Report on the RS/GIS Analysis to map Land Use and Land Use Change in Nagaon

Lowering Emissions and Enhancing Forests (LEEF) in Nagaon, Assam

IORA Ecological Solutions

participation, conservation, empowerment, livelihood security

ASSAM PROJECT ON FOREST & BIODIVERSITY CONSERVATION

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Assam Project on Forest and Biodiversity Conservation

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Abbreviations

AFOLU	Agriculture, Forestry and Other Land Use
APFBC	Assam Project on Forest and Biodiversity Conservation
DoEF	Department of Environment and Forests
EE	Executive Entity
ER	Emission Reductions
FDA	French Development Agency
GHG	Greenhouse Gas
GPS	Global Positioning System
IPCC	Inter-governmental Panel on Climate Change
LEEF	Lowering Emissions, Enhancing Forests
LULC	Land Use Land Cover
REDD	Reducing Emissions from Deforestation and Forest Degradation
RS/GIS	Remote Sensing/Geographic Information System
SDG	Sustainable Development Goals
UNFCCC	United Nations Framework Convention on Climate Change

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1 Development of Forest Reference Emission Level

1.1 Introduction

Reference emission levels are the benchmark compared to which the removals and emissions from all the carbon pools of the project will be compared and is measured in terms of carbon dioxide equivalent (CO_2e). Due to deforestation and forest degradation, there will be change/decrease in the land use type and canopy density while conservation, enhancement and sustainable management will lead to increase in the forest canopy density and quality. The baseline emissions in the year 2000 is considered as the reference year and emissions or reductions of CO_2e will be a benchmark to calculate any reductions that will happen until the baseline is updated, and is termed the Reference Forest Emission Level. This section details how the land use change has been mapped for this project to estimate the reference emission level for this REDD+ project.

1.2 Land Use Land Cover (LULC) Changes over the Historical Reference Period

Detailed geospatial and on ground field analysis was undertaken to identify and assess the actual and accurate changes in land use and forest canopy density in the project area over the selected historical reference period. Analysis on remote sensing platforms, backed up by field data validation, has been undertaken to accurately classify the LULC types in the district. This has enabled the development of maps for various aspects of analysis – LULC maps, forest strata maps and Fractional Cover maps, to map the deforestation and degradation over the historical reference period.

1.3 Methodology

The project area is the jurisdictional boundaries of the Nagaon District. Spatial analysis has been conducted along with corresponding field validation to successfully classify the different forest strata in Nagaon. Satellite imagery of the years 2000, 2006, 2010 and 2015 has been analysed to interpret changes in forest cover over time in the 15 years reference time period. A LULC analysis has been conducted and it is observed that the certain vulnerable patches of forestlands in Nagaon shall be deforested and/or degraded in a mosaic manner in the absence of the interventions proposed as part of the project activity.

- 0-3 years before the project initiation: 2015
- 4-9 years before the project initiation: 2010
- 10-15 years before the project initiation: 2006
- 15 years before the initiation: 2000

Table 1: Characteristics of the satellite imagery used

Data Source	Main Use of Data	Information about data collected		
Medium resolution of 30 m LANDSAT data of at least one image for 4-time periods				
Time Frame	Historical analysis of deforestation and forest degradation	0-3 years before project start date	4-9 years before project start date	10-15 years before project start date.
Year of Satellite Imagery		2015 (Landsat – 8)	2010 (Landsat-TM)	2006 and 2000 (Landsat – TM)
Sources		USGS Earth Explorer		
Type and Resolution (spatial and spectral)		Satellite imagery using visible (Green, Red), near-infrared bands (NIR), Shortwave infrared (SWIR). It is a multi-spectral data with a spatial resolution of 30m, operating in the visible, near infra-red, shortwave infra-red and thermal region.		
Coordinate system and pre-processing (If different sources of remote sensing data are used, a formal comparison of the sensors should be added to the monitoring report to ensure consistency)		WGS 84 – UTM zone 46N Layer Extent: 599872.62 690630.18 3113204.24 2995881.73 LANDSAT multi-spectral sensor with a spatial resolution of 30 m, operating in the visible, and near infra-red bands the shortwave infra-red band, with a swath 185 km.		
Minimum Mapping Unit (ha)	Training of classification procedures Independent verification of the analysis of historical images	≥1 hectare		
Description of method used to produce these data		The LULC maps for historical baseline have been classified using supervised approach with Maximum Likelihood Classifier (MLC).		
Descriptions of the LULC classes and/or LULC-change categories		The LULC classes or categories described are as follows: **1. App. Kamrup Sal Forest (AKS)** **2. East Himalayan Mixed Deciduous Forest (EMMD)** **3. Cachar Semi-Evergreen Forest (CSE)** **4. Bamboo Brakes** **5. Cropland** **6. Waterbodies** **7. Grassland** **8. Other Land** **9. Settlements**		

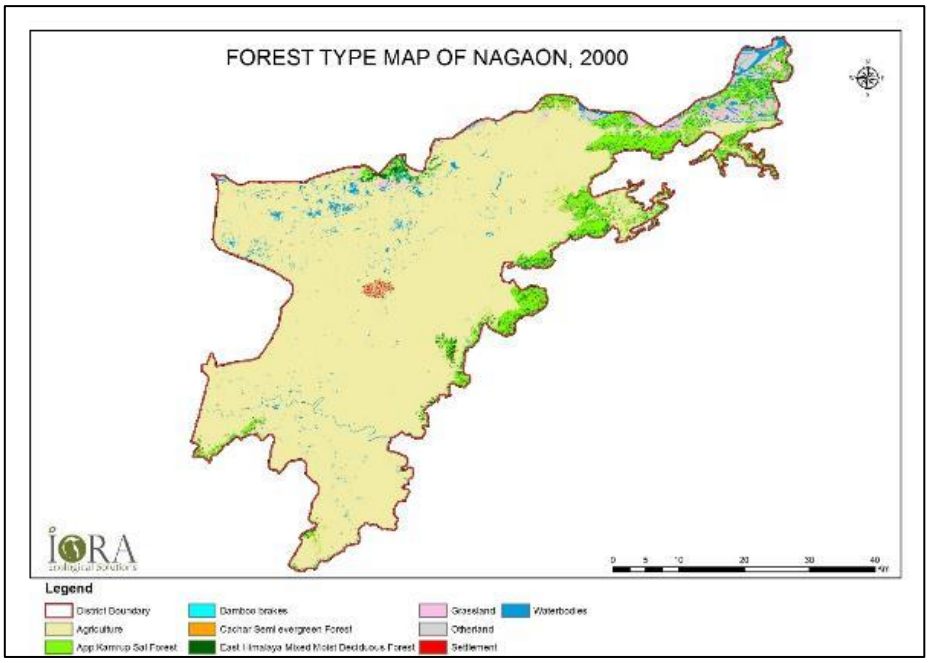

Figure 1: Forest type map Nagaon, 2000

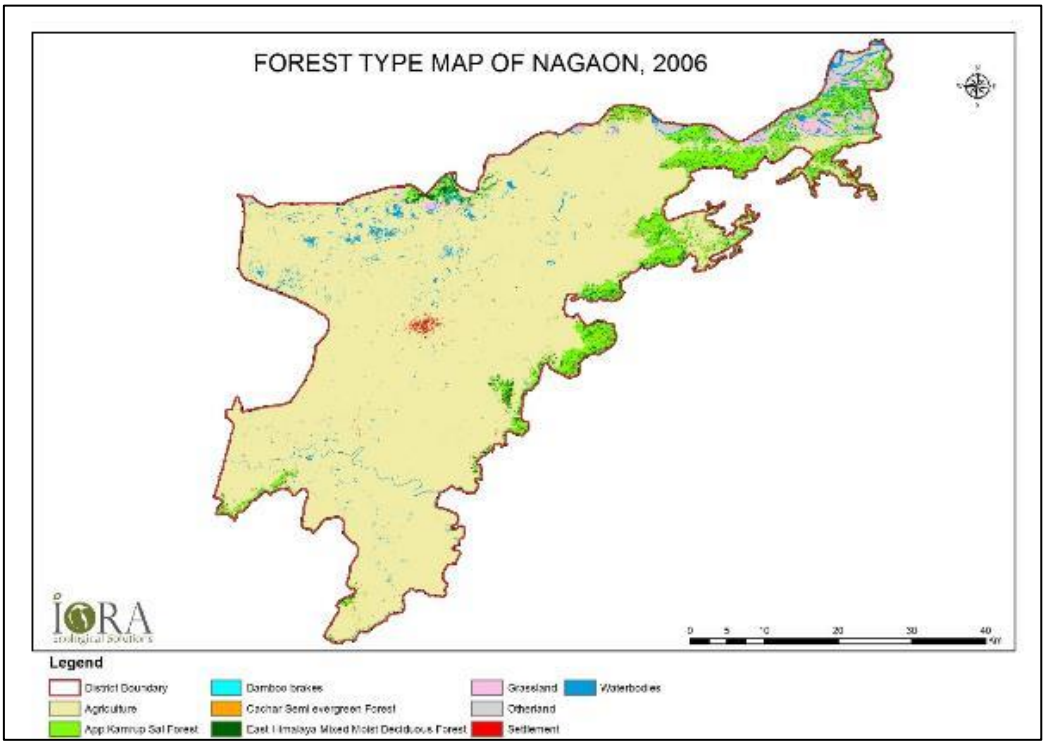

Figure 2: Forest type map Nagaon, 2006

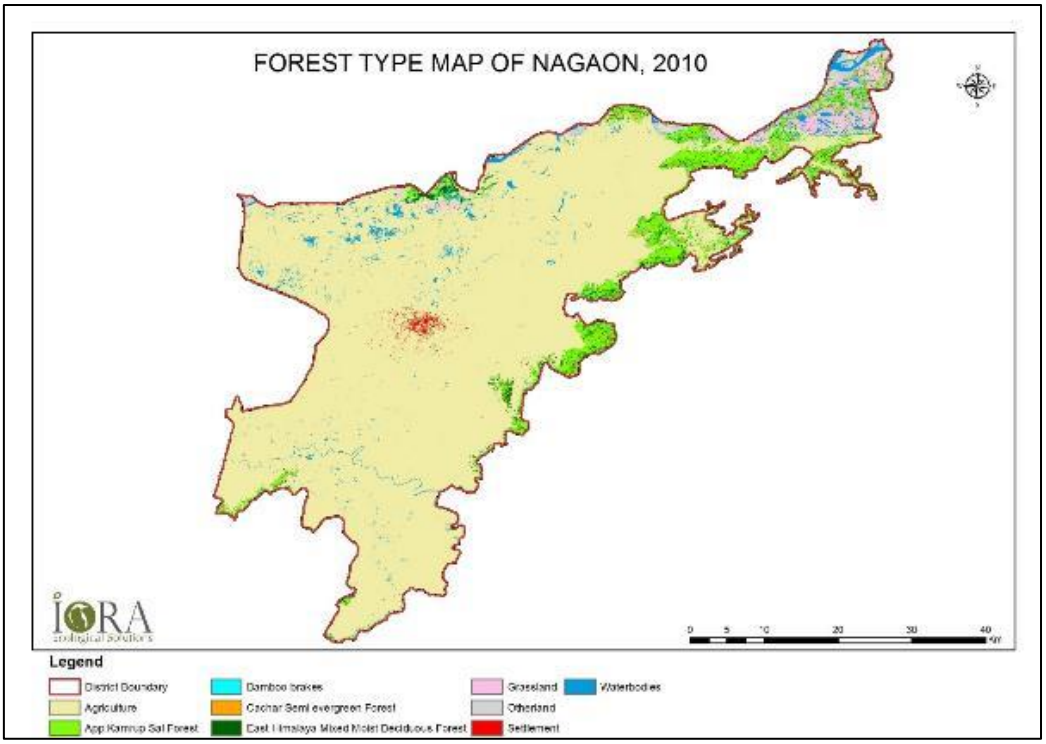

Figure 3: Forest type map Nagaon, 2010

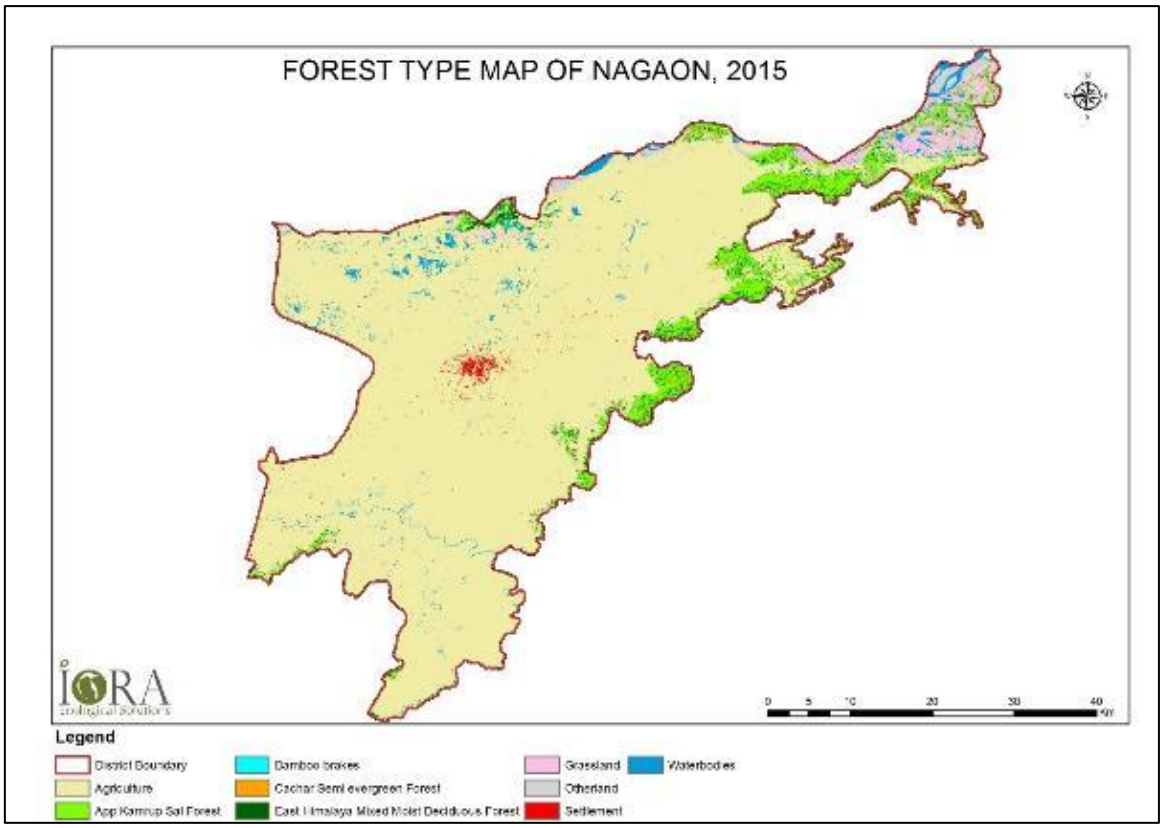

Figure 4: Forest type map Nagaon, 2015

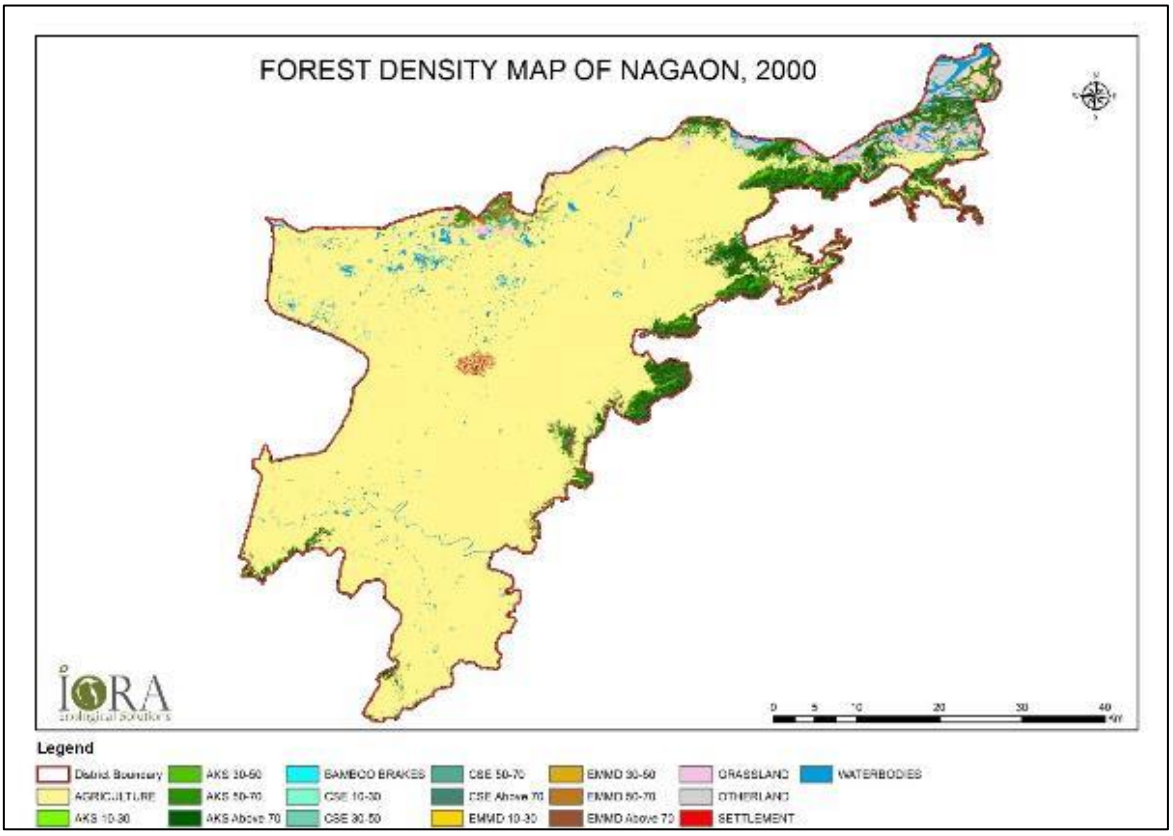

Figure 5: Forest density map of Nagaon, 2000

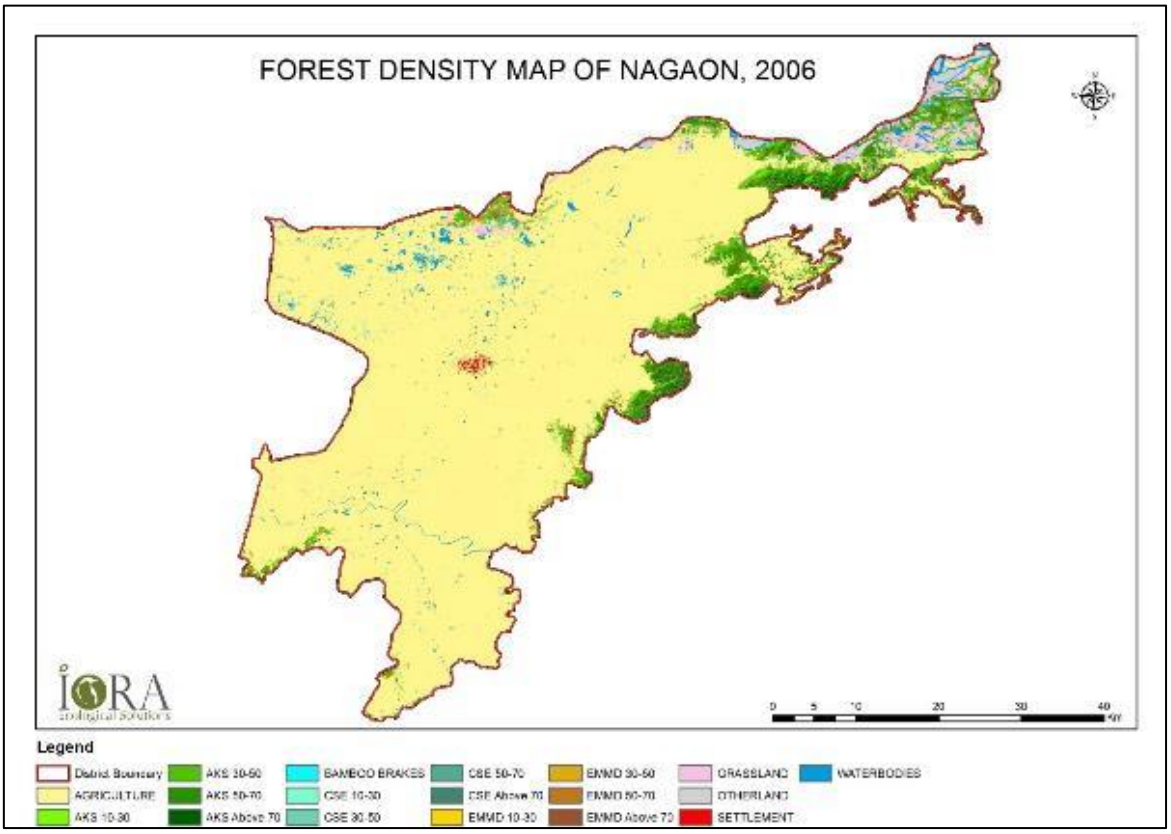

Figure 6: Forest density map Nagaon, 2006

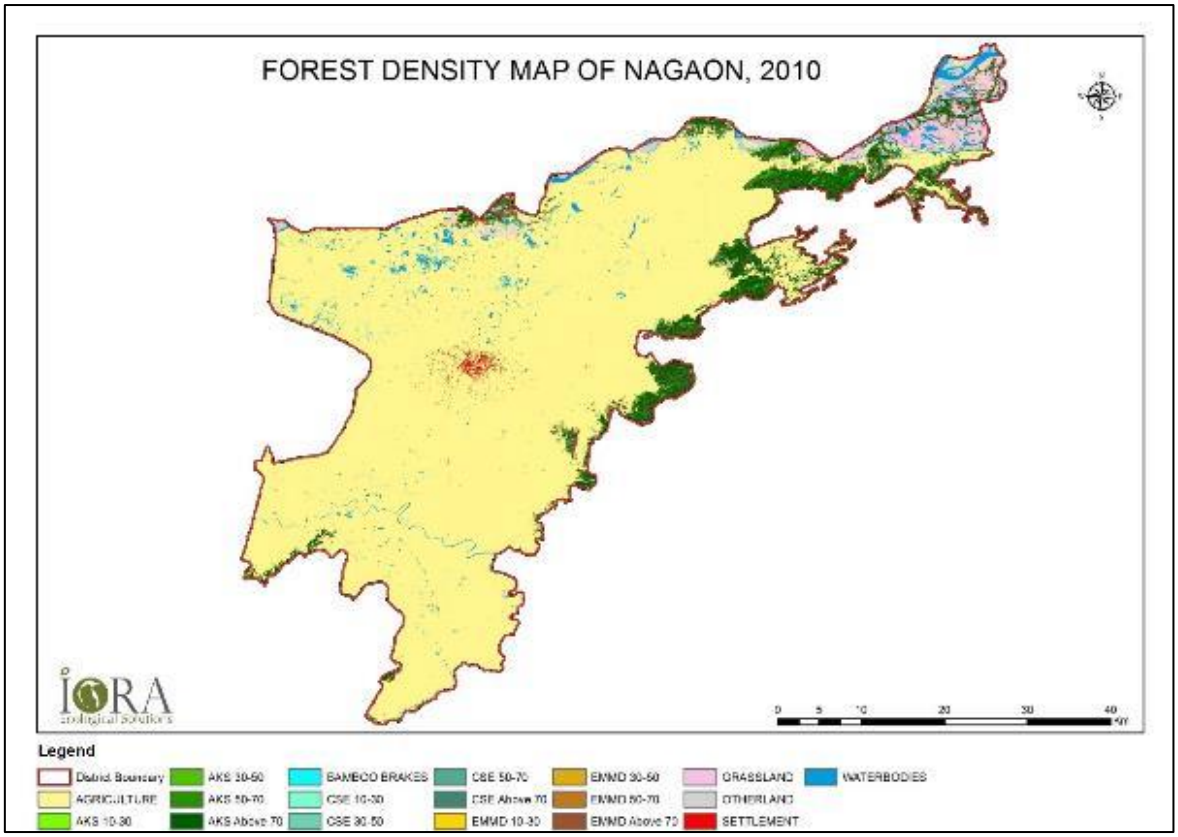

Figure 7: Forest density map Nagaon, 2010

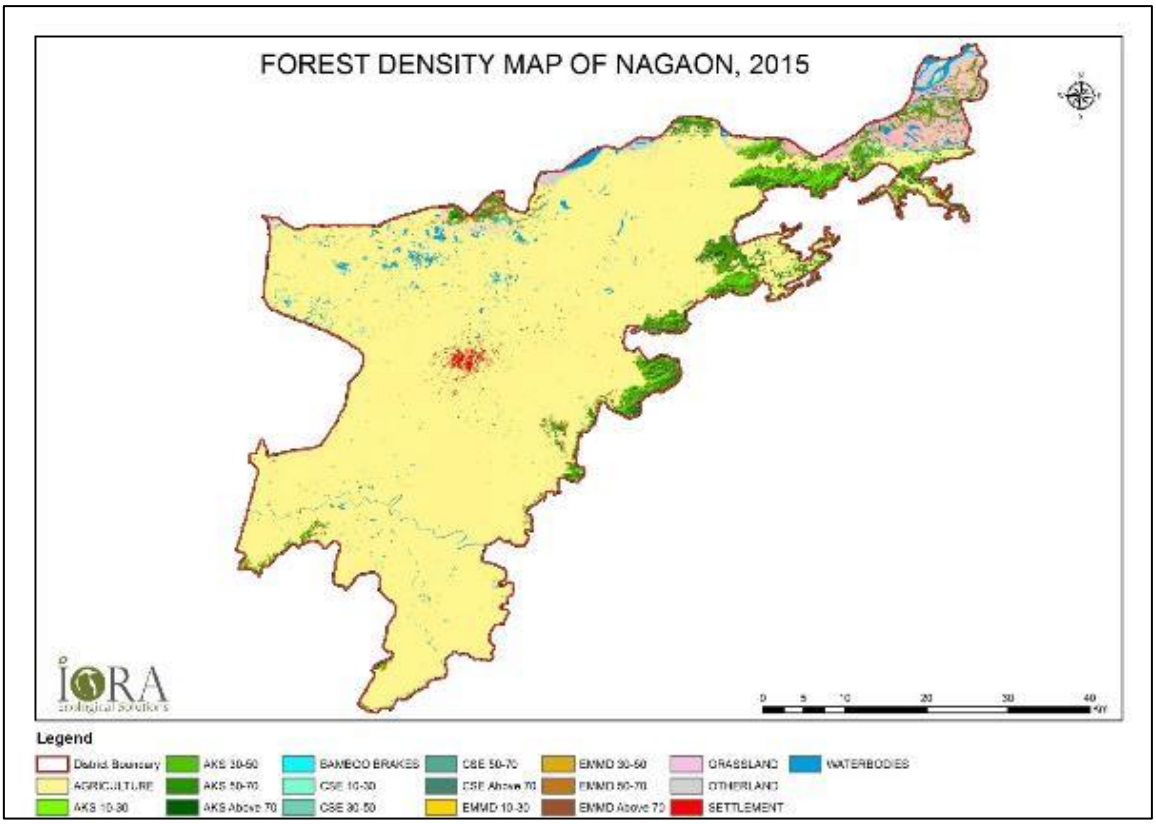

Figure 8: Forest density map Nagaon, 2015

1.4 Ancillary Data

Ancillary data such as ground-truthing information, Working Plans, Forest Circle and Range Boundaries, Administrative Boundary, Slope, Elevation, etc. have been used where available.

1.5 Pre-processing of remote sensing data

Pre-processing included radiometric and geometric correction. Geometric correction ensures that images in a time series overlay properly to each other and to other GIS maps used in the analysis *(i.e.,* for post-classification stratification). The average location error between two images must be less than or equal to one pixel.

1.6 Image Analysis:

A reconnaissance survey was conducted to acquaint with the general patterns of the vegetation of the area, main vegetation types and variation and tonal patterns which were observed in existing imageries and maps. The landscape was traversed along roads, major drainages and hilltops for collecting ground truth information. Global Positioning System (GPS) readings were taken representing various land use classes and Forest types. In addition, existing literature like Working Plans and Annual Reports were consulted.

Classification of land cover using remotely sensed data was done by digital classification algorithms, which allows for automated grouping of spectrally similar pixels in order to classify different features of the landscape. Using Maximum Likelihood Classifier algorithm, a base layer for forest type and density was generated to show the status of forest cover in the project area (Fig 11). Year 2000 has been considered as the baseline.This was followed by the generation of forest type layers of the study area for the years 2000, 2006, 2010 and 2015 (Fig. 4-10). These layers were further run through the change analysis to capture the temporal change in the study area (Fig. 12-14).

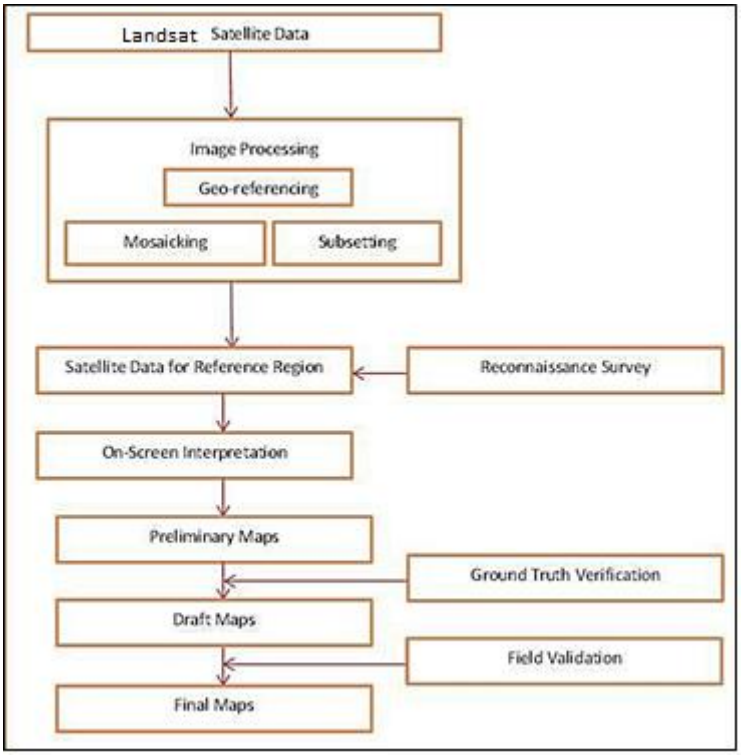

Figure 9: Detailed methodology for analysis of satellite imagery

2 Analysis and Results

The six IPCC LULC classes, namely Forest Land, Crop Land, Grassland, Wetlands, Settlements, and Other Lands, were distinguished as per the IPCC's Good Practice Guidance for Land Use, Land-Use Change and Forestry 2003 (IPCC GPG-LULCF 2003).

To achieve the goal of defining classes that are homogeneous in carbon stock density, the forest LULC class was further sub-divided into forest strata. The preliminary LULC Classes along with Forest Strata and their areas for the 4 time periods are as follows:

Forest lands have been further divided into three major forest types - App. Kamrup Sal Forest, Cachar Semi-Evergreen Forest and East Himalayan Mixed Moist Deciduous (Champion and Seth, 1968[1]), and each forest type has been further divided into 4 forest density sub-stratum to estimate forest carbon with high accuracy. The five other LULC types: Croplands, Waterbodies, Settlements, Grasslands and Other Lands, have also been detailed. Forest type maps for previous years in the reference period have also been included to account for relevant changes (Fig 12-14).

[1] Champion, S. H., & Seth, S. K. (1968). A revised survey of the forest types of India. *A revised survey of the forest types of India.*

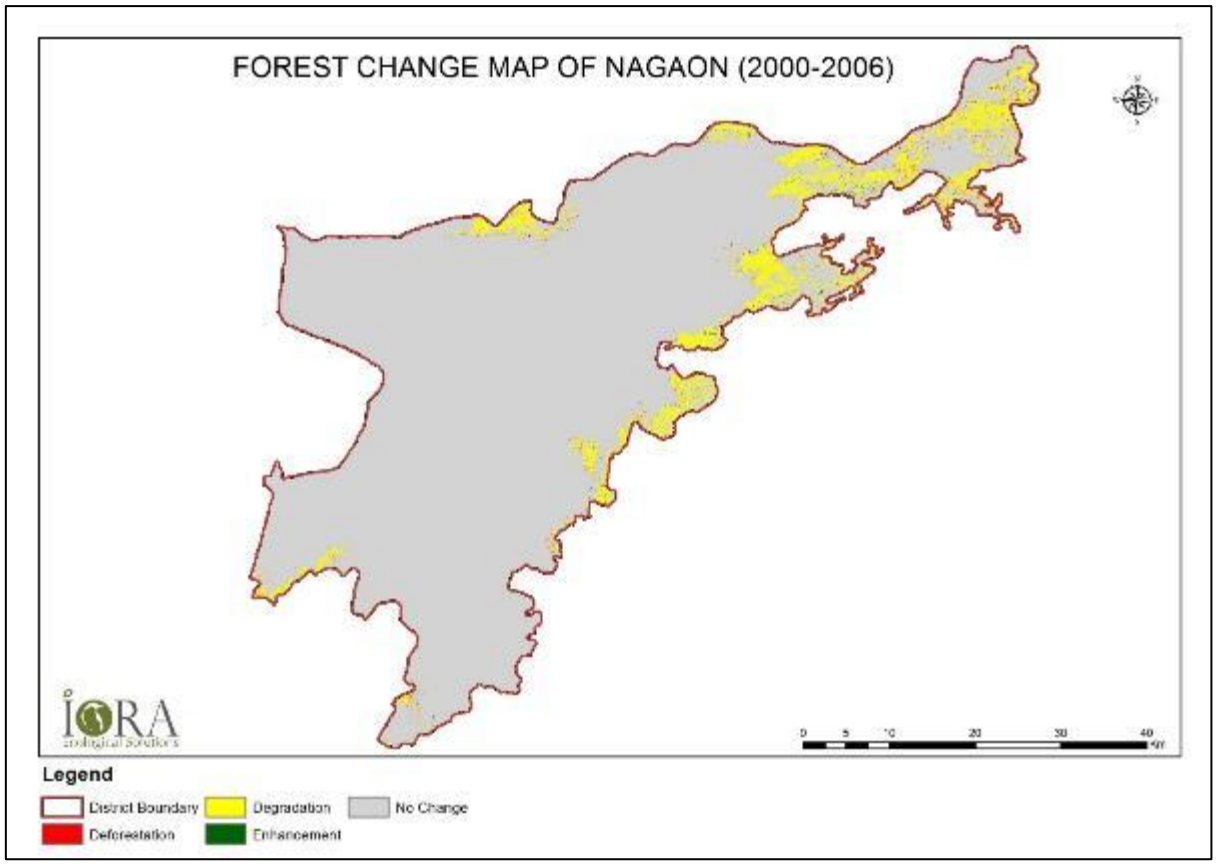

Figure 10: Forest change map of Nagaon, 2000 – 2006

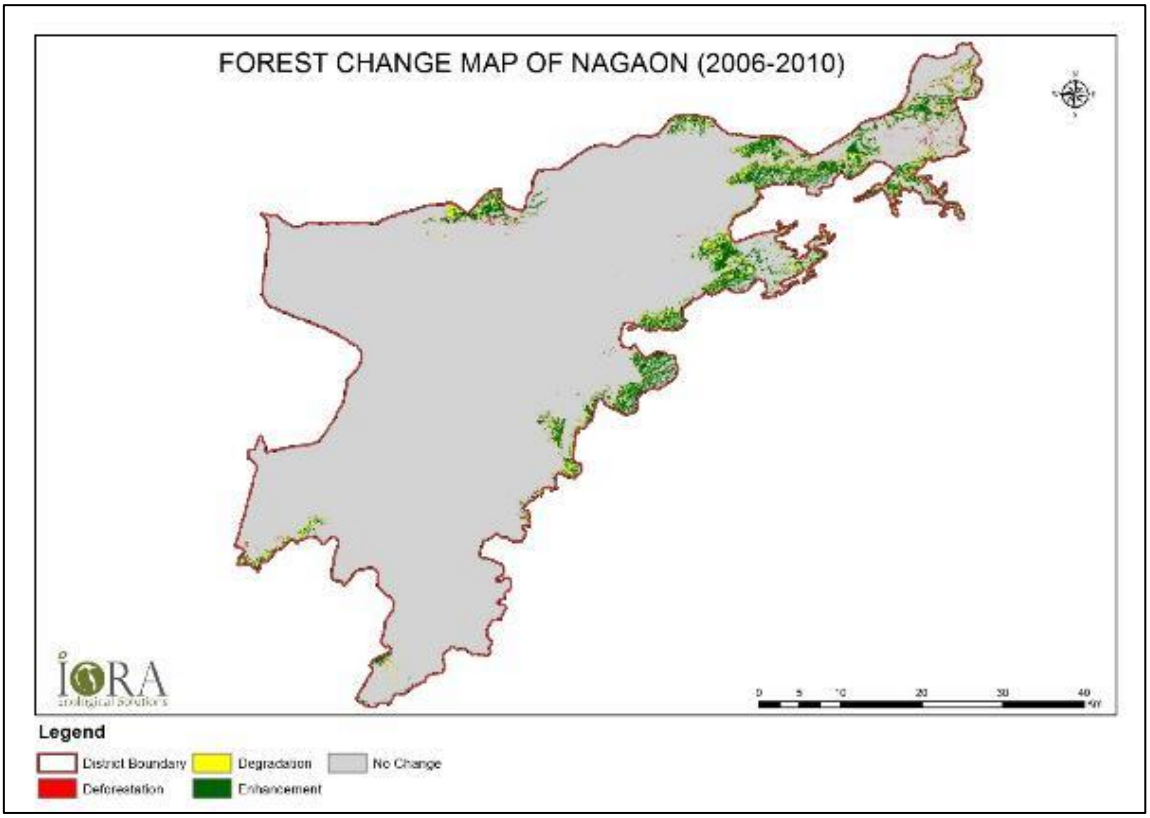

Figure 11: Forest change map of Nagaon, 2006 - 2010

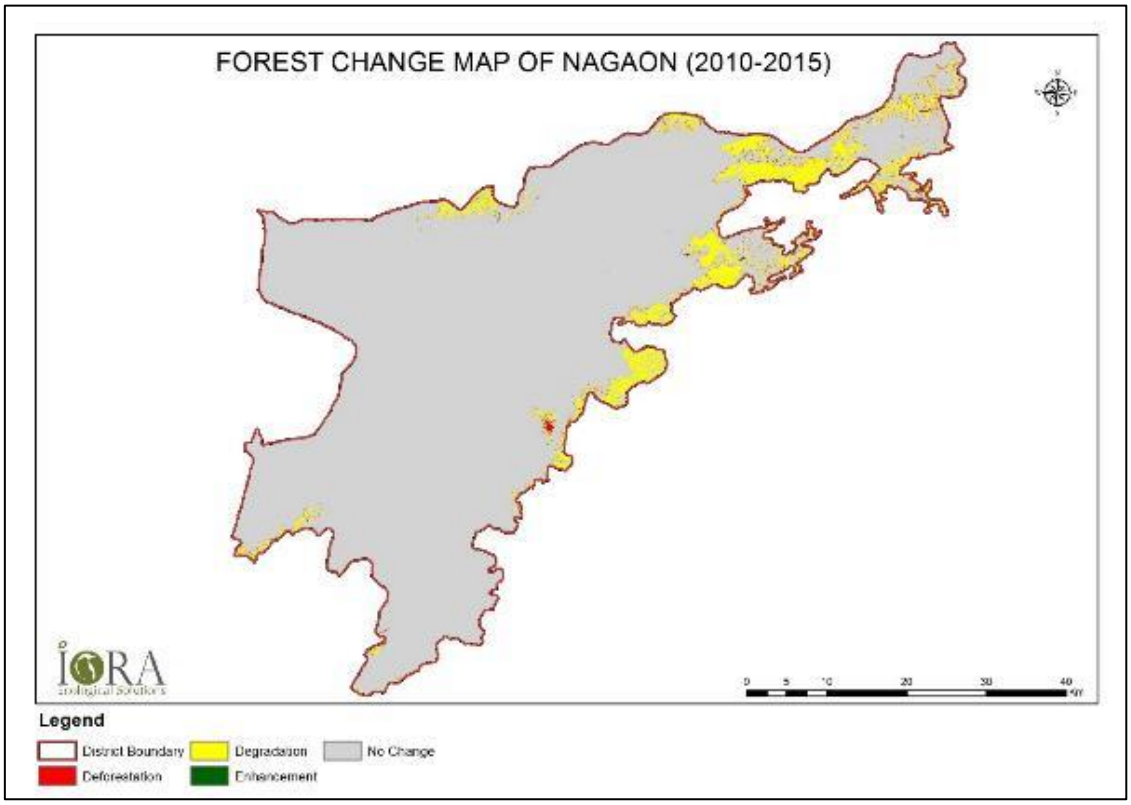

Figure 12: Forest change map of Nagaon, 2010 - 2015

Ecological data has been sourced through the data collected from the landscapes for the preparation of forest working plans. In total 57 plots, each of 1 ha were laid in Nagaon, Hojai and Moregaon districts. We considered ecological data from Hojai and Moregaon also since the bio-geographic characters of these neighbouring regions were very similar, and has been used to develop the carbon mapping of Nagaon to a higher accuracy. Since soil samples to estimate Soil Organic Carbon (SOC) was not collected from these 57 plots, we have not considered SOC in our estimates; and it includes only Above Ground Biomass (AGB) and Below Ground Biomass (BGB). During preparation of working plans the department had laid four more validation plots, each of 0.1 ha in Nagaon division, which was also considered in our estimates. Using the carbon content of the plots, we developed regression equations against canopy density for conducting a full field analysis of Nagaon district. This gave Carbon content of each pixel of the scene for the district. Based on this equation, we have again calculated the Carbon content for rest of the years in each of the forest strata to study the dynamics, and also map the overall shift in forest carbon stock. The analysis shows that there is a net decrease of 1.44% every year in carbon content on an average in the historical period 2000-2015. Since the average annual change in carbon stock in each period (2000 to 2006, 2006-2010 and 2010-2015) was considered, any biases owing to sudden shifts have been weeded out. This baseline is also conservative against a compounded annual decrease rate of -2.94% for years 2000 to 2015. The table 2 below explains the Carbon content in each forest stratum over the historical time period and changes.

Table 2: Organic carbon content in various forest stratum

Forest Stratum	Carbon content in 2000 (tC)	Carbon content in 2006 (tC)	Carbon content in 2010 (tC)	Carbon content in 2015 (tC)
AKS 10-30	1,810	29,747	40,864	50,022

Forest Stratum	Carbon content in 2000 (tC)	Carbon content in 2006 (tC)	Carbon content in 2010 (tC)	Carbon content in 2015 (tC)
AKS 30-50	33,412	1,90,973	2,30,143	1,43,396
AKS 50-70	7,92,612	621,996	517,565	5,58,565
AKS Above 70	7,36,273	2,96,166	355,247	3,65,660
EMMD 10-30	138	1,816	3,985	790
EMMD 30-50	1,599	56,272	79,594	11,193
EMMD 50-70	2,03,580	2,28,725	2,39,683	3,13,935
EMMD Above 70	766,431	1,19,601	2,49,458	1,80,007
CSE 10-30	10	44	168	29
CSE 30-50	417	520	1,081	457
CSE 50-70	15,694	9,847	17,535	16,080
CSE Above 70	2,37,423	1,09,142	1,80,470	1,65,738
BAMBOO BRAKES	1,17,601	42,157	24,244	51,841
Total	29,06,999	17,07,007	19,40,036	18,57,712

Net change in total forest carbon stocks between 2000 and 2006 has been found to be -1,199,992 tC or -41.28%. For the time periods of 2006-10 and 2010-15 the net change has been 233,030 tC and -82324 tC or 13.65% and -4.24% respectively. Annual change in percentage is computed for each of the time period, which is -6.88%, 3.41%, -0.85% respectively. An average of these three values gives the annual average change in AGB and BGB forest carbon stock in Nagaon district, which is -1.44%.

The details the change in carbon stock in each time period has been presented in the Fig 15-17.

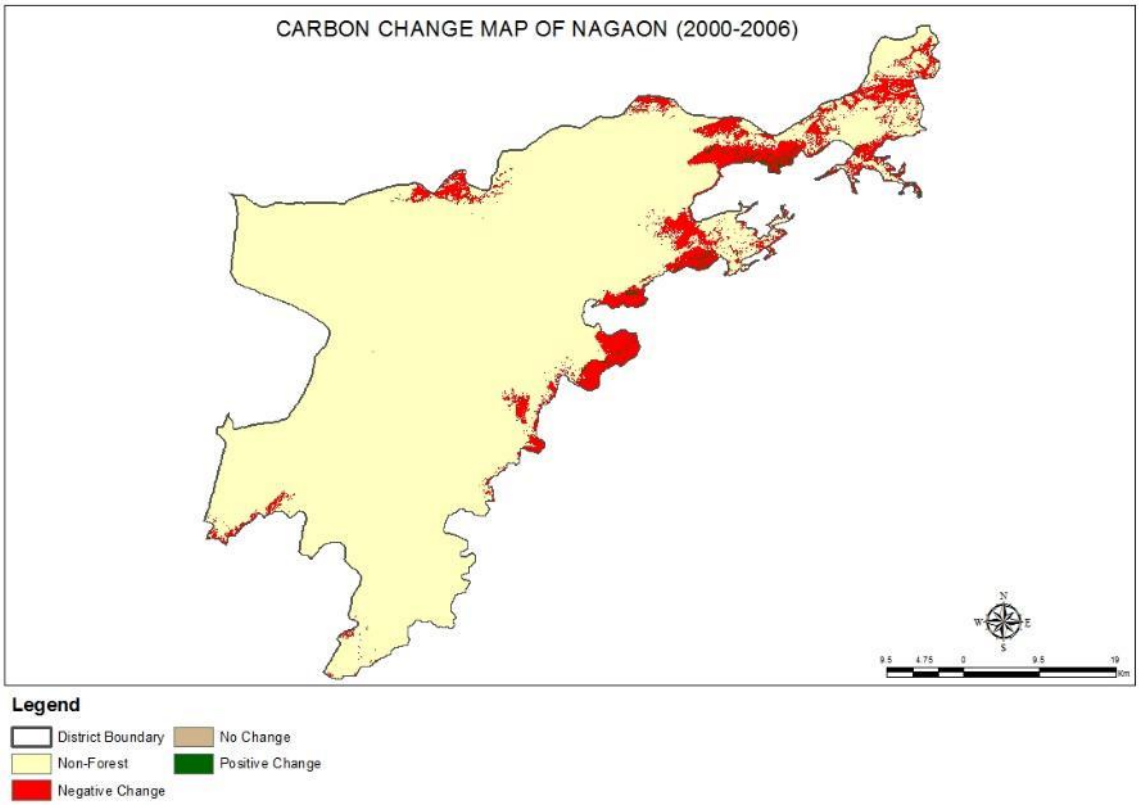

Figure 13: Forest change map of Nagaon, 2000 – 2006

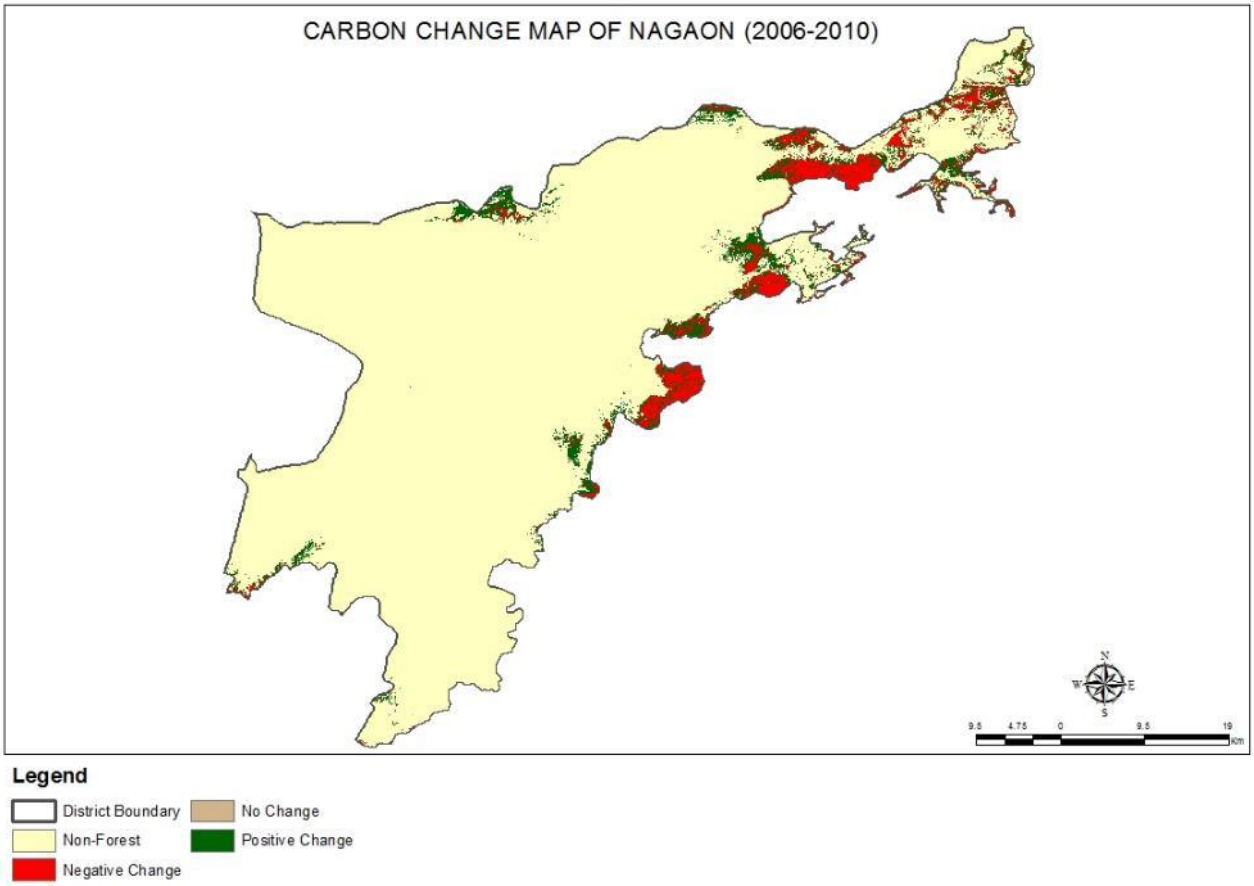

Figure 14: Forest change map of Nagaon, 2006 – 2010

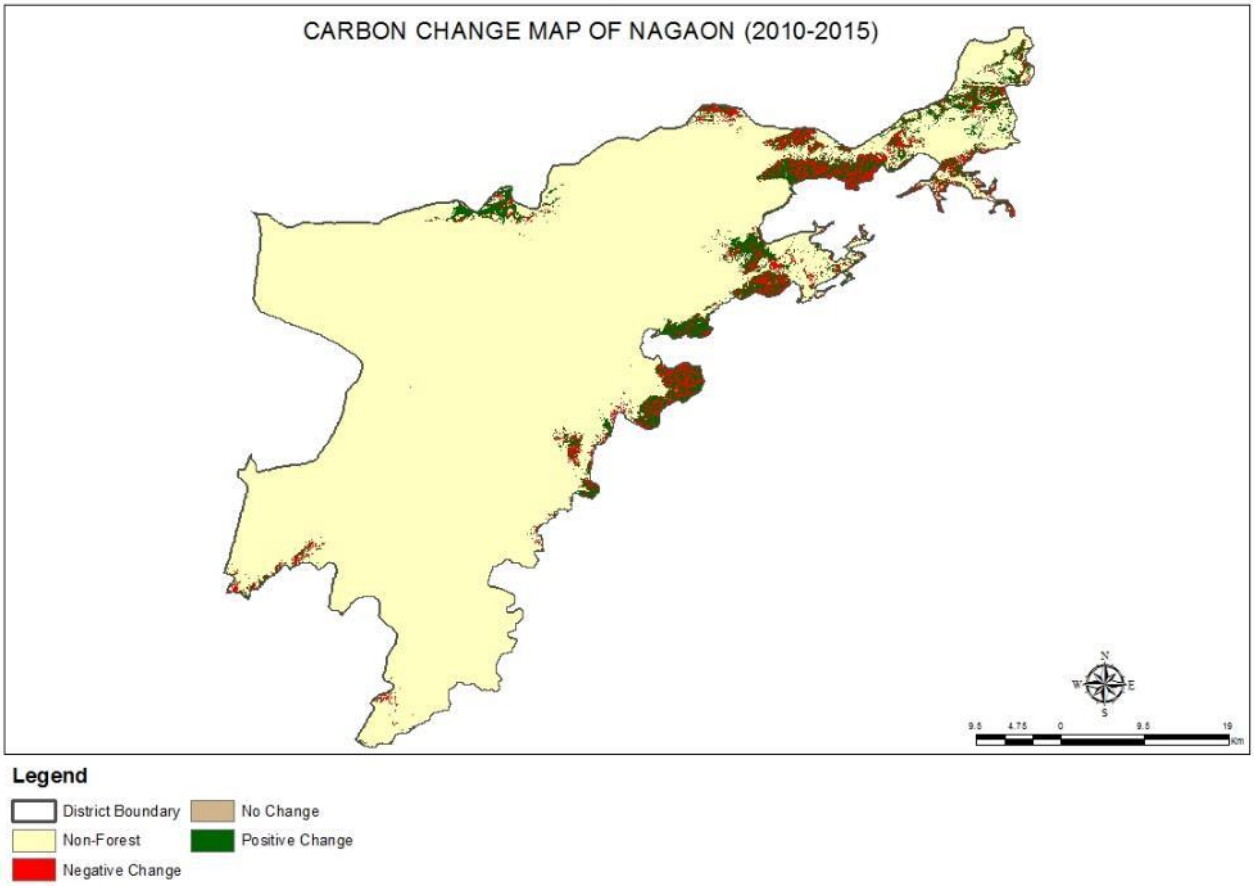

Figure 15: Forest change map of Nagaon, 2010 - 2015

Changes in Land Use and Land Cover has been mapped in the LULC matrix, which is a data spread sheet and is attached with this report.

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