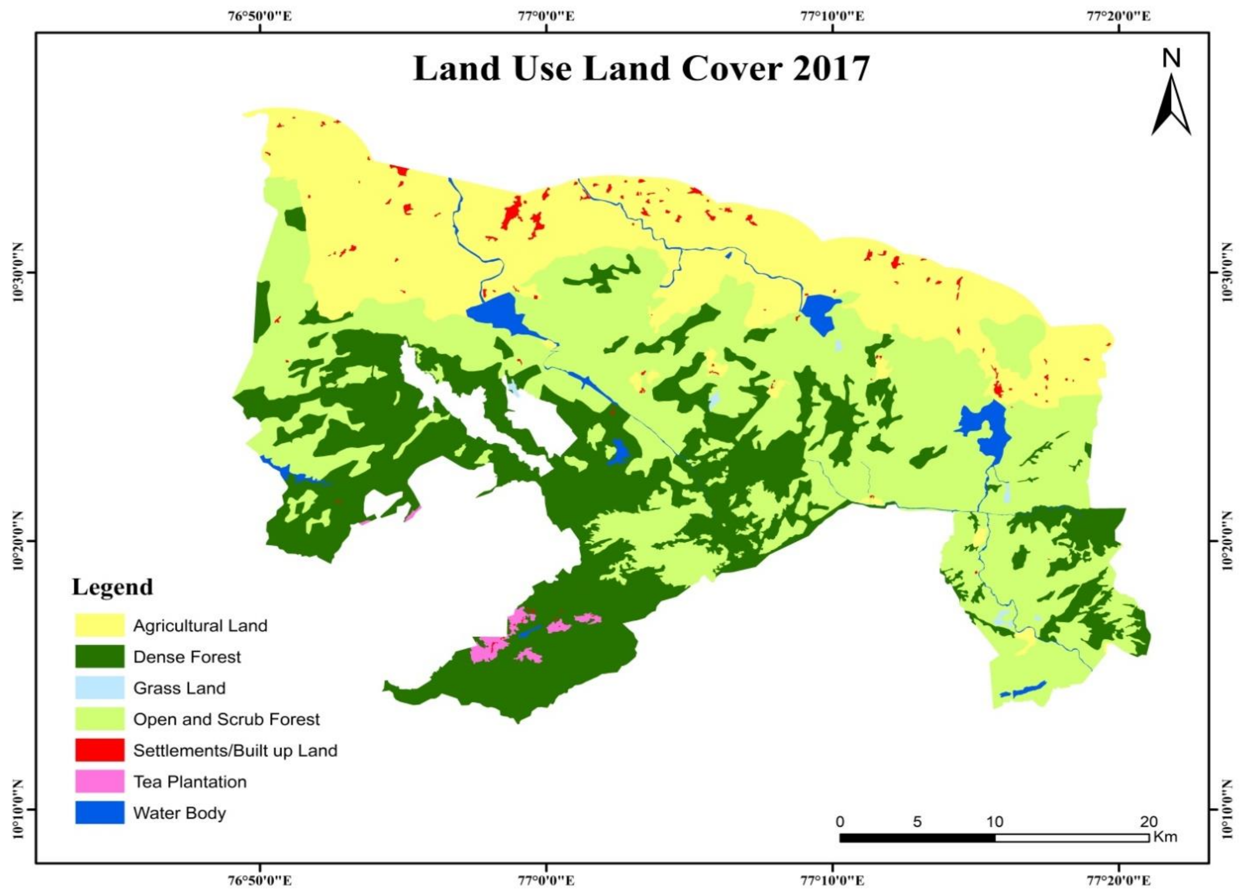

Figure 7. Map shows the LULC of 2017

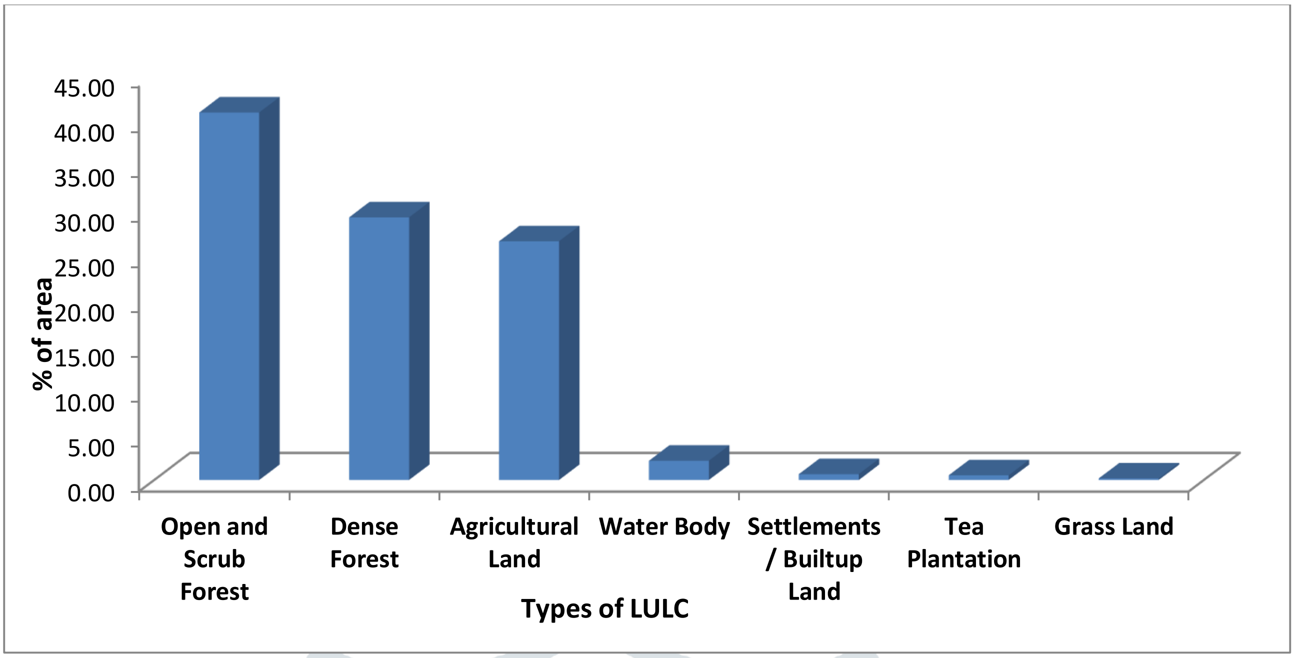

Figure 8. Percentage of area of LULC in 2017

Discussion

LULC detection is very essential for better understanding of landscape dynamic during a known period of time having sustainable management. The study conducted in ATR, Tamil Nadu state (India) advocates that multi temporal satellite imagery plays a vital role in quantifying spatial and temporal phenomena which is otherwise not possible to attempt through conventional mapping. This study deals with the change in land use pattern and vegetation cover using satellite imagery. Both the land use as well as the vegetation shows a drastic change during the study.

From the results obtained from the LULC change we came to know that, agricultural land, grass land, scrub forest, settlements and plantation had increased. Also, the dense forest and water bodies had decreased. In case of agricultural land it was increased about 18.2 sq.km during 1987-1997, then again increased about 0.01 sq.km in 1997-2007 and finally during 2007-2017 it was increased about 3.18 sq.km. The major raise of agricultural land was during 1987-1997. When taking the settlements during 1987-1997 it increased about 0.95 sq.km, in 1997-2007, 2.22 sq.km of area was increased and during 2007-2017, 2.03 sq.km of area was increased and in total it is observed that 5.2 sq.km of area was increased in the built-up land. It shows the increase in population in the study area during the last two decades.

Agriculture is the main occupation of the people those who are residing in and around the ATR. In the, higher elevation like Valparai most of the people occupied as labour in tea, coffee and cardamom, plantation whereas north-eastern part of the ATR dominated by some cereals and cash crops. The present study observed that agricultural land has increased about 21.39 sq.km in the last three decades. Similar result observed by survey of India (2008) it reports that increment of 0.6 sq.km agriculture/fallow/barren lands since 1973 at the expense of forest and grassland in the same study area. The same observation was reported by Geist and Lambin (2002) that agricultural expansion is, by far, the most important land use change associated with deforestation globally. The increase in agriculture area came from forest, scrub-land and shifiting cultivation with 32.815 of forest land which was converted into shifting cultivation and agriculture. The plantation also shows 4.95 sq.km of increase in area. It shows a rapid increase in the change. Conversion of forest land and Agri land into plantation showed drastic changes. Between 1987-1997 plantation is increased 2.79 sq.km, then in 1997-2007 it is increased 0.77 sq.km and during 2007-2017 it is increased about 1.39 sq.km whereas in the case of water bodies showed decreased.

Survey of India (2008) estimated that natural forest cover in this study area between periods of 1973-2006 was degrading at the rate of 0.07% annually while regenerating at a rate of 0.03%. This results a negative rate of change of 0.04% per year. This was lesser than previous estimates available for the region. For example, Menon and Bawa (1997) estimated an annual rate of decline of 0.57% in the whole Western Ghats during 1920- 1990 and a study conducted by Jha *et al*., (2000) estimated a decline of 1.16% per year during the period of 1973-1995. Prasad *et al*., (1998) estimated an amount of 0.9% during the period of 1961-1988 in the Kerala part of Western Ghats.

Conclusion

The study has assessed LULC changes in Anamalai Tiger Reserve, by using GIS and RS technique for 30 years. ATR was found to have experienced rapid changes in LULC, particularly in dense forest/Agricultural land/Settlement/Tea plantation. The result reveal that, in these three decades the dense forest had decreased a lot also the scrub forest, agricultural land, grass land, scrub forest, settlements and plantation had increased. The study concludes that there has been change occurred in dense forest and it has converted into other categories on account growing population, agricultural expansion and other unplanned developmental processes. Therefore, it becomes very important to manage the LULC changes and conserve the resources through a regulated land use planning strategy for its sustainable development. And also, the present study illustrates that GIS and remote sensing technique is important and appropriate for quantification of spatial phenomena which is otherwise not possible to attempt through conventional mapping techniques. It is possible to detect the changes only by these technologies in less time, at low cost and with better accuracy.

Acknowledgement

The authors express their gratitude to Principal Chief Conservator of Forests for permitting us to work in Anamalai Tiger Reserve. We are highly grateful to our Chief Conservator of Forests for his support and encouragement. We extent our heartfelt thanks Forest Range officers, biologist and Office staffs of Anaimalai Tiger Reserve for their valuable support.

References

Baskaran, N., Kannan, G., Anbarasan, U.,Thapa, A., and Sukumar, R. (2013). A Landscape –level assessment of Asian elephant habitat, its population and elephant-human conflict in the Anamalai hill ranges of southern India. *Mammalian Biology:* 78 (2013): 470-481.

Bhuju, D.R., Yonzon P.B. and B Baidya, B.M. (2007). Land-use pattern and its change in the eastern Churiya hills of Nepal Himalaya. *Ecoprint*: 14: 65-71.

Chilar, J. (2000). Land cover mapping of large areas from satellites: status and research priorities. *l International Journal of Remote Sensing*: 21(6-7): 1093–1114.

Forman, R.T.T. (1995). Land mosaics: The ecology of landscape and region. Cambridge university press, Cambridge UK.

Kachhwala, T S. (1985). Temporal monitoring of forest land for change detection and forest cover mapping through satellite remote sensing. In: Proceedings of the 6th Asian Conference. On Remote Sensing. Hyderabad, pp 77–83.

Geist, H.J. and Lambin, E.F.2002. Proximate causes and underlying driving forces of tropical deforestation. *BioScience* 52 (2):143-50.

Jha, C.S., Dutt, C.B.S. and Bawa, K.S. 2000. Deforestation and land use changes in Western Gats, India. *Current Science*,79 (2): 231-238.

Menon, S and Bawa, K.S. (1997). Applications of GIS, remote sensing and landscape ecology approach to biodiversity conservation approach in the western ghats. *Current Science* 73:134-145.

McCracken, S.D., Brondizio, E.S., Nelson, D., Moran E.F., Siqueria, A.D., Rodrifuea-Pedraza, C. 1999. Remote Sensing and GIS at farm property level: demography and deforestation in the Brazilian Amazon.Photogr.Eng. *Remote Sense* 65 (11):1311-20.

Prasad, S.N., Vijayan, L., Balachandran, S. Ramachandran, V.S., Vergheses, C.P.A. (1998). Conservation planning for the Western Ghats of Kerala: I.A.GIS approach for location of biodiversity hotspots. Current Science 75 (3): 211-219.

Ramkumar, K (2014). Studies on the human-elephant conflict with special references to land use land cover changes in elephant migratory route of the Coimbatore forest division, Tamil Nadu. India PhD Thesis.

Sala, O. E., Chapin, F. S., Armesto, J. J., (2009). Global biodiversity scenarios for the year 2100.

Star, J.L., Estes JE, McGwire KC, (1997). Integration of geographic information systems and remote sens ing. New York, NY: Cambridge University Press.