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Geo-Referencing, Mapping and Growth Variables Distribution of Trees Species in Forestry Research Institute Of Nigeria (FRIN), ONNE, Nigeria

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Abstract: *This study evaluated the use of information system in vegetation pattern, tree species abundance, and tree species diversity within the Forestry Research Institute of Nigeria (FRIN), Onne, Rivers State, Nigeria. Tree management requires information on the growing stock, distribution pattern and diversity. Such relevant information will guide managers in proper appraisal and proficient exploitation of the forest resources. All trees within the sampled plots were measured using modern inventory methods. The measurements obtained were grouped into species, diameter at breast height; height classes and their basal area estimates computed. Global Positioning System (GPS) was used to record the coordinates of individual trees, with their points recognized on the imagery for the geo-referencing of the satellite imagery and imported into ArcGIS 10.5 for further geo-processing analyses. Trees within the forested area were measured and the names, families, diameter at breast height were recorded. A total of 1151 trees of 16 different tree species from 12 families recorded were Melicieae family with highest proportion of 11.9%. Pinus caribeae and Nauclea diderrichii were mostly dominated with highest proportion of 21.9% and 20.3% respectively. Majority of the tree species were found in the southern part of the study area while remaining existed along in the northern part. Tree species ranging between 6-10cm of Dbh and the height distribution of 6-10m showed the highest of 44.4%. It can be concluded that the useful tree mapping system and creating a geo-database for spatial analysis can be developed with the aid of Geographical Information System (GIS) technique. Furthermore, it was recommended that the database of the tree species should be properly kept to facilitate update and sustainable management of the trees around the Institute.*

Key words: *Diversity, Mapping, Trees species*

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I. Introduction

Information system remains significant and has become a global asset that is now being used in various sectors for integrating, innovating, improving, and acquiring competent skills that have advanced monitoring and managing forest ecosystems. Information monitoring system when applied in forest management with trees not exceptional have being used for the purpose of planning, organizing and producing available finance and physical resources to achieve human's desired objectives [3]. Our forest remains a gift of nature and fixed commodity that needs adequate planning and management to reduce the occurrences of degradation. Trees, apart from forming the major structural and functional basis of forest, are vital as carbon sinks, water sheds, provide shades and homes to many life forms, above all, act as a primary harvester of energy to the ecosystem [12]. The diversity of trees with respect to their distribution pattern is significant to forest biodiversity, because trees provide homes and resources to a wide variety of plant and animal species [1]. Understanding species diversity and distribution patterns are important for helping managers evaluate the complexity and resources of these forests; especially using geo-referencing tools.

The modification concept of trees for small scale mapping and processing can be achieved through the approach of remote sensing and GIS in determining trees cover for improvement and monitoring purposes, hence transform the forest activities into a working system. According to [11] the wealth of information contained in the maps is widely applied to many fields such as landscape planning, nature conservation and forestry. GIS with combination of ground studies in conjunction with computer-based automated field mapping techniques have been vital gear in the process of creating up-to-date information with several research works using remote sensing and GIS in trees or vegetation mapping in analyzing the spatial distribution of trees species [15;14]. GIS is becoming an important device for forest resources management in Nigeria. To ensure and achieve sustainable forest management concept, forest managers require more intensive, precise methods to accurately generate quick information on situation about the forest resources. Remote sensing and GIS serve as tools that provide quick solutions of information on the environment and earth surface. Trees mapping utilizes both qualitative and quantitative data collection methods to facilitate efficient planning and decision making. The database creates the location, attribute, and table and can be used to find the distribution of trees, damages to the tree, area disturbances and many other factors. With appropriate and precise information on the ground problems related to forest can be solved through available update map. This study therefore evaluated the geo-referencing, mapping and growth variables distribution of trees species in forestry research institute of Nigeria (FRIN), Onne, Nigeria.

II. Materials And Methods

STUDY AREA

The study was carried out at the Forestry Research Institute, Onne of which location covers about 4.5 hectares. Onne is a part of Nchia clan in Eleme Local Government Area of Rivers State, in Nigeria. Rainfall in this forest has a range of 2000 to 2470 mm per annum and terrain is undulating in the lowland areas, with latitude 4^0 44'N and longitude 7^0 15 to Bonny River [8]. The forest zone consist of river, creeks, and estuaries, while stagnant swamps covers about square kilometer with the area dotted with mangrove swamps [16]. The area is known to be characterized with two distinct soil types, a temporarily flooded lowland area during rainy season and permanent marshy lowland toward the extreme end of the areas. The soils may perhaps be considered as uniform, moderate firm darkish sandy clay with very low water table in most part of the areas and gives rise to a diverse floristic composition.

Vegetation: The floristic compositions are dominated with numerous species with dominance species found among *Treculia africana, Dacryodes edulis and Garcinia cola, Terminalia ivoriensis, Mansonia altissima, Enthrandrophragma angolensis, Khaya ivorensis* and so on. The region has most dominated extraction of oil and gas which constitute the largest resources of the Nigeria's economy. This has resulted into vast vulnerable environment caused by climate change and high environmental disasters due to various oil companies around the area.

Data Collection

The data used in this research work was acquired from the physical planning of Federal Research Institute of Nigeria, Onne where satellite imagery of the plantation showing the entire areas and the topographical Map of the Onne in Rivers State was obtained. Total enumeration of growth variables of tree within the premises was also taken from dbh of 0cm to >30cm by species and assigned to families in their respective locations. The height and stand volume were obtained and estimated respectively for appropriate descriptive statistics. The coordinates of individual tree species in the study area were inputted into Microsoft Excel 2007 version and saved in Tab Delimited.

Geo-Referencing and Mapping

The limit of the study area was delineated using satellite image of the study area obtained from the Google Earth 2016 Version. They were in 30m x 30m resolution and projected coordinate system Zone 32 Universal Thematic Mercator (UTM) (Minna Datum). Using the coordinates of specific location already captured with the GPS. The align tool in ArcView 10.5 was used to geo-reference the imagery. The coordinates of the tree species were brought into the ArcGIS 10.5 interface as points data. This process ensured that every point on the satellite imagery has specific coordinates (Latitude and Longitude).The points data represented individual trees and their respective characteristics. This involves the outline features using point, line and polygon as fitting parameters. Points were used to specific locations and small objects, lines were used for linear features such as road and stream, while polygons were used for area features such as land use and vegetation classes. Different color format were used to represent the features for ease of recognition and dissimilarity of the map produced.

III. Results

The analysis of the satellite imagery using ArcView GIS 10.5a showed the map distribution of the Federal Research Institution of Nigeria (FRIN) Rivers State with geo-referenced attribute data collected from the field in Figures 1. The geographic positions of the individual tree distribution on the map in Figure 1 show the diversity pattern of the species. Species such as *Allanblackia sp, Dacryodes edulis, Garcinia cola, Gmelina arborea, Pinus caribaea* and *Treculia africana* are the most abundant in the southern part of the study area but few in the northeastern part of the study area. Similarly, *Irvingia gabonesis, Entandrophragma angolense, Lovoa trichilioides* and *Masnonia altissima*, are equally more abundant in the northern than the southern part of the study area (Figure 1). Species sparsely distributed in the entire study area include *Eucalyptus sp., Nauclea diderrichii* and *Terminalia montalis* (Figure 1). Importantly, *Khaya ivorensis* was only sighted in the southern part of the study area (Figure 1).

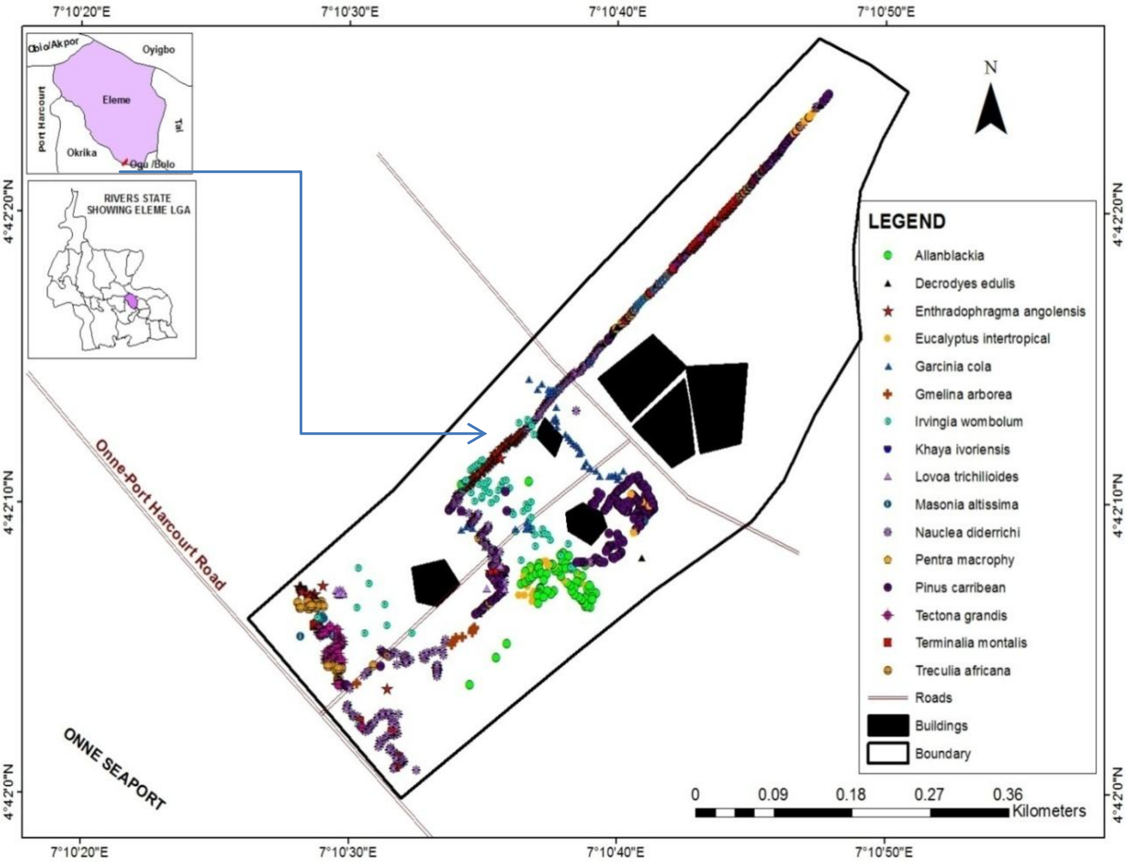

Figure 1: Map showing Land Use and Vegetation Cover pattern of the study area

Trees Growth diversity within the study area

Table 1 reveals the result of trees growth diversity and abundance within the study area. In all, 1,151 trees spread across 12 families belonging to Sixteen (16) species were enumerated in the plantation. Total volume estimated were 1012.279m^3 and Basal area estimated were 2518.63m^2. There were 16 species with *Pinus caribaea* being the most prominent with highest percent of 21.9% and *Nauclea diderrichii* with 20.3% follow by *Entandrophragma angolense(7.4%), Tectona grandis(6.9%), Allanblackia (6.3%), Irvingia gabonesis(5.9%), Terminalia montalis(5.2%), Treculia Africana(5.0%), Mansonia altissima(4.8%), Lovoa trichilioides(4.3%), Garcinia kola(4.1%), Eucalyptus sp(3.9%)* .The least dominant tree species in the area are *Dacryodes edulis(2.7%), Gmelina arborea (1.0%),Khaya ivorensis (0.2%), Pentraclethra macrophylla (0.1%).* The most abundant species is *Pinus caribaea in the family of Pinaceae* (254), this is followed by Rubiaceae with (234 species), Meliceae(137 species) , Guttiferae has 1 20 species , Irvingiaceae has 68 species, Sterculiaceae 55 species, Lecythidaceae 45 species, Burseraceae 31 species while Verbenaceae have 11 species respectively as shown in (Table 1).

Table 1: Families, and volumetric distributions of trees in the study

Names of Trees species	Families	Total Volume(m^3) per plot	Basal area(m^2)	Frequency	Percentage (%)
Allanblackia sp	Guttiferae	16.810	1.641	73	6.3
Dacryodes edulis	Burseraceae	37.342	2.457	31	2.7
Entandrophragma angolense	Meliceae	32.040	2.688	85	7.4
Eucalyptus sp	Lecythidaceae	65.343	3.602	45	3.9
Garcinia kola	Guttiferae	13.994	1.388	47	4.1
Gmelina arborea	Verbenaceae	3.155	0.293	11	1.0
Irvingia gabonesis	Irvingiaceae	3.745	3.745	68	5.9
Khaya ivorensis	Meliaceae	0.892	0.043	2	0.2
Lovoa trichilioides	Meliaceae	50.413	3.440	50	4.3
Mansonia altissima	Sterculiaceae	80.364	1.838	55	4.8
Nauclea diderrichii	Rubiaceae	51.189	5.507	234	20.3
Pentraclethra macrophylla	Leguminoseae	0.825	0.061	1	0.1

Pinus caribaea	Pinaceae	432.43	22.041	252	21.9
Tectona grandis	Verbenaceae	43.336	3.212	79	6.9
Terminalia montalis	Combretaceae	50.328	4.052	60	5.2
Treculia Africana	Moraceae	130.04	8.078	58	5.0
Total		**1012.279**	**2518.63**	**1151**	

Diameter Distribution Class

Table 2 shows the extent of availability of the diameter at beast height (dbh) in the study area. The diameter class increases along the southern part while decrease moving towards northward. In addition, abundant tree species occurred within the range of 21-40cm and 41-60cm were found in the southern part and few in the north (Figure 2). Tree species between 61 and 80cm were also found in abundance in the southern part while the tree species with diameter between 81 and 100cm were found in the north only. In the case of individual distribution of each tree species based on their geographic positions, majority of the tree species in diameter between 0 and 20cm sighted at the southern part were sparsely distributed and very rare in the north. Within the range of 21-40cm and between 41and 60cm were more abundant in the southern part than the moving north part (Figure 2). The tree species distribution ranging between 61 and 80cm can only be situated in the southern part while tree species from 81 to 100cm can only be found in the northern part of the study area (Figure 2).

The geographic position distributions of individual tree species, the tree species between 0 and 20cm in diameter were abundant at the southern part of the study area among which included *Allanblackia sp., Eucalyptus sp., Irvingia gabonesis, Lovoa trichilioides, Pinus caribaea, Garcinia kola,Gmelina arborea* and *Tectona grandis*. Also, along the path to the north of the study area among which included *Nauclea diderrichii,Terminalia montalis* and *Treculia africana* (Figure 2.). Tree species from 21 to 40cm can be sighted at the southern part of the study area among which included *Allanblackia sp., Irvingia gabonesis, Pinus caribaea,Entandrophragma angolense, Tectona grandis, Lovoa trichilioides, Garcinia kola* and *Treculia africana* have more abundance. Moving northwards are*Nauclea diderrichii,Mansonia altissima* and *Eucalyptus sp.* in abundance while *Pinus caribaea* turned out to be less (Figure 2). Most of the tree species ranging from 41 to 60cm were located in the southern part among which included *Decrodyse edulis, Eucalyptus sp., Mansonia altissima* and *Nauclea diderrichii,* while *Mansonia altissima* and *Pinus caribaea* were fewer.

Also tree species like*Treculia africana,Entandrophragma angolense, Pinus caribaea, Lovoa trichilioides* and *Irvingia gabonesis* were found in this group and in abundance while *Dacryodse edulis* and *Eucalyptus sp.,* were fewer (Figure 2).The tree species of diameter distribution ranging from 61-80cm included *Nauclea diderrichii, Treculia africana, Garcinia kola, Allanblackia sp., Irvingia gabonesis, Pinus caribaea,Entandrophragma angolense, Tectona grandis, Lovoa trichilioides, Mansonia altissima,* and *Gmelina aroborea* and *Eucalyptus* sp., shows higher abundance in the southern part while *Dacryodes edulis* and *Terminalia montalis*were higher in the north (Figure 2). *Terminalia montalis* was the only tree species in the study area found within the diameter distribution from 81 to100cm (Figure 2)

Table 2: Diameter Classes of Trees Species in a Stand

Name of species	Number of stem per plot	Diameter(cm)							Planting space
		0-5	6-10	11-15	16-20	21-25	26-30	>30	
Allanblackia sp	73	3	35	33	2	0	0	0	2.5m by 3m
Dacryodes edulis	31	0	15	8	7	3	1	0	2.5m by 3m
Entandrophragma angolense	85	0	58	7	21	0	2	0	3m by 3m
Eucalyptus sp	45	2	15	12	13	2	1	0	2.5m by 3m
Garcinia kola	47	3	29	15	0	0	0	0	3m by 3m
Gmelina arborea	11	0	10	0	0	1	0	0	3m by 3m
Irvingia gabonesis	68	0	19	37	10	1	0	0	3m by 3m
Khaya ivorensis	2	0	0	0	0	2	0	0	3m by 3m
Lovoa trichilioides	50	0	18	14	19	3	1	0	3m by 3m
Mansonia altissima	55	3	25	10	21	0	0	0	3m by 3m

Nauclea diderrichii	234	4	186	38	4	0	0	0	3m by 3m
Pentraclethra macrophylla	1	0	0	1	0	0	0	0	3m by 3m
Pinus caribaea	252	0	57	62	39	53	23	1	3m by 3m
Tectona grandis	79	0	19	70	0	0	0	0	3m by 3m
Terminalia montalis	60	0	42	11	7	0	0	0	3m by 3m
Treculia Africana	58	0	7	27	22	0	0	0	3m by 3m
Frequency		**12**	**535**	**345**	**165**	**65**	**28**	**1**	
Percentage (%)		**53.5**	**46.5**	**30.0**	**14.3**	**5.6**	**2.4**	**1**	

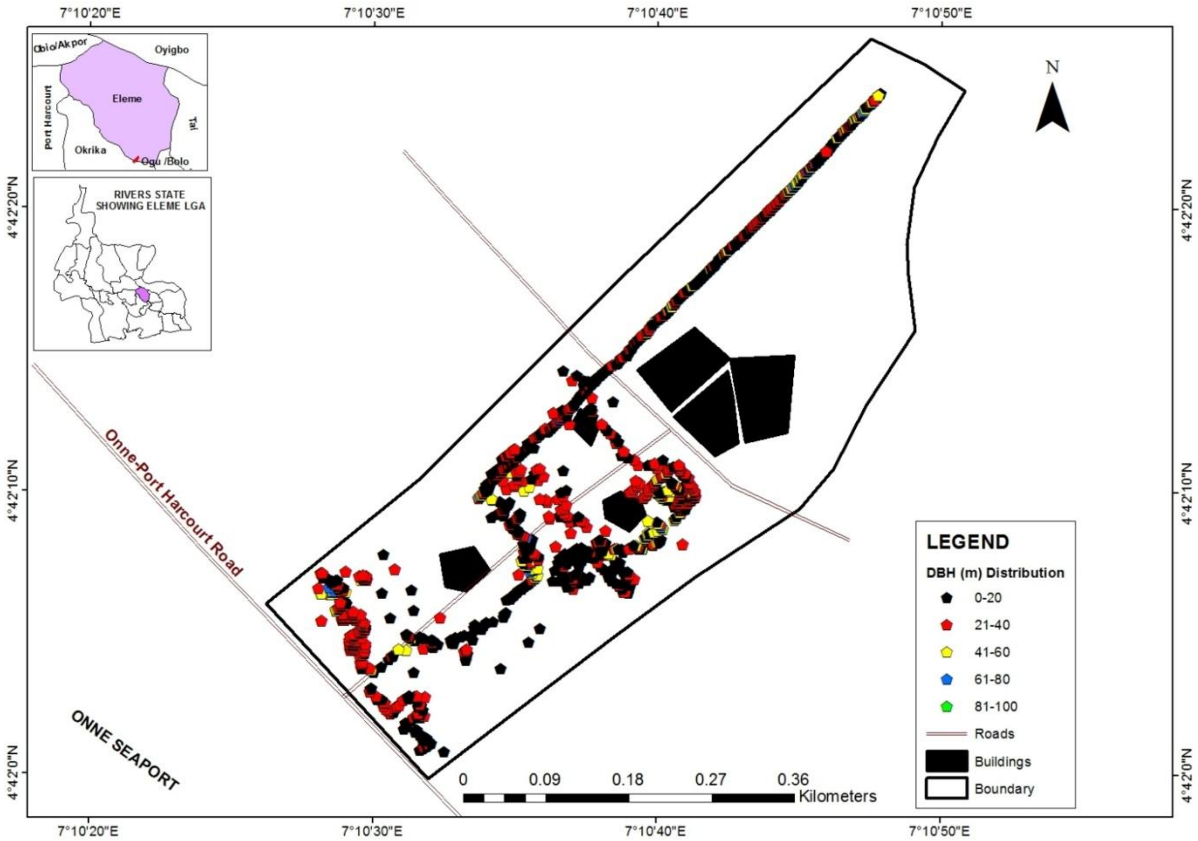

Figure 2: DBH distribution classes in the study

Height Distribution of Species in a Stand

Table 3 shows that the tree height class range of 6-10m was the highest(44.4%) while the tree species with a height above >30 were the least (Table 3).Taking into account the height distribution based on their geographic positions presented in Figure 3, it was pointed out that the tree species ranging between 6-10m,11-15m,16-20m,21-25m and 26-30m were more abundant in the southern part of the study area and fewer in the north. Tree species above >30m in height were few both in the southern and northern part (Figure 3). The majority of the tree species distributions from the range of 0-5m height were found in the southern part of the study area which are *Allanblackia sp., Nauclea diderrichii, Eucalyptus sp., Lovoa trichilioides, Pinus caribaea* and *Garcinia kola* while only *Mansonia altissima* was found in the northern part (Figure3). Trees height ranges of 6-10m were prominent in the north and these include *Nauclea diderrichii, Terminalia montalis* and *Mansonia altissima* whereas *Eucalyptus sp.*, turned out to be few.

At the southern part *Allanblackia sp., Irvingia gabonesis, Gmelina arborea, Eucalyptus sp., Lovoa trichilioides, Pinus caribaea* and *Garcinia kola* were more abundant while *Entandrophragma angolense* was very sparse (Figure 3). Tree species ranging from 11 to 15m that were abundant at the southern part of the study area include *Allanblackia sp., Garcinia kola, Nauclea diderrichii ,Irvingia gabonesis, Pinus caribaea, Tectona grandis, Treculia africana* and *Entandrophragma angolense*. Moving down the northern part *Mansonia altissima, Lovoa trichilioides* and *Dacryodes edulis, Pinus caribaea, Eucalyptus sp., Treculia africana* and *Nauclea diderrichii* were less abundant. Furthermore, tree species height ranging between 16 and 20m were abundant in the northern part of the study area and the tree species include *Dacryodes edulis* and *Eucalyptus sp.*, though *Treculia africana and Nauclea diderrichii* were less abundant. Also, along a path to the southern part *Mansonia altissima, Pinus caribaea, Nauclea diderrichii, Entandrophragma angolense, Lovoa trichilioides* and *Irvingia gabonesis* are more abundant whereas *Eucalyptus sp.* was fewer (Figure 3.). The height distribution of tree species ranging from 21 to 25m are more in the northern part of the study area and they include *Pinus caribaea,Entandrophragma angolense, Lovoa trichilioides, Irvingia gabonesis* and K*haya ivorenesis* while *Eucalyptus sp.,, Lovoa trichilioides* and *Pinus caribaea* were found in the southern part with less abundant (Figure 4.28). *Dacryodes edulis, Lovoa trichiiloides, Entanadrophragma angolense, Eucalyptus sp.,* and *Pinus caribaea* were the only tree species within the range of 26-30m and these tree species were found in the southern part of the study area. *Pinus caribaea* only is located in the southern part of the study area of range >30m (Figure 3).

Table 3: Height class of tree species

Name of species	Height Class							Total
	0-5	6-10	11-15	16-20	21-25	26-30	>30	
Allanblackia sp	3	35	33	2	-	-	-	73
Dacrodes edulis	0	12	8	7	3	1	-	31
Entandrophragma angolense	0	58	4	21	0	2	-	85
Eucalyptus sp	2	10	14	15	3	1	-	46
Garcinia kola	3	29	15	-	-	-	-	45
Gmelina arborea	-	10	-	-	1	-	-	11
Irvingia gabonesis	-	17	39	11	1	-	-	68
Khaya ivorensis	-	-	-	-	2	-	-	2
Lovoa trichilioides	-	18	7	20	4	1	-	50
Mansonia altissima	3	21	8	23	-	-	-	55
Nauclea diderrichii	6	186	38	4	-	-	-	234
Pentraclethra macrophylla	-	-	1	-	-	-	-	1
Pinus caribaea	2	57	62	41	59	30	1	252
Tectona grandis	-	9	70	-	-	-	-	79
Terminalia montalis	-	42	11	7	-	-	-	60
Treculia Africana	-	7	29	22	-	-	-	58
Total	**19**	**511**	**339**	**173**	**73**	**35**	**1**	**1151**
Class Percentage (%)	**1.65**	**44.4**	**29.5**	**15.0**	**6.07**	**3.04**	**0.08**	

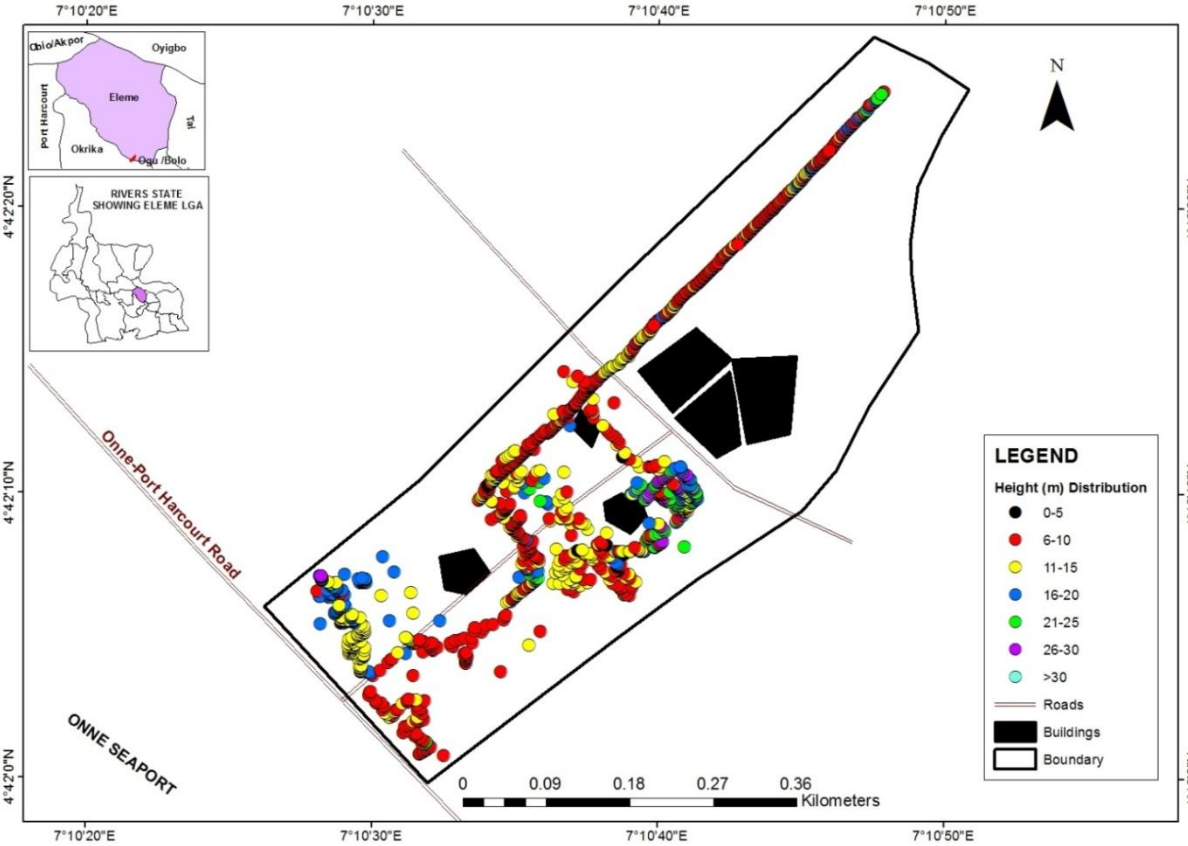

Figure 3: Height distribution Classes in the study area

IV. Discussion

The study has demonstrated the capabilities of geo-information technologies (GIS and remote sensing) can be used in map production to give reliable information about the current state of land use and land cover in forest management. This have enhance the strategic and policy decisions, enabling it to answer adhoc inquires providing to monitor development trends, compare plans and results and to manage the data required for day to day activities. The expanded area comprises of the following features design as themes which are represented roads in lines, buildings and boundary in polygons, in the Figure 1. With the different colours indicating each Trees species and vegetation pattern in dots. The different screen shot display the various functions of GIS in manipulation of data and to indicate the land use pattern and the vegetation classes of the Research area as shown in Figures 1,2 and 3. The locations of the different exciting feature can also be located easily on the map without any difficult. Therefore, attribute information about the different feature in the map makes it easy for viewers to understanding, analyze and interpretation for planning most especially in decision making over the Forest management.[13] had reported that without relevant and accurate information most of the problems cannot be tackled and there cannot be adequate planning and decision making. With the map scale, the result indicated The result indicated that *Pinus caribaea* and *Nauclea diderrichii* have the highest frequencies and percentage. The least dominant tree species in the area are *Dacryodes edulis*, *Gmelina arborea* ,*Khaya ivorensis and Pentraclethra macrophylla with* percentage of 2.7%,1.0%, 0.2%, and 0.1% (Table.2). The most abundant family are *Pinaceae* (254), Rubiaceae with (234 species), Meliceae (137 species) , Guttiferae has 120 species , Irvingiaceae has 68 species, Sterculiaceae 55 species, Lecythidaceae 45 species, Burseraceae 31 species while the least family is Verbenaceae having 11 species respectively as shown in (Table 1). The information acquired from the findings regarding to the knowledge of the available stock can help in future planning, especially for harvesting schedules and recommendation of appropriate silvicultural treatment. [6] reported that information about different forest cover types and extents is important in the assessment and preparation of management plans for conservation development. The reasons for the poor establishment of some families which showed lowest species may be attributed to competition for nutrients, limited light for trees crown and destruction of undergrowth during tree snapped and logged on the forest floor. Similar findings have been reported by [7] on a disturbed and natural regeneration forest in Korup National Park. These also are in agreement with views with [10] that when given good silvicultural treatment tree crop will attain a good timber dimension within a short rotation. Besides, there is no silvicultural treatment observed in these plantations to ensure that the plantations grow to attain their merchantable size.

Considering the geographic positions, majority of the tree species are found in the Southern part while a few in the north part of the study areas (Figure 1). The map reveals tree species such as *Allanblackia sp., Gmelina arborea, Lovoa trichiloides, Nauclea diderrichii, Pinus caribaea,Mansonia altissima, Khaya ivorensis, Pentraclethra macrophylla and Tectona grandis* in the south part of the study area while moving towards the north the most abundant includes *Decrodyse edulis, Enthradophragma angolensis, Irvingia sp, Garcinia cola, Terminalia montalis and Treculia africana*. [5] also reported that sustainable forest management relies on effective information and the affirmed presently forest information systems primarily provide integrated data for soil type, forest cover type, road networks, which contain minimal economic information. The implication of these findings in this study shows that unavailability of the GIS software could affect the integration of managing and planning delivery of forest resources. Therefore, successful discrimination and mapping of tree species with GIS has been reported in several studies [2]. This shows that GIS of tree species is achievable using ArchGIS 10.5 for mapping individual tree species The class diameter distribution ranging between 0 to 60cm are sparsely high in the south part but are rare in the north of the study area while ranging from 81 to 100 are dominant in the north part of the study area. Numerous species classes ranging between 6 to 30m in height have more abundance in the southern part and fewer in the north part of the study area. While species above >30m has few for both north and south part of the study area. *Nauclea diderrichii* and *Pinus caribaea* had a height greater than 30m. The findings confirm the view of [9] that the possible factor for such variation might be due to soil/genetic variation. Also, [4] buttressed that the variation in plots growth rate at plots level may help in explaining the species spatial distinction, while the parameters level (stand) give understanding of site characteristics that control productivity which may be critical in quantifying the general growth performance of the plantation.

V. Conclusion

Precise tree mapping and details resource classification are needed for forest management assessment. A quantitative assessment of the composition of the vegetation area is useful to describe the full range of variation for forest management from species level to level. This study provides the baseline of the competence of GIS technology in tree map production which can be used in areas of forest management and monitoring. The new tree map coupled with GIS analysis provides a means for making informed management decisions about the relative extent and nature of vegetation. The information result provides avenues for strategic and policy decisions, enabling it to answer adhoc inquires providing to monitor development trends, compare plans and results and to manage the data required for day to day activities and over time. The development of a new map for Forest Research Institute of Nigeria (FRIN) shows how GIS can be used to generate reliable information accurately to identify the different vegetation type of an area and mapping land use. It is recommended that Government should assist forest administrators to take advantage of information technologies in achieving an effective and sustainable management of the reserve. To achieve this, building programs capacity should be employ to train forest personnel's in the use of forestry-related information system. Awareness campaign should be initiated in the area to protect and conserve this forest from further deforestation. The study should be carried out periodically possibly every five or ten years. This helps to detect the improvement and failure exhibited in the growth parameters with respect to individual tree species.

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