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COMPARATIVE ANALYSIS OF FOREST COVER CHANGE IN SELECTED FOREST RESERVES IN OYO STATE NIGERIA

OLAJUYIGBE, S.O., *AGWU, O.P. AND EZEKIEL, I.A.
Department of Forest Production and Products, University of Ibadan, Nigeria
*Corresponding author: agwu.o@edu.wascal.org

Abstract
The ability of Nigerian forest reserves to support livelihoods and provide ecosystem services such as improved primary healthcare, sustainable food production, income generation, and carbon sequestration to mitigate climate change impacts; is currently constrained by deforestation and other anthropogenic factors. Hence, a clear understanding of the underlining patterns and processes of forest cover loss is required to ensure that appropriate methods and approaches are developed to promote conservation in these forest reserves. This study assessed the pattern of forest cover change in five forest reserves (Gambari, Ijaiye, Lanlate, Opara, and Igangan) in Oyo State, southwest Nigeria over 30 years. Landsat Enhanced Thematic Mapper Plus (ETM+) and eight OLI satellites images were acquired from the United States Geological Survey and used to assess the forest cover loss for the years 1990, 2000, and 2020. There was a significant change in the vegetation cover of the forest reserves with decreases observed over the three decades. From 1990 to 2020, the reduction in forest cover ranged from 42.26% (Opara forest reserve) to 91.21% (Igangan forest reserve). This high rate of deforestation and forest degradation in Oyo State highlights the need for immediate conservation action. In addition, relevant stakeholders and policymakers must intensify efforts focused on the restoration and rehabilitation of degraded forest reserves in the state.

Key Words: *Forest reserves, Forest cover, Landsat Thematic Mapper, Deforestation*

Introduction

Forests were reported to cover over 25% of the Earth's land surface and contained about 75% of terrestrial carbon (Eludoyin and Iyanda, 2019). These forests provide ecosystem services and support 60% of the population in developing countries with nutritional and health requirements (Faleyimu and Agbeja, 2012; Eludoyin and Iyanda 2019). Unfortunately, the continued increase in the rate of industrialization, agricultural production, urbanization, and the human population have resulted in the destruction of forest ecosystems with negative consequences on global surface temperatures (Arshad *et al.,* 2014). This phenomenon known as global warming, leads to a decline in carbon sequestration because of the conversion of forest regions

to built-up areas (Fattah *et al*., 2021). Different parts of the world are facing the adverse impacts of forest cover loss and this is currently attracting attention from the scientific community and policy makers because of its implications on environmental sustainability and human health (Li *et al*., 2017).

In Africa, the net annual forest cover loss was around 4 million hectares for the period of 2000–2005; and this accounted for over 55% of the total forest cover loss, globally (FAO, 2010). Nigeria used to have a large forest estate, but recently, the country has held the record for majority of forest loss in West Africa (FAO, 2010). Hence, Nigeria has one of the highest rates of deforestation in Africa, approximately 3.5% or 350,000–400,000 hectares per year (Ridder, 2007; Aigbe and Oluku, 2012). The country lost about 410,000 hectares per year between 2010 and 2015 (Keenan *et al.,* 2015). Oyo state is strategically located in the transition zone between the rainforest and savanna ecological zones of Nigeria. The rainforest occurs in the southeastern part of Oyo state while other areas are classified as savannah. The forests in the state are under serious anthropogenic pressure resulting in their degradation, conversion to agricultural lands and urban settlements (Ezebilo, 2004; Yusuff and Alamu, 2019). These threatened forests are important sources of socioeconomic and ecological benefits in the state. Hence, there is an urgent need for immediate conservation action and the promotion of sustainable management (Adedeji *et al.,* 2015; Khadijat *et al.*, 2021).

The lack of current information on forest cover in Oyo State is alarming, especially as forest reserves are being de-reserved and converted to grazing zones and agricultural farms (Khadijat *et al.* 2021). The evaluation of the forest cover changes over the years and the estimation of future forest cover changes in Oyo State, will help provide requisite information necessary for the management of natural resources. This study assessed the pattern of forest cover change in major forest reserves across Oyo State with the view to recommending appropriate strategies for conservation of the forest resources.

Materials and Methods

Study Area

Oyo State is located in the southwestern region of Nigeria and covers approximately 2,650,000 hectares (Jatto *et al.,* 2021). It shares boundaries with Kwara State in the north, Osun State in the east, Ogun State in the south, and Ogun and the Republic of Benin in the west. It is located between latitudes 7°3'0.26"N and 9°11'6.10"N, and longitudes 2°42'25.14"E and 4°33'23.84"E. There are nine designated forest reserves in the state, representing 342,461 hectares of the land mass (Alo, 2018). Four reserves (Opara, Igangan, Ago Are I and II, and Oke Iho) are located in the western part, while five (Olokemeji, Lanlate, Ijaiye, Osho and Gambari) are in the south (Figure 1).

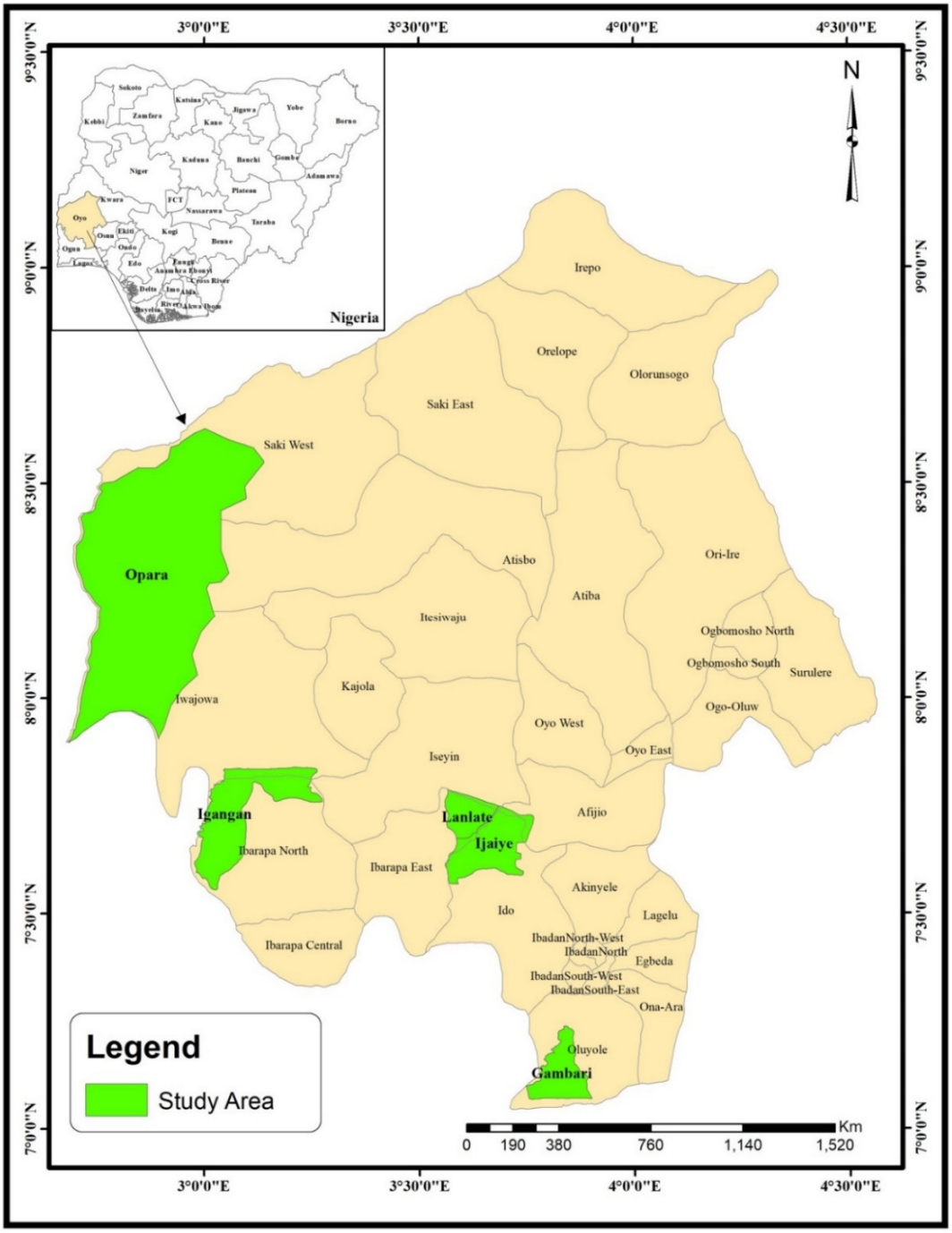

Fig. 1: Five forest reserves in Oyo State (inset: map of Nigeria indicating Oyo State)

Data Sources and Processing

Landsat Enhanced Thematic Mapper Plus (ETM+) and eight OLI satellite data for the years 1990, 2000, and 2020 were downloaded for the selected forest reserves. The images were accessed from the United States Geological Survey National Centre for Earth Resources

Observation and Science. The images were rectified in reference to the Universal Transverse Mercator (UTM). The images were processed using the Geo-tiff format in ArcGIS 10.4. The Landsat 7 ETM + and 8 OLI satellite were generated and re-sampled as described by Adeyemi and Adeleke (2020).

Vegetation Index

The normalized difference vegetation index (NDVI) was used in this study. The NDVI is mostly used and considered as appropriate because it allows the outlining and visualizing of vegetated areas on the map. It also helps to detect abnormal changes in the growth process of vegetation. It is a dimensionless index that describes the difference between visible and near-infrared reflectance for vegetation cover (Bro-Jørgensen *et al*., 2008). This method was adopted for the visual improvement of the images, as described by Jiang *et al.* (2006). The spectral VI was because of higher accuracy and sensitivity to forest cover monitoring. Natural color composite (NCC) was generated using suitable combinations of bands from the acquired Landsat satellite images. The ENVI 5.1 environment was used to classify the Landsat images for the years 1990, 2000, and 2020. The resulting images from the classification were as the forest cover classes, based on the Maximum Likelihood Supervised Classification (MLSC) algorithm (Biro *et al*., 2013).

Land Cover Classification (1990 - 2020)

The Maximum Likelihood Classification algorithm was used to categorize Landsat 8.0 pictures from 1990 to 2020 using a supervised classification procedure. On the image and signature, areas with tree canopy of 20% or more were identified and used as a training set for categorizing forest areas. Non-forests were defined as areas with less than 20% canopy cover (Potapov *et al*., 2009). The identified classes were Forest, Light Forest/Shrub, and No forest. The classified forest cover maps were validated to ensure accuracy. The forest image within the 3-decade range was chosen as stable vegetation. Visual examination was used to conduct qualitative assessment of the photographs. The forest borders, extracted using QGIS geo-database, were analyzed to estimate forest cover loss and gains in hectares from 1990 to 2020.

The annual rate of deforestation was calculated using the equation below:

$$r = \left(\frac{1}{t2 - t1} \times \ln\left(\frac{A2}{A1}\right)\right)$$

where:

$r =$ rate of deforestation. Rate is presented in percentage $(r \times 100)$

$t2\ and\ t1$ = time

$A2\ and\ A1$= Forest Cover at time $t2\ and\ t1$

Accuracy Assessment

The confusion matrix system was used to assess the accuracy of the image classification for the land use land cover classes for 2020. The Ground Control Point (GCPs) data were collected from the study area and used for image classification and overall accuracy assessment in combination with the classified raster images. As described by Rwanga and Ndambuki (2017), the GCPs were analyzed for error matrix using the omission and commission error computation estimated for the different LULC classes.

Results and Discussion

The forest area in Gambari forest reserve (12,065.58 ha in 1990), was reduced to 9530.19 ha in 2000, with 21% forest cover loss in 10 years, and the remaining forest cover was 6848.55 ha by 2020 (Figure 2 and 3). A similar trend was observed in Igangan forest reserve, with the high forest being 60% of the total land area in 1990 (Table 1). This was reduced to 36% in 2000 and 17% in 2020 (Figure 4). Ijaiye forest reserve had a total land area of 27129.24 ha, of which the high forest was 14988.34 ha or 55% of the total land area in 1990 (Figure 5). This reduced to 34% in 2000 and 27% in 2020. Lanlate and Opara forest reserves followed the same pattern. About 26% of Lanlate forest reserve constituted high forest in 1990 but reduced to 20% and 17% in 2000 and 2020 respectively (Figure 6). In Gambari forest reserve, the light forest was mostly dominated by shrubs, while the non-forested area was 4% in 1990, but increased to 5% in 2000, and 10% in 2020 (Table 1). In Igangan forest reserves, 33% was the light forest in 1990, and this increased to 41% in 2000, and 47% in 2020 (Figure 4). The non-forested area was 6% in 1990, but increased 22% and 35% in 2010 and 2020, respectively. The trend follows a similar pattern for all the forest reserves (Table 1). The loss of forest persists and leads to an increase in light forest and non-forest areas. Gambari forest reserves had lost 49.15% while, Ijaiye lost about 56.37% of its forest within the same time. Forest reserves in Lanlate and Opara lost 37.77% and 42.26% of high forest, while Igangan forest reserves lost 91.21% of the forest area.

Olajuyigbe (2018) highlighted the high rate of degradation and forest cover loss in Nigeria, while Alamu and Agbeja (2011) described the massive de-reservation of forests observed in Southwest Nigeria. Hence, if anthropogenic activities are not controlled, they would lead to total degradation and deforestation of Nigeria's forest reserves (Asinwa *et al.,* 2018; Khadijat *et al.*, 2021). Some of the major causes of forest loss include indiscriminate tree harvesting, agricultural expansion and urbanization (Chakraborti *et al*., 2010; Olajuyigbe and Jeminiwa, 2018**).** The forest areas were drastically reduced while the non-forest areas increased. Agricultural expansion caused increased degradation and removal of tree cover to accommodate agro-pastoral and livestock grazing, particularly at Igangan Forest reserve. Igangan forests had been largely converted to a grazing reserve because of the influx of herders and increased settler families (Babalobi, 2011). Phillips *et al.* (2021) reported that about 89.1% of Ijaiye forest reserve had been recently converted to agricultural land. In fact, it was estimated that 2% of forest cover would be lost annually to deforestation and Ijaiye forest reserve would be de-reserved after 15 years (Phillips *et al.* 2021). Lanlate forest reserve has been reported to be porous and accessible to the local dwellers, (Babatunde *et al*., 2020), while Opara forest reserve, which is the largest in Oyo State, had lost a large portion of its area to other land uses (Alo, 2018). However, a slight change was observed in 2000, when non-forest areas in the reserve decreased slightly. This could be due to reforestation or enrichment planting program in the area. This study provides empirical evidences on the ongoing deforestation and dwindling forest cover in Oyo State.

The findings of this study confirm the fact that tropical forests are threatened by human activities which results in degradation, deforestation and conversion of forests to other land uses (Khadijat *et al.*, 2021). There is therefore and urgent need for concerted efforts to conserve the remaining forests. Restoration and rehabilitation are possible only when the light forest areas are protected from repeated exploitation clearing and land conversion to other uses. Silvicultural treatments such as plantation establishment, seed supplementation and enrichment planting could encourage the rapid return of the complex and species-rich natural forests in Oyo state. There is also a need for the development of forest laws and policies that would guide use and conservation of forest resources (Olajuyigbe and Adaja, 2014; Olajuyigbe and Akwarandu, 2019).

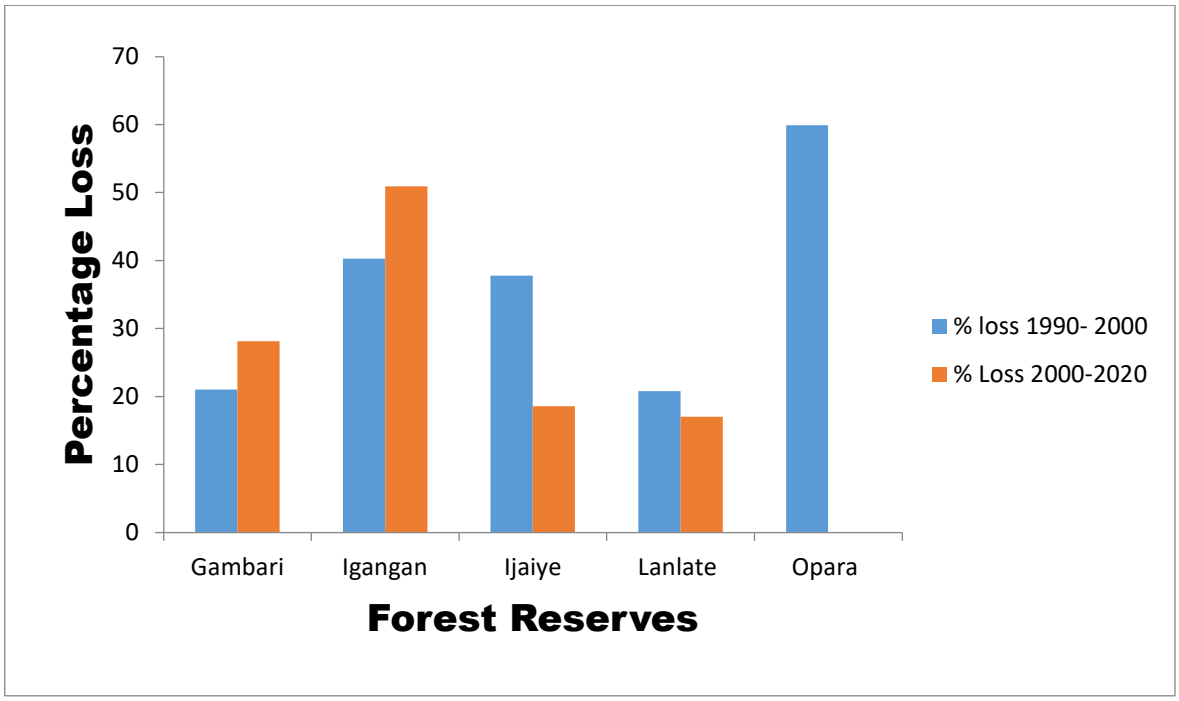

Fig. 2: Percentage forest cover loss in the selected forest reserves in Oyo State

Table 1 Land use classification of selected forest reserves in Oyo State Nigeria

Category		1990 (Ha)	1990(%)	2000 (Ha)	2000(%)	2020 (Ha)	2020(%)
Gambari Forest Reserve							
Forest		12066	67.719	9530.2	53.489	6848.6	38.438
Light Forest/Shrub		68.5	28.448	7410.6	41.593	9160.4	51.414
Non-Forest		682.92	3.833	876.24	4.918	1808.1	10.148
Total		17817	100	17817	100	17817	100
Igangan Forest Reserve							
Forest		23673	60.505	14137	36.132	6936.4	17.729
Light Forest/Shrub		12935	33.059	16218	41.451	18494	47.27
Non-Forest		2517.8	6.4353	8770.9	22.417	13695	35.002
Total		39126	100	39126	100	39126	100
Reserve	Ijaiye						
Forest		14988	55.248	9322.5	34.363	7591.6	27.983
Light Forest/Shrub		8939.8	32.953	9219.8	33.985	9528.5	35.123
Non-Forest		3201.1	11.8	8587	31.652	10009	36.894
Total		27129	100	27129	100	27129	100
Reserves	Lanlate						
Forest		2692.6	26.272	2133.3	20.814	1770.8	17.278
Light Forest/Shrub		6864.3	66.975	6295.6	61.426	4795.8	46.793
Non-Forest		692.11	6.7529	1820.2	17.759	3682.4	35.929
Total		10249	100	10249	100	10249	100
Reserve	Opara						
Forest		100853	45.86	40409	18.372	47549	21.618
Light Forest/Shrub		76138	34.66	141117	64.158	113292	51.507
Non-Forest		42962	19.53	38427	17.471	59111	26.875
Total		219953	100	219953	100	219953	100

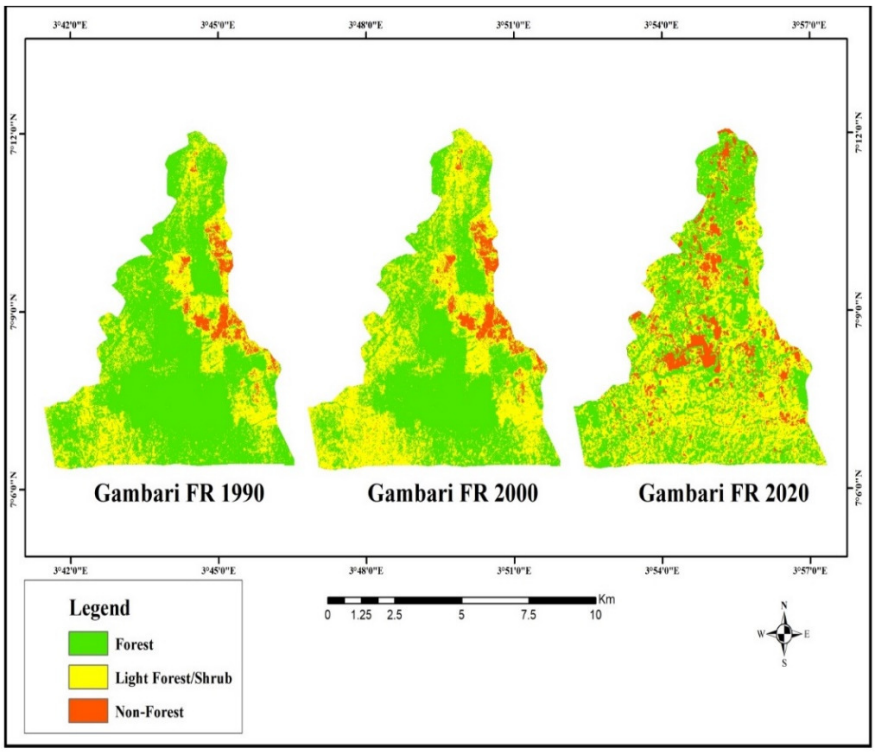

Fig. 3: Forest cover Change in Gambari Forest Reserves

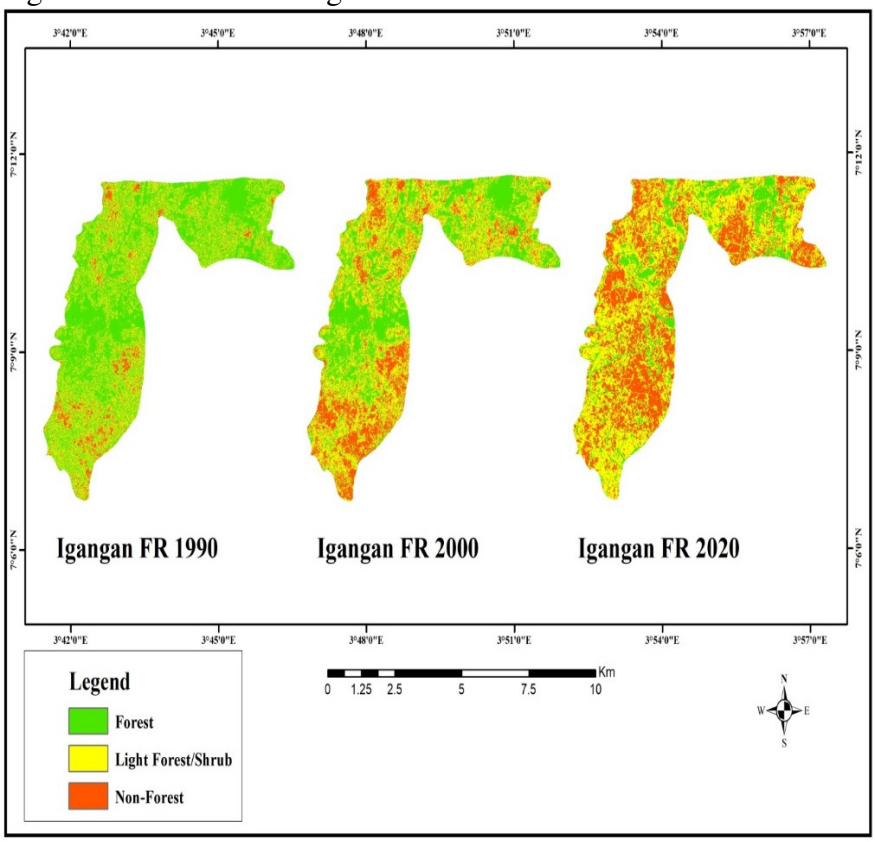

Fig. 4: Forest cover Change in Igangan Forest Reserves

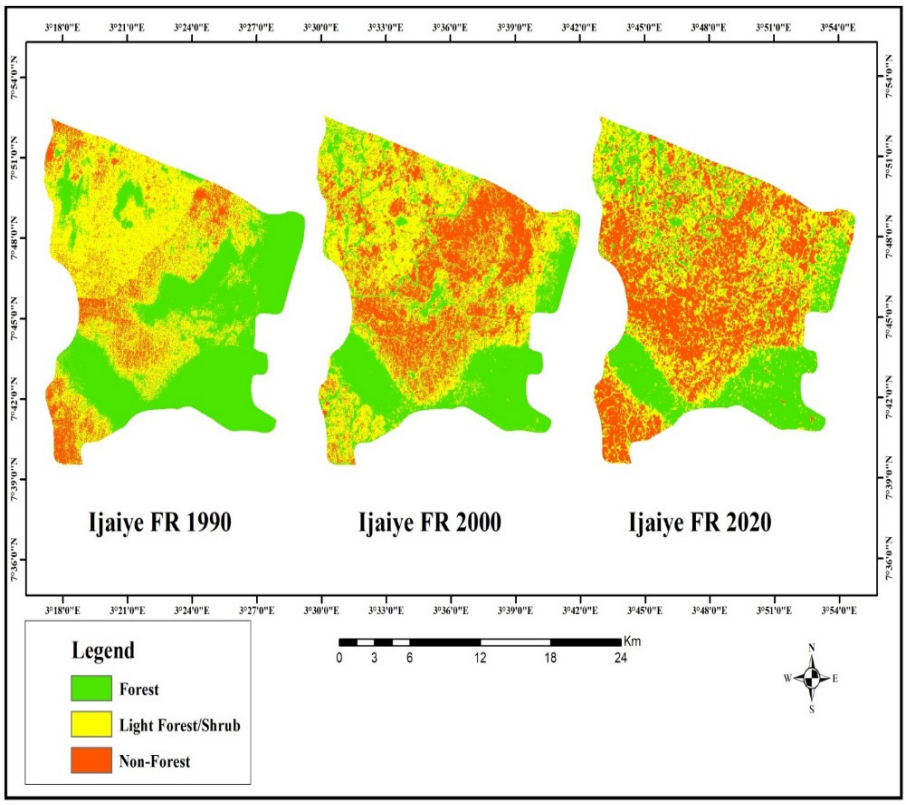

Fig. 5: Ijaiye FR Landsat Image Classification

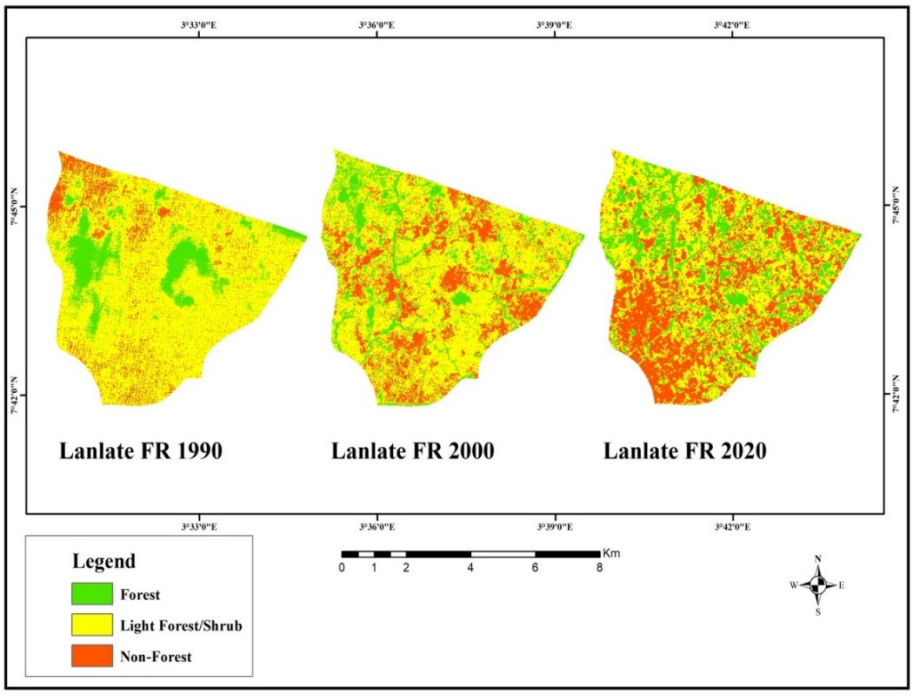

Fig. 6: Forest cover Change in Lanlate Forest Reserves

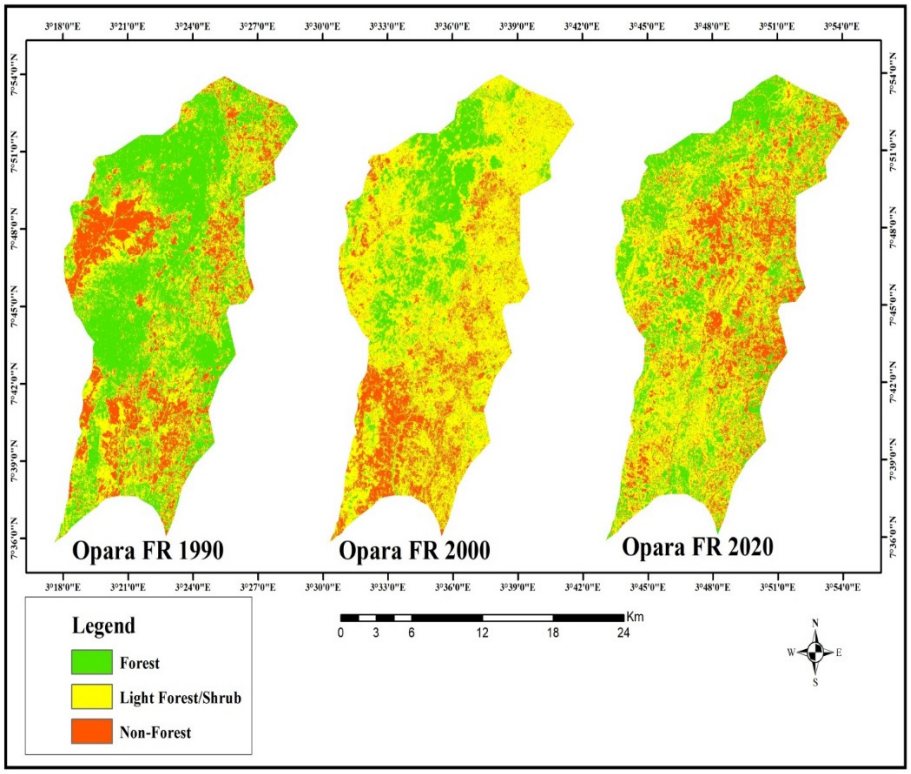

Fig. 7: Forest cover Change in Opara Forest Reserves

Conclusion

This study investigated the pattern of forest cover change in five forest reserves in Oyo State, Nigeria. Landsat Enhanced Thematic Mapper Plus (ETM+) was used to assess the forest cover loss for the years 1990-2020. The forest reserves were degraded at a high rate and this portends danger to the natural resources and the fast-growing population in the state. Both the rural and urban dwellers in the state depend largely on the forest resources for livelihood sustenance. Therefore, conservation action is required to halt the deforestation and degradation. There is an urgent need for the government intervention and the promotion of community-based forest management practices, where all the stakeholders are involved in the process of rehabilitation and reforestation in the state.

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