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Development of Information System for Wood-Based Industries in Ekiti State, Nigeria.

Alo Akintunde Abiodun

Department of Forest Resources Management, University of Ibadan, Ibadan, Nigeria.

E-mail: sharonvaltt@gmail.com

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Abstract

Development of information system in forestry sector is crucial in order to manage resources in a sustainable manner. Spatial distribution of forest and wood-based industries is important for sustainability. However, geographic location and other information about the wood-based industries in Ekiti state, which can provide baseline information for investors in wood industry, are dearth. To proffer solution to this, information system was developed for wood-based industries in the State using geographic information system. This was done by taking the coordinates and photographs of all wood-based industries in the State. Types of equipment used for different wood conversion were assessed with the aim of determining their strength and capacity. The photographs and coordinates were loaded into ArcView GIS for analysis. The wood-based industries were represented on the State map using their coordinates while respective pictures were hotlinked appropriately. Various local governments in the State were represented with polygons of different sizes and wood industries were represented with points. The results obtained from the analysis were used to produce database in MS SQL server. The database created by Microsoft SQL server formed the data access (back end) of the software developed using C# Programming Language. Appropriate codes were written at the business logic layer for both the back and the front ends. The software was developed in an Interactive Development Environment (IDE) using visual studio.

It was observed that most of the wood-based industries were concentrated at the southern part of the State where there were more forest reserves. Gbonyin Local Government has the highest number of wood industry (46) while Efon Local Government has none at all. Over 95% of the existing wood industry was functioning with 91% of them using CD6 machine. The software developed is user-friendly, facilitates efficient data storage and prompt information retrieval, adequate and has provision for regular updates.

Keywords*:* Sawmills, Geographic Information System, database, Structural Query Language, software.

INTRODUCTION

The major wood-based industry in Nigeria is sawmill since other wood industries that depend on the forest for source of raw materials had folded up. Sawmill Information System (SIS) was developed by the Forestry Department Peninsular Malaysia using the Microsoft Access Database software. It runs on the Microsoft Windows 95/98 operating system. The SIS was used to capture data gathered through all the

Sawmills in Peninsular Malaysia (Poh *et al.,* 2001). In United States and Canada, Geographical Information System (GIS) was used to map out and develop information system for 273 sawmills and the spatial distribution of these sawmills was accessed (Anderson, *et al.,* 2011). Similar research on sawmills was documented in the northeastern United States (Alig *et al*. 2003; Nowak and Walton, 2005; Germain *et al*. 2006; McDonald *et al*. 2006; Anderson and Germain 2007; Egan, *et al.,* 2007; Vickery, *et al*., 2009; Eisen and Eisen 2011; Anderson *et el.,* 2011; Valley *et al.,* 2012; Pant *et al.* 2014). Up till now, no information on the spatial distribution of sawmills in Nigeria have been reported especially in the study area. Research work that was near to this in Nigeria was the survey carried out on sawmills in the country by Nigeria Institute of Social and Economic Research (NISER, 1974). In the survey carried out by NISER, GIS was not used and thus made it difficult to determine at a glance the spatial distribution of sawmills in the country. It was reported by Alo, *et al.,* (2014) that information gathered on the Nigeria Forest Information System (NFIS) website on the study area was very scanty where only the names of the sawmills made available and nothing more. However, this study is aimed at; determining the spatial distribution of all the sawmills and if their locations are influenced by the presence of forest reserves; collecting available information on each sawmill for GIS incorporation, and developing sawmill information system (SIS) for the study area.

METHODOLOGY

The Study Area

The study was carried out in all the sawmills in Ekiti State, Nigeria. The State has sixteen local government areas (LGAs). It is located between latitudes 7^0 23' N and 7^0 46' N and longitudes 4^0 47' E and 5^0 45' E. The State covers a total land area of 6,353 km^2. It is bounded at the south by Ondo State, at the north by Kwara State, at the east by Kogi State and at the west by Osun State. (Alo *et al.,* 2012; Alo *et al.,* 2015). Mean temperature of the State ranges between 21° and 29°C with high humidity (Onyekwelu, 2001) and the population was about 2.74 million (Alo *et al.,* 2012*;* Alo and Akindele, 2012).

Data Collection and Analysis

The list of sawmills in Ekiti State with the year each was licensed was obtained from Ekiti State Department of Forestry (ESDF). Coordinates and photographs of all sawmills in the State were also obtained using global positioning system and digital camera respectively. Transport distance between the sources of raw materials and the sawmills was obtained from the sawmills transport officers and confirmed using GIS. Type of machines used for wood conversion was determined. The coordinates and photographs were loaded into ArcViewGIS for analysis. The wood-based industries were represented on the State map using their coordinates while their pictures were hotlinked appropriately. Transport distance for all sawmills in each local government was averaged. Various local governments in the State were represented with polygons of different sizes and wood industries were represented with points. Sawmills in the State were classified into two categories namely: Functioning Sawmills (FS) and Non-Functioning Sawmills (NFS). Functioning Sawmills (FS) were sawmills that were functioning as at the time of this field work. Non-Functioning Sawmills (NFS) were sawmills that were not functioning but had their CD machine damaged or faulty while some other equipment may be in good condition, which implies that they may be functioning as soon as the CD machines used for conversion of logs are repaired. Student's t-test was used to test for significant difference between them. To determine the influence of forest reserves on the location of sawmills in some local governments in the state, all the sixteen (16) local government areas in the State were grouped into three categories according to occurrence of forest reserve in them: Local governments with forest reserve within them are referred to as Local Government Areas with Forest Reserves (LGA_FR); Local governments that do not have forest reserves within them but are surrounded by forest reserve in such a way that the distance of the forest reserve to such a local government is so short that the local governments derive

some benefits from the forest reserve(s). In this case, they are referred to as Local Government Areas with Effects of Forest Reserve (LGA_EFR); the last category is the local governments that do not have forest reserve(s) either within or around them and are referred to as local government Areas with No Forest Reserve (LGA_NFR).

Test for significant differences was carried out for the three categories of local government to test if the presence of forest reserves has any influence in the locations of various sawmills within the state using one way analysis of variance (ANOVA).

Database Development

MS SQL server was used to develop the database for sawmills in this study. The analyzed data were loaded into MS SQL server to create Tables at the data access layer. The Tables were created for sawmills, which were populated using the analyzed data and the database generated from the information provided in the Tables. DataSets were obtained from the database and relevant relationships were built among them as appropriate. DataTable were created with TableAdapter and binding source. The TableAdapter received the query (*i.e*. the SQL statement) while the binding source was the channels that bonded the DataTable and the Tables in the database together. At this stage of adding query to the TableAdapter, the DataTable was configured and ready to perform the basic database transactions (*i.e*. insert/input, select/retrieve, delete and update). DataSets was used to relate with the data in the database. Geospatial database for sawmills in Ekiti State was developed using C# programming language. The 'back end' was developed using Microsoft Structural Query Language. The Interactive Development Environment (IDE), which made the packaging and deployment possible was the Visual Studio. The codes were written for both the back and front ends at the business logic layer. The front end was designed to in such a way to make it user friendly. Hence, the developed geospatial database for sawmills software was deployed using Visual Studio in a personal computer (PC). Prior to deployment, the PC was checked for system requirement by the software; bearing in mind that the volume of the database was over 3.15GB before deployment and about 1.2GB after deployment.

RESULTS

Figure 1 shows the distribution of sawmills in Ekiti State in relation to forest reserves. The Figure indicates that more sawmills are concentrated at the southern part of the State. Large clusters of sawmills were observed in Gboyin, Ise-Orun, Emure, Ekiti East, Ado, southern part of Ikole and Oye local government areas of the State. In contrast, at Ijero Ido Osi, Ekiti West, Ijero, Ilejemeje, Irepodun/Ifelodun and Moba local government areas situated at the northern part of the state were sparsely populated with sawmills. The high concentration of sawmills as observed at the southern part of the state could be attributed to the preponderance forest reserves in this part of the state. Except Ikole and Oye local government areas, the other five local government areas with more than 20 sawmills are situated where forest reserves are concentrated. The high number of sawmills recorded in Gboyin is as a result of its location near the source of raw material as stated by NISER (1974) and buttressed by Alo *et al*. (2012). A critical look at Figure 1 revealed that Gboyin is located at the southeastern part of the state where there is tropical rainforest vegetation, surrounded by Ogbese, little Ose and Eda forest reserves. Similar reasons were responsible for the high number of sawmills recorded for Ise/Orun, Ekiti East and southern parts of Oye and Ikole local government areas. It has been shown by Sollins (1998), Pitman *et al.* (2005) and Onyekwelu *et al*. (2008) that tropical rainforest ecosystems contain a high number of tree species. This high number of trees in the tropical rainforest ecosystem guarantees a lot of varieties of timber species, which has contributed to the high number of sawmills in the southern parts of Ikole and Oye local government areas. The concentration of sawmills in areas where there were forest reserves is a reflection of nearness to the source of raw materials (NISER, 1974; Alo *et al*., 2012) at the same time a very serious threat to sustainable forest management. The low

concentration of sawmills at the northern part of Ikole and Oye Local Government Areas despite the presence of forest reserve in the LGAs, could be attributed to the fact that the forest type is savannah where there were more of shrubs than trees. Thus, the presence of forest reserves in the LGAs with little impact on the distribution of sawmills. The pictorial representation of some sawmills are shown in Figure 2, enhancing appreciation of how they actually were in their respective locations. Table 1 presents the distribution of sawmills in Ekiti state, current status and transport distance to the source of raw materials. There was a total 244 sawmills in Ekiti State, out of which 232 were functioning and 12 were not functioning. Only 95.08% of the existing sawmills in Ekiti State were functioning while 4.92% were not functioning. During the field survey for this study, it was observed that some sawmills were springing up. Gboyin local government area had 41 functioning sawmills and five not functioning, thus making it the LGA with the highest sawmills. Other local governments with a good concentration of sawmills were: Ise/Orun, Ado-Ekiti, Ekiti East, Ikole, Oye and Ikere while LGAs with low concentration of sawmills were: Aramoko, Moba, Ijero and Irepodun/Ifelodun. Efon LGA had no sawmill at all. It had earlier been established that these sawmills were located very close to the source of raw materials and thus might still be having a continuous supply of raw material (NISER, 1974). The percentage of functioning sawmills were likely to be negatively affected as most of the forest reserves in the state were being depleted. Average transport distance from the forest to the sawmills ranged from 5.67 Km at Moba LGA to 2.45 at Emure LGA. General average transport distance for all the local governments was 3.70 Km. Moba (5.67 Km), Ilejemeje (4.75 Km), Irepodun/Ifelodun (4.41 Km), Ido/Osi (4.21 Km), and Oye (3.97 Km) local government areas of the State recorded average transport distance above the general average. Those local governments whose average transport distance was greater than the general average were those who were located at the northern fringe of the state in derived savanna region (Moba, Oye and Ilejemeje). Hence, they were not influenced by either the presence of lowland rain forest zone of the state or the forest reserves (Irepodun/Ifeloduna and Ido/Osi). The only exception of this was Sawmills in Ado local government, which recorded high transport distance because is a city and the State capital. A critical look at the trend of transport distance across the local government revealed that high transport distance may partly be responsible for low number of sawmills recorded in affected LGAs because they are not near the source of raw materials. This result has been argued earlier by NISER, (1974) and corroborated by Alo *et al.,* (2012).

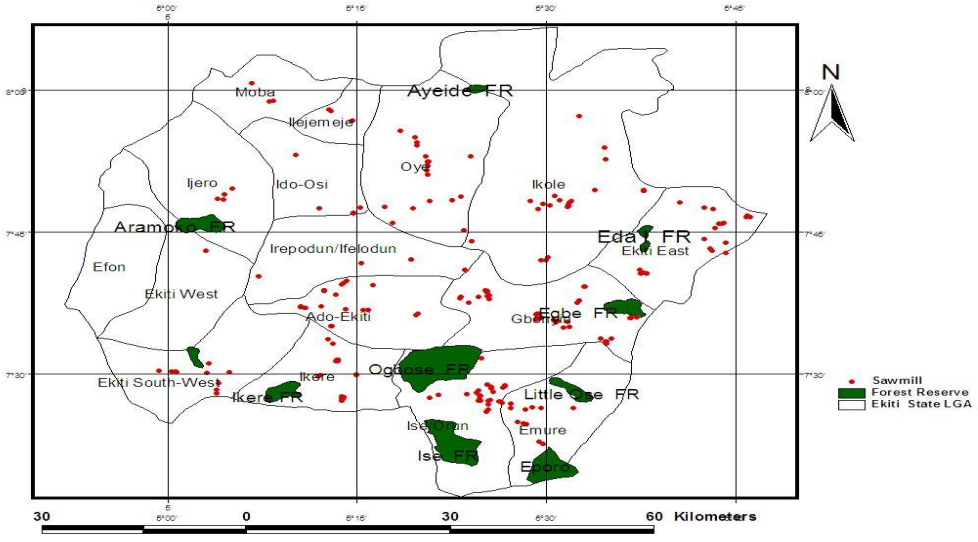

Figure 1: Distribution of forest reserves and sawmills in Ekiti State, Nigeria.
***Source**: Field survey*

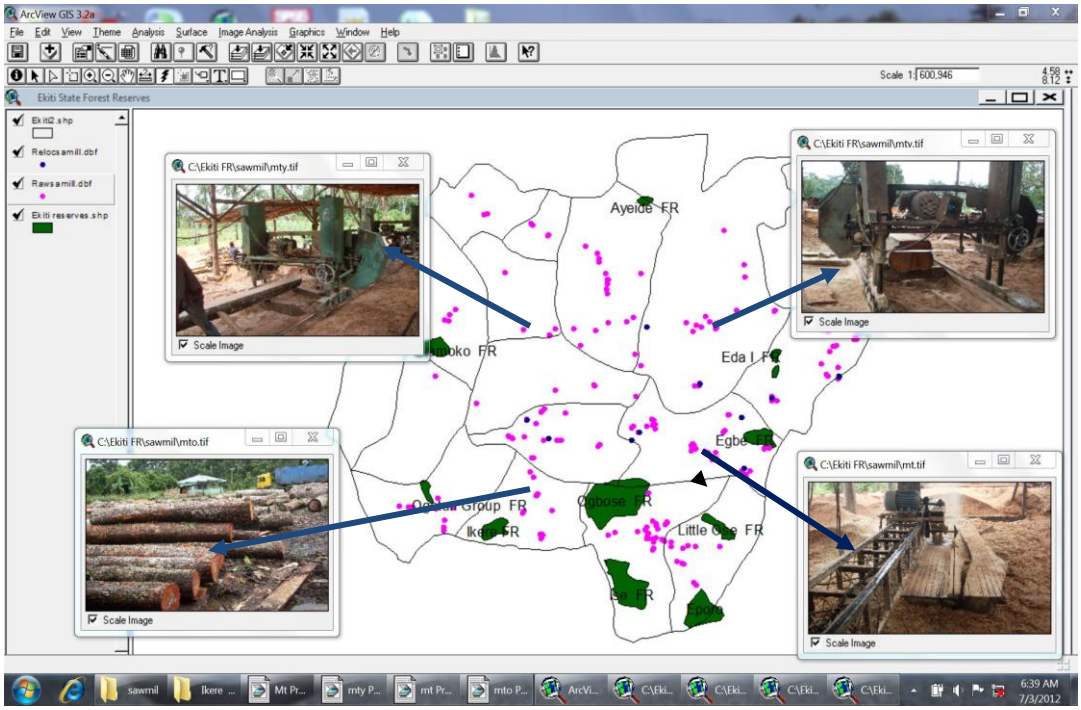

Figure 2: Hotlink of sawmills in Ekiti State, Nigeria.

***Source**: Field survey*

There was no significant difference in the number of sawmills between local governments, which had forest reserves inside them and local government, which had forest reserves in their adjoining local government around them but not inside them (Tables 2 and 3).The significant difference noticed between the numbers of sawmills in LGAs with forest reserves and LGA without forest reserve could be as a result of the fact that the wood-based industries were situated nearer to the source of raw materials (*i.e*. forest reserves). The nearness of sawmills to the source of raw materials would reduce the cost of transportation and save time of transporting raw material to the industry.

Table 1: Distribution of sawmills with respect to their status and local government areas in Ekiti State, Nigeria.

S/N	LGA	Functioning	Non-Functioning	Total	Average Transport Distance (km)
1	Gbonyin	41	5	46	3.45
2	Ise/Orun	29	0	29	3.36
3	Ado	25	2	27	3.61
4	Ekiti East	24	3	27	3.54
5	Ikole	23	1	24	3.70
6	Oye	20	1	21	3.97
7	Ikere	20	0	20	2.68
8	Emure	11	0	11	2.45
9	Ekiti Southwest	10	0	10	2.49
10	Ido/Osi	6	0	6	4.21
11	Ilejemeje	6	0	6	4.75
12	Irepodun/Ifelodun	8	0	8	4.41
13	Ijero	4	0	4	3.51
14	Moba	4	0	4	5.67
15	Ekiti West	1	0	1	3.65
16	Efon	0	0	0	0
	Total	232	12	244	
	Percentage (%)	95.08	4.92	100	
	Average				3.70

Comparison among the Status of Sawmills within the State.

The result of the students' t-test for the two categories of sawmills in the state showed that there is a significant difference between functioning and non-functioning in the state.

The result of the ANOVA for the local government areas classes based on the presence of forest reserves (Table 2) revealed that there is a significant difference ($p<0.05$) among the distribution of sawmills in the three classes of local government. It also indicated that the number of sawmills in local government areas with forest reserves (LGA_FR) is significantly higher than those in local government without forest reserve. Table 3 showed the result of follow-up analysis of classes of local government area on distribution of sawmills. From the table, spatial distribution of sawmills occurred most within the local governments with forest reserves within them (LGA_FR), more in local governments having forest reserves around them (LGA_EFR) and least in the local governments with no forest reserve (LGA_NFR).

Table 2: ANOVA for the three classes of LGA

Sources of variation	Sum of Squares	df	Mean Square	F	Sig.
LGA Classes	893.215	2	446.608	4.585*	0.031
Error	1266.222	13	97.402		
Total	2159.438	15			

*Significant ($p < 0.05$).

Table 3: Result of follow-up analysis of classes of local government area.

Type of Local Government Area	Mean
LGA_FR	20.56[a]
LGA_EFR	12.00[ab]

LGA_FR = *Local Government Areas with forest reserves*
LGA_EFR = *Local Government Areas having forest reserves around them.*
LGA_NFR = *Local Government Areas without forest reserve.*

Types of Machine used in Sawmills in Ekiti State

Summary of the types of machines in sawmills in Ekiti State is presented in Table 4. Despite the fact that Ise/Orun ranked second in the distribution of sawmills in the state, it has the highest number of Units of machines (64) while Ekiti West has the least number of units (2) in the state. Five types of machines are currently used for wood conversion in sawmills in the study area; CD4, CD5, CD6, Mighty Mites (MM) and Omkar Z. The CD6 machine accounted for 91.00% of all the machines, MM and CD4 accounted for 4.1% each while CD5 and Omkar Z. 0.3% and 0.5%, respectively. A total of 180 circular saw machines and nine (9) planning machines were installed in different locations of the sawmills (Table 4). Among the five different wood conversion machines used in sawmills, CD6 is the commonest and biggest. The CD4 machine, which can either be vertical or horizontal, is capable of converting logs whose diameter is not greater than 1.5 m (NISER, 1974).

This implies that most sawmills have machines that are capable of converting logs above 1.5 m diameter, which account for over 91% of the total number of machine used. CD6 machine therefore, has the ability of converting both small and large dimension logs. Since CD6 machine has a higher capacity than CD4 machine, it implies that energy consumption of CD6 will be higher than CD4. Consequently, 91% of available machines in the sawmills would converted most of the logs with an ease since most of the logs sawn in the sawmills are now relatively small sizes. Mighty Mites (MM) machine is designed with two circular saws, one sawing vertically and the other sawing horizontally at the same time. This type of machine, due to the peculiarity of the way it functions, in addition to converting logs into 2.5 cm by 30 cm, it also capable of converting logs directly into 7.5 cm by 10 cm or 5 cm by 2 cm in. Omkar Z. was only encountered in two places (Ikere and Ikole Ekiti) in the study area. The two were owned by the same expatriate company which produces for export and not for local consumption.

Table 4: Summary of the types of machines in sawmills in Ekiti State, Nigeria

S/N	Local government areas	Number of Sawmills	Types of Machine for Wood Conversion						Circular saw	Planning machine
			No. of Units	CD6	CD5	CD4	Mighty Mite	Omkar Z		
1	Ado	27	40	36	-	4	-	-	34	5
2	Efon	-	-	-	-	-	-	-	-	-
3	Ekiti East	27	34	33	-	1	-	-	19	-
4	Ekiti South West	10	16	14	-	-	2	-	10	1
5	Ekiti West	1	2	2	-	0	-	-	2	-
6	Emure	11	26	22	-	4	-	-	9	-
7	Gbonyin	46	63	59	-	4	-	-	29	-
8	Ido-Osi	6	9	9	-	-	-	-	11	2
9	Ijero	4	8	8	-	-	-	-	5	-
10	Ikere	20	30	26	-	-	3	1	18	-
11	Ikole	24	36	32	-	-	3	1	14	1
12	Ilejemeje/Moba	6	6	6	-	-	-	-	2	-
13	Irepodun/Ifelodun	8	15	12	-	3	-	-	1	-
14	Ise	29	64	58	-	-	6	-	26	-
15	Moba	5	5	5	-	-	-	-	-	-
16	Oye	21	40	37	1	-	2	-	-	-
Total		244	393	359	1	16	16	2	180	9
Percentage				91.0	0.3	4.1	4.1	0.5		

Geospatial Database for Sawmills in the Study Area.

Homepage

The developed database opens to the homepage after installation on the computer when the shortcut icon is double clicked from the desktop. At the home page (Figure 3), there are three menus at the menu bar namely; *'File', 'Admin', 'Sawmills*'. From the same homepage, there is a quick search on the sawmills at the top right corner of the page that gives a brief information of a specific sawmill by selecting its local government and then, the name of the sawmill. Just below the 'sawmills quick search'. From the menu bar of the homepage, a click on the file takes the user to *'Exit'*. When *'Exit'* is selected, the programme stops running and is closed. The menu bars (file, Admin, sawmills) used in the development of geospatial database were not standard items like file, edit, tools and help, which are used in conventional software like Microsoft Office made for all kind of users. Geospatial database for wood-based industry is not meant for all users but users specifically in the forestry sector. In essence, it is designed for the purpose of making relevant information available on sawmills, for quick retrieval of forestry related information and regular update. Majority of the sub-menu under the standard items in conventional software like new, open, preview, cut copy, past select all, customize, option and contents were considered not to be relevant in this database. The peculiarity of the database developed in this study is that it does not permit such standard items. The provision for Administrator in the menu bar, which is the function for updating the content of the database with a password, helps to protect the integrity of the data in the database. Thus, an unauthorized person has limited access to the database since he/she cannot alter any information stored in the database without the permission of the Administrator. This is similar to the one

developed for the forest reserves in the State by Alo *et al. (*2014).

Administrative Page

The next menu on the menu bar from Figure 3 is '*Admin*'. When '*Admin*' is selected, it navigates to '*Sawmills'*. When '*Admin Sawmills'* is selected, it loads the password page and the user is required to supply an administration pin for authentication. The pin or password page is discussed below. Each time there are changes (updates) in the database through the *Administrative page*, all changes must be saved before exiting the *Administrative page* (Figure 4). The rectangular box *'View this sawmill'* is selected to display information on the selected sawmill (Figure 4). Having viewed the selected sawmill, all other relevant changes can be effected as appropriate. To create a new sawmill record, after "*Activate Update/Edit"* button has been activated, under '*create new sawmill record*', local government can be selected or added to the existing ones and other information can be updated appropriately.

Password Page

When a specific item is selected from the Admin menu, a dialog box is displayed expecting the user to supply his/her password. This dialog box is referred to as the password page of the Admin in Figure 5. As soon as the password is supplied, another dialog box is displayed requesting the user to select category from a list of three items; *sawmills, natural* and *plantation* as a confirmation that the password supplied was correct. A click on any of the categories offers the user an opportunity to perform any transactions with the database. Such transactions as input data, delete data, select and update information as may be necessary on any selected category. From same password page, if an authorized user suspects there is an eternal interference with the *Admin,* there is provision for a change of password as many times he wants. In case the password is not correctly supplied, password page offers users opportunity to navigate to *Sawmill* by selecting it from the menu bar of the *password page*. From the same page, when file is selected form the menu bar, '*Home'* cam be selected to return to the homepage or '*exist'* to close the programme. This is provided so that an incorrect supply of password does not lead to hanging or sudden stoppage of the database.

Sawmills Page

When sawmill is selected, it opens a new page called the sawmills page (Figures 6). From the sawmill page, the sawmill can be sorted according to their local government by selecting local government at the top left corner of the page and then select the name of the specific sawmill one is interested in at the top right corner of same page. When a particular sawmill is eventually selected, details on such sawmill is displayed.

At least, a photograph of each sawmill will be displayed alongside with other details. Where two photographs are provided, the first picture shows the sawmill while the second picture shows the environment of the sawmill location. At the bottom right corner is the statistics of the sawmills for each local government. From the statistics at the bottom right corner of the page, the following values can be obtained; the number of functioning sawmills, the number of non-functioning sawmill as well as the total sawmill in the selected local government.

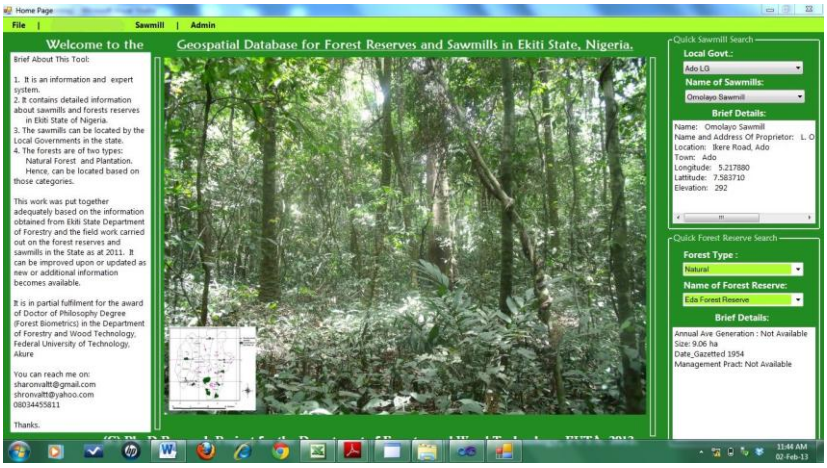

Figure 3: Home page of the database

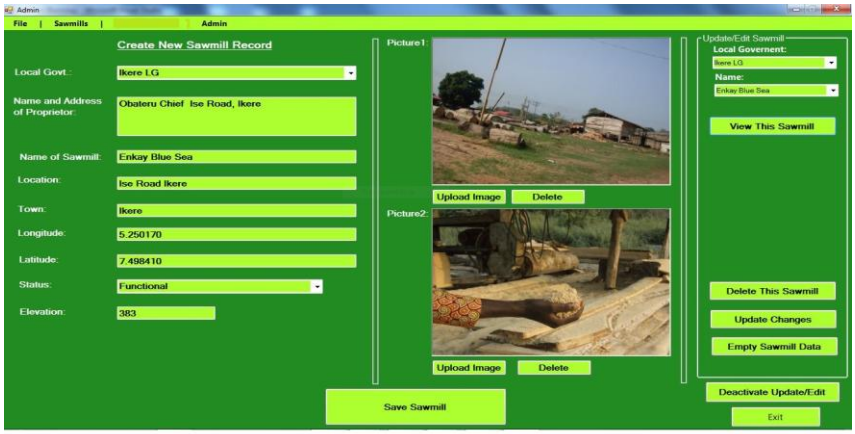

Figure 4: Administrative page for updating sawmills information

Figure 5: Password page of the database

Information provided in the sawmill page offers the user an opportunity of knowing who established a particular sawmill, its location, and how it looks like without any physical contact with the sawmill. Group box containing the statistics on sawmills for each local government area helps to know the status of sawmill such as how many sawmills are functioning and non-functioning. The result obtained in this study is similar to others who have developed a computer based information system (Eisen and Eisen 2011; Valley *et al.,* 2012; Pant *et al.* 2014), using GIS in which is computer-based (Anderson, *et al.,*2011; Porto *et al.,* 2011). The information system in this study is computer-based because, the end users do not have access to the internet. Hence, developing a web-based information system will not be assessable by the end users.

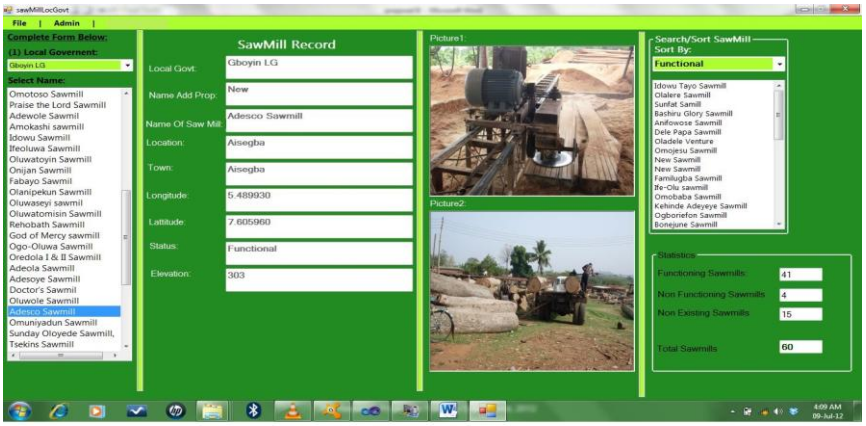

Figure 6: Sawmill page of the database

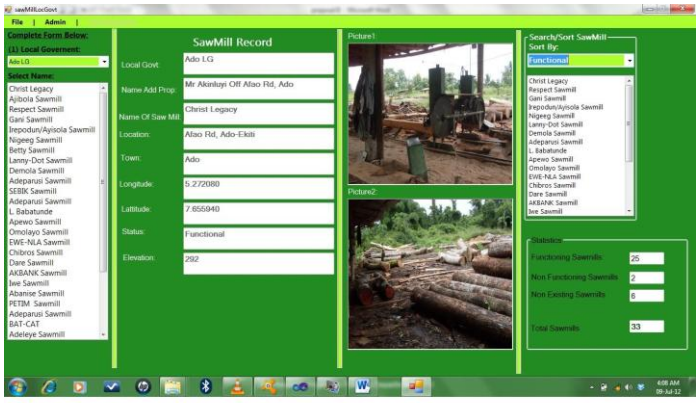

Figure 7: Sawmill page of the database

CONCLUSION

The distribution of sawmills followed similar pattern with that of forest reserves in the state. In other words, distribution of sawmills is influenced by availability of raw material as well as nearest to the source of market for the products produced by the wood-based industry in the state. The type of machines used in sawmills is predominantly CD6 (91%), while a few others use Mighty Mite (4.1%) and CD4 (4.1%). The growing rate of the sawmills in the state vis-a-vis the available raw materials, though economically and socially good, if there is no effort at sustaining the raw materials, it will get to a time when there will be no raw material for the sawmills, which at present, over 95% of the existing ones are functioning.

Going by the details made available by the database generated for this study, capturing a

total of 244 sawmills across 16 local governments areas of the State and available data obtained from the State Department of Forestry, the information in this database is adequate to help investors in wood industry determine the location, type of machines used for log conversion and where to purchase timber. The database developed was user friendly with provision of regular updates. Although all users can have access to the database, only personnel that are authorized can update the information in it. This has immensely increased the integrity of the data in the database. It has been proven beyond reasonable doubt that GIS is veritable tool in forestry and in the development of geospatial database for sawmills in Ekiti State.

RECOMMENDATIONS

The rate of removal of trees from our forest by the wood base industries is so alarming. Hence, the State Government should ensure that the regeneration fees paid by the timber contractors be used for no other purpose other than forest regeneration for which it is meant for as matter of urgency.

The Geospatial database developed in this study for sawmills in the State contained a pool of information from various sections of the forestry sector. The database constitutes a single source of relevant information for sustainable forest management in relation to timber consumption of the sawmills. It should therefore be utilized by all stakeholders in the forestry sector. The database in this study was designed to accommodate regular updates as soon as additional information is made available because the nature of data collected for the database is dynamic.

There is currently no unit in Ekiti State Department of Forestry saddled with the responsibility of managing and maintaining sawmill information system since there was no sawmill information system for the state before now. In order to effectively manage and maintain this information system developed, Sawmills Information System Unit (SISU) should be setup in Ekiti State Department of Forestry (EKSDF) to warehouse the database and maintain it.

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