CHANGE DETECTION OF FOREST COVER IN MANNAR DISTRICT BY LANDSAT IMAGES

R.Ramya[1] and D.D.D. Weragodatenna [2]
[1]Vavuniya Campus of University of Jaffna, Kurumankadu, Vavuniya, Sri Lanka, Email: ramyaastro91@gmail.com
[2]National Aquatic Resource Research and Development Agency, Crow Island, Colombo 15, Sri Lanka, Email: dddilhari@gmail.com

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ABSTRACT: Sri Lanka is bestowed with natural resources, including substantial amount of forest cover. However due to the growth of population deforestation is occurred at most of the places. Therefore, Assessment of forest cover is vital to manage the forest resources in a sustainable manner. This study was attempted to analyse the spatial and temporal changes of forest cover using remote sensing technology during a 27 year period expanding from 1988 to 2015 in Mannar district. Landsat imageries acquired in 1988, 2010 and 2015 were analysed. Remotely sensed data were pre-processed. Radiometric corrections were made in order to monitor terrestrial surfaces over time and make multi-date image datasets comparable in terms of radiometric scale. Absorption and scattering of the imageries were removed at the atmospheric correction process. Unsupervised classification was performed on a series of input raster bands using the Iso Cluster and Maximum Likelihood algorithms. Change detection was performed by matrix function. Thermal band data of the imageries were converted to effective at-satellite temperature from spectral radiance. The analysis shows that totally 15,839 ha of forest cover exist at present in the study area. Significant net reduction in forest cover by 8.5% can be observed during the study period. The forest cover had deforested by 699.3 ha and 1365.3 ha from 1988 to 2010 and 2010 to 2015 respectively which is 12% of forest cover of 1988. It was observed that effective at-satellite temperature was high in barren land, roads and settlements and also increased in change detected areas after deforestation. Deforestation had mainly occurred in the Musali DS division as a result of urbanization and population growth.

1 INTRODUCTION

Forest biota constitutes one of the most precious resource to maintain the environmental balance. Sri Lanka is blessed with forest resources which are rich in endemic flora and fauna. This luxurious forest cover of Sri Lanka has also experienced a rapid decrease in last 100 years parallel to most of other regions of the world. Deforestation is accelerated due to urbanization, agricultural expansion, illegal logging. This strongly increases global warming and also leads to a reduction in biodiversity, disturbances in water regulation, and destruction of the livelihood of farmers. Most of these adverse environmental effects can be reduced by implementation of proper urban planning systems with sustainable solutions.

Over 50% of Mannar district is under forest cover; largely tropical dry mixed evergreen forest and dry thorny scrublands. Since forest is so vital for the existence of the ecosystem it is important to make predictions about the forest cover in the future to suggest appropriate policy measures.

Remote sensing provides a viable source of data from which updated land-cover information can be extracted efficiently and cheaply in order to maintain inventory and monitor these changes effectively. Thus change detection has become a major application of remotely sensed data because of repetitive coverage at short intervals and consistent image quality. This study aimed to assess the change detection of forest cover with the use of remote sensing techniques. Assessing this forest cover can be significantly important to protect and conserve the existing forest cover.

2 STUDY AREA

The study area covers most part of south region of Mannar District. Mannar District is bordered to the west by the Gulf of Mannar, to the north by Kilinochchi District, to the south by Wilpattu National Park and to the east by Anuradhapura District. It has a total land area of 2,002 km2 of which, over 50% is covered with forest. The district has a coastline of 222 km (including lagoons), a fresh water area of 4,867 ha and a brackish water area of 3,828 ha.

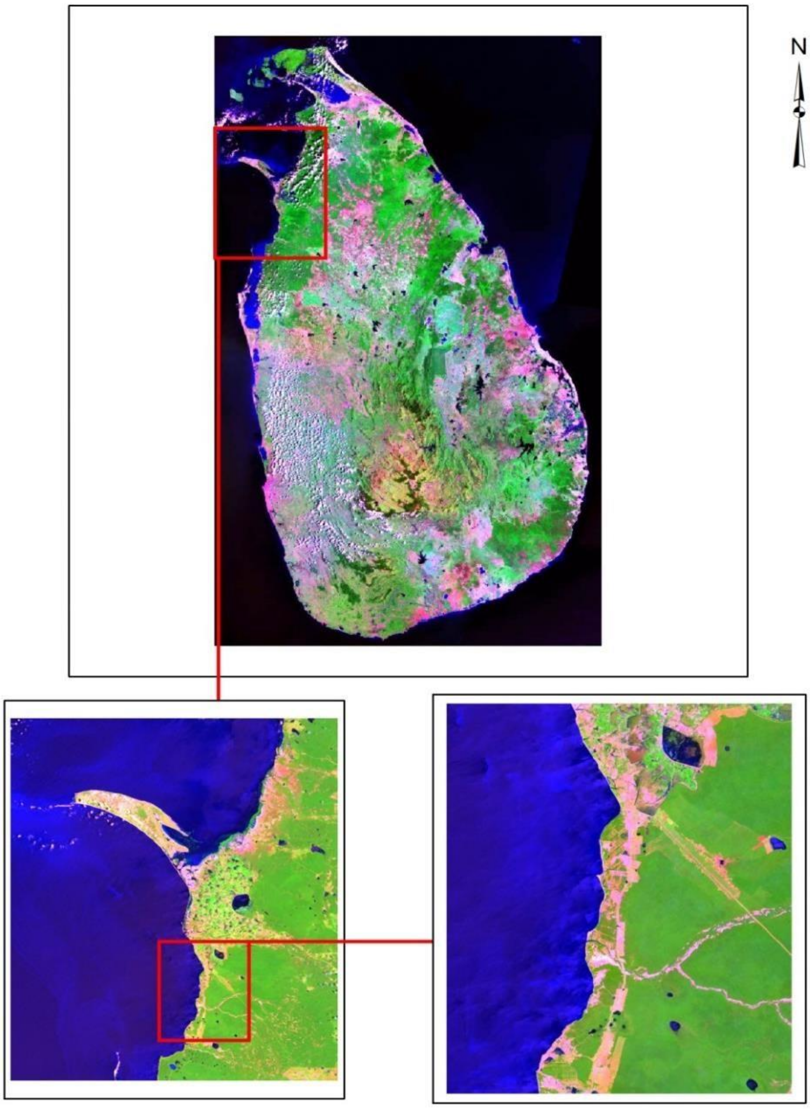

Figure 1Study area

3 DATA AND METHODOLOGY

Landsat images are the primary data source for the analysis of forest cover changes. In this analysis multi-temporal Landsat images were used (Landsat 5 & Landsat 8) since it is inexpensive, with high monitoring frequency and covers large areas appropriate for change detection analysis. Landsat images (for the 1988 and 2015 periods) have been acquired from the USGS archive freely. And three clear, cloud free Landsat images (Path = 142, Row =054) were selected to classify the study area for the years of 1988, 2010, 2015. The information of image acquisition is listed in the table below. These satellite images have undergone Standard Terrain Correction (Level 1T) processing. The processed images were geo-referenced using WGS84/UTM Zone 44 N projection system. The Landsat has a temporal revisit time of 16 days and a spatial resolution of 30 m, panchromatic resolution 15m.

Satellite scene	Sensor ID	Date acquired	Resolution
1. Landsat 5	TM	1988-02-06	30m, 15m(pan)
2. Landsat 5	TM	2010-02-18	30m, 15m(pan)
3. Landsat 8	OLI_TIRS	2015-03-20	30m, 15m(pan)

3.1 Image pre-processing

Dealing with multi-date image datasets requires that images obtained by sensors at different times are comparable in terms of radiometric characteristics. This is usually caused by the distortions of sensors. TM, OLI_TIRS sensors have different radiometric resolutions. Therefore, if those datasets are to be used for quantitative analysis based on radiometric information they have to be adjusted for radiometric divergence. The Image processing was performed using ERDAS Imagine.

3.1.1 Conversion of DN to radiance: Landsat Science Data Users Handbook describes the retrieval method of radiance. The digital number (DN) values of the bands of the 3 images were converted to spectral radiance values by using offset (bias) and gain values of the images

L_λ = Grescale * QCAL + Brescale

This is also expressed as:

$L_\lambda = ((LMAX_\lambda - LMIN_\lambda)/(QCALMAX-QCALMIN)) * (QCAL-QCALMIN) + LMIN_\lambda$

where *L*min is minimum spectral radiance, *L*max is maximum spectral radiance, QCALmin is the minimum quantised calibrated pixel value (corresponding to *L*min) in DN and QCALmin is the minimum quantised calibrated pixel value (corresponding to*L*min) in DN and QCALmax is the maximum quantised calibrated pixel value (corresponding to *L*max) in DN (Haibin et al., 2010, Li et al., 2012 and NASA, 2012). QCALmax, QCALmin, *L*max and *L*min values can be obtained from the header (metadata) files of the images.

3.1.2 Conversion to At-Satellite Brightness Temperature: TIRS band data can be converted from spectral radiance to brightness temperature using the thermal constants provided in the metadata file.(For Landsat 5, band 6 and Landsat 8, band 10 can be used)

$$K = \frac{K_2}{\ln(\frac{K_1}{L_\lambda} + 1)}$$

Where:
T = At-satellite brightness temperature (K)
Lλ = TOA spectral radiance (Watts/(m2 * srad * μm))
K1 = Band-specific thermal conversion constant from the metadata (K1_CONSTANT_BAND_x, where x is the thermal band number)
K2 = Band-specific thermal conversion constant from the metadata (K2_CONSTANT_BAND_x, where x is the thermal band number)

3.1.2 Radiance to reflectance: For relatively clear Landsat scenes, a reduction in between-scene variability can be achieved through a normalization for solar irradiance by converting spectral radiance, as calculated above, to planetary reflectance or albedo. This combined surface and atmospheric reflectance of the Earth is computed with the following formula:

$$P_\lambda = (\pi . L_\lambda . d^2) / (ESUN_\lambda . COS\theta_s)$$

Where; L and ρ are spectral radiance and reflectance, respectively. The subscript λ refers to spectral band λ, ESUNλ is the solar irradiance, θ is sun elevation and d is sun–earth distance. The most current exo-atmospheric solar irradiance values for the Landsat ETM were used in the radiance to reflectance conversion. The conversion from DN to reflectance value can substantially improve the quality of image.

3.1.3 Layer stacking: Radiometrically corrected each multispectral band was combined into single image for enhanced visualization and interpretation.

3.1.4 Atmospheric correction: Various atmospheric effects cause absorption and scattering of the solar radiation. Reflected or emitted radiation from an object and atmospheric scattering should be corrected. It is corrected using ATCOR2 tool. Sun and sensor geometries were modified according to the image recording conditions as extracted from the image's metadata.

3.1.5 Spectral band selection: Band selection is mainly required to improve the interpretability of information in images for human viewers. Forest area is better visualised in band 5, 4, 2 combinations in Landsat 5 scene and band 7, 5, 2 combinations in Landsat 8 scene. And the main advantage of this colour composite is that vegetation appears in green colour which makes the interpretation easier.

3.2 Image classification

Unsupervised classification was carried out using Iso Cluster algorithm for the multitemporal image in order to classify the image into 100 clusters and to identify potential change classes. The resulting classified image of the classification was displayed and examined in order to determine the land covers which corresponded to each cluster. Land cover classes considered were forest cover, non-forest land, water. These spectral classes were then assigned to the information classes which were the more important.

The radiometrically corrected images were classified using unsupervised classification and the spectral classes were merged according to the information classes. And the forest cover of study area in 1988, 2010, and 2015 were analysed and mapped. Extent of forest cover is calculated for each image in ERDAS IMAGINE and the difference and statistical analysis was performed using Microsoft Excel.

3.3 Change detection

Following the classification of imagery from the individual years, a multi-temporal image was used to determine changes in land cover in three intervals, 1988–2010, 2010– 2015 and 1988 –2015. Change detection was performed for the intervals of 1988-2010, 2010-2015 and 1988-2015. The resulted image was helpful for visual interpretation and to analyse the changes in spectral classes. Matrix show the changes in the two input images which is the images belongs to two years. It shows the areas changed from forest to non-forest and areas changed from non-forest to forest also. And other changes also can be identified from the matrix

4 RESULTS AND DISCUSSION

The results show that 17310.1 ha of forest area were present in 1988 in the study area and the extent of forest cover in 2010 was 16689.2 ha and it is 15839.3 ha in 2015. And a significant reduction in forest cover is observed from 1988 to 2015.

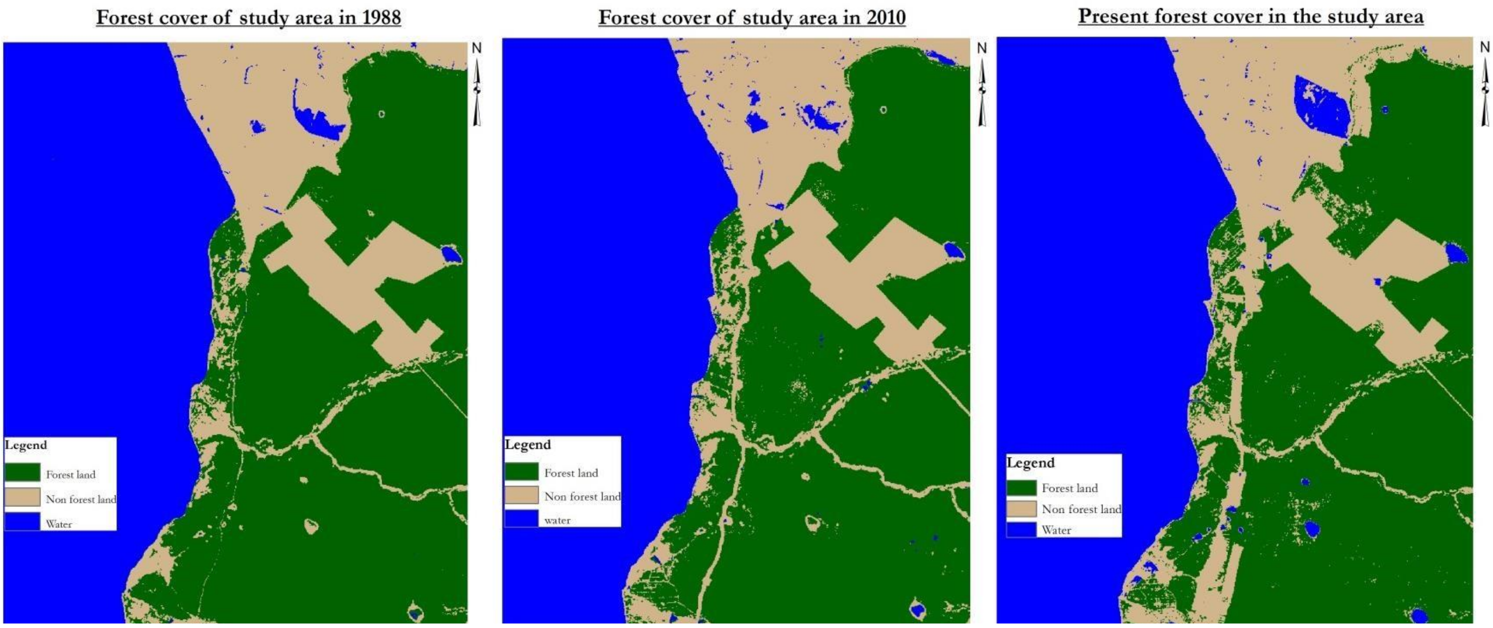

Figure 2 Extent of Forest cover

Table 1 Extent of forest cover

Years	Forest cover (ha)
1988	17310.1
2010	16689.2
2015	15839.3

The above shows the extent of forest cover calculated in each year. And a scatter graph is produced of above data to depict the changes in forest cover with years and the rate of deforestation is calculated.

Forest cover is declining over the years and slope of deforestation between 1988 -2010 is slow and there is a rapid declining in slope as it indicates fastest rate of deforestation in between 2010-2015

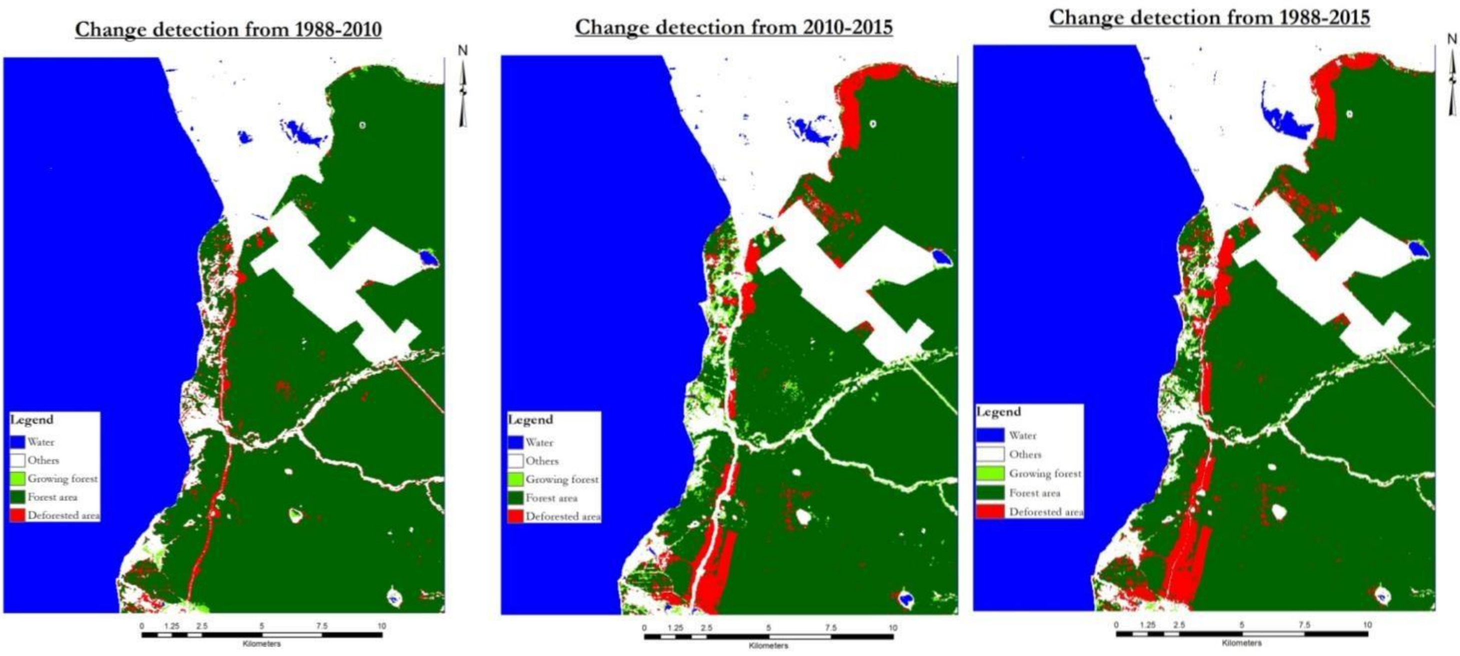

Figure 3 Change detection of forest cover in study area

The spectral classes of change detection map was analysed and the area was calculated for each class and the classes were identified. It was found that 699.3 ha of forest were cleared in between 1988-2010 and 1365.3 ha of forest were cleared in between 2010-2015. The reason may be population increase and urbanization.
The areas highlighted in red colour are the deforested area which is increasing over the years. And the rate of deforestation is calculated. It is 31.79 ha/year in the interval of 1988-2010 and 273.06 ha/ year in the interval of 20102015. The rapid increase in the deforestation could resulted due to the increased land clearance for settlements.

The below figure shows the LST in Celsius of study area. Study area had a high effective at satellite temperature in roads, barren lands, settlements. Temperature was observed to be increased in change detected areas.

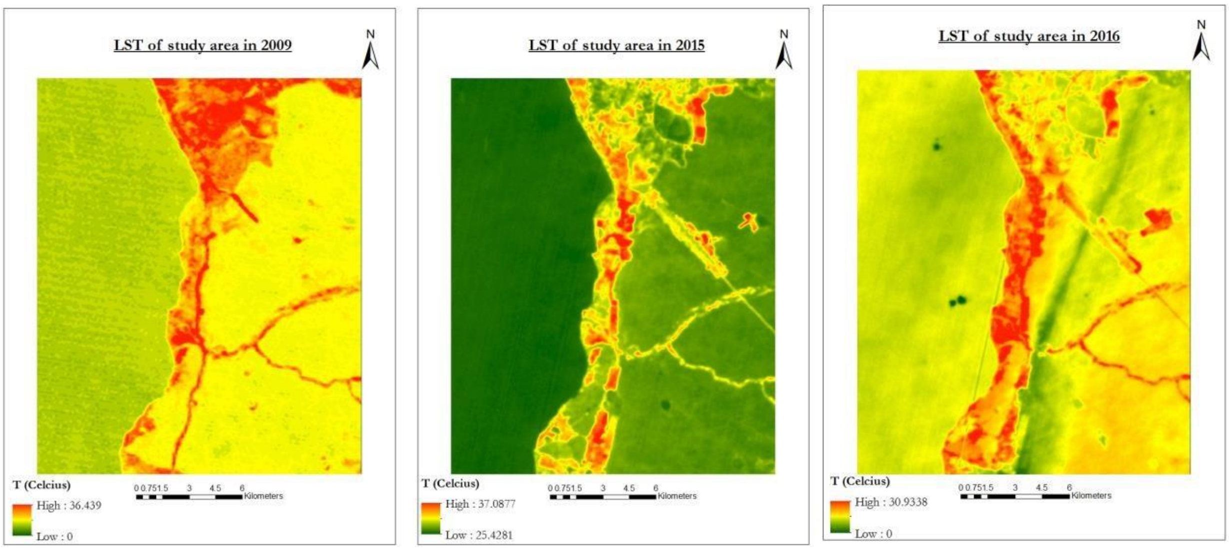

Figure 4 EST of study area

5 CONCLUSION

Changes in the forest cover were observed through the analysis. Forest cover seems to be declined over the years. It is observed that the forest cover rapidly declining during last interval. So, the rate of deforestation is higher during 2010-2015 interval. The major forest area was cleared for settlement purposes of migrated people.
Major deforestation is seen in the Musali DS division. Major quantity of forest was deforested for settlements and urbanization.

Effective at satellite temperature was increased in change detected areas. So, the degradation of forest ecosystem increases the temperature of environment.

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