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APPLICATION OF REMOTE SENSING & GIS IN FOREST CHANGE DETECTION OF KATEPURNA SANCTUARY, AKOLA (MAHARASHTRA) AND IT'S IMPACT ON RURAL LIVELIHOOD

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Abstract

Rural India has vast natural resources and one of the important natural resources in rural area is the forest. Rural India has an abundance of forest and they have been dependent on forest for their livelihood. Forest is one of the vital components of the ecosystem and the anthropogenic activities as well as the natural processes are continuously changing its cover. It is a fact that human life is dependent on the forests. But anthropogenic factors had played a degrading role in these biodiversity rich forests. To protect the rich biodiversity Wildlife Sanctuaries has been notified by our Government. Consequently, proper monitoring of forest cover becomes a matter of great concern. , and hence it turns out to be the theme of the study. This study it attempted whether due to notification as wildlife sanctuary an enhanced protection whether there has been an increase of forest or not. Hence, the major objective of this study is to detect the magnitude of forest cover change in the duration of the last 10 years (between 2008 and 2018) in Katepurna Wildlife Sanctuary, India.

The study uses a series of topographical sheets of the open series map having scale 1:50,000, and satellite imageries from Landsat-8 to recognize forest cover changes during the chosen period. A very simple method is used here to complete the study which requires generation of Land Use/Land Cover (LU/LC) map and Normalised Difference Vegetation Index (NDVI) model of the study area. On the classified map, accuracy assessment is performed, which produced error matrices and overall accuracy, the calculated overall accuracy is found 87.18% for 2008 and 86.11% for 2018. The objective of detection of net forest cover change area is done by observing the change in light vegetation and dense vegetation areas. This study shows that area was well protected and the vegetation regeneration was improved. The growth was better for the wildlife as the vegetation improved inside the wildlife sanctuary. The negative was the rural people were not allowed to graze the animal inside the sanctuary and had look for an alternative. Hence, it is a positive sign of the wildlife manager so that he can have the area for the wild animal which feed on grasses and plants

Key words : Land Use/Land Cover (LU/LC), Normalized Difference Vegetation Index (NDVI), Remote Sensing (RS), Geographic Information System (GIS).

1.1 Introduction

'India resides in rural area' is a famous anecdote. Truly Indian economy backbone i.e. agriculture is carried out in the hinterland of our country. The foods we have are derived mainly from the rural area. The forest cover and the natural resource are found abundant in the villages of India. This vegetation or the forest area is source for food for the wildlife as well as the local domestic animals. These resources should be used in a sustainable way so it is available to all the stakeholders in a measured amount.

Earth's vegetation plays a major part in shaping the composition and character of the land surface. Information about the vegetation cover is an indirect indicator of land-use and is highly relevant for environmental studies. Forests are vital for life, home to millions of species, they protect the soil from wearing away, create oxygen, store carbon dioxide, and help control climate. Forests are also essential for us to survive as they supply us food, shelter, and medications as well as many other useful materials. They also purify the air we breathe and water that we require to live.

Mapping of landscape processes like vegetation, land use/land cover, soil survey, the geological mapping is traditionally done based on hierarchical systems. Depending on the aim, diagnostic features or measures are preferred. The data required also depends on the aim of the survey, though different studies may employ the same data or different ones. Various methods are available to identify the alteration in the earth's surface, all treating the environmental variables as a set of patterns occurring at specific scales.

Now getting to the topic, i.e. the change detection in forest cover, before dealing that some basic things should be read first.

The use of GIS and remotely sensed data in mapping different natural resources management and environmental modeling are gaining appreciation in recent years. The majority of work in remote sensing was mainly focused on environmental studies in the last few decades. The implication of Remote Sensing and Geographic Information System to forest cover change and urban planning is now getting attention and interest among GIS and remote sensing professionals. Remotely sensed data provide advantages like synoptic coverage, consistency in data, global reach and readability, precision and maximum accuracy in data provision.

1.2 Aim

To precisely demarcate the net change area in the forest cover in Katepurna Wildlife Sanctuary, India by the help of temporal satellite data.

1.3 Study Objectives

The study compares two different satellite images and analyses their results to come up with an answer which can provide the end–users, using this technique, about the optimal method, spatial resolution and spectral band which can be used to detect the change in forest cover type found in the study area.

This will help not only to save time and effort but also help reduce the complications of large data handling and processing.

Main objective

- The main objective of the study is to compare the satellite images and different models (NDVI and LULC) for analyzing the forest cover change at different resolutions.

Sub-Objectives

- To make the Normalized Difference Vegetation Index (NDVI) of the study area.

2.1 Materials & Methods

Study Area

Katepurna Sanctuary is situated in the district of Akola, which comes under the Vidarbha region. Akola district has an area about 10,606, Sq. Km and has about 812 Sq. Km. of reserve forest. The

total area of the Sanctuary is 73.69 Sq. Km. The temperature ranges for 21^oC to 45^oC. The forest type is dry deciduous type. The sanctuary occupies a large part of catchment area of the Katepurna reservoir. Due to the presence of large amount of water, birds get attracted towards the place. The period between Octobers to June is the ideal time for visiting the place. Flora- The place is very rich in vegetation cover and mainly comprises of southern tropical deciduous forests.
forests.

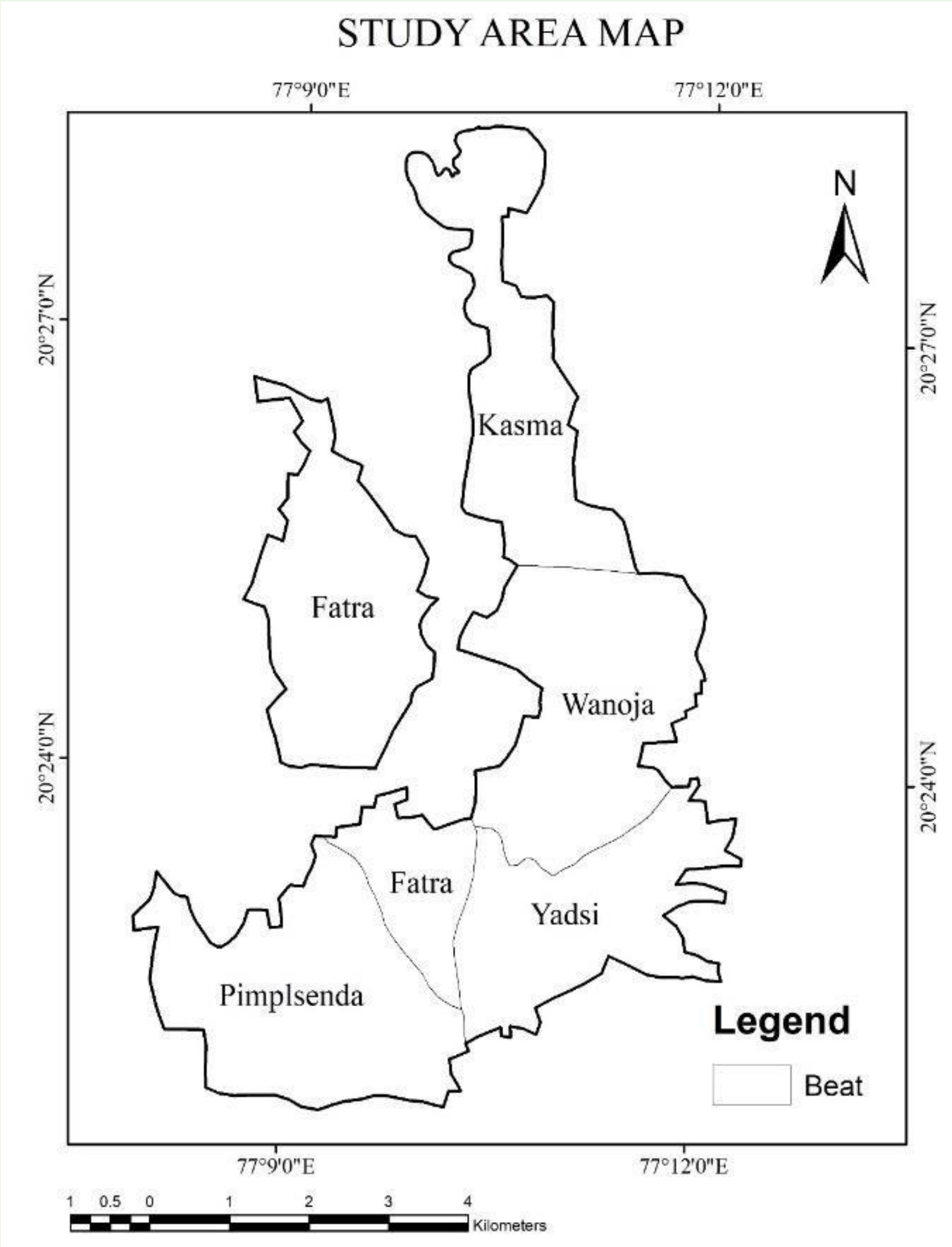


Fig-1. Location map of the Katepurna Sanctuary

In Katepurna Wildlife Sanctuary there is no large human settlement inside the sanctuary area. Only three villages are inside the sanctuary namely Devari and Chichkhed Band. But there are twelve villages on the fringes of the sanctuary which make the area susceptible. There are three villages and two more cultivation areas inside the sanctuary. Once they are re-located outside the sanctuary area, any likely activity forest offence in future will be stopped.

a) The major part of the sanctuary area is largely free from illicit felling. However the peripheral parts adjoining to villages are susceptible for illicit cutting for timber and fuel wood.
b) The villagers on the periphery do indulge in illicit removal of tendu leaves, thatched grass, flowers and fruits.
c) Firewood wood collection is not allowed in the Wildlife Sanctuary area.
d) The Wildlife Sanctuary area is susceptible to fire during dry season.
e) The Wild Life Sanctuary is susceptible to grazing as the cattle of the villages tend to sneak in the area.

2.2 Satellite Imageries and Collateral (Ancillary) Data

Satellite imageries and ancillary data were collected in order to identify successive forest cover changes. The image data that was used for this study are Landsat TM & OLI, Topographic maps of Open Series at the scale of 1:50,000 were procured from the Survey of India (SOI), Study area boundary was generated from collateral or ancillary data that was map of the Katepurna Sanctuary, the study area.
Google Earth along with ground truthing is also most important tool for ground assessment, or to make ground verification.

The majority of primary data necessary for the study has been extracted from satellite images. Forest cover types at various times have been extracted from Landsat.

The Open Series Topographic maps 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.

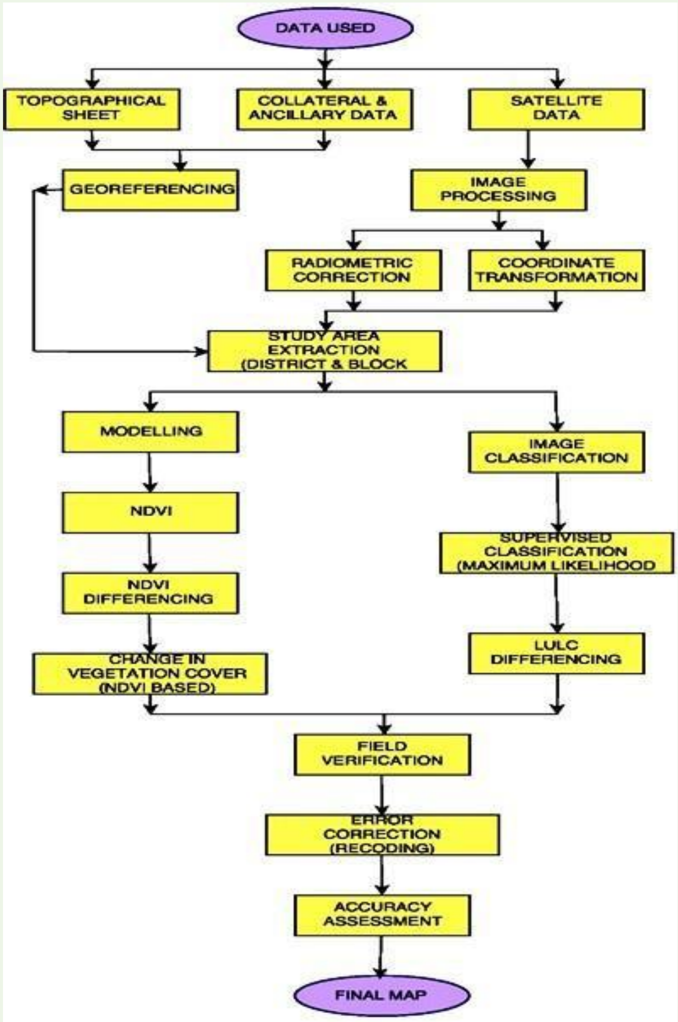
All the data and the softwares that are used in the study are enlisted in the table 1.

Table-1 : List of data sources and material

I. SATELLITE IMAGES				
Sensor	**Path**	**Row**	**Spatial resolution**	**Source**
Landsat TM	140	044, 045	30 x 30 m resolution	USGS
Landsat 8 OLI	140	044, 045	15 x 15 m resolution	USGS
II. TOPOGRAPHICAL MAPS				
			Source	
Topographic Map			SOI	
III. SOFTWARES USED				
1. ERDAS Imagine 2014 : used for Georeferencing, Resampling, and Image Processing and Image classification. 2. ArcGIS 10.3 (Arc Map) : used for GIS analysis and mapping. 3. Other software used in this study include Google Chrome, Earth, Microsoft Word, and Excel.				

2.3 Methodology

The methodological flow chart of the study, represents all about the procedure, methods, and steps used to achieve the main aim of the study that is to map the change in the vegetation cover in Katepurna Sanctuary in 10 years from 2008-18.



2.4. Modelling

The Model Maker tool of the ERDAS IMAGINE 2014 software is used to make the models required for the study. The required model for the study NDVI (Normalised Difference Vegetation Index) is the required model for the study.

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 analyze remote sensing measurements and assess whether the target being observed contains live green vegetation or not.

NDVI = {(IR - R)/ (IR + R)}
 IR = pixel values from the infrared band
 R = pixel values from the red band

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. Very low values (0.1 and below) of NDVI correspond to barren areas of rock, sand, or snow. Moderate values (0.2 to 0.3) represent shrub and grassland, while high values (0.6 to 0.8) indicate temperate and tropical rainforests.

The NDVI technique is used for extracting the various features presented in the Satellite image of Katepurna sanctuary. Vegetation indices allow us to delineate the distribution of vegetation and soil based on the characteristic reflectance patterns of green vegetation.

2.5. NDVI differencing

After making the NDVI model of both the satellite images of the study area of 2008 and 2018 Image Difference tool of ERDAS IMAGINE 2014 is used to produce the difference image of the two NDVI model images. The difference image is produced by keeping a threshold of 10% that the image will show those areas which have at least 10% of increase or decrease in the pre-existing feature. The image shows four types of areas increased, some increase, some decrease, decreased. But this differenced image does not say about the exact or net change in vegetation only. Because the NDVI describes vegetation along with the other features.

2.6. Image Classification

Image classification techniques group pixels to represent land cover features. The land cover could be forested, urban, agricultural and other types of features. There are three main image classification techniques.

Image Classification Techniques in Remote Sensing :

2.7. Unsupervised Image Classification

Pixels are grouped based on the reflectance properties of pixels. These groupings are called “clusters”. The user identifies the number of clusters to generate and which bands to use. With this information, the image classification software generates clusters. There are different image clustering algorithms such as K-means and ISODATA. The user manually identifies each cluster with land cover classes. It’s often the case that multiple clusters represent a single land cover class. The user merges clusters into a land cover type. The unsupervised classification image classification technique is commonly used when no sample sites exist.

Unsupervised Classification Steps:

- Generate clusters
- Assign classes

2.8. Supervised Image Classification

The user selects representative samples for each land cover class in the digital image. These sample land cover classes are called “training sites”. The image classification software uses the training sites to identify the land cover classes in the entire image. The classification of land cover is based on the spectral signature defined in the training set. The digital image classification software determines each class on what it resembles most in the training set. The common supervised classification algorithms are maximum likelihood and minimum distance classification. The image classification was performed by the help of Classification tool of the Raster menu of ERDAS IMAGINE 2014. Then several training sites representing different features are selected. Then on the basis of those selected training sites signature file is created. And lastly, supervised classification is performed by using Maximum likelihood algorithm.

2.9. Accuracy Assessment

The increased use of remote sensing data and techniques has made geospatial analysis faster and more powerful, but the increased complexity also creates increased possibilities for error. In the past, accuracy assessment was not a priority in image classification studies. Because of the increased chances of error presented by digital imagery, however, accuracy assessment has become more important than ever (Congalton 1991). A common tool to assess accuracy is the error matrix. Error matrices compare pixels or polygons in a classified image against ground reference data (Jensen 2005). These matrices can measure accuracy in several ways. The overall accuracy of the classified image compares how each of the pixels is classified versus the actual land cover conditions obtained from their corresponding ground truth data. Error matrices have been used in many land classification studies and they were an essential component of this study. The change detection method was applied in different application areas ranging from monitoring the land cover and land use change using satellite imageries to difference detection on risky locations. A change detection matrix was shaped with the help of ERDAS IMAGINE software. The change in the forest cover based on the Land Use/Land Cover is shown with the help of changing image visualization properties in ArcMap10.3 and then a proper map showing the net change in the forest cover of the study area.

2.10. Field Verification

Ground truth refers to information that is collected "on location." In remote sensing, this is especially important in order to relate image data to real features and materials on the ground. The forest area surrounding the Sanctuary area is mostly degraded 'C' class forest. Naturally the area is not self-sufficient eco-system with its flora and fauna. Though the topographical features are same but vegetation of surrounding forest area defers in crop condition. Isolated populations of wild animals do occur in the adjoining forest areas. During summer, water availability is limited. The wild animals do have negative impact on the adjoining agricultural areas in certain periods of the year. The collection of ground-truth data enables calibration of remote-sensing data, and aids in the interpretation and analysis of what is being sensed.

More specifically, the ground truth may refer to a process in which a pixel on a satellite image is compared to what is there in reality (at the present time) in order to verify the contents of the pixel on the image. In the case of a classified image, it allows supervised classification to help determine the accuracy of the classification performed by the remote sensing software and therefore minimize errors in the classification.

When performing LU/LC classifications, one needs ground truth data to provide an unbiased reference necessary to conduct accuracy assessments. Because landscapes can change rapidly, it is important that training data and ground truth data are acquired at dates as close to each other as possible. While it is ideal to acquire ground truth data by visiting sites on the ground and performing direct observations, there can be factors that prevent gathering such in situ measurements. These limiting factors include prohibitive costs (Alrababah and Alhamad 2006), the sheer size of the study area (Hung and Wu 2005), an inability to temporally match ground truth data with acquisition dates for remotely sensed imagery (Madhavan *et. al.,* 2001), and inaccessibility to certain parts of the study area (Hung and Wu 2005, Campbell 2007). When in situ measurements are not possible, many researchers substitute direct observations with imagery that has a much 13 higher spatial and/or spectral resolution than the imagery used for the LU/LC classifications (Jensen 2005).

The same thing is done in this study, the in situ observations by ground truthing and using Google Earth as an ancillary data, ground truthing are used for the field verification purpose. Google Earth provides a very good spatial resolution that is from 15m to 15cm.

2.11. Error Correction

The post-classification correction technique was developed and used to improve the class assignment of a pixel after its initial Maximum Likelihood Classification. The derived LU/LC maps were noisy due to spectral similarity among different classes.

3.1 Result and Discussions

{A} NDVI of 2008 : The NDVI map of Katepurna of 2008 (Fig-2), illustrating vegetation of different health conditions of the forest cover .The image indicates high to low values. The values vary between 0.47 to 0.01. The positive values (0 to 0.47) show healthy vegetation cover of the study area and the negative values (0 to 0.01) show other features of the study area.

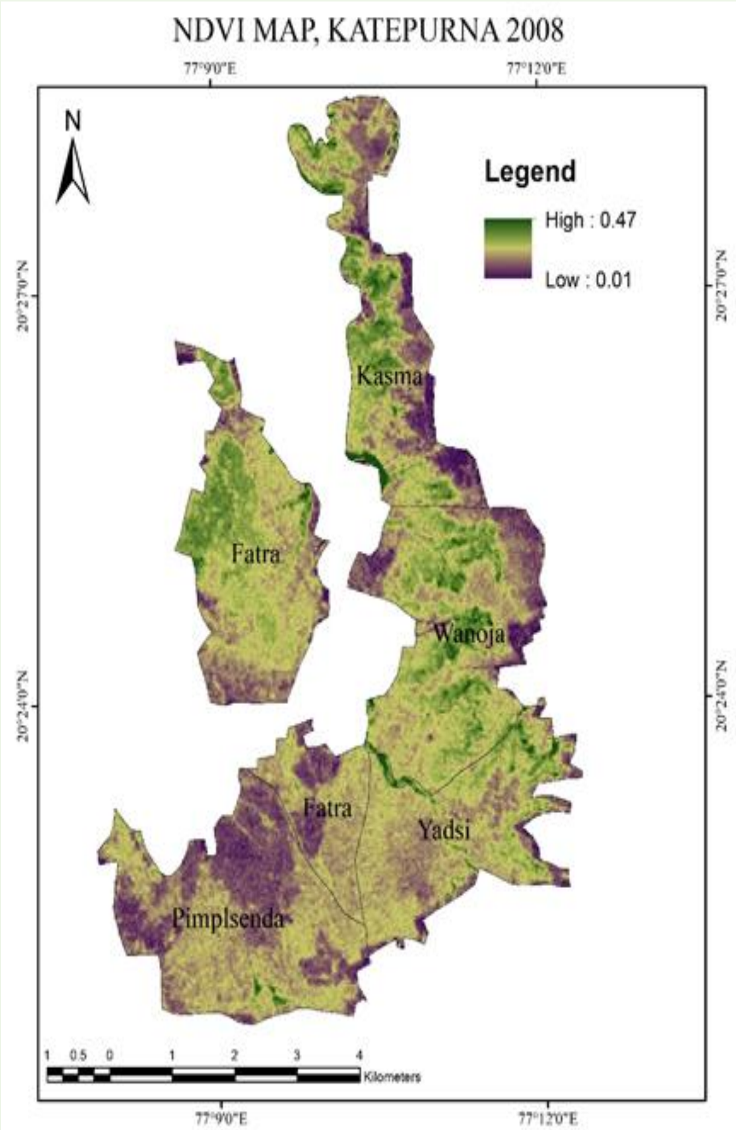


Fig-2- Map showing NDVI of Katepurna (2008)

{C} NDVI Change between (2008-2018) : The comparing NDVI map of two different years (2008 & 2018) indicates NDVI value. The decreases positive value of NDVI indicates the change of healthy and dense vegetation. On the other hand, the increase negative values of NDVI indicates increased the non-vegetated areas. **Fig-3** shows the difference image of NDVI images of 2008 & 2018.The two different NDVI image (2008 & 2018) used to prepare NDVI change map and it's found two different changed zone namely increase and decrease. NDVI image differencing cannot provide detailed change information, particularly in the study area because it does not have NDVI value different features. It can only give overall information about the healthiness of vegetation cover in the study area based on NDVI value. The negative threshold indicates a loss in NDVI and positive threshold indicates the area of increased NDVI (restoration or healthy vegetation).

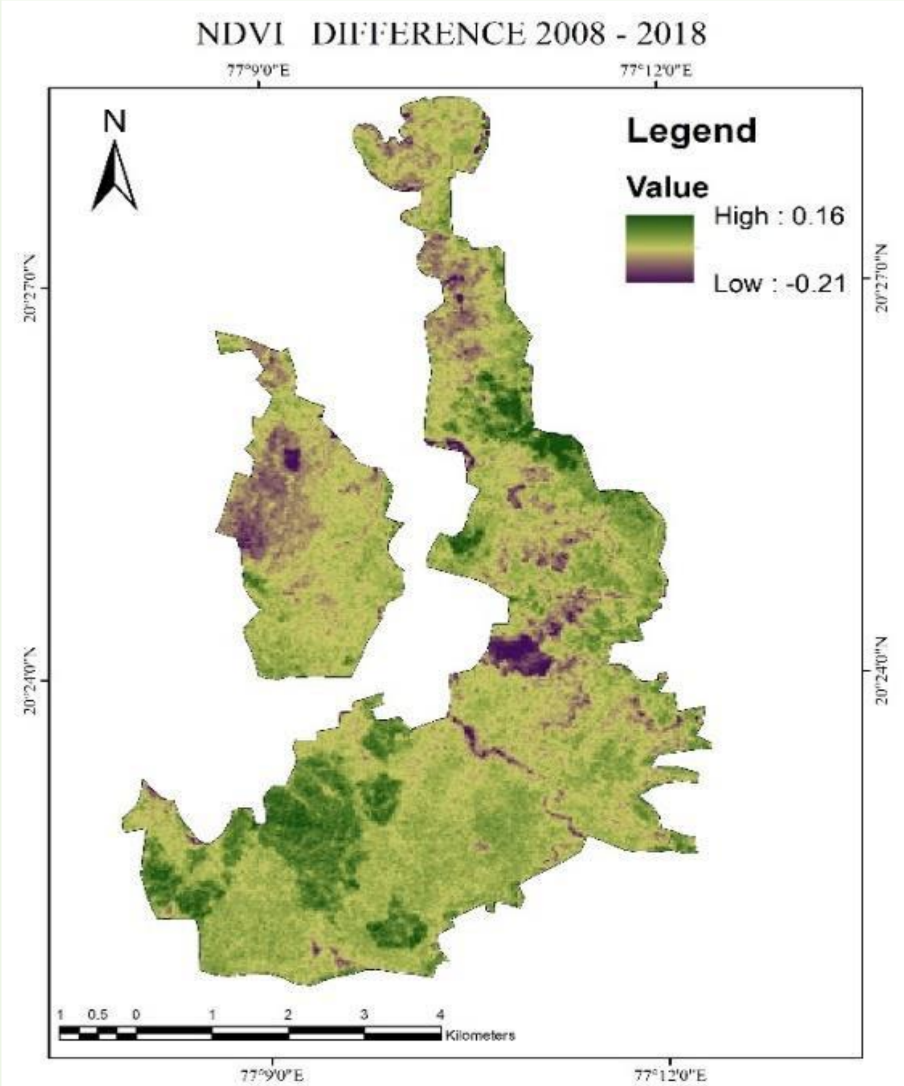


Fig-4- Map showing change detection using NDVI of Katepurna

{D} LU/LC of Katepurna in 2008 : The spatial extent of the 2008 LU/LC map after the Supervised Classification four land cover classes found in the study area **(Figure-5)**. With the wasteland occupying the highest percentage of the area (20.23 km^2). This is scattered approximately throughout the study area. Dense vegetation (9.63km^2), is the next highest area coverage located in the study area. Light vegetation comes next with 4.06 km^2 of the study area.The barren land about 4.45 km^2 of the study area.

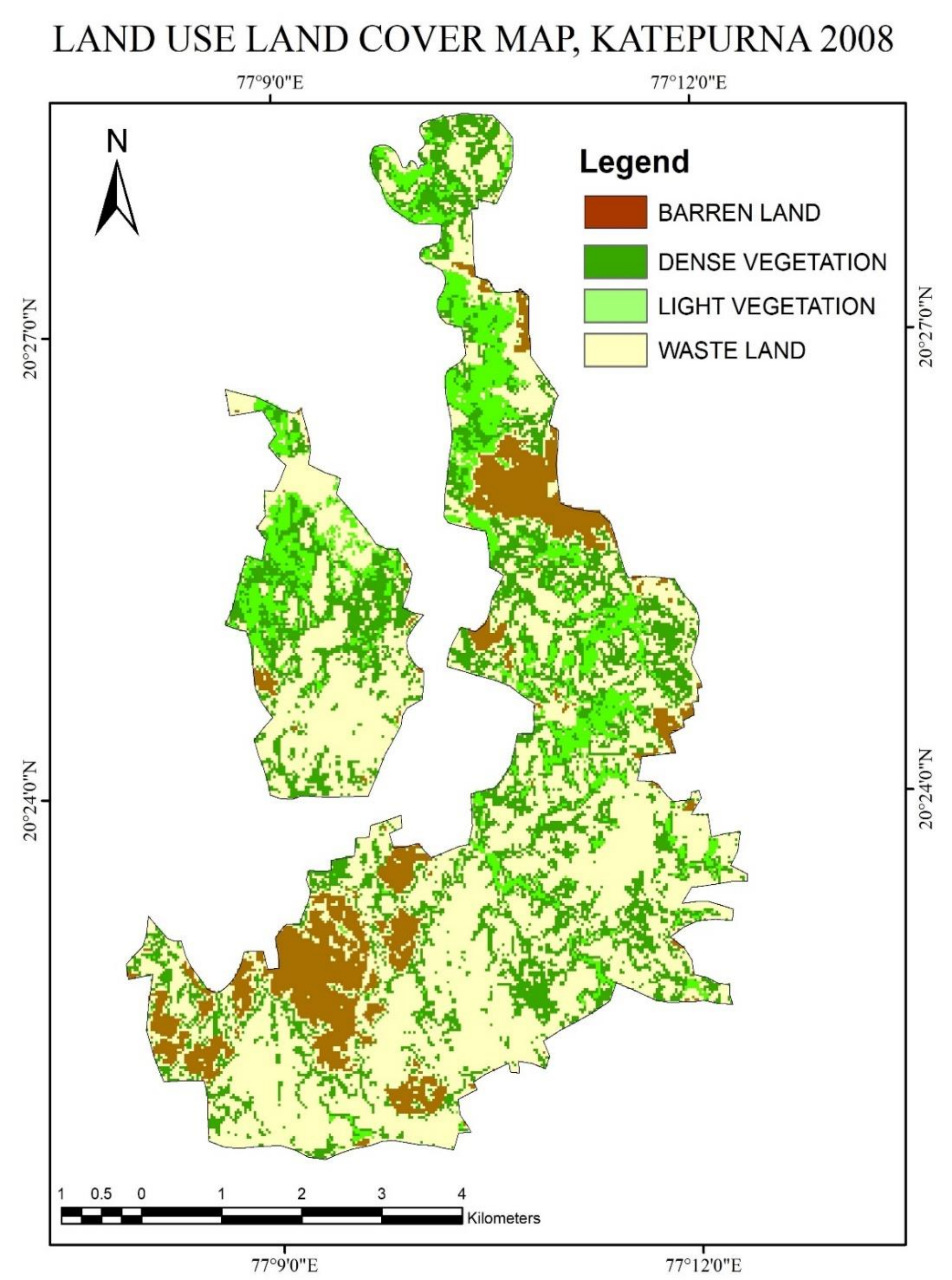


Fig -5- Land Use Land Cover classification of Katepurna of 2008.

Table 2 : Area statistics of the land use and land cover units from 2008 of Katepurna Sanctuary.

Sl. No	Land use and land cover classes	2008 Area (km^2)	% Total Area
1	WASTELAND	20.23	53.53
2	DENSE VEGETATION	9.63	25.48
3	LIGHT VEGETATION	4.47	11.83
4	BARREN LAND	3.46	9.16
5	WATERBODIES	0	0
6	ROAD	0	0
	Total :	**37.79**	**100**

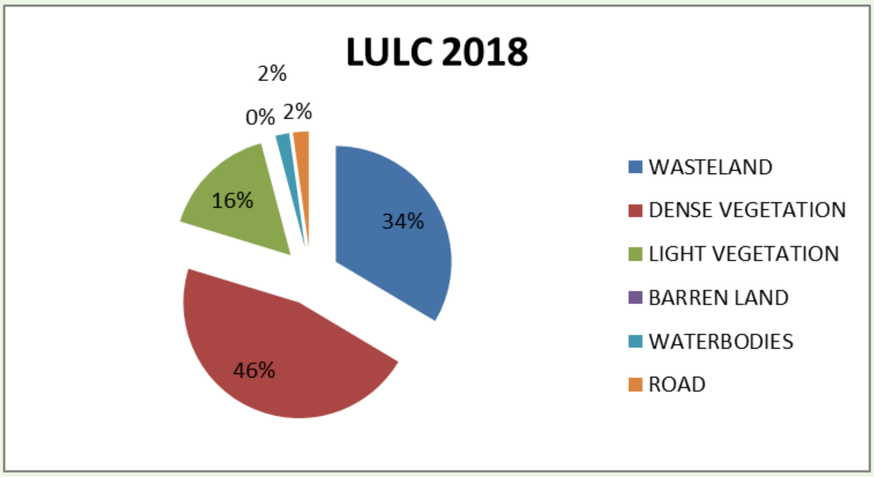


Fig-6 - Pie-Chart of LU/LC classification of Katepurna of 2018

{E} LU/LC of Katepurna in 2018 : Using supervised classification method it was classified into five LU/LC class **(Figure)** found in the study area namely dense vegetation cover 17.44 km2 which are mainly present in the study area. Wasteland covers an area of 12.68 km^2, which is scattered approximately all around the study area. Light vegetation occupies the third largest area coverage as compared to other LU/LC classes having 6.11 km^2 scattered in the entire study area. Water bodies consisting river and surface water cover an area of 0.73km^2 (0.38%) and the road consists of area 0.83 km^2.

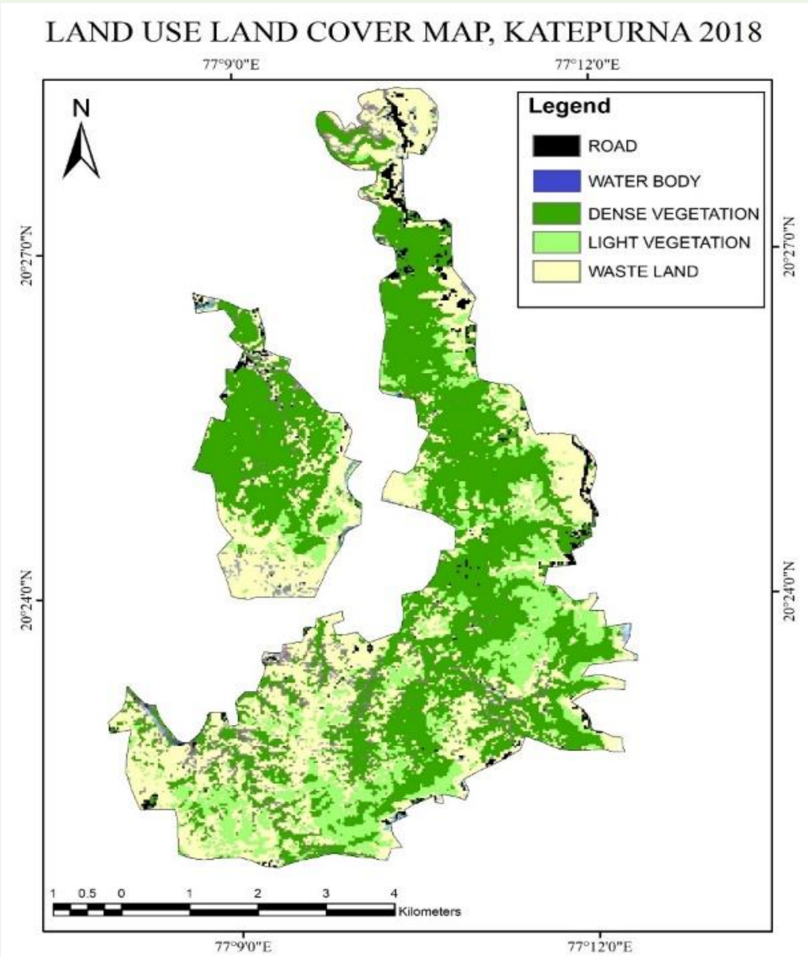


Fig-7 - LU/LC classification of Katepurna of 2018

Table 3 : - Area statistics of the land use and land cover units from 2018 of Katepurna Sanctuary.

Sl. No	Land use and Land Cover Classes	2018	%
		Area(km^2)	Total Area
1	WASTELAND	12.68	33.55
2	DENSE VEGETATION	17.44	46.15
3	LIGHT VEGETATION	6.11	16.17
4	BARREN LAND	0	0
5	WATERBODIES	0.73	1.93
6	ROAD	0.83	2.20
	Total :	**37.79**	**100**

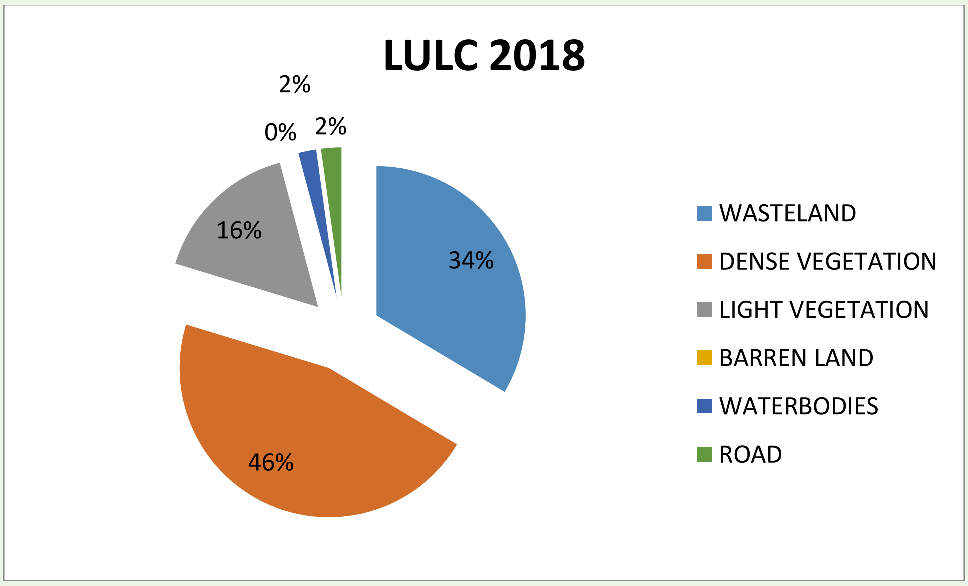


Fig-8 - Pie-Chart of LU/LC classification of Katepurna of 2018

{F} Producer Accuracy

Producer 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).This value represents how well reference pixels of the ground cover type are classified in below(Table 4 & 5)

Table 4: - Confusion matrix for land use and land cover map of 2008 of Katepurna Sanctuary.

Classified Data	Wasteland	Dense Vegetation	Light Vegetation	Barren Land	Row Total	User Accuracy
Wasteland	3708	0	0	0	3708	100%
Dense Vegetation	9	307	15	22	353	86.96%
Light Vegetation	30	23	247	11	314	78%
Barren Land	3	60	9	351	420	83.57%
Column Total	3750	390	271	384	4795	
Producer Accuracy	98.88%	78.71%	91.14%	91.40%		
Over all Accuracy	96.20%					

Table 5: - Confusion matrix for land use and land cover map of 2008 of Katepurna Sanctuary

Classified Data	Dense Vegetation	Waste-land	Light Vegetation	Water bodies	Road	Row Total	User Accuracy
Dense Vegetation	208	11	22	5	4	250	83.20%
Wasteland	17	1305	19	115	0	1456	89.62%
Light Vegetation	0	7	1537	41	11	1596	96.30%
Water bodies	30	9	1	1802	0	1842	97.82%
Road	0	11	27	1078	1391	2507	55.48%
Column Total	255	1343	1606	3041	1406	7651	
Producer Accuracy	81.56%	97.17%	95.70%	59.25%	98.93%		
Over all Accuracy	81.59%						

{G} Over all 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 showed overall results of the tabular error matrix. The overall accuracies performed in this study period 2008 was 96.20%, in 2018 was 81.59%. As mentioned for reliable land cover classification the minimum overall accuracy value computed from an error matrix should be 80%. However, Foody (2002) showed that this baseline makes no sense to be a universal standard for accuracy under the practical application. This is because a universal standard is not exactly related to any specific study area.

Conclusion

The study significantly focuses on integrated techniques of GIS and remote sensing for forest cover change mapping. The study starts from data extraction up to forest cover changed the mapping. The several methods and procedures used to find the forest cover change detection. In order to explain forest cover change, both NDVI and Land Use/Land Cover classification techniques are used. The post-classification technique used to classify the different year's satellite image to get the quantitatively changed area. The NDVI map does not represent different features of the earth surface, it only shows forest and vegetation covers with chlorophyll content. Particularly, expansion of wasteland was observed in the year 2008 (20.23 km^2) and decline of both forest cover as well as shrub land were observed but in the year 2018 the wasteland areas was declined by 8%. In the year 2008 the wasteland areas is 20.23 km^2, the wasteland in the year 2018 is 12.68 km2 it is being decreased in the area. As in the case of dense vegetation the area is 9.63 km^2 (2008) and in the year 2018 the area is 17.44 km^2 (2018) it is being seen that it may be planted the areas has been increased by 7.81 km^2 whereas the light vegetation (2008) the areas is 4.47 km^2 and the areas in (2018) is 6.11 km^2, so the areas 1.64 km^2 is increased.

Table 6 : Area statistics of the land use and land cover units from 2008-2018 of Katepurna Sanctuary.

Sl. No	Land use and Land Cover Classes	2008	2018	%Increase/ Decrease
		Area (km2)	Area(km2)	
1	WASTELAND	20.23	12.68	-37.32
2	DENSE VEGETATION	9.63	17.44	81.10
3	LIGHT VEGETATION	4.47	6.11	36.69
4	BARREN LAND	3.46	-	-
5	WATERBODIES	-	0.73	-
6	ROAD	-	0.83	-
	Total :	**37.79**	**37.79**	**-**

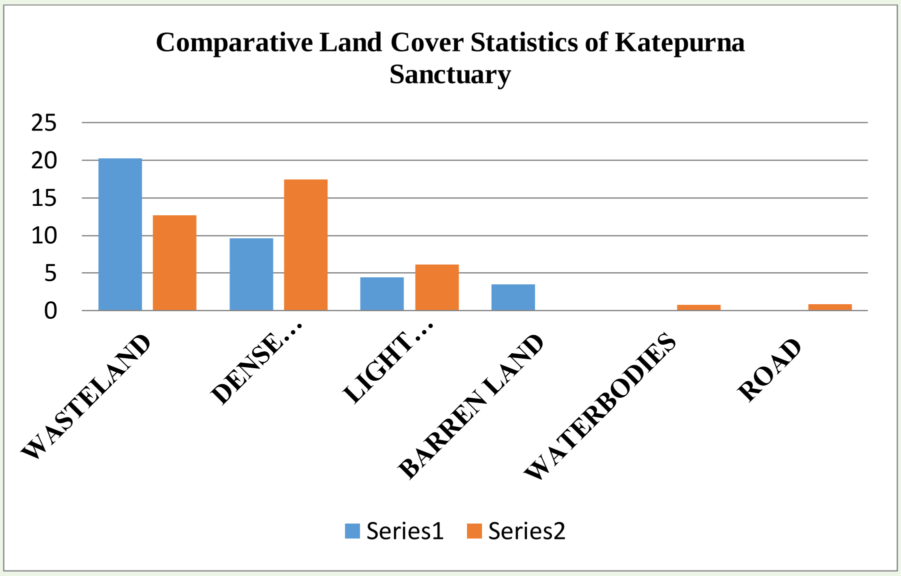


Figure 9. Comparative pie chart of Land Cover Change

Recommendations

From the whole study, GIS and Remote sensing tools are found to be very important tools for forest cover change detection mapping. It has been recognized that the forest cover land of the area has much declined. For the future application of this tool for forest cover change detection and to protect the forest resources of the study area from further depletion in particular, and to use these precious resources in a sustainable way, the following feasible suggestions are forwarded based on the findings and the conclusions were drawn.

- The integrated application of GIS and Remote sensing tools will minimize error for forest resource mapping and management, so it will be carried out in a better way in future.
- It is strongly recommended to local people and the government to take action about forest degradation & unauthorized deforestation and plan for forest restoration.
- Monitoring could be easily carried out.

References

Abbas, A., Khan, S., Hussain, N., Hanjra, M. A. and Akbar, S. (2013), 'Characterizing soil salinity in irrigated agriculture using a remote sensing approach', *Physics and Chemistry of the Earth, Parts A/B/C* **55**, 43-52.

Ahmadi H, and Nusrath A. (2012), 'Vegetation change Detection of Neka river in Iran by using remote sensing and GIS', *Journal of Geography and Geology*, 2 (1), 58-67.

Bedru Sherefa. (2011), 'Landuse/landcover changes in Andracha and Masha Woredas of Sheka Zone, SNNP Regional State, In Masresha fetene and Tadesse W.gole', (Ed), *Forest of Sheka*, 47-56.

Billington, C., Kapos, V., Edwards, M.S., Blyth, S. and Iremonger, S. (1996), 'Estimated Original Forest Cover Map a First Attempt'. *WCMC*, Cambridge.

Burrough, P.A, and MC Donnel, R.A. (1986). 'Principles of a geographical information system for land resource assessment, monographs on soil and resource survey' 12, *clarndo*, 65-67.

Butler, R. A. (2005), 'World deforestation rates and forest cover statistics', 2000- 2005, *http://news.mongabay.com/2005/1115-forests.html*, accessed June 2020.

Byron N and Arnold M. (1999) What Futures for the People of the Tropical Forests? ,*World Development Volume 27*, Issue 5, 789-805

Chouhan R, Rao N, (2012), 'Vegetation Detection in Multispectral remote sensing images: protective Role-analysis of coastal vegetation in 2004 Indian Ocean Tsunami. Geo-Information for Disaster Management", *Procedia Technology 6*, 612 – 621.

Cihlar, H. (2000), 'Land cover mapping of large areas from satellites: status and research priorities. *International Journal of Remote Sensing 21*, 1093-1114.

Cohen, X. (2000). 'Using remote sensing and GIS to analyze land cover Change and its impacts on the regional sustainable development'. *International Journal of Remote Sensing*, *Vol 41*, 107-114.

Congalton, R.G., (1991). 'A review of Assessing the Accuracy of Classifications of Remotely Sensed Data', *Remote Sensing of Environment, Vol 37*, 35–46.

Coppin, P., Jonckheere, I., Nackaerts, K., Muys, B. and Lambin, E. (2004), 'Digital Change Detection Methods in Ecosystem Monitoring: A Review. *International Journal of Remote Sensing, 25*, 1565-1596.

http://dx.doi.org/10.1080/0143116031000101675

CSA. (2007). 'Ethiopian Agricultural Sample Enumeration results for SNNP Region. Statistical Reports. Central Statistical Authority, Addis Ababa, Ethiopia. Federal Democratic Republic of Ethiopia, National Census report of 2011', *Statistical Reports. Central Statistical Authority, Addis Ababa. Ethiopia.* http://www.csa.gov.et/index.php/census-2007,pdf, retrived, June,2020

Daniel Mengistu. (2008). 'Remote sensing and GIS based land cover change detection' in Dijjo river catchement, Silte Zone, Southern Ethiopia', AAU. http://www.svt.ntnu.no/geo/Doklager/Acta/SerieA_23_Daniel_Mengistu.pdf, retrieved June, 2020.

Demel Teketay, (2010). 'Forest resources and challenges of sustainable forest management and conservation in Ethiopia'. In: F. Bongers, & T. Tennigkeit, (Eds). Degraded forests in Eastern Africa*. Management and Restoration. Earthscan Publications*.

Desanker, P. and Magadza, C. (2001). Forest covers change as an influential factor on Climate Change: Working Group II: Impacts, adaptation, and vulnerability.

http://www.grida.no/climate/ipcc_tar/wg2/377htm 78, Retrieved 30/06/2020

EARO. (2008). 'Draft strategy and action plan for integrated forest development in Ethiopia'. *Forestry Research Center, Addis Ababa*,

Eastman, R. J. (2001). 'Guide to GIS and image processing'*. Volume 2, Manual Version 32, Clark University*, 21.

Edward, G. (1990). Image segmentation, cartographic information, and knowledge.

Elijah Kaberia Mujuri. (2007). 'Deforestation and Afforestation, A world perspective With Three Case Studies in Brazil, Nigeria, and Japan Paper for NRES 523' *International Resource Management.*

http://www.uwsp.edu/forestry/stujournals/documents/irm/mujuri.pdf retrieved 26/06/ 2020.

Elias N. (2008). 'Dawdling Ethiopian forest, the carrot and stick dilemma'. *Inter- journal Vol 2(2).*

Els bogenetteau. (2006). 'Linking Forests and People: A potential for sustainable development of the South-West Ethiopian highlands Addis Ababa'. *Ethiopian people revolutionary democratic front revised Constitution, Proclamation No. 542/2007*

Eric K Forkuo, 'Adubofour Frimpong Analysis of Forest Cover Change Detection'

FAO, Land Cover Classification System: Classification Concepts and User Manual: LCCS By Antonio Di Gregorio, Food and Agriculture Organization of the United Nations

FRA 2000 on definitions of forest and forest change. http://www.fao.org/docrep/006/ad665e/ad665e04.htm

G. G. Wilkinson, et *al*. (ed.) 1994. 'Fractals in Geosciences and Remote Sensing'. *Proceedings of A Joint JRC/EARSeL Expert Meeting Ispra, Italy. European Commission, Luxembourg*

http://fsi.nic.in/sfr2005/chapter3.pdf

http://gisgeography.com/supervised-unsupervised-classification-arcgis/25.

http://www.climateandweather.net/global-warming/deforestation.html

http://www.crisp.nus.edu.sg/~research/tutorial/intro.htm

http://www.fao.org/docrep/006/ad665e/ad665e06.htm

http://www.insightsonindia.com/2015/12/31/20-difference-forest-area-forest-coverin- light-recent-forest-survey-report-examine-india-dealing-forest-area-forest-cover/

http://www.nationalgeographic.com/environment/global-warming/deforestation/

http://www.nwmissouri.edu/library/theses/2014/PeacockRexA.pdf

http://www.sameti.org/Success_WSinghbhum.pdf

http://www.wrm.org.uy/oldsite/deforestation/cifor.html

https://en.wikipedia.org/wiki/Saranda_forest

https://www.cbd.int/forest/definitions.shtml

https://www.coursehero.com/file/13846603/global-warming-final-paperdocx/

https://www.forestry.gov.uk/pdf/Table1UKReport.pdf/$FILE/Table1UK, Report.pdf

https://www.quora.com/What-is-the-difference-between-the-forest-area-and-the- actual-forest-cover Bottom of Form. International Journal of Remote Sensing, Pp: 89-103.

J. Barkhordari, T. Vardanian, (2012) Using post-classification enhancement in improving the classification of Land Use/Land Cover of arid region (A case study in Pishkoush Watershed, Center of Iran) *J. Range Sci.*, 2 (2). 459–463

Jannat M., Hossain M. K.., Uddin M.M., Hossain M. A. and Kamruzzaman (20180. 'People's dependency on forest resources and contributions of forests to the livelihoods: a case study in Chittagong Hill Tracts (CHT) of Bangladesh, *International Journal of Sustainable Development & World Ecology, Volume 25. 2018 –issue 6.* 554-561

Jensen, J. R. (1996). Introductory Digital Image Processing (3rd Ed.). Upper Saddle River, *NJ: Prentice Hall.*

Jensen, J. R. (2000). Remote Sensing of the Environment: An Earth Resource Perspective. Upper Saddle River, *New Jersey, Prentice Hall*.

Jenson, J.R. (1996). *Introductory Digital Image Processing Prentice Hall Inc.*

Jin, S., & Sader, S. (2005). 'Comparison of time series tasseled cap wetness and the normalized difference moisture index in detecting forest disturbances'. *Remote Sensing of Environment', 94(3)*. 364–372.

Johnson, R.D., & E.S. Kasischke. (1998). 'Change Vector Analysis: A Technique for Multispectral Monitoring of Land Cover and Condition'. *International Journal of Remote Sensing*, 411-426.

Jolly, A., Guyon, D., & Riom, J. (1996). 'Use of middle-infrared Landsat Thematic Mapper data for a representation of clear cuts in the Landes region'. *International Journal of Remote Sensing, 17(18).* 3615–3645.

Jong, S.D., and P.A. Burrough. (1995). 'A Fractal Approach to the Classification of Mediterranean Vegetation Types in Remotely Sensed Images'. *Photogrammetric*

Kayet N and Pathak K (2015) 'Remote Sensing and GIS Based Land use/Land Cover Change Detection Mapping in Saranda Forest, Jharkhand, India'. *Int Res J of Earth Science 3*, 1–6.

Kindu M, Schneider T, Teketay D, *et. al.,* (2013). 'Land Use/Land Cover change analysis using object-based classification approach in the Munessa-Shashemene landscape of the Ethiopian highlands'. *Remote Sensing 5*, 2411–2435.

Lambing, E.F. (1997). ' Modeling and Monitoring Land Cover Change Processes in Tropical Regions. *Progress in Physical Geography, 2,* 375-393. http://dx.doi.org/10.1177/030913339702100303

Langat D. K., Maranga E. K., Aboud A. A. and Cheboiwo J. K., (2016). 'Role of Forest Resources to Local Livelihoods: The Case of East Mau Forest Ecosystem, Kenya' International Journal of Forestry Research Volume 2016, Article ID 4537354, 10 pages http://dx.doi.org/10.1155/2016/4537354/ retrieved 07/07/2020

Lunetta, R. S., & Elvidge, C. D. E. (1999). 'Applications, project formulation, and analytical approach, remote sensing change detection, Environmental Monitoring Methods, and Applications'. *London:Taylor & Francis.*, 1-20.

M.M. El-Hattab. (2016). 'Applying post classification change detection technique to monitor an Egyptian coastal zone (Abu Qir Bay)'. *Egypt. J. Remote Sens. Space Sci., 19*, 23–36.