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Spatial Distribution of Forest Reserves and Sawmills in Oyo State, Nigeria

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Abstract

Geographic Information System (GIS) is a veritable tool for spatial analysis in forestry. The proximity to forest reserves has been considered one of the major factors affecting the spatial distribution of wood based industries. However, information on number of sawmills and spatial distribution of both the forest reserves and sawmill in Oyo Sate is lacking. Hence, this study employed GIS to develop spatial distribution map of forest reserves and sawmills in Oyo State, Nigeria. The secondary data used in this study included sketch maps and high resolution satellite imagery of all the forest reserves in Oyo State as well as the shapefile of the State. The primary data included the coordinates of locations of all the sawmills' location in all the four forestry zones (Ibadan, Oyo, Shaki and Ogbomosho) in the state and coordinates of some bench-mark places within each forest reserve that could easily be identified on ground.. Interview guide was used to obtain information on factors responsible for the location of each sawmill. The sketch maps were georeferenced using the coordinates of the bench-mark places and the area covered by forest reserves were digitized. This was superimposed on the satellite imageries and also vectorized. The coordinates of sawmill locations were used to develop spatial distribution map for the sawmills. The shapefile of forest reserves and the point coordinates of the sawmills were superimposed on the shapefile of Oyo State in layers to produce a spatial distribution prediction surface for both the forest reserves and the sawmills in the study area.The mean distance from each sawmill to the forest was determined. This procedure was used to obtain Average Transport Distance (ATD) for local government and finally for forestry zones. It was observed that forest reserves in Oyo State covered a total of 342,461 ha of land which accounted for 12.92% of the total land area of the state. Opara forest reserve recorded the highest area of land (248,640 ha), accounting for about 72.60% of the total land area of forest reserves in the state while the least was Olokemeji forest reserve (75.11 ha), accounting for about 0.02%.About 135 sawmills were recorded in all the forestry zones in Oyo State. Sawmills in Oyo forestry zone is significantly higher than Ibadan zone.ATD was highest in Ibadan forestry zones (12.55 km) with corresponding lowest percentage (3.70 %) of sawmills. Oyo Forestry Zone accounted for about 56.30 % of the total number of sawmills in the state with the least ATD of 4.02 km. Availability of electricity and nearness to source of raw material favoured sawmills location in Oyo and Shaki forestry zones. Spatial distribution of sawmills was more influenced by constant supply of electricity and nearness to free forest areas than the presence of forest reserves.

Keywords: Forest reserves, sawmills, geographic information system, spatial distribution, forestry zones.

Introduction

Forest ecosystems are parts of the Earth's greatest treasures, which have rich habitats crowded with many flora and fauna species as well as soils (Carlson, *et al.,* 2010; Lan Thompson and Kimiko, 2010; Saadia, 2012; IUCN, 2015). Forest ecosystems are habitat for about 80% of the world's terrestrial biodiversity, and they also form the source of livelihood for many different human settlements, including 60 million indigenous people (Saadia, 2012; INTACT, 2016). In addition, about 300 million people live in forests in one way or the other. This includes about 60 million indigenous people who are spread over different villages and towns across the globe. In spite of these benefits, we are fast losing these forest ecosystems. It was reported that between 1990 and 2015, the world lost about 129 million ha of forest (IUCN, 2015 and INTACT, 2016), and this is an area equivalent to the size of South Africa (IUCN, 2015). Each time there is

deforestation, it is not only the trees that go from the forest but the entire ecosystem falls apart, with dire consequences (Lan Thompson and Kimiko, 2010; Carlson, *et al.,* 2010; Carlson, *et al.,* 2015). This, to a large extent affects the biodiversity within the forest ecosystem. Forest ecosystems provide a number of services that are fundamental to human welfare (IUCN, 2015; Carlson, *et al.,* 2015). These include: absorption of harmful greenhouse gasses ; provision of clean water for domestic and other household needs; protection of watersheds and reduction of the amount of erosion and chemicals that reach waterways; provision of food and medicine, and provision of habitat to more than half of the world's land-based species (Carlson, *et al.,* 2010;Arun, *et al.,* 2013; IUCN, 2015). These services are more evident in the tropics, since there is more biodiversity in the tropical forest, than in the temperate forest of the world.

Nigeria is one of the countries situated in the tropical region of the world. Thus, its forests are very rich with over 300 different tree species. This makes it support a wide range of forest industries, which include both the formal and informal sub-sectors (FAO, 2010a; 2010b). The formal sector is essentially wood based and is fairly well developed and comprise mechanical wood industries, including sawmills, veneer and plywood manufactures, particle board, paper and paper board manufactures (FAO, 2010a; Faleyimu and Agbeja, 2012; IUCN, 2015). It was reported by FAO, (2010a) and IUCN, (2015) that vast majority of the Nigerian populace depend on these industries, thus placing a lot of pressure on the forest resources of the nation. FAO, (2010b) also reported that there was a gradual decline in the forest area of Nigeria from 22.56 million ha in 1977 to 9.04 million ha in 2010. From this FAO report, about 59.93% of total forest area has been converted to other land used within a period of about 30 years. The informal forest sector comprises an informal wood based sector, which is the country's largest user of wood, and the non-wood forest products sector. To a large extent, the wood-based industry is essentially managed by private sector in Nigeria. For continual functioning of these industries, raw materials are sourced from the forest ecosystems. This, also has increased the pressure on the forest of the nation mostly through illegal means (Faleyimu and Agbeja, 2012). Therefore, if the forest is to be managed in a sustainable manner, apart from determining the growing stock through forest inventory or remote sensing, monitoring the activities of the saw millers from the assigned compartment in the forest, transportation of logs from the forest to the sawmills for conversion is highly essential. This is necessary to preclude the saw millers from indiscriminate conversion of undersized logs. However, spatial distribution of these sawmills, which will help the government to dispatch uniform officers to the respective sawmill for proper monitoring, have not been determined especially in Oyo State. Therefore, this study examines the spatial distribution of forest reserves and sawmills in Oyo State, Nigeria, using geographic information system with a view to providing information on the locations of the sawmill for proper monitoring of the activities of the saw millers in wood conversion in Oyo State, Nigeria.

Methodology

Oyo state is located in southwestern part of Nigeria occupying about 2,650,000 ha (NBS, 2012). It is bounded in the north by Kwara State, in the east by Osun State, in the south by Ogun State and in the west partly by Ogun State and partly by the Republic of Benin. It is situated 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. The Climate is equatorial, notably with dry season spanning from November to March and wet season spanning from April to October. The average annual rainfall is 1252.5 mm, while the average daily temperature ranges between

23.2°C and 31.9 °C, almost throughout the year.There is an annual mean radiation of 18.3 mm and an annual mean relative humidity of 59.1 %. Its annual mean evaporation is 4.4 mm while annual mean cloud coverage is 7 OCATS (NBS, 2012).

The data for this study, which were of two types (primary and secondary) were collected across the four forestry zones (Ibadan, Shaki Ogbomosho and Oyo) in the state. The secondary data collection include the list of all the forest reserves and sawmill from the State Department of Forestry, the sketch map of the forest reserves, high resolution satellite imageries of all the forest reserves obtained for the purpose of vectorization, and shapefile of Oyo State. The primary data collection comprised coordinates of some bench mark places within the forest reserves that could be identified on the satellite imagery, the sketch map and on ground, the coordinates of all the sawmills within the state, and the distance between the sawmills and various forest where raw materials were obtained. Interview guide were prepared for saw millers to obtain information on the factors that influenced location of their sawmills, which may not be easily obtained using geographical information system and remote sensing. The saw millers were randomly selected using 20 % sampling intensity. The sketch map was georeferenced using the coordinates of some bench mark places earlier obtained from the forest reserve. This was followed by vectorization, clipping and location of forest reserves were digitized. The coordinates obtained from the sawmills were used to digitize location of the sawmills on the map of the state, thereby producing the spatial distribution of the sawmills and forest reserves. Points were used to digitize the sawmill locations, while polygons were used to digitize area covered by individual forest reserve as was done by Agbelade and Akindele, (2013), Alo *et al.,* (2014), Alo, (2017). Spatial distribution of sawmills were studied under the four zones. Distances from each sawmills to various forest where raw materials were sourcedwere obtained and averaged to produce average transport distance for each sawmill. The values were also averaged for all the sawmills in each local government and forestry zones of the state. Factors influencing the sawmill location which may not be revealed by the use of GIS were obtained from the interview guide and collated. One way ANOVA was carried out to determine if there were significant difference in the number of sawmills spatially distributed across the four forestry zones in the state. Follow up analysis using Duncan Multiple Range Test was used to determine which of the forestry zones has the highest distribution of sawmills.

Results and Discussion

There were nine (9) gazetted forest reserves in Oyo State covering about 342,461 ha of land (Table 1). Four of these forest reserves (Opara, Igangan, Ago Are I and II, Oke-Iho),were situated at the western part of the state, while five (Olokemeji, Lanlate, Ijaiye, Osho and Gambari),were situated at the southern part (Figure 1).There was no forest reserve at both the Eastern and northern parts of the state aside the Old Oyo National Park at the north, which of course, was a protected area for both flora and fauna. Opara Forest Reserve (248,640 ha) was the largest of all the forest reserves accounting for about 72.6 % of the entire forest reserves in the state (Table 1). It spanned through Atishbo, Saki west and Iwajowa local government areas of the state (Figure 1). This was followed by Igangan forest reserve with 39,627 ha, accounting for about 11.57 % of the total forest reserve in the state. Next to Igangan forest reserve wasIjaiye (28,491 ha), Gambari (11,431 ha), Lanlate (7,507 ha), Osho (3,704 ha), Oke-Iho (2,300 ha) Olasehinde (686 ha),in that order, while the least was Olokemeji (75.11 ha) and accounting for 8.32%, 3.34%, 2.19%,

1.08%, 0.67%, 0.2%, and 0.02% of the total land area of the forest reserves respectively.

The total land area of the state as stated by NBS, (2012) was 2,650,000 ha and the total land area of forest reserves was 342,461 ha with forest reserves accounting for only 12.92 % of the total land area. This result is similar to the report of World Bank, (1992) and FAO, (1999) that the forest reserves accounted for about 10% of the total land area in Nigeria but at variance with the recommendation of FAO, (2001), that 25% of the total land area of the country should be protected and managed in a sustainable manner. However, with the level of depletion, deforestation, dereservation through illegal felling and encroachment of individual forest reserve in the state as reported by Sanwo, *et al.,* (2015) and Ige, (2017), the actual area of land covered with forest reserves (natural and plantation) would have become far less than the land area presented above.

This illegal felling and encroachment into the forest reserves cannot be dissociated from the activities of the saw millers in the state who depend solely on the forest for the source of their raw materials (Faleyimu and Agbeja, 2012:Alo *et al.,* 2014; Alo, 2017). There was high concentration of sawmills at the northwest (Irepo, Orelope, Shaki East, Shaki West Local Government Areas), centre (Oyo West, Iseyin, Iwayowa Local Government Areas), a little at the west (Ogbomosho North Local Government Area) and very few at the south (Ibadan North, Akinyele and Ona Ara Local Government Areas) (Table 2).From Table 2, there are about 135 sawmills in Oyo state with about 76 of them in Oyo forestry zone, thus, making Oyo zone accounting for about 56.30 % of the total sawmills in the state.

Table 1: Distribution of Forest Reserves in Oyo State

S/N	Forest Reserves	Domicile LGA	Area (ha)	Percentage (%)
1	Gambari	Oluyole	11,431	3.34
2	Igangan	Ibarapa North	39,627	11.57
3	Ijaiye	Akinyele	28,491	8.32
4	Lanlate	Ibarapa East	7,507	2.19
5	Okoo/iro	Ogo- Oluwa	2,300	0.67
6	Olaseinde	Iseyin	686	0.20
7	Olokemeji	Ibarapa East	75.11	0.02
8	Opara	Atisbo, Saki West and Iwajowa	248,640	72.60
9	Osho	Ido	3,704	1.08
		Total	342,461	100.00

This was followed by Shaki forestry zone with a total of 37 sawmills accounting for about 27.41% of the total number of sawmills in the state. Ogbomosho forestry zone recorded 17 sawmills, accounting for 12.59% while the least (5) was recorded for Ibadan forestry zone, accounting for about 3.70% of the total number of sawmills in the state. Table 3 further provides information on the follow up analysis of the distribution of sawmills in the four forestry zones. Sawmills in Oyo forestry zone was significantly higher than that of Ibadan.The number of sawmills recorded for Oyo forestry zone was high compared to that in Ibadan

because Oyo forestry zone had more free forest areas where timberscould be obtained aside the forest reserves.

This is better explained by the average transport distance for the two forestry zones (Oyo = 4.02 km; Ibadan = 12.33 km). Increase in average transportation distance will increase the cost of production and vice versa (Palmer, 2005; Johansson, 2007). It is difficult to obtain raw materials within Ibadan metropolis, being the largest city in West Africa sub-region, This finding is similar to Alo *et al.,* (2012) and Alo, (2017) who maintained that nearness to raw materials is one of the factors that influenced the location of sawmill establishment in Ekiti State.

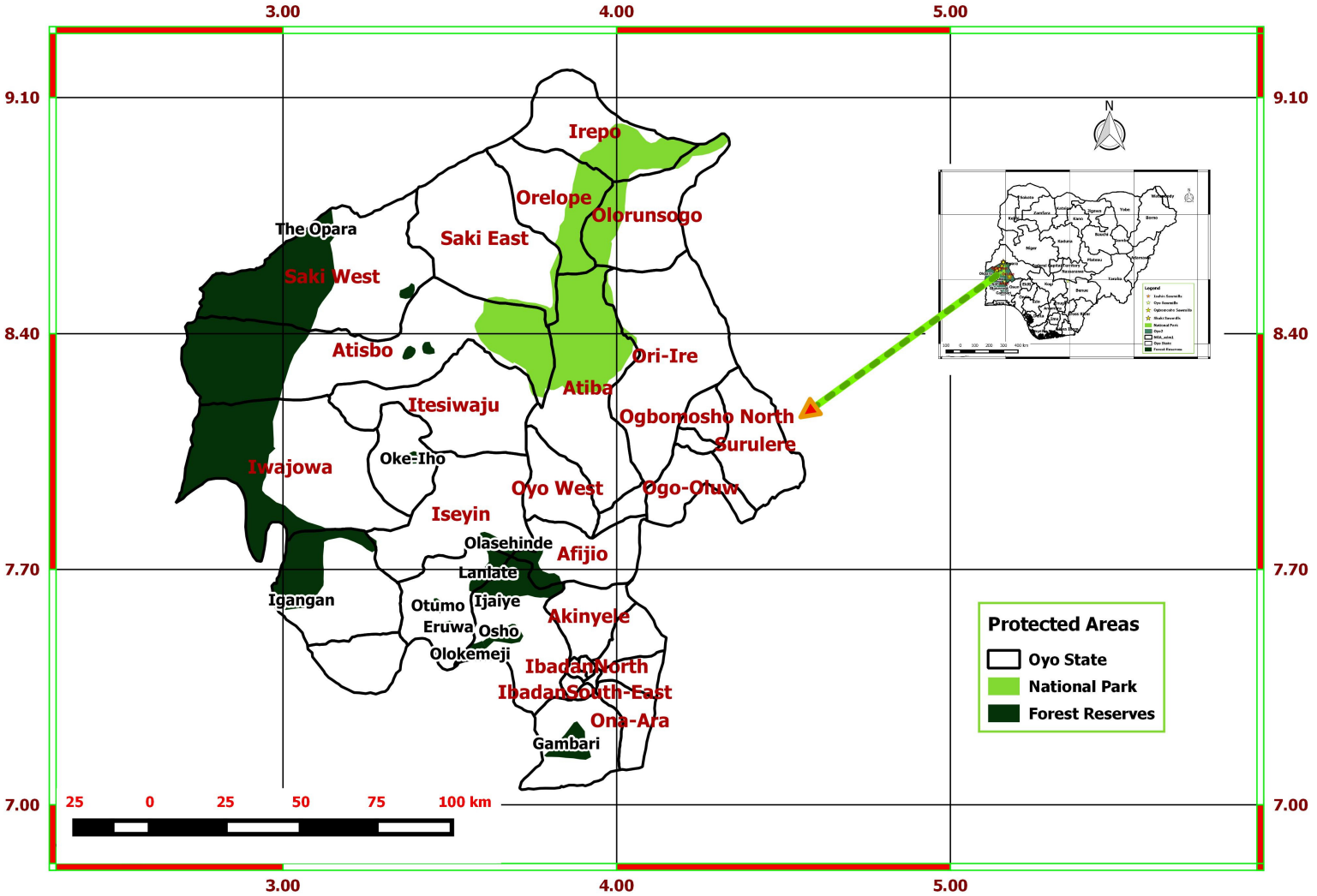

Figure 1: Spatial distribution of forest reserves in Oyo State, Nigeria

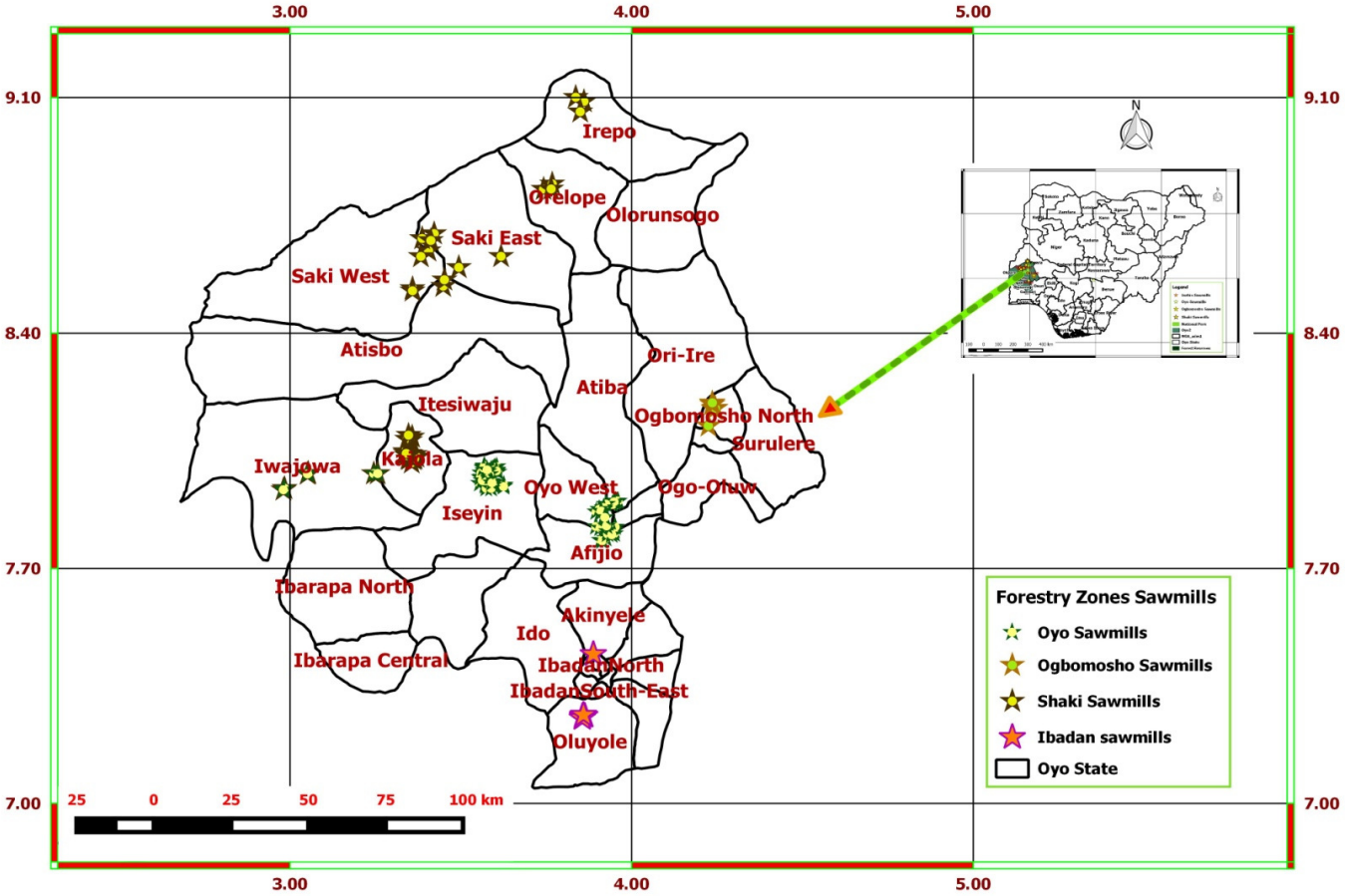

Figure 2: Spatial distribution of sawmills in Oyo State, Nigeria

Table 2: Distribution of sawmills in Oyo State, Nigeria

S/N	Zones	LGA	LGA Total	Zonal Total	Zonal %	State %	ATD[1] (Km)	Zonal %	Remarks
1	Ibadan	Akinyele	1	5	20.00	0.74	12.33	3.70	Lack of regular supply of electricity Remoteness to raw materials Provision of market for the products Scanty forest reserves in the zone
2		Lagelu	0		0.00	0.00			
3		Egbeda	0		0.00	0.00			
4		IbadanNorth	4		80.00	2.96			
5		IbadanNorth-East	0		0.00	0.00			
6		IbadanNorth-West	0		0.00	0.00			
7		IbadanSouth-East	0		0.00	0.00			
8		IbadanSouth-West	0		0.00	0.00			
9		Ibarapa Central	0		0.00	0.00			
10		Ibarapa East	0		0.00	0.00			
11		Ibarapa North	0		0.00	0.00			
12		Ido	0		0.00	0.00			
13		Oluyole	0		0.00	0.00			
14		Ona-Ara	0		0.00	0.00			
15	Oyo	Afijio	3	76	3.95	2.22	4.02	56.30	There is regular supply of electricity. Proximity to raw materials Provision of market for the products Ample forest reserves in the zone
16		Atiba	5		6.58	3.70			
17		Iseyin	47		61.84	34.81			
18		Iwajowa	6		7.89	4.44			
19		Itesiwaju	0		0.00	0.00			
20		Oyo East	4		5.26	2.96			
21		Oyo West	11		14.47	8.15			

[1] Average Transport distance from the sawmills to the forest

Table 2: Distribution of sawmills in Oyo State, Nigeria (Contd.)

S/N	Zones	LGA	LGA Total	Zonal Total	% of Zonal	% State	ATD[2] (Km)	% Zone	Remarks
22		Saki East	5		13.51	3.70			
23		Saki West	4		10.81	2.96			There is regular supply of electricity.
24		Kajola	20		54.05	14.81			Proximity to raw materials
25	Shaki	Orelope	3	37	8.11	2.22	5.60	27.41	Provision of market for the products
26		Olorunsogo	0		0.00	0.00			
27		Atisbo	2		5.41	1.48			Ample forest reserves in the zone
28		Irepo	3		8.11	2.22			
29		Ogbomosho North	17		100.00	12.59			Lack of regular supply of electricity
30		Ogbomosho South	0		0.00	0.00			
31		Ori-Ire	0		0.00	0.00			Remoteness to raw materials
32	Ogbomosho	Surulere	0	17	0.00	0.00	7.44	12.59	Provision of market for the products
			0						Scanty forest reserves in the zone
33		Ogo-Oluwa			0.00	0.00			
		Total		135					

[2] Average Transport distance from the sawmills to the forest

Table 3: Follow up analysis of the distribution of sawmills in four forestry zones

Forestry Zones	No. of LGA	Sawmills No.	Mean sawmills per LGA	Approximate Mean sawmills per LGA
Ibadan Forestry Zone	14	5	0.36^{b}	0^{b}
Ogbomosho Forestry Zone	5	17	3.40^{ab}	3^{ab}
Shaki Forestry Zone	7	35	5.29^{ab}	5^{ab}
Oyo Forestry Zone	7	76	10.86^{a}	11^{a}

Means with different superscript are significantly different from one another

Another factor that influenced the location of sawmills as stated by NISER, (1974) and corroborated by Alo *et al*., (2012) and Alo, (2017) was availability of market for the products. Although, market for sawn timber is expected to be more in Ibadan than Oyo but information obtained from the interview guide revealed that non-availability of raw material coupled with the lack of electricity supply caused serious setback to sawmill establishment in Ibadan forestry zone (Table 2). The saw millers also added that the use of electricity as source of power supply reduced the cost of conversion of wood at all levels compared to the use of diesel as an alternative source of power, which at times, may be very scarce or experience hike in price. The lower the production cost of sawmill business, the lower the selling price of the sawn timber and the better the patronage and the profit generated from such sawmill business (Mason, 2004: Palmer, 2005; Johansson, 2007).

The distribution of sawmills as discussed above did not follow a particular pattern (Figure 2). Its distribution did not depend on the spatial distribution of forest reserves in the State (Figure 3). There were no forest reserve at the northern part of the state yet,a good number of sawmills were located in this area. This is because the Old Oyo National park and vast free forest area at the north coupled with regular supply of electricity have largely contributed to the concentration of sawmill at the north. This result corroborates the findings of Alo, (2017) who submitted that the sawmill location was influenced by nearness to the source of raw materials.

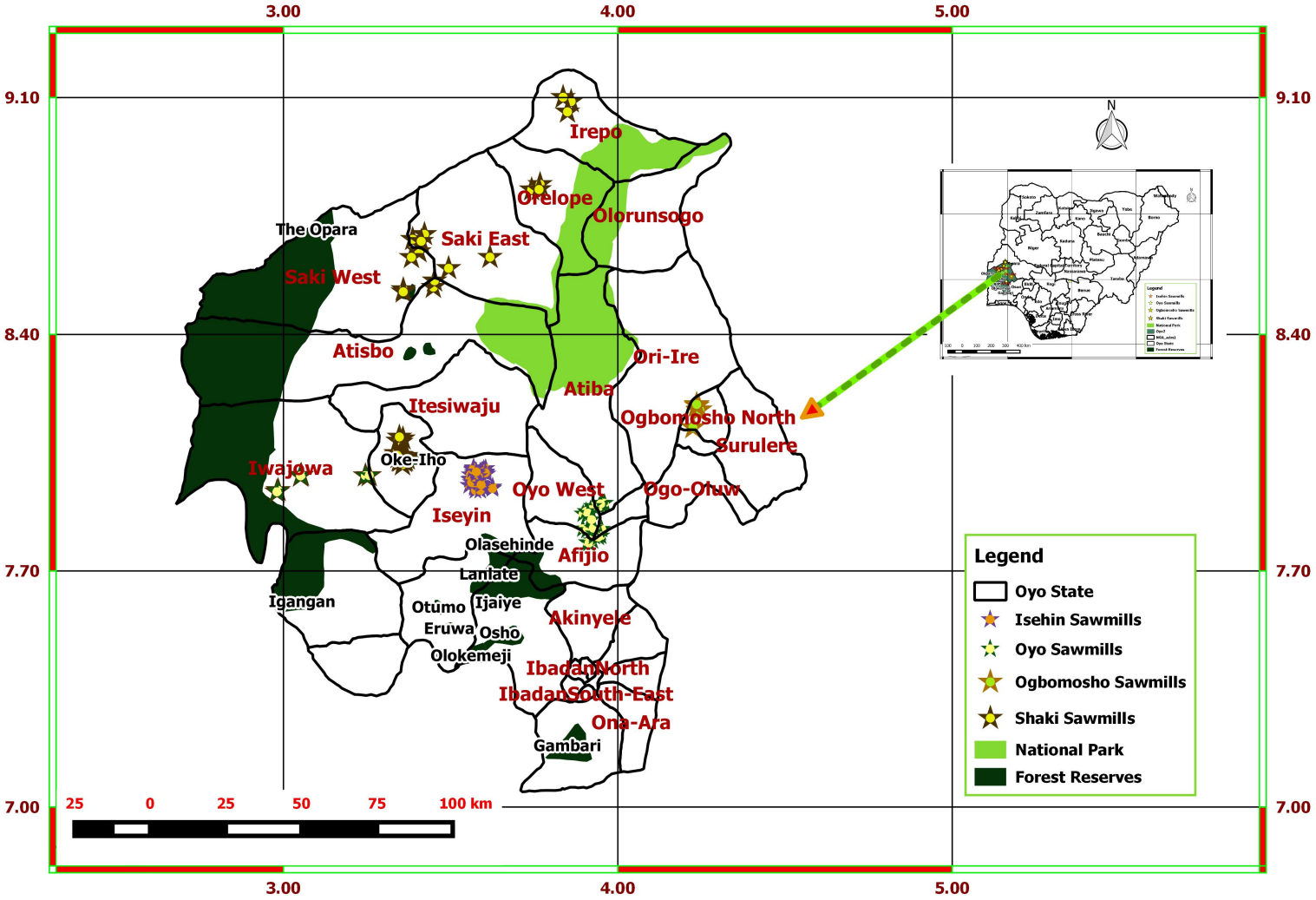

Figure 3: Spatial distribution of forest reserves and sawmills in Oyo State, Nigeria

Conclusion and Recommendations

Forest reserves were spatially distributed at western and southern part of Oyo state, while the eastern and northern parts, had no forest reserves at all. The Forest reserves accounted for a total of 12.92 % of the total land area of the state. Opara forest reserve was the largest forest reserve in the state while the smallest was Olokemeji forest reserve. Distribution of sawmill did not follow any regular pattern. Presence of forest reserve in the state did not influence the spatial distribution of sawmills. Sawmill location was influenced by nearness to the source of raw material, which were free forest areas other than forest reserves in the state. Other factors that influenced the location of sawmills in the state were the availability of regular supply of electricity and market for the products. Spatial distribution map developed in this study is adequate and can be used by relevant stakeholders to take appropriate decisions in monitoring the activities of the saw millers in the state to avert further deforestation in the forest reserves.

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