Regional Remote Sensing Centre

(90)

Template - 4.1

Project Report – User

Date :03June 2019

Interim/Final: Final

1. Project Title: Investigation on the decadal changes of green coverage in Nagpur region			
2. RRSC	Central, Nagpur	**3. Principal Investigator**	Alok Taori
		4. Co-Investigator	Arun Suryavanshi, A. O. Varghese

1. Introduction

a. Background & scope of the project: Infrastructure developments and urbanization of Nagpur and nearby regions have been in fast pace in last several years. This has led to erosion of green coverage viz., removal of trees and plants and building up the resident area. This does create an imbalance between the resources and the number of people who are using the resources.

To understand how the green coverage is changing in Nagpur region with a radius of 25 km, Forestry department of Nagpur approached RRSC-Central which is going to be utilized for further infrastructural planning.

b. Need for study: The information is critical for any future decisions of infrastructural development so that a proper care can be taken to preserve the green patches available at present within and around the Nagpur city.

2. Objectives: Objectives defined by the user are 1) The status of changing green cover in the last few decades of Nagpur city with a periphery of approximately 25 kms from the city centre. And, 2) Identify and pin point last few green covers available today in the Nagpur city.

3. Study area: Nagpur city with 25 km radius

4. Scientific rationale: One of the reasons of climate change are unbalanced development of various landscapes. This leads to various issues in long term such as creation of isolated heat regions, pure air availability, chocking of pollutants. In this regard, knowing the rapidness of green cover changes are a meaningful effort.

(91)

5. Data Used: Landsat 7 and Landsat 8.

6. Methodology: Multispectral data obtained by Landsat7 (for the years 1999 & 2002) and Landsat8 data for the years 2013 and 2018 have been used to analyse the green coverage. The images were corrected for the top of the atmosphere (TOA) reflectivity estimation. After the TOA corrections, the normalized difference vegetation index (NDVI) was calculated. Depending on the threshold values, the green coverage and non-green coverage were estimated. The process is elaborated in the following flow chart (*figure 1*).

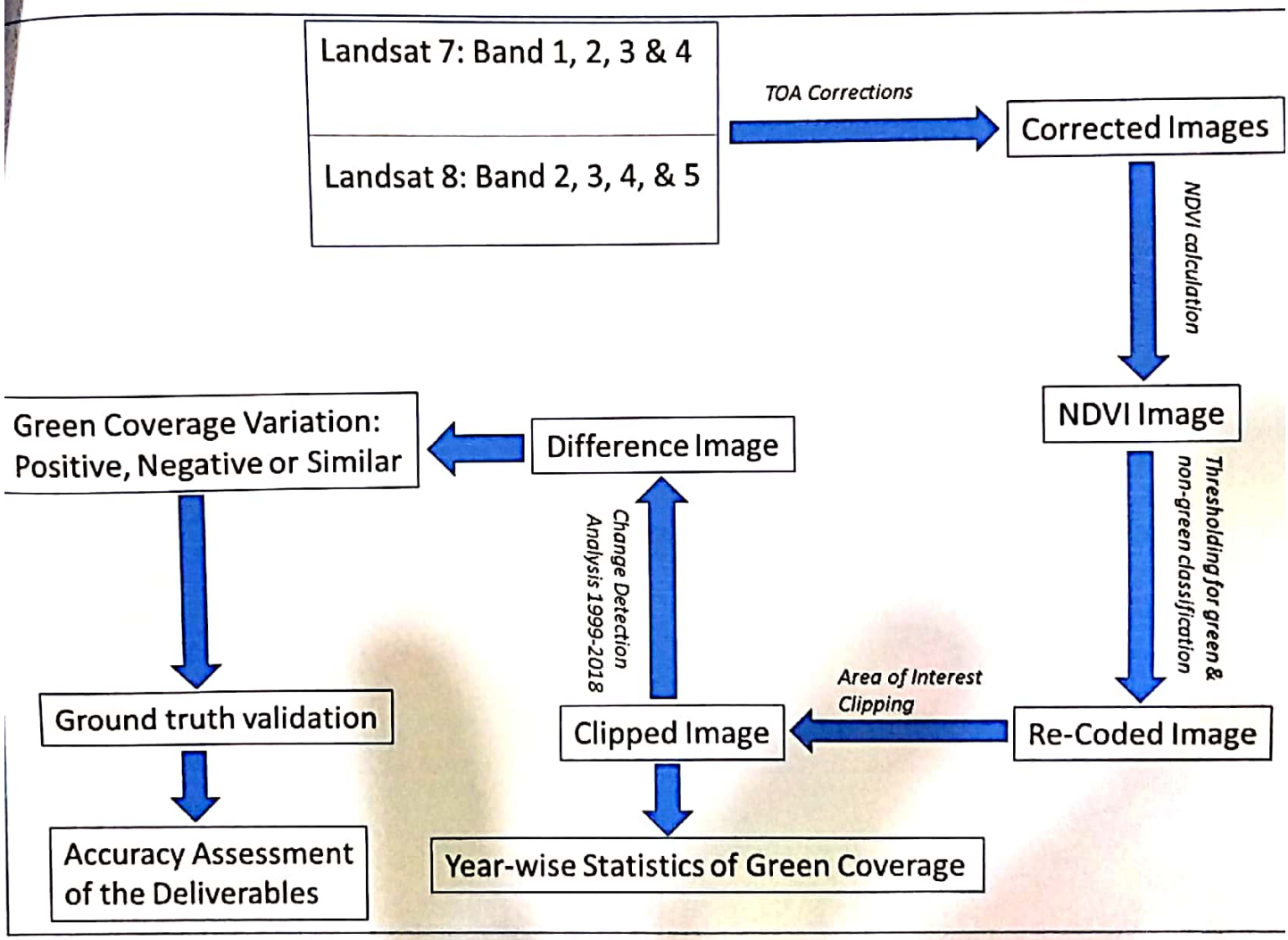


Figure 1. Flow chart showing the retrieval methodology of green coverage

(92)

Top of the Atmosphere (TOA) Correction: This is a process which requires information on the gain and bias of the sensor in each band. The transformation is based on a calibration curve of DN to reflectance which has been calculated by the operators of the satellite system. The calibration is carried out before the sensor is launched and the accuracy declines as the sensitivity of the sensor changes over time. Gain represents the gradient of the calibration. Bias defines the spectral reflectance of the sensor for a DN of zero. The calibration is given by the following expression for at satellite spectral reflectance,

$$P_\lambda = \text{Bias} + (\text{Gain} \times \text{DN})$$

Bias and Gain are provided in the metadata of the multispectral file.

Normalized Difference Vegetation Index (NDVI): Normalized Difference Vegetation Index (NDVI) quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs) (Rouse et al., 1974).

$$NDVI = [\rho(nir) - \rho(red)] / [\rho(nir) + \rho(red)]$$

7. Preparation of Input data variables: The surface reflectance products of Landsat data are radiometrically and geometrically corrected products (Irons et al., 2012; Markham et al., 2014) and are available as GeoTIFF from http://earthexplorer.usgs.gov/. Cloud free digital data of Landsat TM and OLI, acquired on November months of the years 1999, 2002, 2013, and 2018 were downloaded and corrected to top of atmosphere (TOA) reflectance.

9. Results and Analysis: Required data were first plotted as images to check whether data was of required quality (cloud free) and to ascertain that coverage of about 30 km from Nagpur city is obtained as per the user requirement. *Figure 2* show sample image downloaded from earthexplorer site with centre being 21.14° N, 79.1° E.

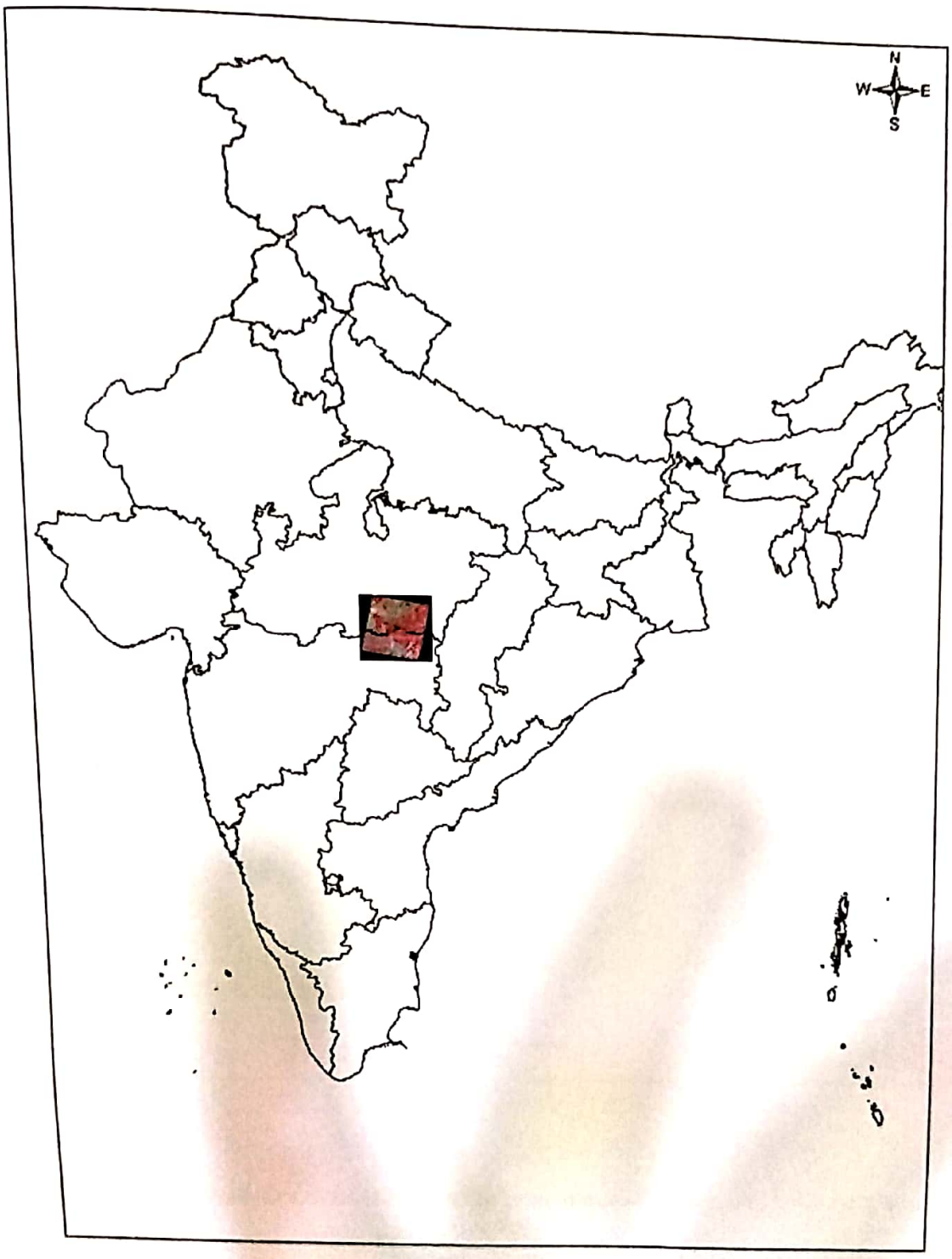


Figure 2. Sample Landsat Image corresponding to our region of study

After downloading the data, the multispectral data was corrected for the top of atmosphere reflectance. Then area of interest was defined to be 30 km radius around Nagpur centre. For which the images were clipped and NDVI was calculated for each image. Thus, calculated images are shown in *Figure 3*.In the image background is landsat images while the green circles show a circle of 30 km radius with Nagpur city at the centre. The Green colour show the area covered with vegetation while the grey area shows non-green coverage.

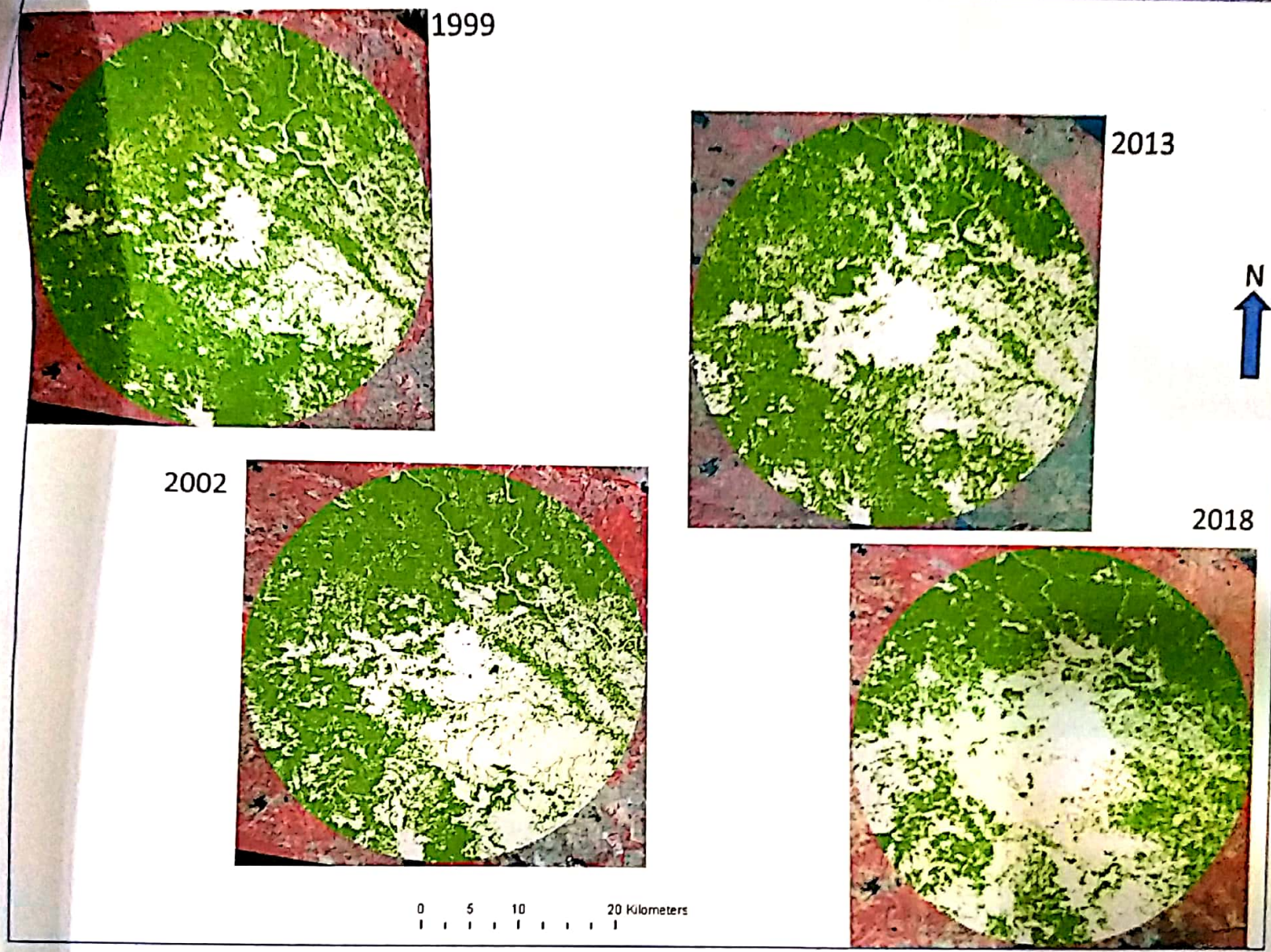


Figure 3. Image corresponding to the NDVI variation in our region of interest, viz., Nagpur city with 30 km radius.

It is evident from the figure 3 that green coverage in Nagpur city has been decreasing. Drastic changes can be noted in South West side of the Nagpur city. The changes brought in during these years are plotted in *figure 4*.

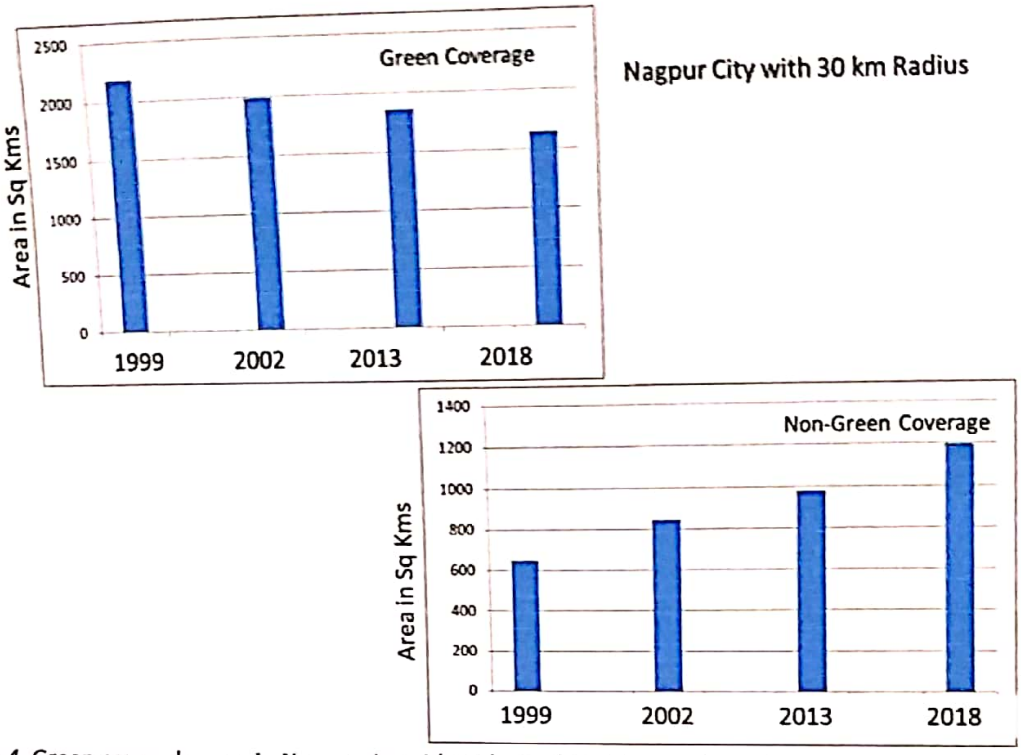


Figure 4. Green cover changes in Nagpur city with 30 km radius. It is noted that infrastructural establishments have been nearly doubled during 1999 and 2018 while the green coverage has been decreased significantly.

After the above analysis it was pertinent to investigate the city region within municipal boundaries and that how changes are occurring within the Nagpur city. *Figure 5* plots the changes occurring Nagpur city in terms of green coverage and infrastructural changes. The background in each image represents the landsat images in the plot, while the green colour patches show presence of the green coverage / vegetation while the grey/cyan colour show non-green coverages.

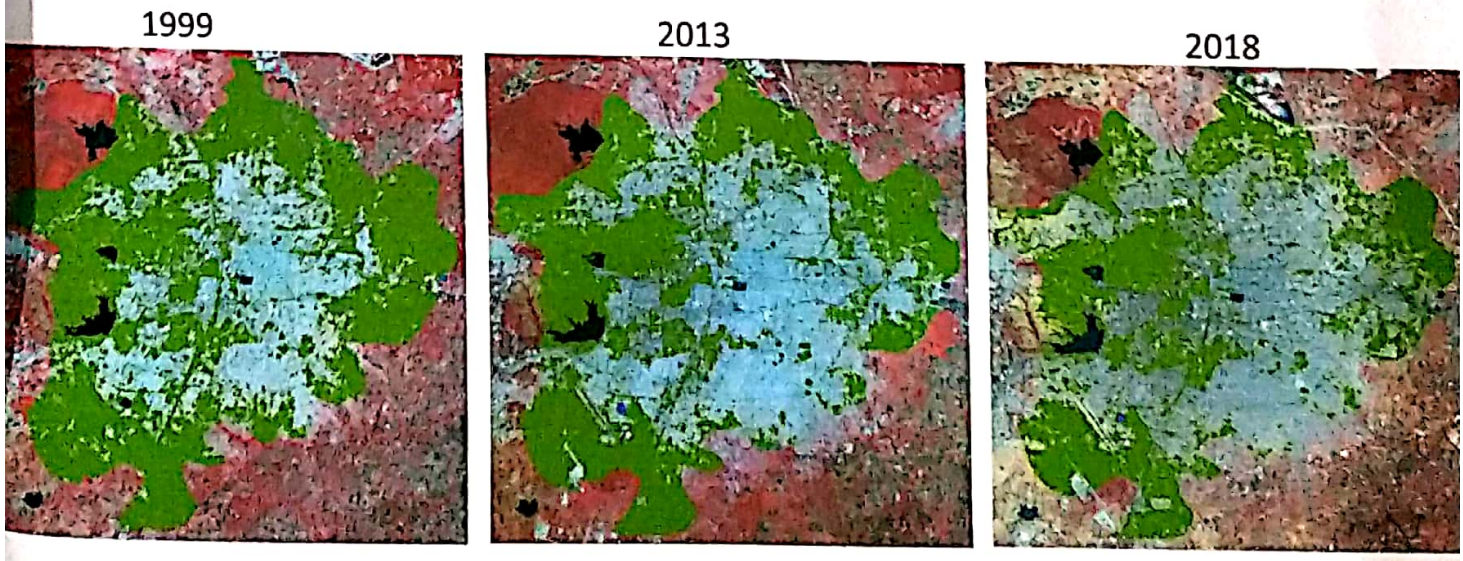


Figure 5. Green cover changes as noted in Nagpur city. It is noteworthy that infrastructural establishments have been increasing very fast while the green cover is decreasing. The black spots show the presence of water bodies.

It is noted that the percentage of green cover shrinkage is very fast within the city limits. The calculated area covered by the green and urban cover is shown in *table 1*.

Year	Nagpur City Area (municipal boundary)	Green Cover	% Green Cover	Non-Green Cover	% Non-Green Cover
1999	~372 sq km	~116 sq km	31	~256 sq km	69
2013		~ 91	25	~281	75
2018		~76	21	~295	79

*Table 1.*Changes in green cover and non-green coverage as noted in figure 5.

The analysis was further extended to detect the changes during these years which relies on the image subtraction procedure. To see the changes, we selected the years 1999 and 2018. Results of this analysis are shown in *figure 6*.

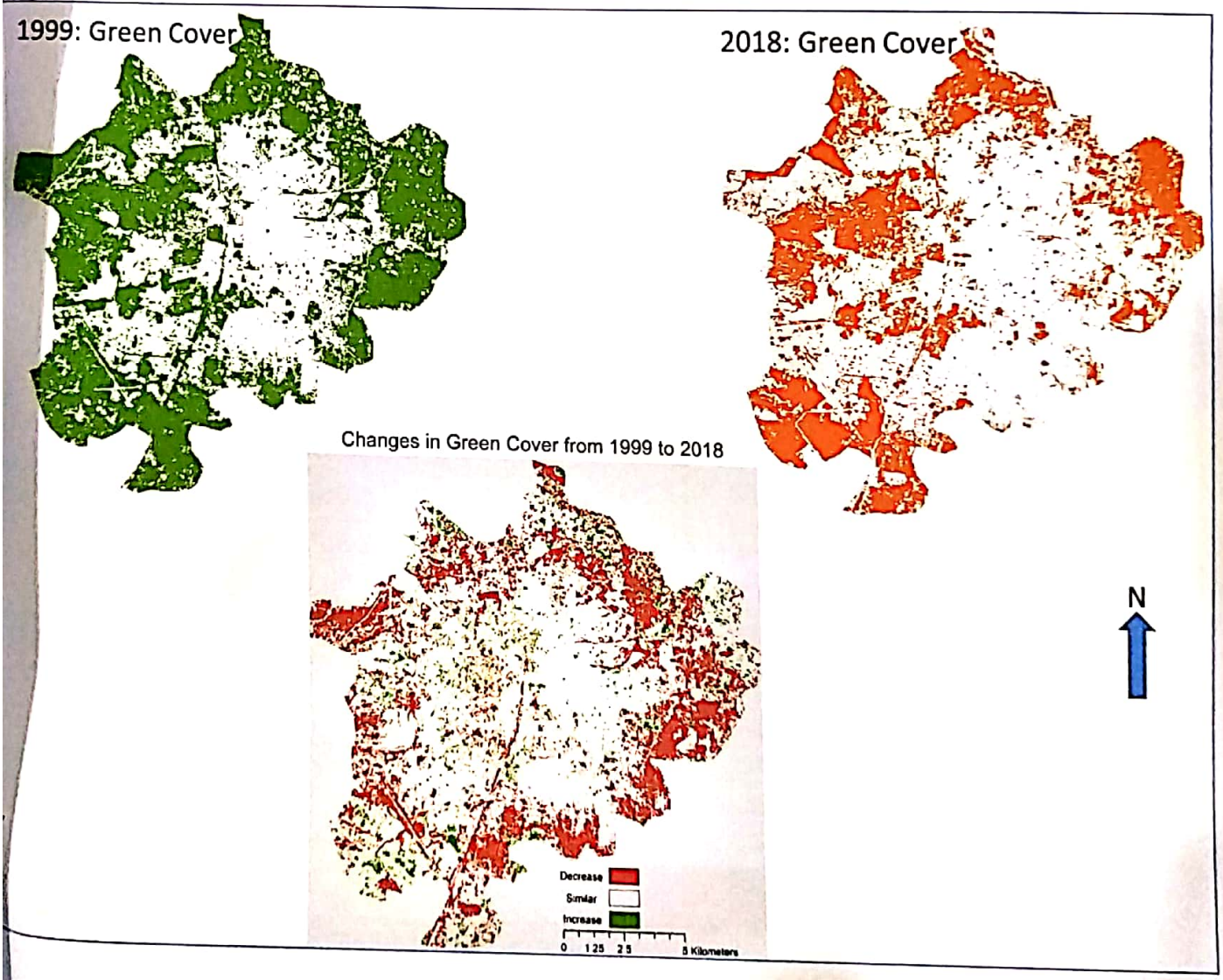


Figure 5. Top plots show the green coverage in the years 1999 and 2018 while the bottom plot is the changes noted in green cover. The red patches show decrease in the green cover while green show increase.

Important to note is that percentage variation of green and infrastructural cover to the area available in the municipal boundary of the city. The green cover was about 31% (non-green cover 69 %) of the city area in the year 1999 which decreased to 21% in the year 2018. This suggests the shrinkage of natural resources within the city limits.

It was further important to know how much green coverage is existing in present times for which utmost care shall be taken. To understand this, November 2018 data was used and compared with the year 1999 as reference. The 4 classes which were identified are infrastructure area, area where green cover has increased, area where no changes occurred, and area where green cover has decreased. Results of this are elaborated in *figure 6*.

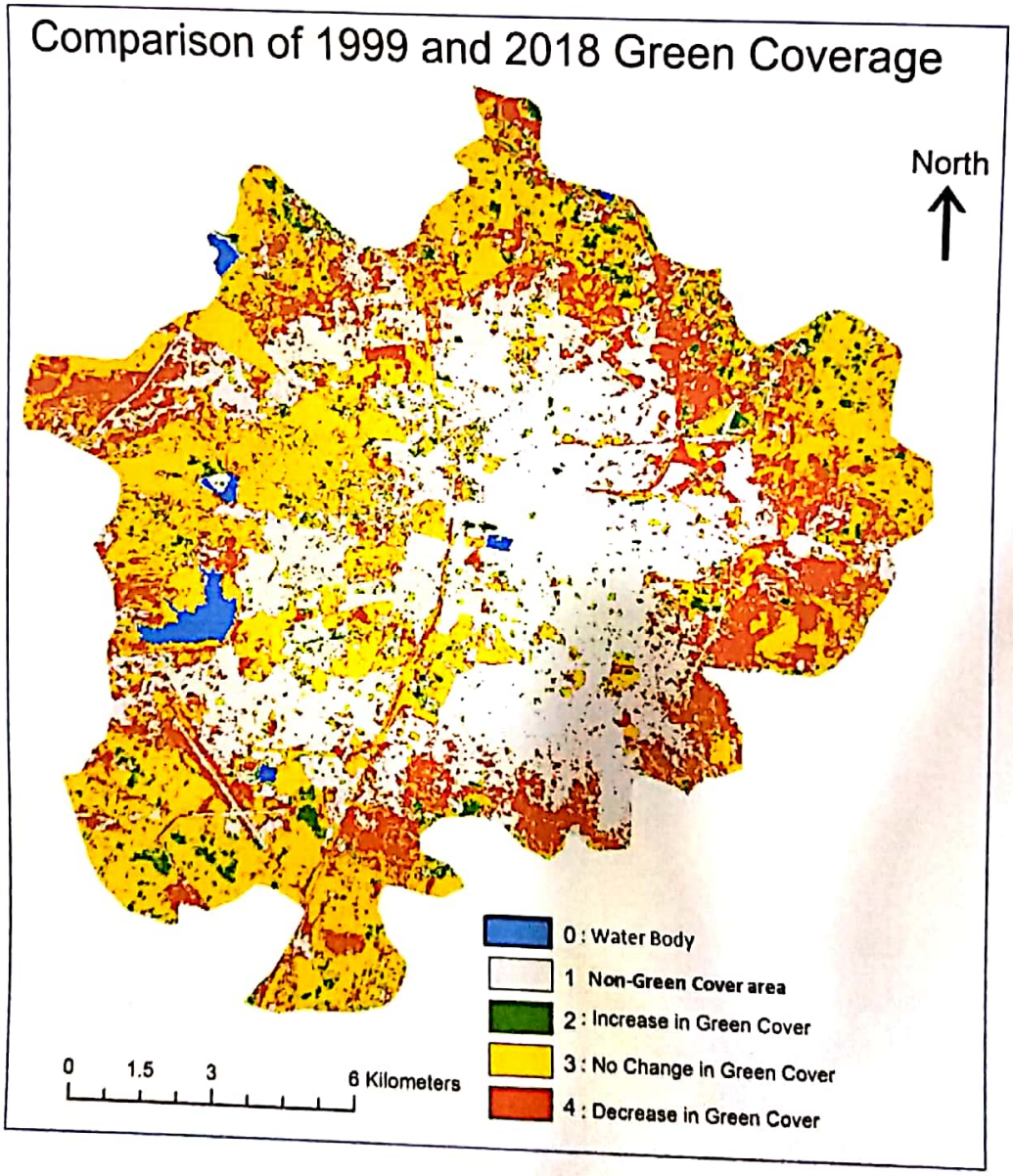


Figure 6. Current scenario of Nagpur city compared to the year 1999. We note that green cover decreased drastically as the city expanded. Few green patches within the city are noteworthy.

It is noted that with infrastructure developments city expanded in outward direction and green cover decreased (emphasized as red colour). There are areas within the city where no changes in green cover were noted and shall be preserved. To our surprise, there were few green patches which were new within the city may be due to conscious efforts by municipal authorities. The ratio of such development is summarized in *figure 7*.

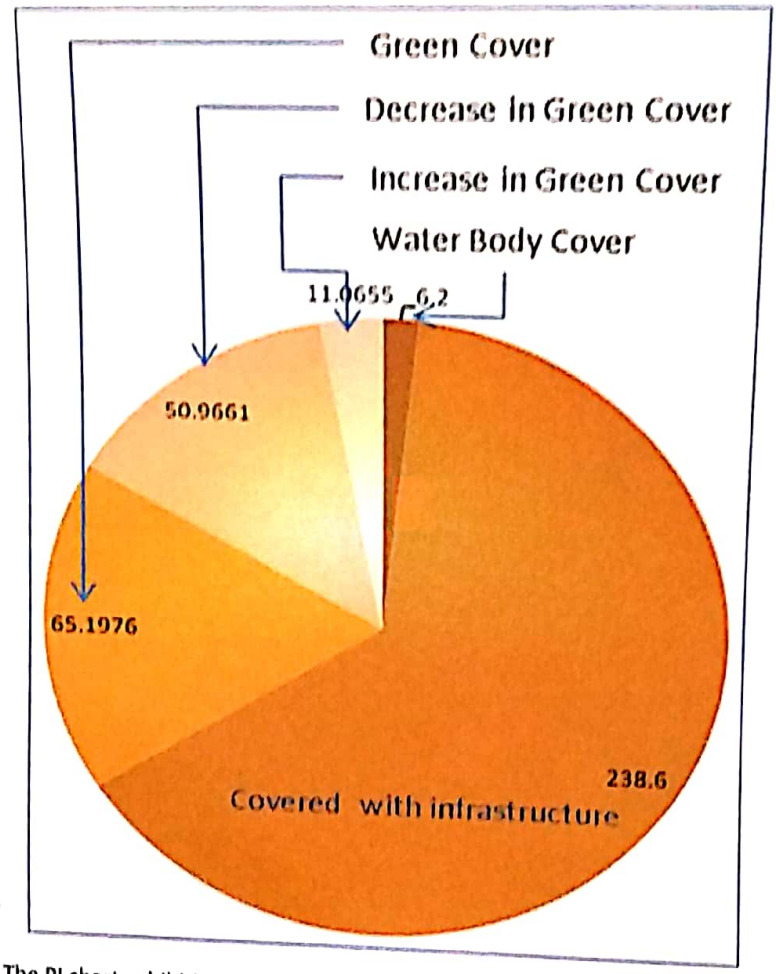


Figure 7. The PI chart exhibiting the are under different categories in Nagpur city limits.

10. Deliverables: a) Decadal changes in the green cover in Nagpur region within 30 km radius, and, b) Available green cover patches in present days.

11. Ground Truth Validation: The ground truth points were provided by the users in which they have identified green and non-green cover regions and GPS locations were saved. Total 42 points were collected (21 for Green and 21 for non-green coverage). Four ground truth green points were on the edge where satellite data show transition therefore, were omitted for the accuracy assessment. The accuracy assessment of the classifications reveals the non-green cover to be 100% accurate while the green cover shows 82.35% accuracy with overall

accuracy to be 92.11%. The overall Kappa statistics is 0.8376. The classification and ground truth data are plotted in *figure 8*.

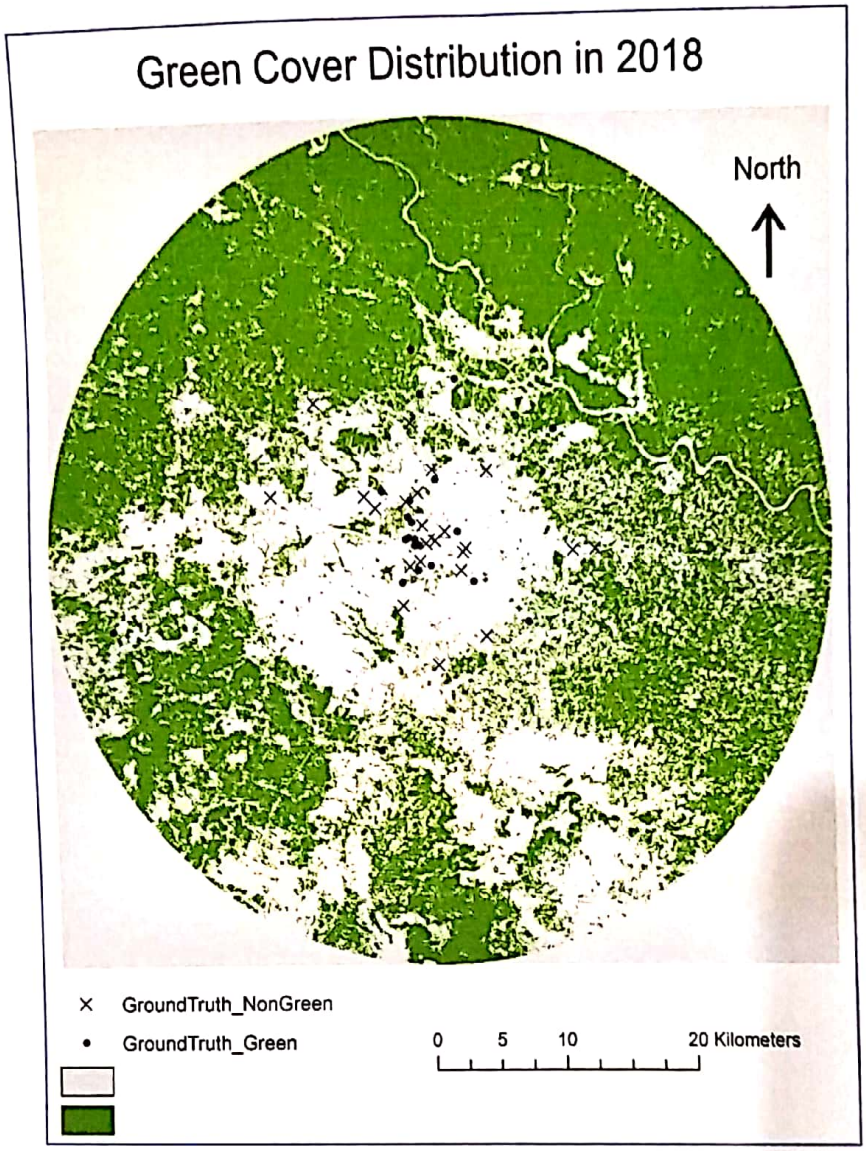


Figure 8. The collected ground truth data (during May 2019) by the user plotted on the classified image for green and non-green coverage for the year 2018.

11. Summary and Conclusions: The green coverage in Nagpur region and in particular within the Nagpur city is decreasing rapidly. Overall, from the year 1999 to 2018, Nagpur within 30 km radius, the green cover decreased by approximately 30% while the non-green cover which includes infrastructural cover increased about 83%. While within the city the green cover decreased about 34% and infrastructural cover increased about 16%. This also suggests that outside the Nagpur city green cover have eroded faster, though, this may be related to phases of urban development of the city.

100

12. Recommendations: As the city is growing, to maintain the available natural resources and to combat the climate change issues for healthy environment, the ratio of developmental activities and green coverage as well as water resources must be maintained.

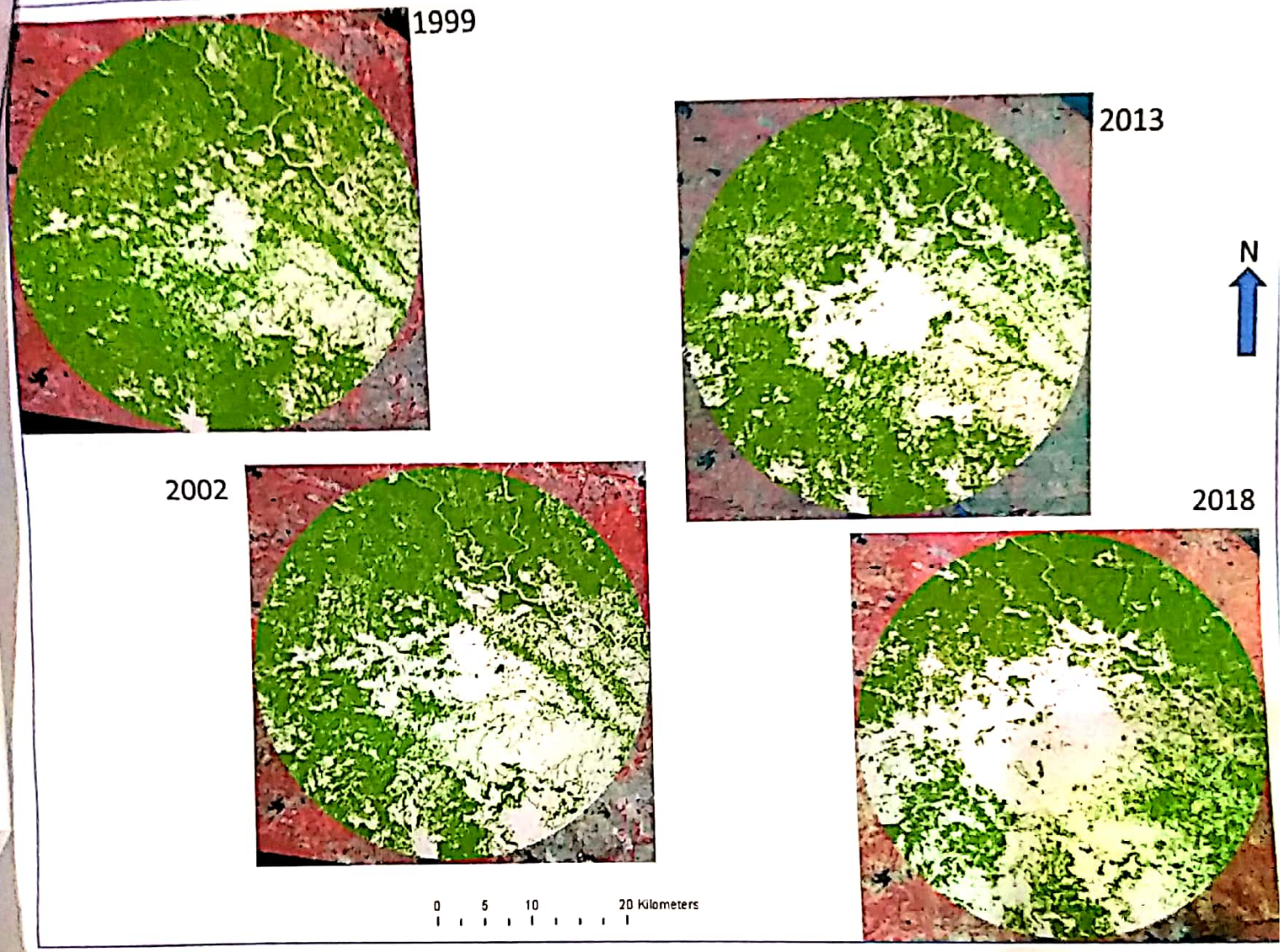
13. Assumptions and Limitations: Demarcation between agricultural land and trees/forest is not carried out in this study as both are considered as green cover.

14. References:

Irons, J. R., John, L. D., Julia, A. B., 2012. The next Landsat satellite: The Landsat data continuity mission. Remote Sensing of Environment, 122, pp. 11-21.

Markham, B., Barsi, J., Kvaran, G., Ong, L., Kaita, E., Biggar, S., Czapla-Myers, J., Mishra, N., Helder, D., 2014. Landsat-8 Operational Land Imager radiometric calibration and stability. Remote Sensing, 6(12), pp. 12275-12308.

Rouse, J. W., Haas, R., Schell, J., Deering, D, 1974. Monitoring vegetation systems in the great plains with erts, NASA Special Publication351, pp. 309.



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