



Geospatial Application in Forest Reserves Distribution and Sawmills Proximity as a Major Sources of Timber Product in Ibadan and Ibarapa Divisions, Oyo State, Southwest Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author FO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AGK managed the literature searches and analyses of the study. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRAF/2021/v7i330129

Editor(s):

(1) Dr. Lucia Bortolini, University of Padova, Italy.

Reviewers:

(1) Carmelle Myrese, University of Abomey-calavi, Benin.

(2) Saka M. G, Modibbo Adama University, Nigeria.

Complete Peer review History: <https://www.sdiarticle4.com/review-history/70168>

Original Research Article

Received 25 April 2021

Accepted 05 July 2021

Published 13 July 2021

ABSTRACT

The proximity to forest reserves has been considered one of the major factors affecting the spatial distribution of timber based industries. This study assesses the spatial distribution of forest reserves and sawmills in Ibadan and Ibarapa divisions, Oyo State, Nigeria. Existing map of forest reserves of Oyo State and Oyo State shape file was used. The primary data included the geographical coordinates of locations of all existing and functioning sawmills in Ibadan and Ibarapa divisions and this was acquired with Handheld Global Positioning System (eTrex Garmin 30x). The base maps were georeferenced in ArcGIS 10.2 using the coordinates of the base map and the area covered by each forest reserve was digitized. The distance from each sawmill to the nearest forest reserve was determined to ascertain their proximity. The results shows that the forest reserves in Ibadan division covered a total of 47,874.691 hectares of land while a total of 59,011.146 hectares were accounted for the Ibarapa division. From Ibadan division, Ijaiye forest reserve has the highest area

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of land of 25,544.856 ha (53.36%) and Eleyele forest reserve has the least 526.092 ha (1.10%). Irgan with highest forest reserve of 40,643.885 ha (68.87%) from Ibarapa division, and Eruwa forest reserve has the least 7,488.207 ha (12.69%). Generally from the study area, twenty-one (21) sawmills were visited and recorded in all the forestry zones. Four (4) forest reserves are in Ibadan and three (3) in Ibarapa divisions. The travel distance from sawmills to the nearest forest reserve in Ibadan; Gambari, Osho and Eleyele forest reserves was within 5-15km while other are far. It can be concluded that, more sawmills is needed in the study area like Ijaiye, Lanlate as the travel distance of sawmills to the forest reserves is far and this may cause high price in the price of timbers and other forest products.

Keywords: Distribution; forest reserves; divisions; georeferenced; proximity; travel distance.

1. 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 [1,2,3,4]. 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 [3,5]. It was reported that between 1990 and 2015, the world lost about 129 million ha of forest [4,5], and this is an area equivalent to the size of South Africa [4].

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 [2,1,6]. 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 [4,6]. 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 [7,8].

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 [7,9,4]. It was reported by FAO, (2010a) [7] and IUCN, (2015) [4] that vast majority of the Nigerian populace depends on these industries, thus placing a lot of pressure on the forest resources of the nation. FAO, (2010b) [8] 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.

Forests globally are home of diverse benefits such as regulation of climate, habitat for plants

and animals and sources of fodder, timber and non-timber forest products [10,11] but have suffered unprecedented destruction due to unsustainable use and management of resources [12,13].

Natural forest ecosystems are a key resource serving a multitude of functions in the provision of goods and services [14,15,16,17] which contributes immensely to the wellbeing of society. These include the provision of habitat for wildlife species and maintenance of biodiversity, amelioration of local climate, carbon sequestration, provision of aesthetic values, protection of watersheds as well serving as a source of food, medicine, timber, and non-timber forest products [NTFPs] [18,19,20,21].

These multiple benefits can be sustained when forests are intact and undisturbed. However, forest ecosystems are threatened by deforestation and degradation over time mainly due to human activities [22]. Forest cover mapping and monitoring are therefore essential to provide adequate data and information on the status and condition of the forest to assist in planning and initiatives geared towards sustainable forest management. Some of these information might include the spatial coverage and scale [23], functional composition [24], afforestation and deforestation rates [25,26], forest types and successional stages [27], and tree species information [28]. The generation of such data and information on natural forest ecosystems is vital as they could be proxy or input data for carbon stock estimation [29], forest species distribution modeling [30]; forest cover change detection and ecosystem services assessment [31]. Therefore, this study assesses the spatial distribution of forest reserves and proximity of sawmills to the forest reserves in Ibadan and Ibarapa divisions, Oyo State, Nigeria with the purpose of determining the forest reserves and sawmills spatial locations, forest

reserves boundary area covered, and the distances of sawmills to the forest reserves.

2. MATERIAL AND METHODS

2.1 Description of the Study Area

The study Area comprises of Ibadan division forest reserves consisting of Ijaiye, Gambari, Oso and Eleyele while the Ibarapa division consisting of Igangan, Lanlate and Eruwa. Ijaiye forest reserve is located southwest of Atan, Ibadan, Nigeria and lies at approximately at latitude $7^{\circ} 40'N$ and longitude $3^{\circ} 45'E$ with elevation of 263 meters (863 feet). Eleyele forest reserve is located at Ibadan North West Local Government Area, Oyo State. It lies within latitude 7.41° and $7.45^{\circ}N$ and longitude 3.83° - $3.88^{\circ}E$ with a total land area of 526.092ha. Oso forest reserve is located at Ido Local Government Area, Oyo State and lies within latitude $7^{\circ} 00' - 7^{\circ} 45'N$ and longitude $3^{\circ} 25'$ and $5^{\circ} 00'E$ with a total land area of 5,180ha and reduced to 3,500ha by amendment order with an elevation of 152meters above mean sea level. Gambari forest reserve is located at Oluyole Local Government Area, Oyo State and lies within latitude $7^{\circ} 08'$ and $7^{\circ} 03'N$ and longitude $3^{\circ} 49'$ and $3^{\circ} 22'E$. Igangan forest reserve is located in Ibarapa North Local Government Area, Oyo State and lies at approximately latitude $7^{\circ} 45' 00''N$ and longitude $3^{\circ} 05' 00''E$, an elevation of 187m and falls into (Class L - Area) in Nigeria general with farming as the major economic activities and means of livelihood. Eruwa forest reserve is located at

Ibarapa East Local Government Area of Oyo state and lies within latitude $7^{\circ} 31' 59''N$ and longitude $3^{\circ} 27' 00''E$. Eruwa forest reserve is a forested area set aside for controlled use. Lanlate forest reserve is located in Ibarapa East Local Government Area, Oyo State and lies at approximately latitude $7^{\circ} 43' 0.01''N$ and longitude $3^{\circ} 37' 0.01''E$ with elevation of 192 meters and total land area of 7,507ha.

2.2 Data Source and Usage for the Study

A map of 1:200,000 was used and obtained from office of the Surveyor General of Oyo State, Nigeria; Published by Oyo State Surveys 1976 was used as a base map. Also, the study area boundary was extracted from Oyo State shape files which was obtained from the office of the Surveyor General of the Federation Abuja and was used to compare with the base map boundary since it was stated from the base map that the position of State and Divisional boundaries are not accurate from the forest reserve map (see Figs. 5(a & b), 6).

2.3 Image Processing

2.3.1 Image georeferencing procedures using ArcGIS 10.2 (Arcmap 10.2)

Accurate position of four points were georeferenced using the geographical coordinates from the base map used and this was done in ArcGIS 10.2 (Arcmap 10.2) environment (see Fig. 2a). The add control point

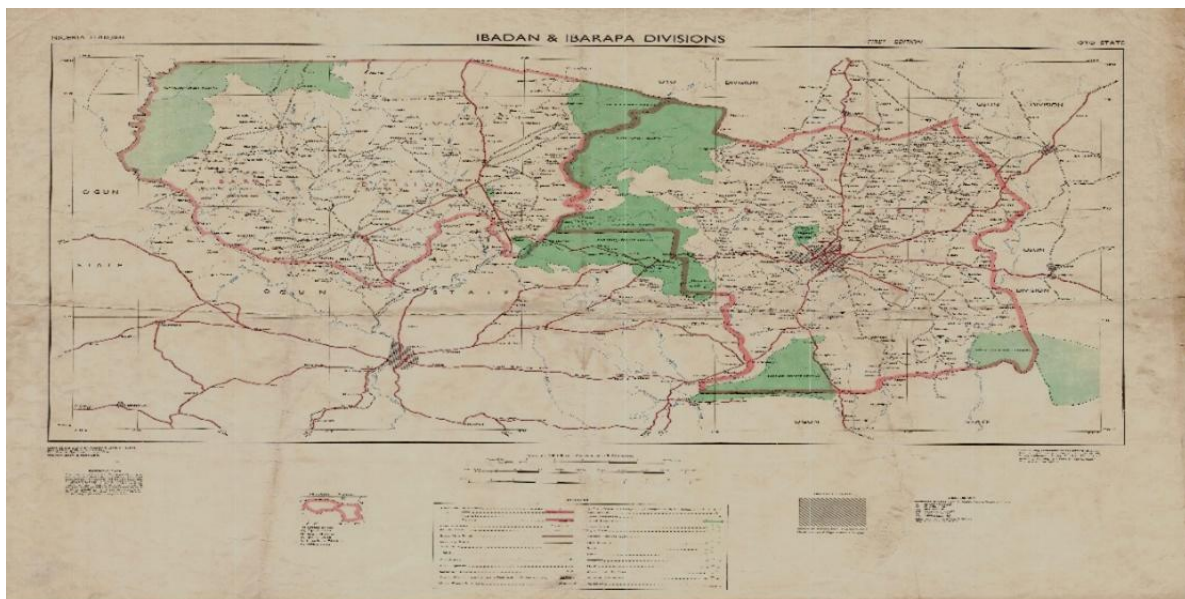


Fig. 1. Base map used for the study area

Source: office of the Surveyor General, Oyo State, Nigeria

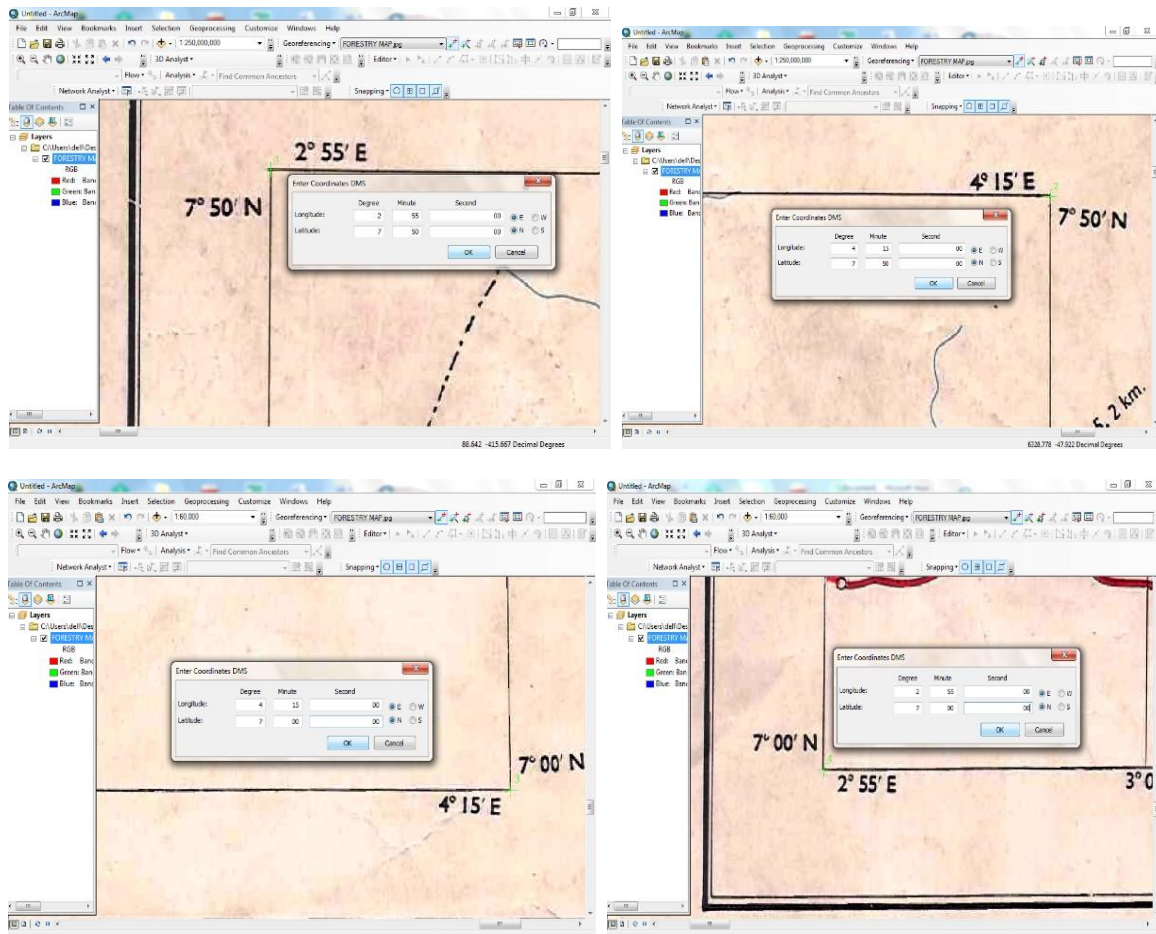


Fig. 2a. Georeferencing procedure for the four corner points selected on the base map

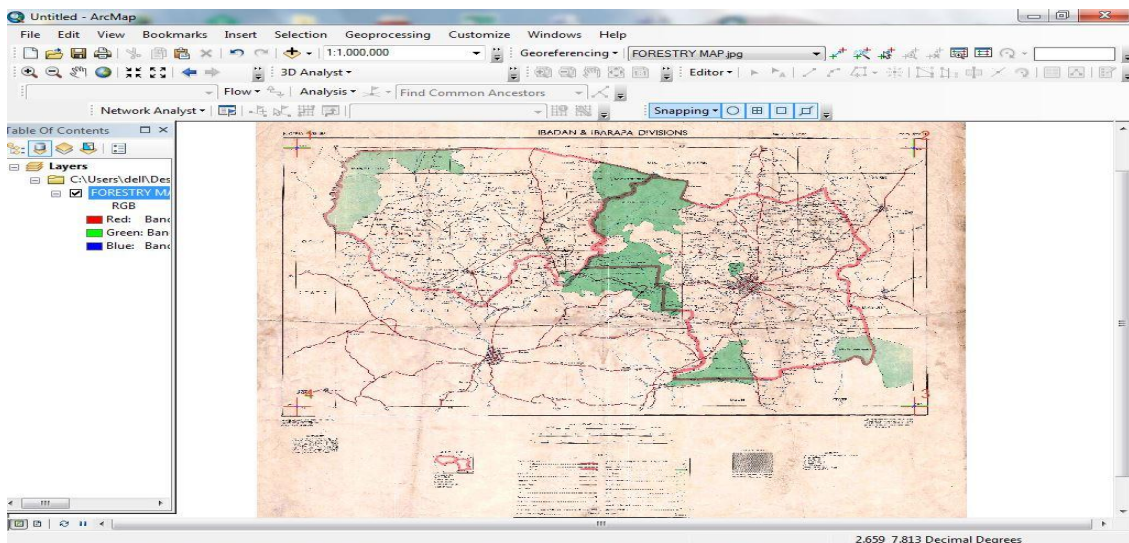


Fig. 2b. Georeferenced points (1-4) on the base map with the edge geographical coordinates

was selected to add the geographic coordinates of four point so that the position of the image of the base map can conform with the position of

the extracted study area generated from Oyo state shapefile.

2.3.2 Digitizing procedures

Polygon was used to digitize the area covered by each forest reserve and line was used for roads and river as the result is similar to the result produced by [32,33,34].

2.3.3 Overlay of sawmills on the image

The coordinates (x, y) of sawmills obtained during the field observation was overlaid on the image to show their spatial position as it was on the ground (Figs. 5-6). The distance of sawmills to forest reserves was done in ArcGIS 10.2 using measure icon and unit of area selected in hectares.

3. RESULTS

The results of this study presented are the information obtained from the field observation made and image processing. Fig. 4 shows variations and percentages in area covered by each forest reserves in Ibadan and Ibarapa division. Fig. 5a shows the composite map produced from the base map used and Fig. 5b shows the composite map from new map produced from the extracted region of the study area from Oyo State shape file. Fig. 6 shows the overlay of both the base map and new map created from Oyo State shape file. Figs. 7-10 presents the query of proximity of sawmills to the nearest forest reserve. Figs. 11-12 describes the number of forest reserve per location in each of the division.

3.1 Discussion of Results

From Table 1, the result shows that Ijaiye forest reserve has the highest forest boundary cover with 25,544.856 ha (53.36%) and Eleyele forest reserve with the least 526.092 ha (1.10%) from Ibadan division. Also from the same Table in Ibarapa division, Igangan has the highest forest reserve boundary cover of 40,643.885 ha (68.87%) and Eruwa with the least of 7,488.207 ha (12.69%) and the result is similar to the result produced by [35]. From the base map used, it shows that Ago-Owu falls within Ibadan division, Oyo State, Nigeria (Fig. 5a) while in the new map produced from the Oyo state shape file, it show that larger percentage of Ago-Owu forest reserve falls in Osun State, Nigeria and with smaller portion in Ibadan (Fig. 5a). Fig. 6 shows scattered location of forest reserves in both Ibadan division and Ibarapa division except Ijaiye and Oso forest reserves that are close (Fig. 6). From the map showing the Ibadan division, the closest forest reserve to Moniya sawmill in

Akinyele Local Government area is Ijaiye forest reserve with a distance of about 19km and Akerele Rufus plank dealer with a distance of about 23km. This shows farther distance from these two sawmills to Ijaiye forest reserve.

To Osho forest reserve, the closest sawmills are challenge sawmills with about 15km, New Garage sawmill with about 14km, Toyinoye sawmill about 16km and Ifelodun sawmill with a distance of approximately 14km. These also shows farther distance between the forest reserves and the sawmills. To Gambari forest reserve, challenge sawmill was about 16km, New Garage sawmill approximately 14km, Toyinoye sawmill about 16km and Ifelodun sawmill about 11km and all are the closest with a distance ranges from 10km-16km which also shows father distance from the forest reserve to the aforementioned sawmills (Fig. 7). Akerele Rufus plank dealer is approximately 4km, Isopako sawmill Bodija market is about 5km, and personal business site is approximately 6km to Eleyele forest reserve (Fig. 8). All the travel distance results produced from this study is similar to the result produced by [35]. Though, Eleyele forest reserve is no more in use since it falls in the inner core of Ibadan metropolis. Therefore, Oso forest reserve is the nearest to the three sawmills mentioned.

All existing sawmills in Ibadan are too far to Ibadan forest reserve divisions except the three aforementioned above that are between (4-6) km to Apete forest reserve. In Ibarapa division, all the available sawmills are within 1km to 6km to Eruwa forest reserve, Ibarapa North Local Government (Fig. 10). Since there is no forest reserve in Ibarapa Central Local Government area, the closest forest reserve to the available sawmills was Eruwa forest reserve but with distance of 20km to 22km. From Ibarapa division, the spatial location of sawmills in Igangan cannot be determined due to incessant killings ongoing in the area, therefore, the area cannot be visited. Factors that may encourage the location and activities of sawmills are; closeness to the forest reserve or other free forest areas as source of raw material, the adequate supply of electricity and product marketing in the study areas. However, with these father distances from sawmills to the forest reserves in the study area, factors such as increase in travel time and cost of transportation to and from will leads to increase in cost of timbers and other forest products [36,37]. From Figs. 11 and 12, location of forest reserves was selected from by division.

Table 1. Distribution of Forest Reserves in Ibadan and Ibarapa Divisions, Oyo State, Nigeria

S/No.	Forest Reserves	Location by LGA	Landed Area Covered (Ha)	Percentage (%)
Ibadan Division				
1	Eleyele	Ibadan North-West	526.092	1.10
2	Gambari	Oluyole	17,982.964	37.56
3	Ijaiye	Akinyele	25,544.856	53.36
4	Oso	Ido	3,820.779	7.98
Total			47874.691	100
Ibarapa Division				
1	Eruwa	Ibarapa East	7488.207	12.69
2	Igangan	Ibarapa North	40,643.885	68.87
3	Lanlate	Ibarapa East	10,879.054	18.44
Total			59011.146	100

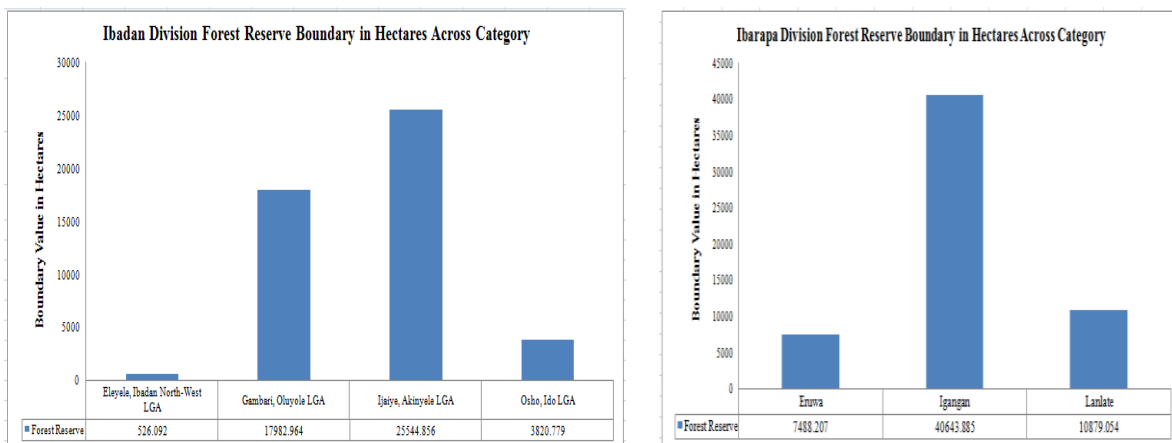


Fig. 3. variation in area covered by forest reserves in Ibadan and Ibarapa Divisions

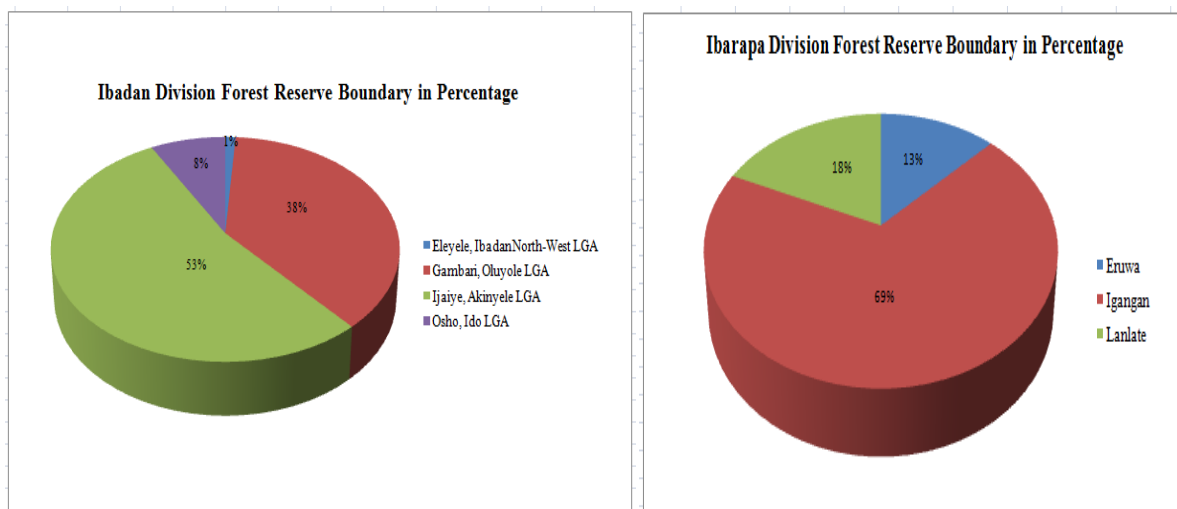


Fig. 4. Percentage in area covered by forest reserve in Ibadan and Ibarapa Divisions

Table 2. Geographic coordinates of ibadan and ibarapa divisions forest reserve

S/No.	Forest Reserves	Location by LGA	Longitude (E)	Latitude (N)
Ibadan Division				
1	Eleyele	Ibadan North-West	3° 52' 7.4"	7° 26' 59.6"
2	Gambari	Oluyole	3° 51' 18.3"	7° 08' 20.8"
3	Ijaiye	Akinyele	3° 40' 45.5"	7° 38' 15.4"
4	Oso	Ido	3° 39' 43.2"	7° 28' 55.2"
Ibarapa Division				
1	Eruwa	Ibarapa East	3° 27' 27.5"	7° 32' 7.8"
2	Igangan	Ibarapa North	3° 03' 24.8"	7° 43' 47.3"
3	Lanlate	Ibarapa East	3° 35' 34.3"	7° 43' 57.7"

Table 3. Spatial geographic location coordinates of sawmills in the study area

Sawmill Name	Latitude (N)	Longitude (E)	Sawmill Location
Ibadan Division			
Moniya sawmill	7° 32' 16.4"	3° 54' 24.6"	Irepodun Street, Moniya Ibadan, Akinyele LGA.
AkereleRufus Plank Dealer	7° 28' 3.6"	3° 54' 45"	10, Oyo Road beside Tantalizer, Shoetan Complex, Ibadan (Business Site)
Sawmill Market, Old Ife Road	7° 23' 30.7"	3° 57' 44.4"	Old Ife Road, Ibadan, Egbeda LGA.
Orita Challenge Sawmill	7° 20' 29.4"	3° 52' 15.9"	Challenge, Oluyole Ibadan, Ibadan Southwest LGA.
Toyinoye Sawmill	7° 20' 43.5"	3° 53' 5.4"	Alh. Aleshinloye House, Aleshinloye Close Felele Challenge Ibadan (Business Unit) Ibadan S/W LGA.
New Garage sawmill	7° 19' 48"	3° 52' 1.7"	New Garage, Ibadan, Oluyole LGA.
Ifelodun Sawmill	7° 17' 50.6"	3° 52' 00"	Ayetoro village Lagos/Ibadan Express Road Opposite Guru Maraji, Ibadan, Ona-Ara LGA.
Temidire Plank Market	7° 22' 30"	4° 03' 37"	Fashade Opposite Badeku/Jago Road, Ibadan, Ona-Ara LGA.
Isopako Sawmill Bodija Market	7° 26' 09"	3° 55' 09"	Bodija Market Road, Bodija Ibadan
Personal Business site sawmill	7° 24' 33.8"	3° 55' 09"	Ibadan, Ibadan North LGA.
The wood Anatomy Innovation Service	7° 25' 52.7"	4° 00' 15.7"	Olodo Ibadan. Olodo Road Egbeda LGA Ibadan.
Ibarapa Division			
Orile Igbo-Ora Sawmill	7° 25' 24.2"	3° 18' 04"	Idere Road, Igbo-Ora, Ibarapa Central LGA.
Pako Sawmill	7° 27' 30"	3° 16' 08"	Igbole Road, Igbo-Ora, Ibarapa Central LGA.
Private sawmill	7° 33' 11"	3° 26' 21.4"	Along Orita Sango Road, Eruwa, Ibarapa East LGA.
Private sawmill	7° 33' 06"	3° 26' 14.8"	Along Orita Sango Road, Eruwa, Ibarapa East LGA.
Private sawmill	7° 32' 52.4"	3° 25' 55.1"	Along Orita Sango Road, Eruwa, Ibarapa East LGA.
Private sawmill	7° 32' 32"	3° 27' 41.5"	Along Ibadan/Okolo Road, New Eruwa, Ibarapa East LGA.
Private sawmill	7° 32' 35.2"	3° 27' 32.8"	Along Ibadan/Okolo Road, New Eruwa, Ibarapa East LGA.
Private sawmill	7° 33' 3.5"	3° 27' 15.4"	Along School of Deaf Road, NEW Eruwa, Ibarapa East LGA.
Private sawmill	7° 33' 11.2"	3° 24' 16"	Along Apode High School Road, Eruwa, Ibarapa East LGA.
Private sawmill	7° 34' 19.3"	3° 26' 40.2"	Along Lanlate Road, Lanlate, Ibarapa East LGA.

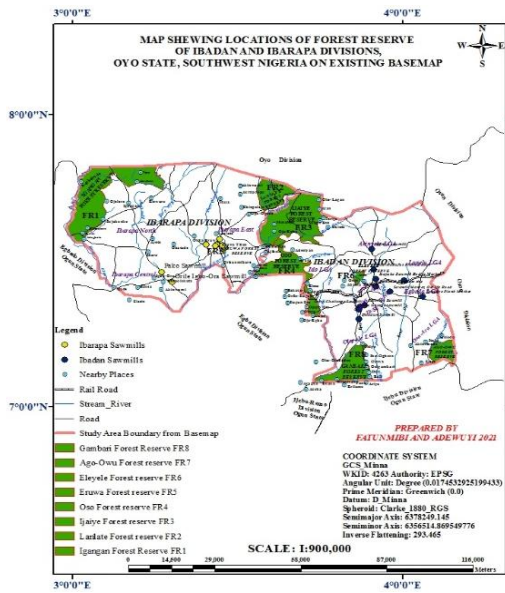


Fig. 5a. Composite map from base map

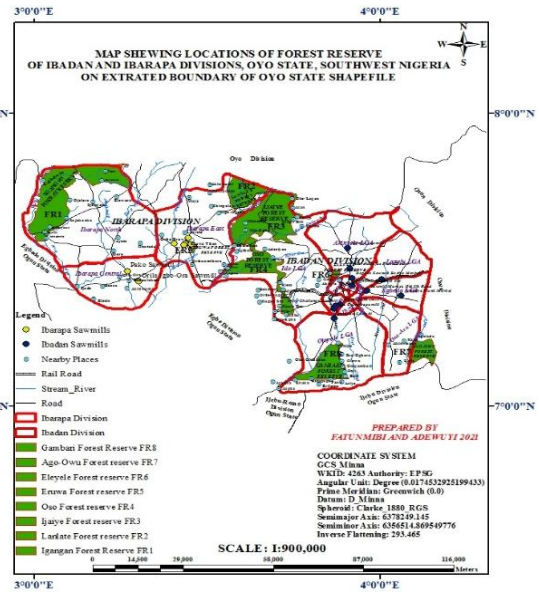


Fig. 5b. Composite map from new map

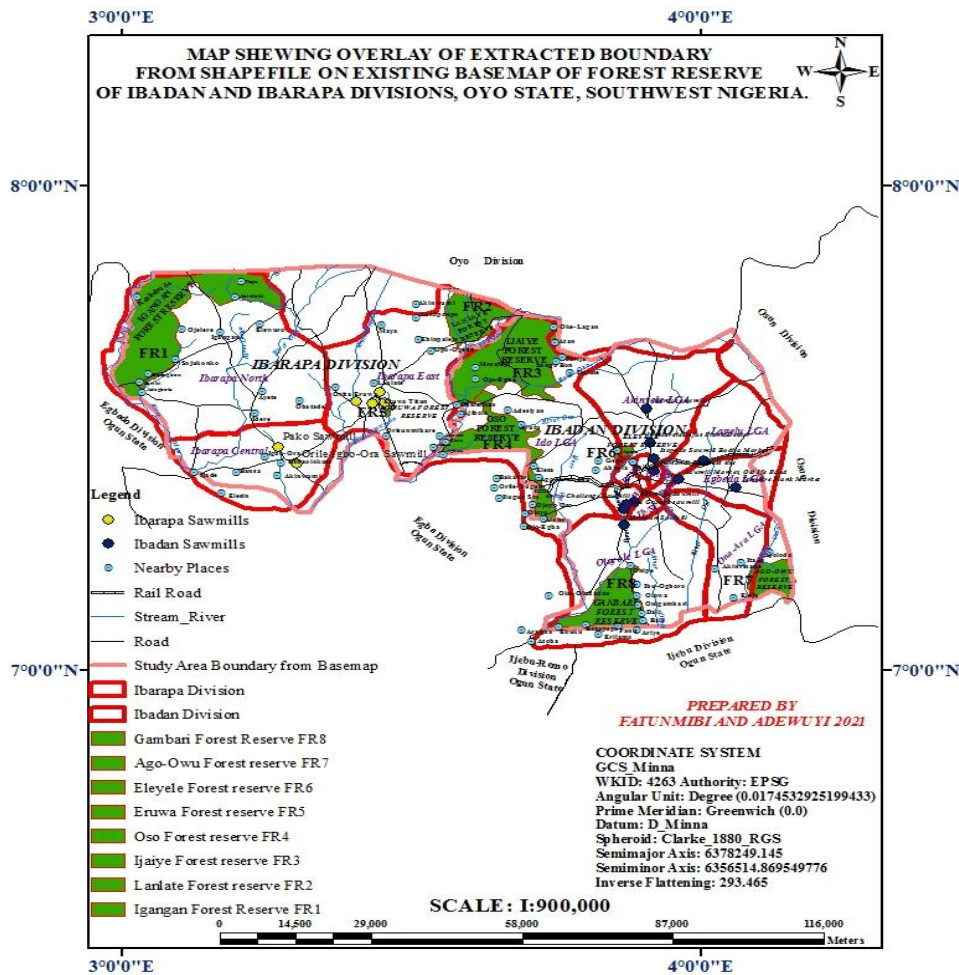


Fig. 6. Composite of overlay map of Extracted boundary on existing base map of the study area

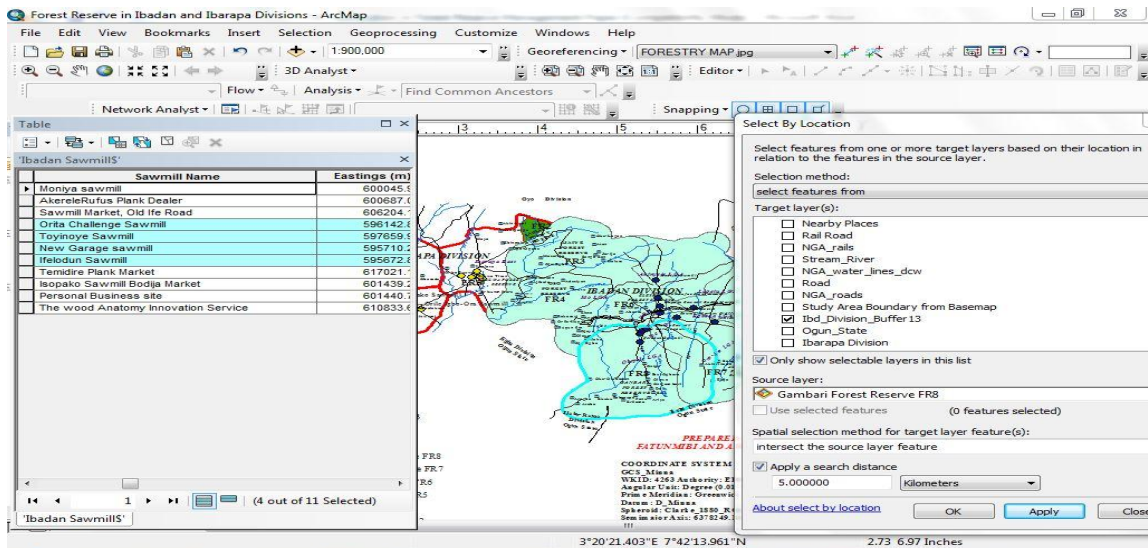


Fig. 7. Query showing Sawmills within the buffer zone radius of 5km to Gambari forest reserve

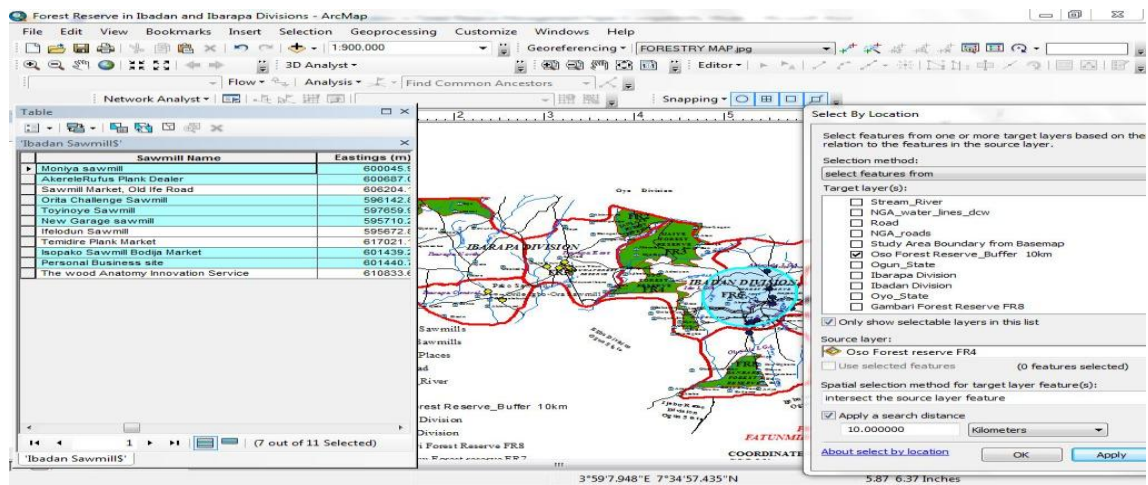


Fig. 8. Query showing Sawmills within the radius of 10km to Eleyele forest reserve

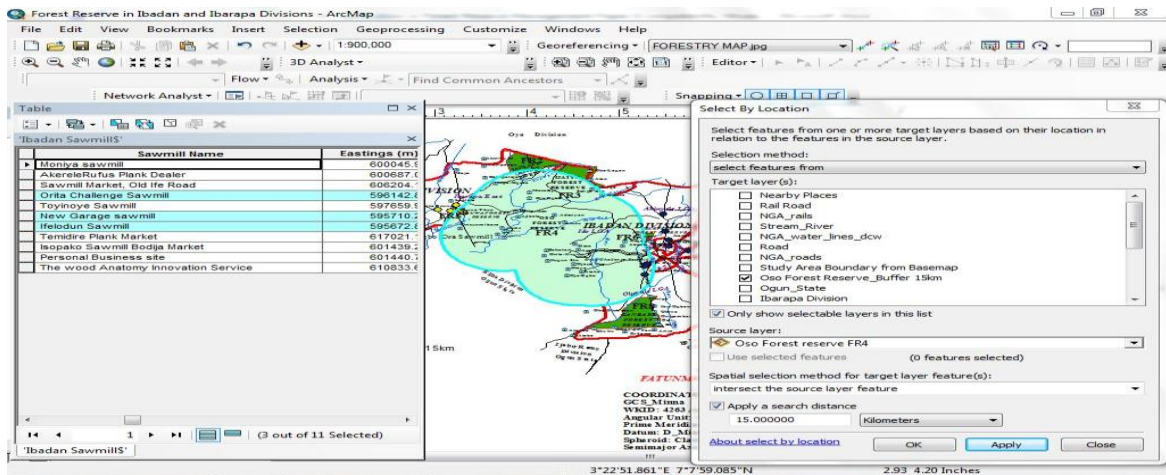


Fig. 9. Query showing Sawmills within the buffer zone radius of 15km to Oso forest reserve

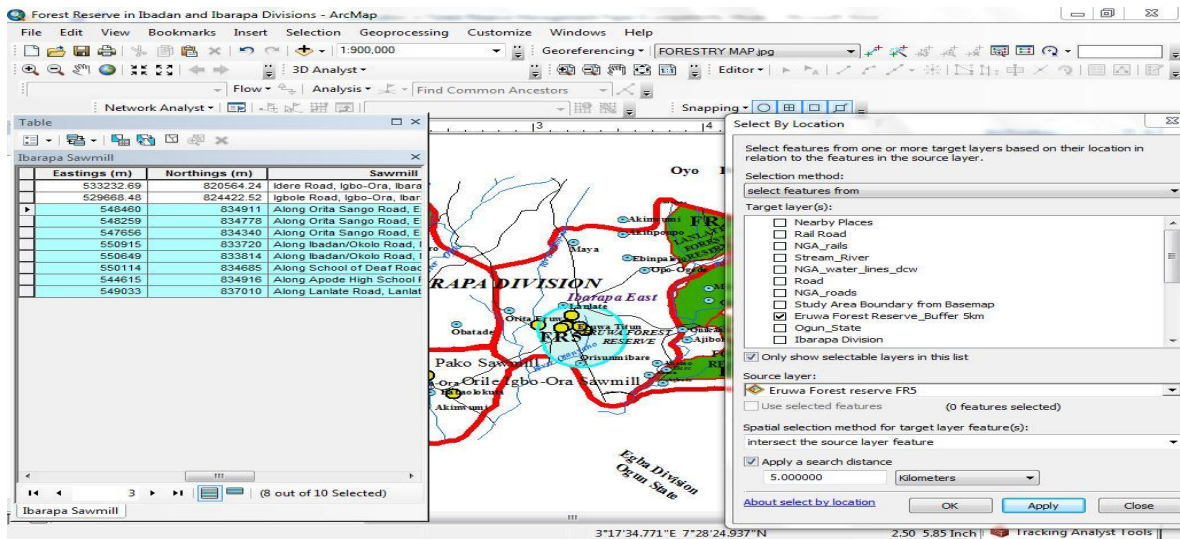


Fig. 10. Query showing Sawmills within the buffer zone radius of 5km to Eruwa forest reserve

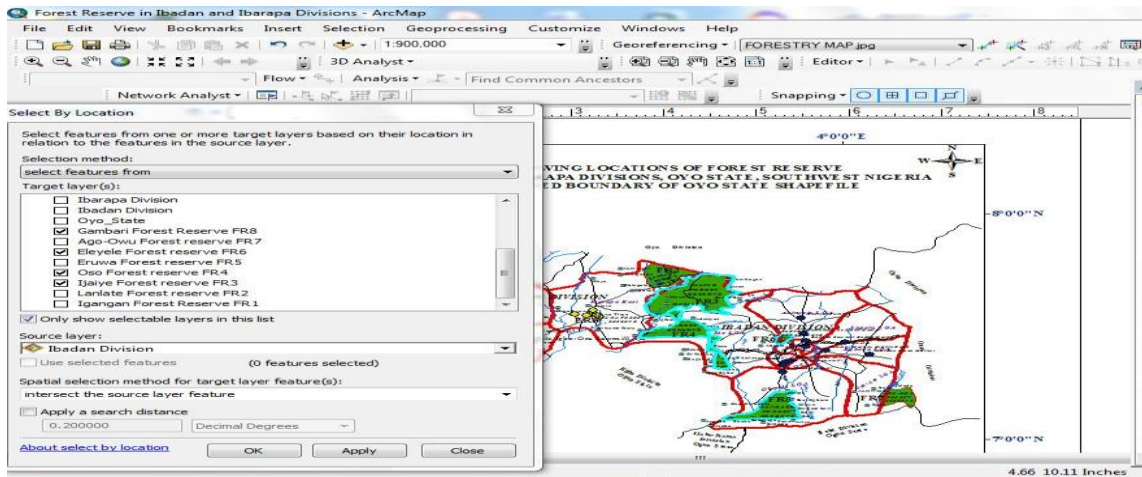


Fig. 11. Selection by location of Ibadan forest reserve divisions

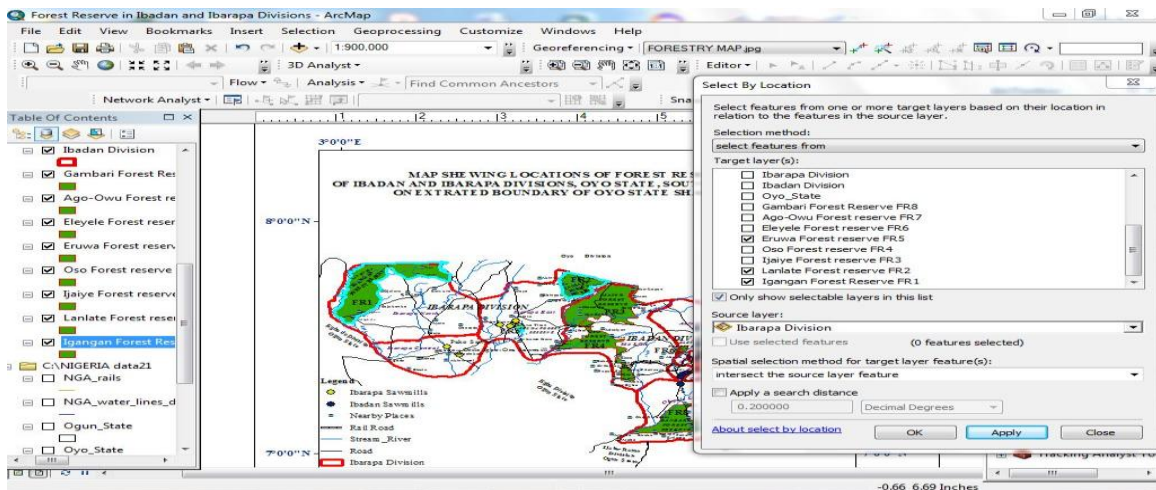


Fig. 12. Selection by location of Ibarapa forest reserve divisions

4. CONCLUSION

Geographical information system has been used in this study as the best tool in mapping the exact locations of forest reserves and sawmills in Ibadan and Ibarapa. Without existence of forest reserves and forest reserve not well stocked both in the urban and rural areas, sawmill will not exist. Sawmills plays an important roles in the wellbeing of the society and as well as the economy of a nation. Availability of sawmills create employment opportunity and nearness of forest reserve to the sawmills improve the productivity rate of timber products. The result from the findings of this study shows that many of the sawmills are no more in use or functioning since there is no more raw material (timber for processing) as view sawmills are located and the location of the forest reserve both in Ibadan and Ibarapa divisions are too far as they falls at the boundary of each divisions and only Eleyele forest reserve and Eruwa forest reserve are at the centre in Ibadan and Ibarapa division. By comparing the base map used with the new map produced in this study, it can be seen from the new map that Ago-Owu forest reserve did not fall within the study areas as it appears from the base map. With the new map produced, the location of boundary from the base map differs from the boundary of the new map. Therefore, new map can be taken as the original map showing the exact boundary and location of each of the forest reserve since it has been stated on the base map that the position of the state and divisional boundary are not correct. Therefore, it can be concluded from the study that, more sawmills is required in area like Ijaiye and Lanlate as the travel distance of sawmills to the two forest reserves is far and this may lead to high price of timbers and other forest products. Application of GIS used in this study for distribution of forest reserve and sawmills is accurate and can be used for further studies. Also, the concerns stakeholders should set up a monitoring committee in the study area and as well as Oyo State to monitor activities of forest deforestation in the forest reserves. Government can also help in improving the productivity of the saw millers by constructing good roads to the forest reserves which will help in transportation of forest products to the community and city.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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