Land Use Mapping of Dalma Wildlife Sanctuary Using Remote Sensing & Geographical Information System

Narendra Prasad*and U.K. Sahoo**
*Faculty of Forestry, Birsa Agricultural University, Ranchi- 834006 (Jharkhand), India
** Department of Forestry, Mizoram University, Aizawl

Abstract

Spatially-explicit information on forest composition provides valuable information to fulfil scientific, ecological and management objectives and to monitor the forest ecosystems. In the present study of Dalma Wildlife Sanctuary, NDVI (Normalised Difference Vegetation Index) system was adopted for Land Use/Land Cover (LU/LC) analysis and mapping. The study is targeted to find improved classification accuracy with the use of spectral information from Landsat-8 OLI satellite imagery. The Sanctuary area was classified into seven major land use/land cover classes viz. Agriculture, Evergreen forest, Deciduous forest, open/degraded forest, Grass land, Settlement and Water bodies occupying about 13%, 17%, 36%, 2%, 27% 4% and 1%, respectively. This indicated presence of maximum patch of deciduous forest area in the Dalma Wild Life Sanctuary. The data observed from this study will be useful to policy makers in formulation of future management and development plan of the area.

Introduction

Forests, the renewable natural resources play important role in human life and are considered as significant contributor for development of civilizations. It protects and stabilizes soils and local climates as well as soil hydrology and efficiency of the nutrient cycles between soil and vegetation. Forests also contribute to create varied essential habitat for numerous plant and animal species. Virgin forests, especially those in the tropics are an irreplaceable repository of the genetic heritage of the world's flora and fauna.

The total forest cover of the country, as per current assessment State Forest Report, 2017 is 7,08,273sqkm which is 21.54% of the geographical area of the country, which has been regularly monitored and published in the form of "State of Forest Report" by Forest Survey of India, where as the recorded forest area of the Jharkhand state is 23,0605 sqkm which is 29.61% of its geographical area, The Reserve, Protected and Unclassed Forest are 18.58 %,81.28 %and 0.14 % respectively of the recorded forest area. Due to forest dependent developmental activities monitoring of day to day status of forest cover is required as entire ecosystems on earth is dependent on forests, which are also direct cause of change of environmental condition in the country. Therefore, information is needed and the progressive change in land cover over periods of decades is of interest. Remotely sensed data may provide a better source for derivations of land cover due to internal consistency, reproducibility and coverage in locations where ground based knowledge is sparse (Roy and Joshi, 2002). Thus, remote sensing is one of the potential tools to carry out vegetation mapping.

Land is becoming a scarce resource due to immense agricultural and demographic pressure, while land use refers the management of natural environment into settlement & semi natural habitats. Hence, information on land use/land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. The land cover is the physical material at the surface of earth, i.e. grass cover, tree, water bodies etc. Pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space and this information also assists in monitoring the dynamics of land use resulting out increasing population.

Viewing the earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base over time. In situations of rapid and often unrecorded land use change, observations of the earth from space provide objective information of human utilization of the landscape. Over the past years, data from Earth sensing satellites has become vital in mapping the Earth's features and infrastructures, managing natural resources and studying environmental change. Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of Earth system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Walkie and Finn, 1996).

Classification of forest categories and types is strongly required for addressing a wide range of ecological questions related to the determination of forest classes and/or succession stages (Laurin *et al.*, 2013), rate of afforestation/deforestation (Hirose et al., 2016; Omruuzun et al., 2015), functional composition (Laurin *et al.*, 2016) and global environmental changes (Trumbore *et al.*, 2015). All these kinds of application require very fine mapping and monitoring of forest types, which have so far been limited by the spectral, spatial and temporal resolution available from current satellite open ac-cess data (e.g., Landsat, MODIS).

In comparison to two earlier satellites (Landsat 5 and Landsat 7), Landsat 8 ensures continued acquisition and availability of Landsat data utilizing a two-sensor payload, the (OLI) and the Thermal Infrared Sensor (TIRS). These instruments collect image data for nine shortwave bands and two long wave thermal bands. The satellite was developed with a 5.25 years mission design life but was launched with enough fuel on board to provide for upwards of ten years of operations. Landsat 8 consists of three key mission and science objectives:

- Landsat 8 collects and archive medium resolution of 30-meter spatial resolution, multispectral image data affording seasonal coverage of the global landmasses for a period of no less than 5 years.
- Ensure that Landsat 8 data are sufficiently consistent with data from the earlier Landsat missions in terms of acquisition geometry, calibration, coverage characteristics, spectral characteristics, output product quality, and data availability to permit studies of land cover and land-use change over time.
- Landsat 8 distributes data to the general public on a non-discriminatory basis at no cost to the user.

Study Area

The study was conducted at Dalma wildlife sanctuary (Figure 1) which is situated in Chotanagpur plateau of Jharkhand near the steel city of Jamshedpur and extends into portions of the East Singhbhum and Saraikela-Kharsawan districts of Jharkhand it lies between Latitudes 22^0 46' 30" N and 22^0 57'N and Longitudes 86^0 3' 15" E and 86^0 26'30"E (Figure1). It's eastern limit extends up to the border of Purulia district of west Bengal on the eastern side. The entire Forest of Dalma Sanctuary falls in catchment area of Subarnarekha River and Dimna Lake of Jamshedpur.

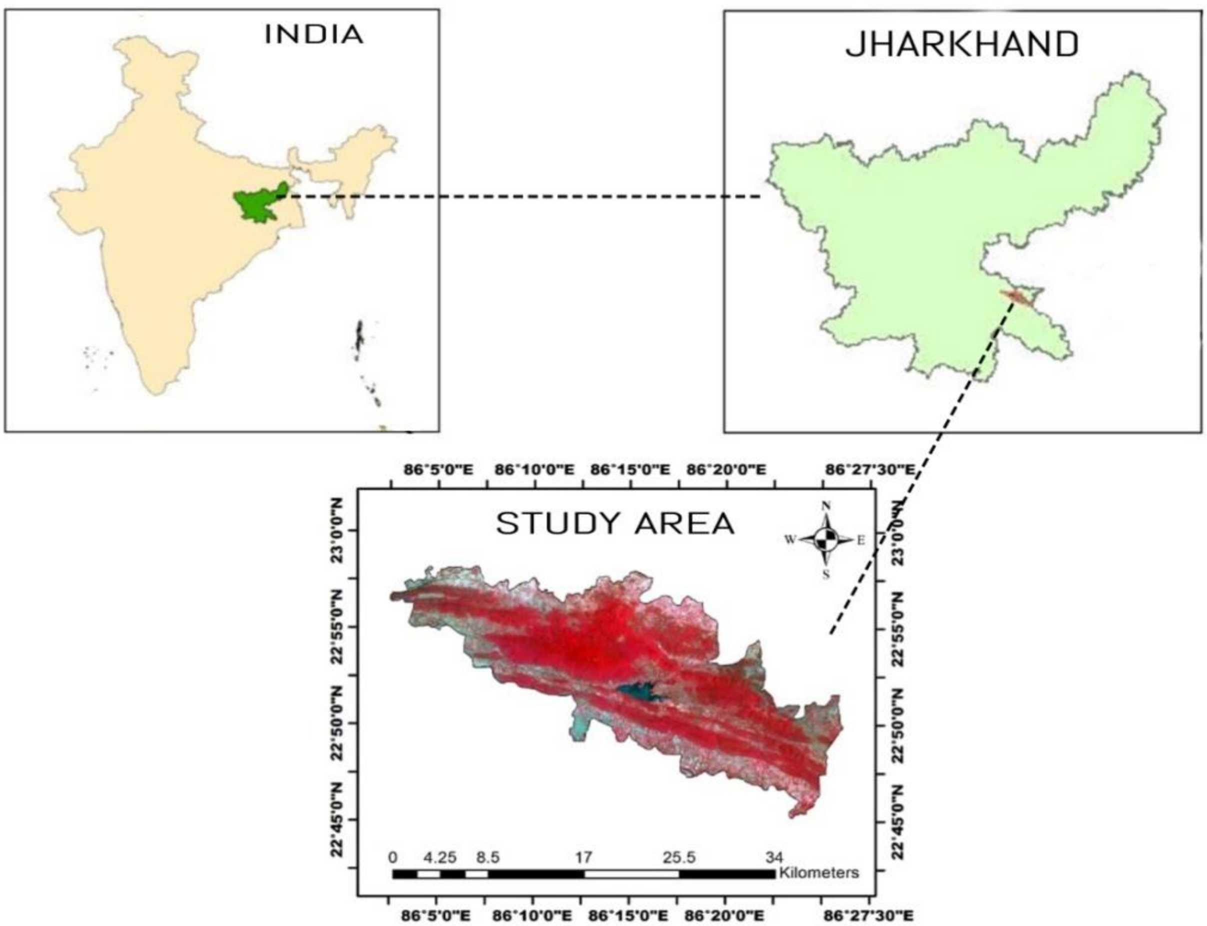


Figure 1: Study Area

Methodologies

Satellite Imageries and Collateral (Ancillary) Data Used- Satellite imageries and ancillary data were collected in order to forest & land use mapping of Dalma wildlife sanctuary. The image data that was used for this study are Landsat-8 (Figure 2). Open Series Topographic maps (topographic map no. F45I1 and 73J/5) of 1:50,000 scales were obtained from Survey of India (SOI) and Drainage, road networks, railway network, specific locations and places were generated from topographic maps through manual digitizing and geo-referenced according to WGS 1984 UTM ZONE 45N.

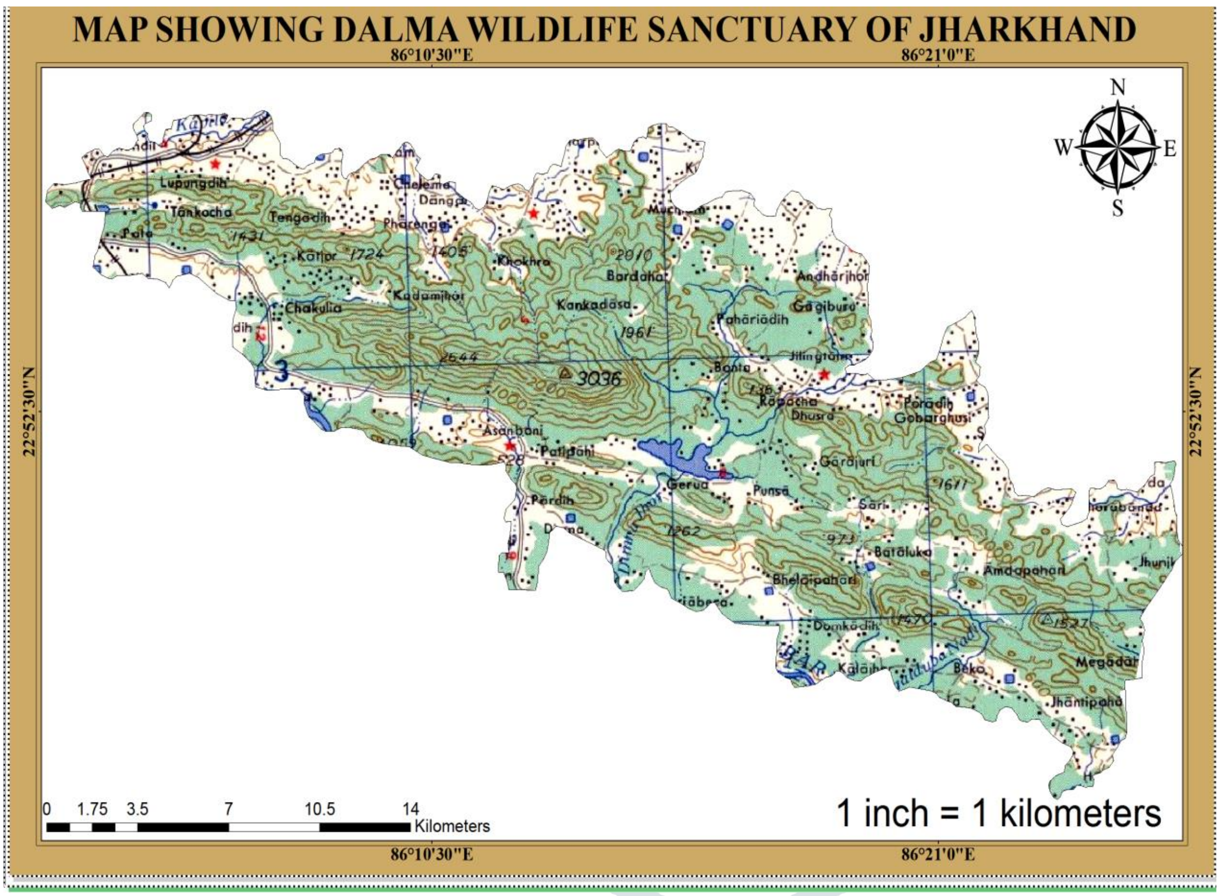


Figure 2: Topographic map of Dalma Wildlife Sanctuary (**Source:** SOI)

Google Earth along with ground truething is most important tool for ground assessment, or to make ground verification. Landsat imageries of OLI were employed and acquired in the same season and the same level of resolution for the period 2016. The satellite image was downloaded from the earth explorer portal of the USGS domain. It was conducive for comparison of changes and patterns occurred in the time under discussion. The images were downloaded from the Global Land Cover Facility of the University of Maryland (GLCF, 2013) and the United States Geological Survey (USGS) and spatially referenced in the Universal Transverse Mercator (UTM) projection with datum World Geodetic System (WGS) 1984 UTM. These data sets were imported in ERDAS Imagine version (Leica Geosystems, Atlanta, U.S.A.), satellite image processing software to create a false colour composite (FCC). The layer stack option in image interpreter tool box was used to generate FCCs for the study areas as shown in Figure 3.

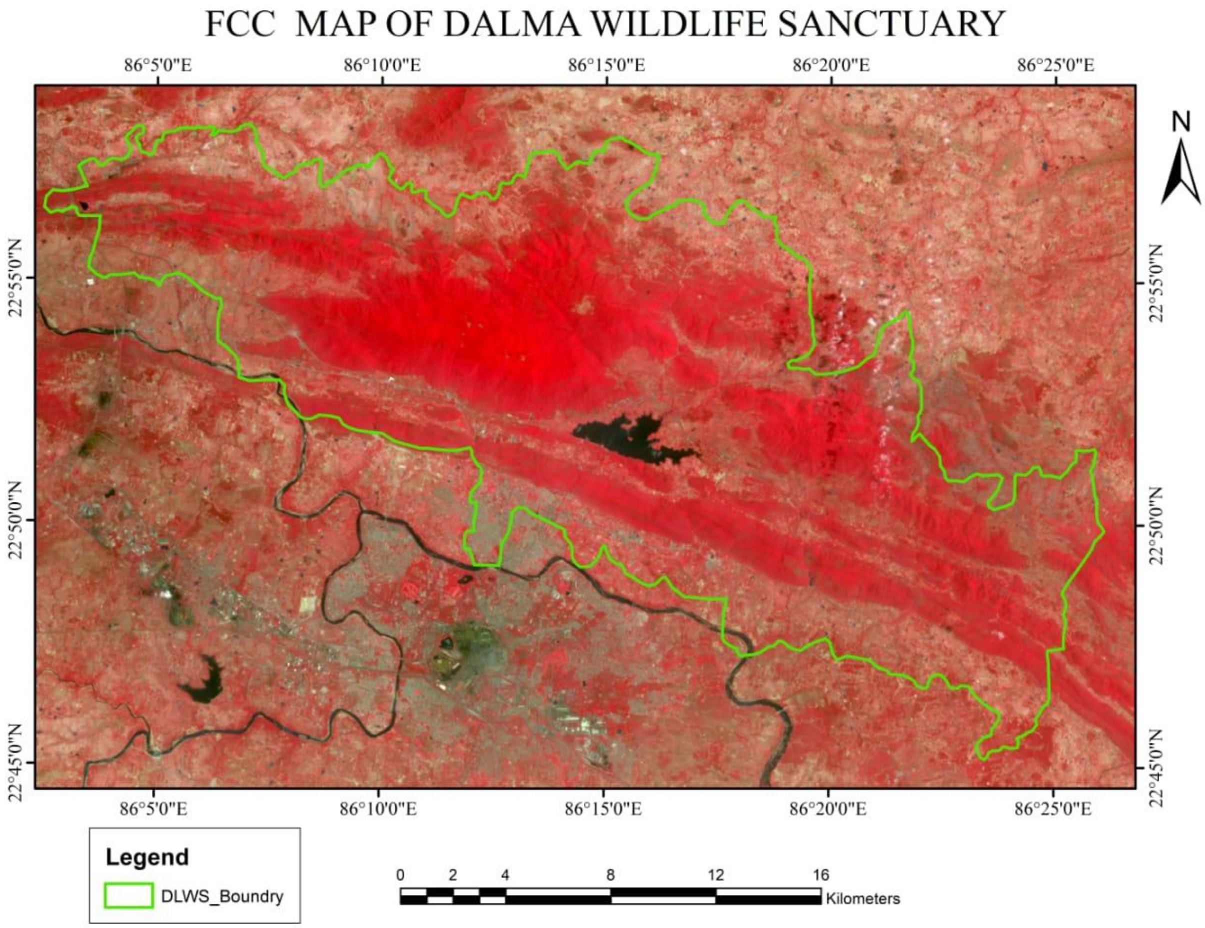


Figure 3: FCC Map of the year 2016 of Dalma Wildlife Sanctuary (**Source:** USGS)

The sub-setting of satellite images were performed for extracting study area from both images by taking geo-referenced out line boundary. All the data and the software that are used in the study are enlisted in the Table 1.

The collected images are pre-processed by radiometric or geometric corrections. Radiometric corrections include correcting the data for sensor irregularities and unwanted sensor or atmospheric noise, and converting the data so they accurately represent the reflected or emitted radiation measured by the sensor.

Table 1: List of Data Sources and Material

I. SATELLITE IMAGES					
I. Sensor	**Path**	**Row**	**Spatial Resolution**	**Date of Accusation**	**Source**
Landsat 8 OLI	140	044,045	30*30 meter	15 July 2016	USGS
II. TOPOGRAPHICAL MAPS			SOURCE		
Topographic Map Number			SOI		
III. SOFTWARE USED					
• Erdas Imagine 2014 used for Geo-referencing, Re-sampling, Image Processing and Image Classification • Arc Gis 10.3 (Arc Map) used for GIS analysis & mapping • Other Software used in this study include Google Chrome, Earth, Microsoft Excel, Word					

Image enhancement is solely to improve the appearance of the imagery to assist in visual interpretation and analysis. Contrast stretching has been performed to increase the tonal distinction between various features in a scene, and spatial filtering to enhance (or suppress) specific spatial patterns in an image. Arithmetic operations (i.e. subtraction, addition, multiplication, division) are performed to combine and transform the original bands into "new" images which better display or highlight certain features in the scene. The image pre-processing, enhancement and transformation operations are done using ERDAS IMAGINE.

Table 2: Details of Bands used in this study

Spectral Bands	Wave Length	Resolution
Band 1- Coastal/Aerosol	0.433 to 0.453 µm	30 m
Band 2- Blue	0.450 to 0.515 µm	30 m
Band 3- Green	0.525 to 0.600 µm	30 m
Band 4- Red	0.630 to 0.680 µm	30 m
Band 5- Near Infra Red	0.845 to 0.885 µm	30 m
Band 6- Short Wave Infra Red	1.560 to 1.660 µm	30 m
Band 7- Short Wave Infra Red	2.100 to 2.300 µm	30 m
Band 8- Panchromatic	0.500 to 0.680 µm	15 m
Band 9- Cirrus	1.360 to 1.390 µm	30 m

The forest types that covered the study area, according to Champion and Seth (1968) are Northern Tropical dry Deciduous Forest (5B), Dry Peninsular Sal Forest (5B/C1) and Northern dry mixed Deciduous Forest (5B/C2).

Paradigm of study

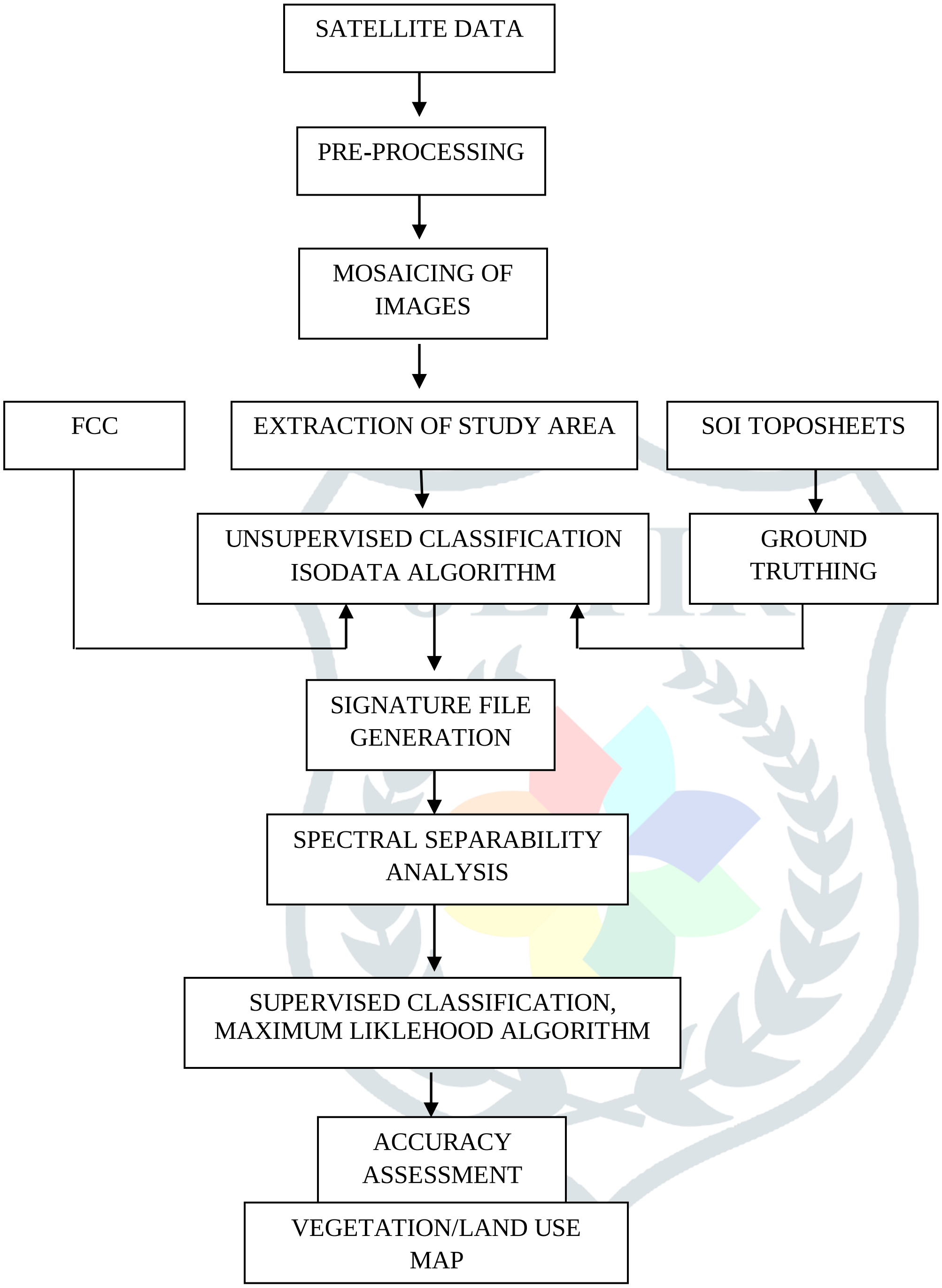


Figure 4: Showing Methodology & Procedure

Image Processing

- Brightness Correction
- Contrast Adjustment
- Generating False Colour Composite

Coordinate Transformation & Geo referencing - All the data are transformed into the common projection system that is WGS_1984_UTM_Zone_45N by geo referencing them, which the process of assigning real – world coordinates to each pixel of the raster. The topographical maps are geo referenced with the help of GCPs which are the proper latitude and longitude values.

Methodology for preparation of NDVI (Normalised difference Vegetation Index)- This vegetation index is a ratio based VI calculated by the difference of the infrared and red bands as ratio to their sum. Thus

- NDVI = {(IR - R)/ (IR + R)} **(Source Akike, Slady, and Sailesh Samanta. "Land Use/Land Cover and Forest Canopy Density Monitoring of Wafi-Golpu Project Area, Papua New Guinea."** ***Journal of Geoscience and Environment Protection*****, vol. 04, no. 08, 2016, doi:10.4236/gep.2016.48001.)**
- IR = pixel values from the infrared band
- R = pixel values from the red band

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum and is adopted to analyse remote sensing measurements and assess whether the target being observed contains live green vegetation or not.

This index outputs values between -1.0 and 1.0, mostly representing greenness, where any negative values are mainly generated from clouds, water, and snow, and values near zero are mainly generated from rock and bare soil.

Conversion to TOA Radiance- Landsat 8 used in this study consists of quantized and calibrated scaled Digital Numbers (DN). It is 16-bit unsigned integer format with range value from 0 to 2 8= 65536. It needs to convert into radiance value to calculate the vegetation indices. This process has been done by using equation (1).

$$L\lambda = ML * Qcal + AL$$

Where, Lλ= TOA spectral radiance (Watts/ (m2 * srad * µm))

ML= Band-specific multiplicative rescaling factor from the metadata.

AL= Band-specific additive rescaling factor from the metadata.

Qcal= Quantized and calibrated standard product pixel values (DN).

3.6 Nomenclatures of Land cover Classes- The classification and nomenclature of land cover classes is shown in **Table .**

Table 3: Land cover class nomenclature (**Source:** Wikipedia)

Land cover classes	Description
Artificial (Built-up) surfaces	Consists of Urban fabric, Industrial, commercial and transport units, Mine, dump and construction sites, and artificial non-agricultural vegetated areas
Agricultural areas	Arable land, Permanent crops, Pastures and Heterogeneous agricultural areas
Forests and semi-natural areas	Forests, Shrub and/or herbaceous vegetation association
Open/barren areas	Open spaces with little or no vegetation, beaches, dunes sands, bare rocks, sparsely vegetated areas
Water bodies	Inland wetlands and Coastal wetlands
Wetlands	Water courses, water bodies, sea and ocean areas, coastal lagoons

Accuracy Assessment- Accuracy assessment is a general term for comparing a classification to geographical data that are assumed to be true, in order to determine the accuracy of the classification process. It is performed by comparing a map created by using remote sensing analysis to a reference map based on different information sources such as Google earth and original mosaic images for those time periods where Google earth is not available. An interpretation is then made of how close the newly produced map from the remotely-sensed data matches the reference (source) map. Although the basic approaches to accuracy assessment seems relatively direct and easy, a variety of errors encountered when evaluating an image classification and capturing remotely sensed data. Evaluation of the accuracy of a classified image can be done using an error matrix sometimes called confusion matrix (Senseman et al, 1995; Foody, 2002).

Error Matrix- It is a square array of numbers laid out in rows and columns that express the number of sample units assigned to a particular category relative to the actual category as verified in the field. The columns normally represent the reference data, while the rows indicate the classification generated from classified image. It also provides an excellent summary of the two types of thematic error that can occur, namely, omission and commission. Error of omission refers to pixels in the reference map that were identified as something other than their "accepted" value, whereas error of commission, on the other hand, refers to pixels that were incorrectly classified as a class in a row (Senseman et al, 1995; Maingietal, 2002).

Most of the classification accuracy measurements are derived from an error matrix. However, the most popular one is the correctly allocated cases in a percentage. Based on this, user's accuracy refers to the probability that a given pixel can be found in the ground as it is in the classified image, whereas producer's accuracy refers to the percentage of a given class that is correctly identified on the map (Yesserie, 2009).

Results and Discussions

Land Use /Land Cover Map of 2016- With the help of classification method of Landsat 8 OLI land use land cover change of Dalma Wildlife Sanctuary was distributed into seven classes such as agriculture, evergreen forest, deciduous forest, degraded forest, grassland, settlement, water body. The dominating class in land use land cover change for the year 2016 was evergreen forest and deciduous forest.

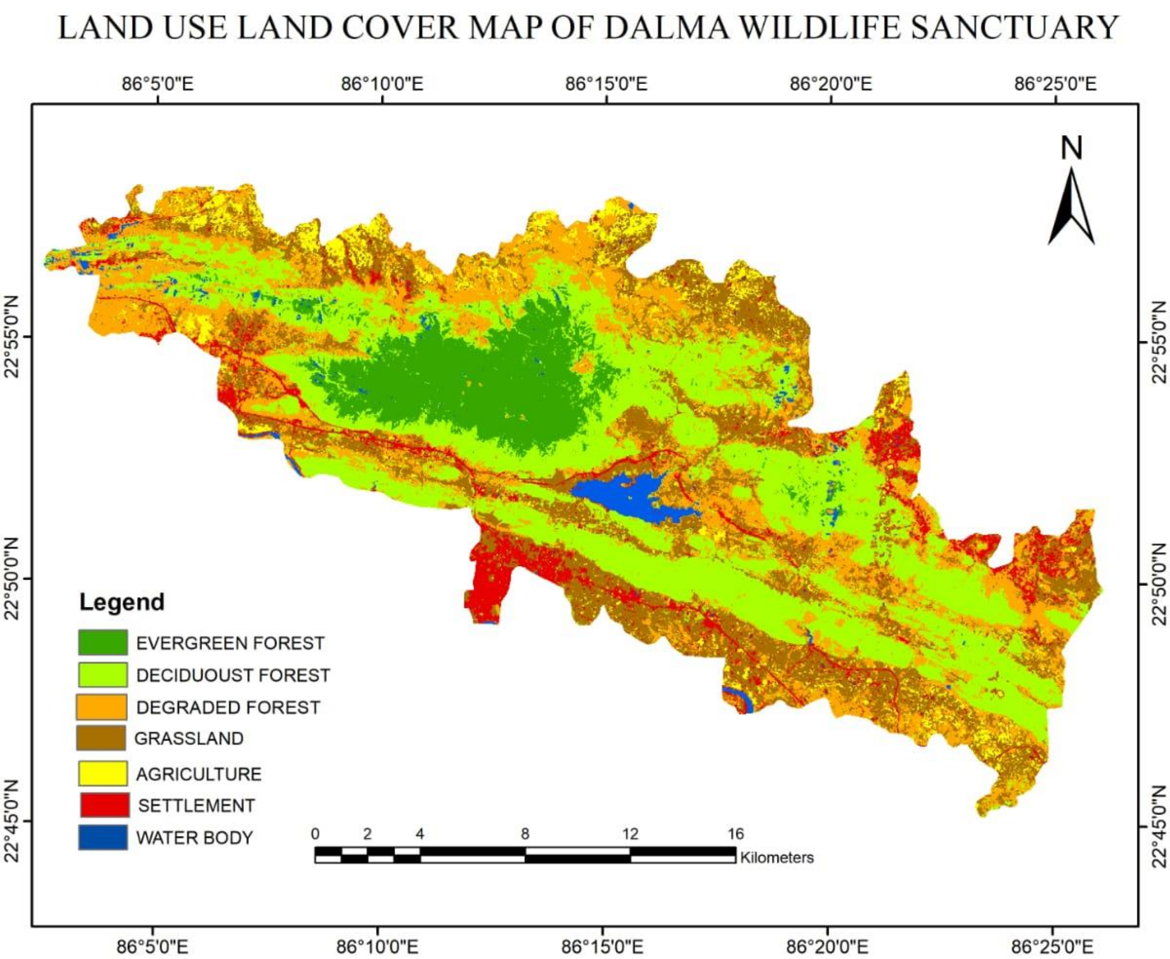


Figure 5: Map Showing LULC of Dalma Wildlife Sanctuary for the year 2016

In this study according to Vegetation Map (Figure 6) of Dalma Wildlife Sanctuary, the upper zone covering Core area consists of mainly Evergreen forest, Dry mixed deciduous forests with small patches of moist mixed forests near water stream (Barka bandh & Chhotaka bandh) and in the northern aspects. The upper portion of the hills are particularly on the northern aspects consists of comparatively better quality of mixed forests of evergreen and deciduous. Field survey was completed in two continuous years 2016 and 2017 respectively to find out information of various vegetation types. Information was documented to assign different attribute for preparation of vegetation map.

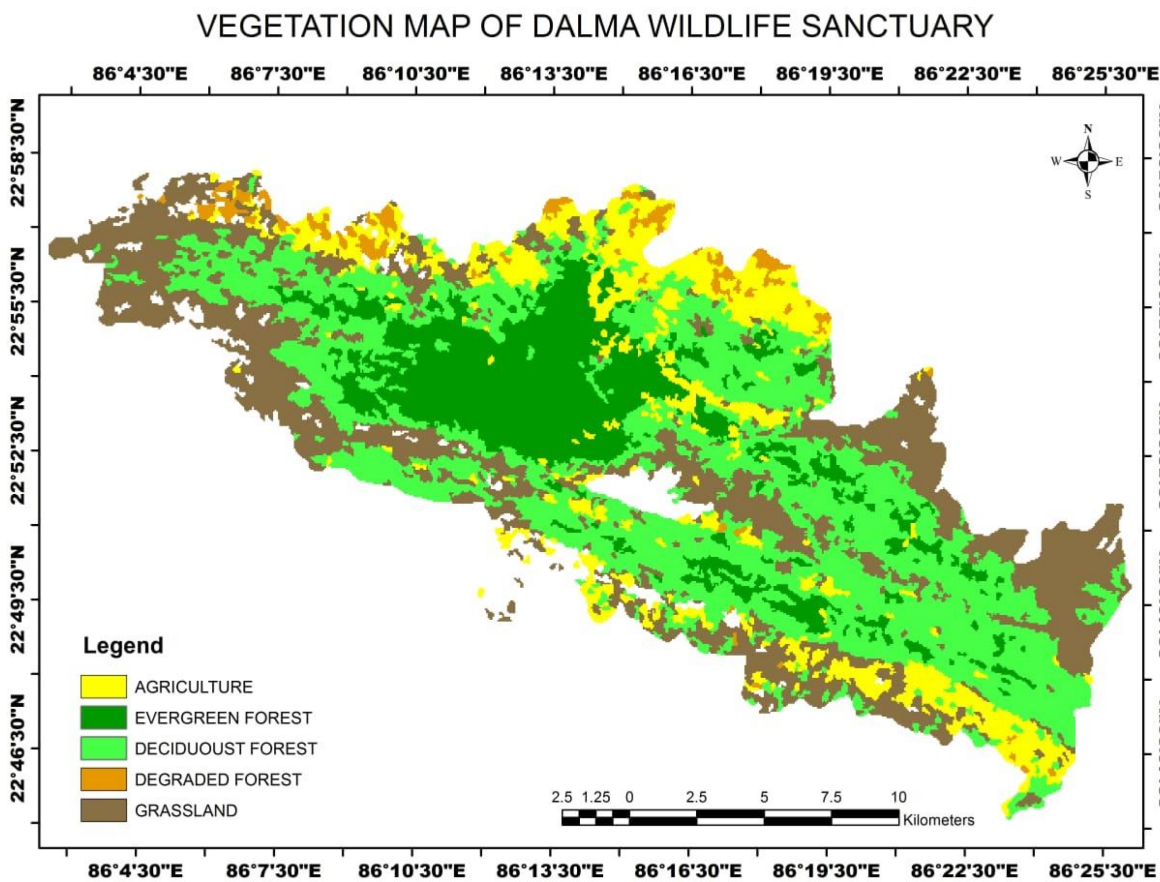


Figure 6: Vegetation Map of Dalma Wildlife Sanctuary for the year 2016

NDVI of 2016- The NDVI map of Dalma Wildlife Sanctuary of 2016, illustrating vegetation of different health conditions and various other features like barren land settlement, river, water bodies etc. The image indicates high to low values. The values vary between -0.39 to 0.93 (**Figure 5).** The NDVI was found to be related to many properties of the plants. It was, and in many cases still is, used to identify the health status of plants, to depict phonological changes, to estimate green biomass and crop yield and in other applications. However, the NDVI has particular weaknesses. Atmospheric condition and thin clouds can influence the calculation of the NDVI when satellite data are used. When vegetation cover is low, whatever is under the vegetation canopy contributes to the recorded reflectance signal.

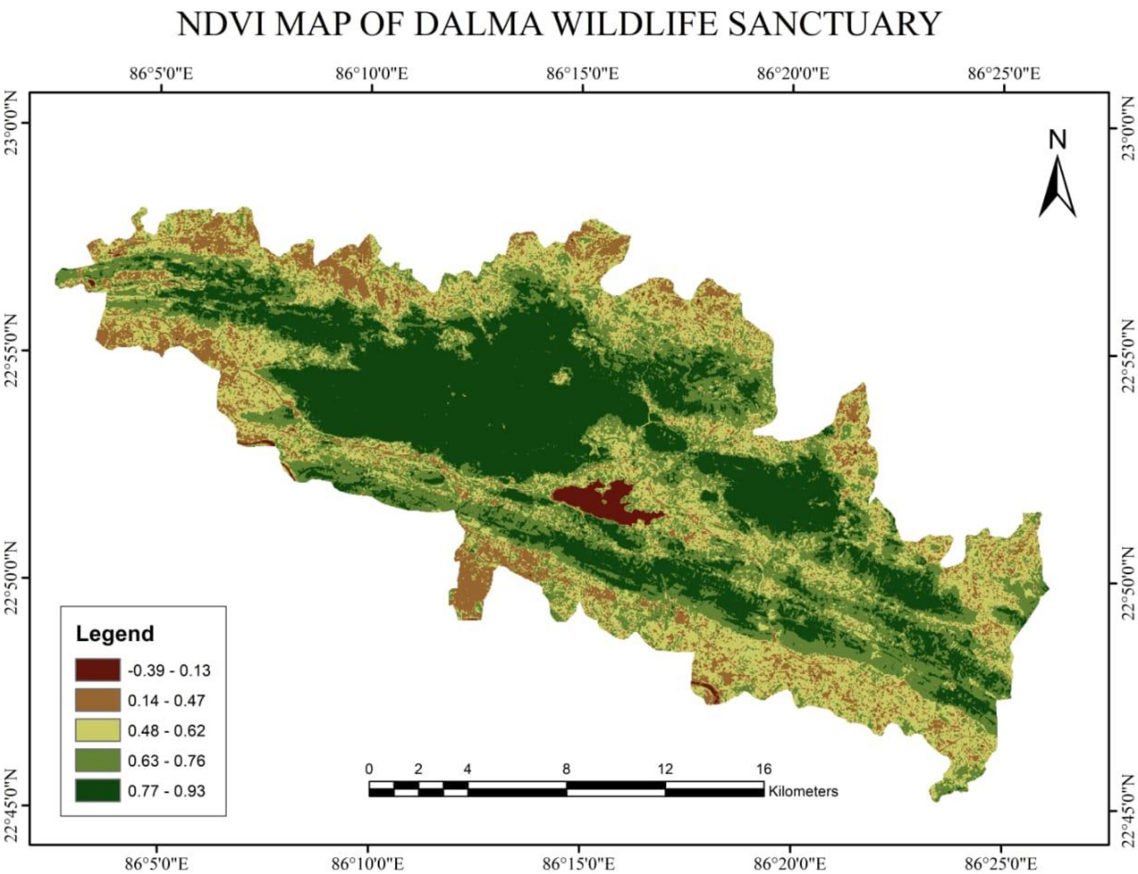
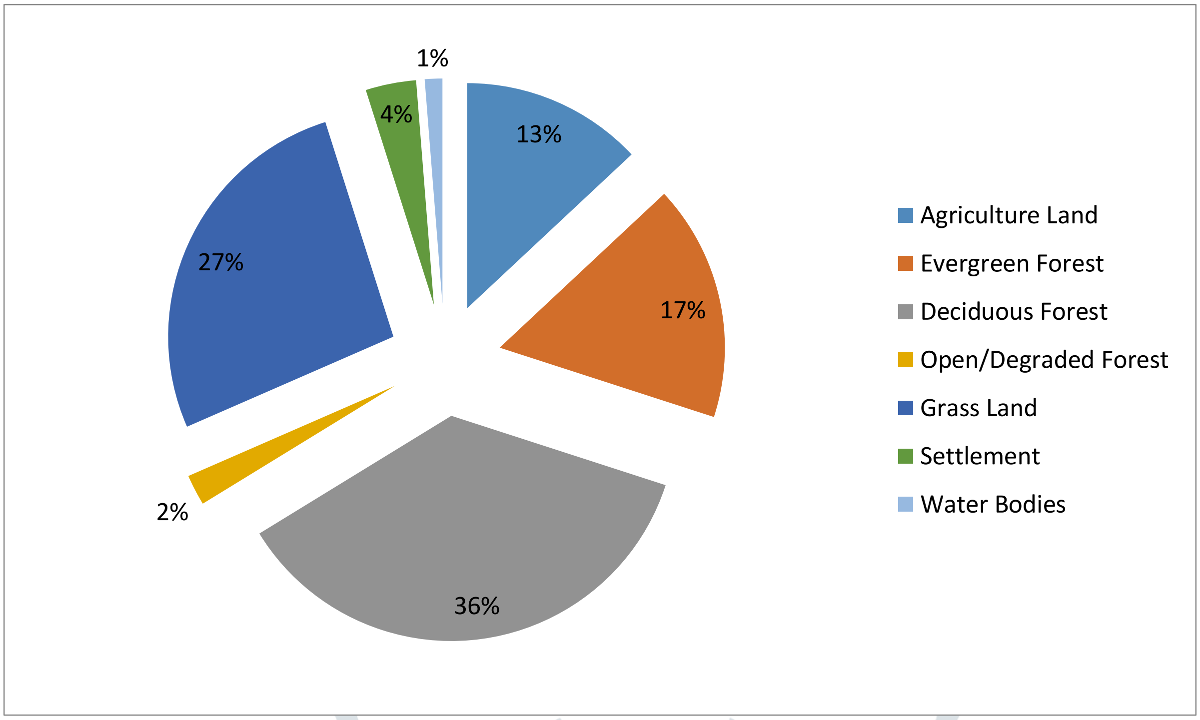


Figure 5 : NDVI Map of Dalma Wildlife Sanctuary for the year 2016

Actual area observed is shown in Table .

Table 4: Area statistics and percentage distribution of Vegetation & Land Use

Vegetation/Land Cover Types	Land Covers Area (Sq.km)
Agriculture Land	**25.80**
Evergreen Forest	**33.74**
Deciduous Forest	**71.45**
Open/Degraded Forest	**3.96**
Grass Land	**53.59**
Settlement	**7.93**
Water Bodies	**1.98**
TOTAL	**198.45**



FiguFigure 6 : Percentage distribution of Vegetation & Land Use Types

Spectral Reflectance Curve of Cover Type- The spectral reflectance for all the identified land use systems of Dalma Wildlife Sanctuary is shown in Figure 5.

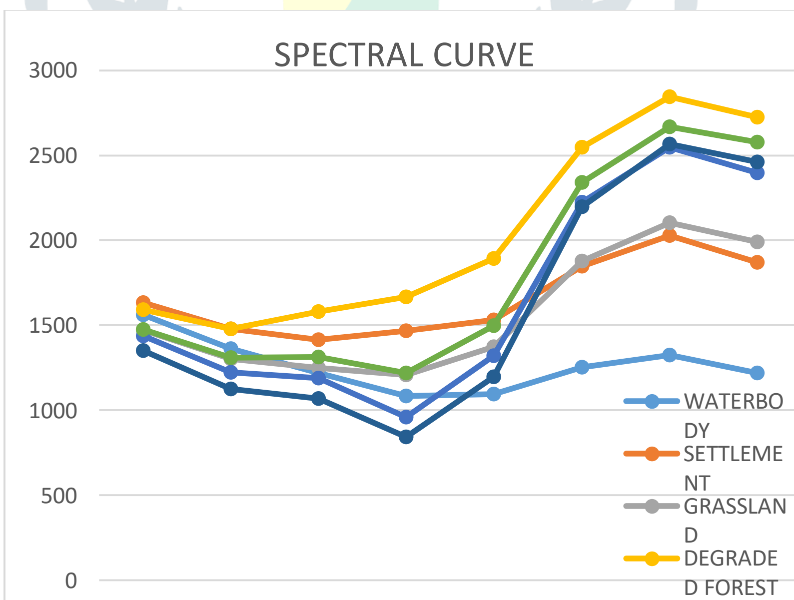


Figure 6: Spectral reflectance from different vegetation & Landuse types in Dalma Wildlife Sanctuary

Producer's Accuracy- Producer's accuracy refers to the number of correctly classified pixels in each class (category) divided by the total number of pixels in the reference data to be of that category (column total).

Overall Accuracy- It is computed by dividing the total number of correctly classified pixels (i.e., the sum of the elements along the major diagonal) by the total number of reference pixels. It shows overall results of the tabular error matrix. The overall accuracies performed in this study period 2016 was 84.39%. As mentioned by Anderson et al (1976) for a reliable land cover classification, the minimum overall accuracy value computed from an error matrix should be 85%. However, Foody (2002) showed that this baseline makes no sense to be a universal standard for accuracy under practical applications. This is because a universal standard is not exactly related to any specific study area. Foody (2002) also noted that Anderson et al (1976) do not explain in detail about the criteria of map evaluation for universal applications. Moreover, Lu et al (2004) noted that the accuracies of change detection results highly depend on many factors, such as: availability and quality of ground truth data, the complexity of landscape of the study area, the change detection methods or algorithms used as well as classification and change detection schemes.

Kappa Coefficient- It provides a difference measurement between the observed agreement of two maps and agreement that is contributed by chance alone. For accuracy assessment the kappa statistic is frequently calculated, characterizing the degree of matching between reference data set and classication. In fact, it is a statistic that compares two matrices: here, it describes the difference between the agreement found in the actual matrix and the chance agreement given the same marginal frequencies.

User's Accuracy- Users accuracy refers to the number of correctly classified pixels in each class (category) divided by the total number of pixels that were classified in that category of the classified image (row total). It represents the probability that a pixel classified into a given category actually represents that category on the ground. Results of user's accuracy in this study showed that in 2016 the maximum class accuracy was 99.17%, which was settlement where correctly classified and the minimum was agriculture with an accuracy of 68.05% as presented in table below. According to Václavík and Rogan (2009), the category of agriculture was the most problematic because it represented a mixture of various crops in different phonological stages as well as bare soil (ploughed fields). In addition to this, the spatial resolution of Landsat data could have an influence on the image classification. According to Zhou et al (2009) for detailed land use and land cover mapping at very fine scales, high spatial resolution imagery from satellite sensors such as IKONOS and QuickBird become more accurate.

Table 5 : Error Matrix of LU/LC classification of 2016

Classified Data	Agriculture	Evergreen Forest	Deciduous forest	Degraded forest	Grass land	Settlement	Row Total	User Accuracy
Agriculture	2058	610	500	00	02	01	3171	68.05%
Evergreen Forest	00	2582	53	00	20	00	2655	97.25%
Deciduous forest	84	01	1129	154	270	22	1660	70.55%
Degraded forest	00	00	00	4588	190	73	4851	94.57%
Grass land	116	00	16	00	598	40	770	77.66%
Settlement	00	05	01	00	00	720	726	99.17%
Column Total	2258	3198	1699	4742	1080	856	13833	
Producer Accuracy	91.14%	80.73%	66.45%	96.75%	55.37%	84.11%		
Over All Accuracy is -84.39%								

Po = 2058+2582+1129+4588+598+720 =10546

Pc=(3171*2258/13833)+(2655*3198/13833)+(1660*1699/13833)+(4851*4742/13833)+(770*1080/13833)+(726*856/13833)

References

1. Forest Survey of India, 2017, State Forest Report, Forest Cover, 25p.

2. Forest Survey of India, 2017, State Forest Report, Forest Cover of Jharkhand, 207p.

3. Roy, P. S. and P. K. Joshi. 2002. Forest cover assessment in north-east India-the potential of temporal wide swath satellite sensor data (IRS-1C WiFS).*International Journal of Remote Sensing*. 23(22): 4881-4896.

4. Wilkie, D.S. and J.T. Finn. 1996. *Remote sensing imagery for natural resource monitoring: a guide for first-time users.* Columbia University Press, New York.295 pp.

5. Champion, H.G .and S.K. Seth. 1968. The forest types of India-A revised survey. Manager of Publication, Delhi.

6. Laurin, G.V.; Puletti, N.; Hawthorne, W.; Liesenberg, V.; Corona, P.; Papale, D.; Chen, Q.; Valentini, R. Discrimination of tropical forest types, dominant species, and mapping of functional guilds by hyperspectral and simulated multispectral Sentinel-2 data. Remote Sens. Environ. **2016**, 176, 163–176

7. Laurin G.V., Liesenberg V., Chen, Q., Guerriero, L. Del Frate, F., Bartolini, A., Coomes D., Wilebore, B., Lindsell, J., Valentini, R. 2013 - Optical and SAR sensor synergies for forest and land cover mapping in a tropical site in West Africa. International Journal of Applied Earth Observation and Geoinformation 21: 7-16.

8. Omruuzun F., Baskurt D.O., Daglayan H., Cetin Y.Y. 2015 - Utilizing hyperspectral remote sensing imagery for afforesta-tion planning of partially covered areas. In SPIE Remote Sensing (pp. 96432N-96432N). International Society for Optics and Photonics.

9. Trumbore S., Brando P., Hartmann H. 2015 - Forest health and global change. Science 349: 814-818.

10. Foody, G. M. (2002). Status of land covers classification accuracy assessment. Remote Sensing of Environment, 80(1), 185–201.

11. Bekalo, M. T. (2009). Spatial metrics and Landsat data for urban landuse change detection: case of Addis Ababa, Ethiopia.

12. Senseman, G. M., Bagley, C. F and Tweddale, S. A. (1995). Accuracy Assessment of the Discrete Classification of Remotely-Sensed Digital Data for Landcover Mapping. DTIC Document.

13. Yesserie, A. G. (2009). Spatio-temporal land use/land cover changes analysis and monitoring in the Valencia Municipality, Spain.

14. Anderson, J. R., Hardy, J. T. R and Witmer, R. E. (1976). A land use and land cover classification A. Pensuk and RP Shrestha/GMSARN International Journal 2 (2008), 190.

15. Lu, D., Mausel, P., Brondizio, E and Moran, E. (2004). Change detection techniques. International Journal of Remote Sensing, 25(12), 2365–2401.

16. Václavík, T and Rogan, J. (2009). Identifying trends in land use/land cover changes in the context of post-socialist transformation in central Europe: a case study of the greater Olomouc region, Czech Republic. GIScience & Remote Sensing, 46(1), 54–76.

17. Zhou, W., Huang, G., Troy, A and Cadenasso, M. L. (2009). Object-based land cover classification of shaded areas in high spatial resolution imagery of urban areas: A comparison study. Remote Sensing of Environment, 113(8), 1769–1777.

18. Hirose K., Osaki, M., Takeda, T., Kashimura O., Ohki, T., Segah H., Gao Y., Evri, M. 2016 - *Contribution of Hyperspectral Applications to Tropical Peatland Ecosystem Monitoring.* Tropical Peatland Ecosystems (pp. 421-431). Springer Japan.

19. Akike, Slady, and Sailesh Samanta. "Land Use/Land Cover and Forest Canopy Density Monitoring of Wafi-Golpu Project Area, Papua New Guinea." *Journal of Geoscience and Environment Protection*, vol. 04, no. 08, 2016, doi:10.4236/gep.2016.48001