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Developement of Information System for Forest Reserves in Ekiti State, Nigeria

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Abstract **– An information system was developed for forest reserves in Ekiti State, Nigeria. Primary data were collected from the field, which comprise stand growth data, geographic coordinates of selected locations within forest reserves, and information on non-timber forest products (NTFPs) in the natural forest. Photographs of the forest reserves were taken as part of the primary data. Growth data were taken from both plantations and natural forests. From the plantations, stands of *Gmelina arborea, Tectona grandis* and *Terminalia superba* were inventoried. Four temporary sample plots were randomly selected for enumeration from each age series of each stand. For the natural forest, two transects 500 m apart were laid parallel to each other. Along each transect, four 50m by 50m temporary sample plots were laid adjacent each other at 200m intervals. From each sample plot, growth data were taken as well. Secondary data were also collected, which involved the list of all forest reserves in the State, size, date gazetted, revenue generation records and management practice. Sketched maps of all the forest reserves and satellite imageries of the State were also collected as part of the secondary data obtained.**

The coordinates and photographs were loaded into ArcView GIS 3.2a for geographical information analysis, which involves vectorization of the raster data model, map production and image processing. Yield estimates of the trees were obtained using Newton's formula. All the analyzed primary and secondary data were used to generate a database in Microsoft SQL server 2008. The database created by Microsoft SQL server 2008 formed the data access of the software developed using C# Programming Language. The software was developed in an Interactive Development Environment (IDE) using visual studio 2010 Edition. The database generated was user-friendly, adequate and has provision for regular updates.

Keywords **– Database, Forest Reserves, Information System, Microsoft SQL, Data Access.**

I. INTRODUCTION

Over the years, Global Forest Information Service (GFIS) has been developed to enhance access to all forest-related information, ensuring that it is accessible to all stakeholders including policy-makers, forest managers, non-governmental organizations, community groups and the public at large [7], [12], [15], Similarly, It has been reported that forest information system (FIS) was developed for Philippines, which was envisioned to promote and enhance the sustainable management of forest in the Philippines through improved data collection and information processes, Turkey, [14] and America, [9]. However in Nigeria, several efforts have been made to develop forest information system for the forestry sector but lacked of reliable data from various sub-sector of forestry has hampered the success. Where data exist, they are obsolete, incomplete or incorrect. The absence of reliable data is a major setback to the forestry sector [4], [5]. Recenty, a level of progress was made to develop forest information system (NFIS) for the country by the Forestry Association of Nigeria (FAN) for the Federal Department of Forestry (FDF), Abuja. This was done to make available forestry related information (administrative, forest reserves) to all stakeholders. As at of this research, information gathered by NFIS website on the study area was very scanty. Information provided on forest reserve was only their sizes Other information on the growth characteristics of the tree species in the forest reserves, the digital maps of the reserve *etc*., This study is aimed at providing this information gap by obtaining relevant information both from the field and records on the study area, analyse, generate a databae in form of a software that will enhance quick data storage and information retreaval as well as reguar update.

II. METHODOLOGY

The study area

This study was carried out in Forest Reserves in Ekiti State, Nigeria. Namely; Aramoko, Eda, Egbe, Eporo, Ikere, Isan/Ayede, Ise, Little Ose Ogbese and Ogotun group. The State is located between Latitudes 7^0 23'N and 7^0 46'N and Longitudes 4^0 47' and 5^0 45'E. The State covers a total land area of 6,353 km^2. The State is mainly an upland zone, rising between 360 m above sea level (asl) at Igbara-Odo to 560 m asl at Omuo – Ekiti [3].

Method of data collection

Reconnaissance survey carried out before the major field work revealed that Eda forest resereve was the only forest reserve in Ekiti State and one of the few in southwestern Nigeria that logging activities has been put on hold in the last five years.

Generally, two types of data was collected for this study namely; primary and secondary data. For detaliled study, only two forest reserves were selected for the collection of primary data namely; Eda and Ikere Forest Reserves. All the ten Forest Reserves in Ekiti State were chosen for secondary data collection in this study. Eda Forest Reserve in Ekiti State is one of the Forest Reserves in the lowland rain forest ecosystem of southwestern Nigeria that is relatively in its natural state while a good number of forest reserves have been depleted.

Method of data collection

Primary data, which comprise growth and geographical information data were obtained. Growth data were collected from temporary plots of both natural forest and plantations of *Gmelina arborea, Tectona grandis and Terminalia superba* established within the forest reserves as was done by [1], [2], [6], [10] and [11]. Geographical information data involves coordinates of some places using Global Positioning System (GPS) in the forest

reserves, satellite imagery from google earth and photographs of all the forest reserves showing both the natural and artificial forest. Secondary data collected include records on individual forest reserve by Ekiti State Department of Forestry (ESDF), list and sizes of the forest reserves in the state, average revenue generated from the reserves within the last five years, management practice in the forest reserve, the date each reserve was gazette and existing maps of all the forest reserves.

Method of Data Analysis

Growth data were analysed to obtain yield estimates while the geographical information data were analysed to obtain digital maps for the forest resereves. Volumes were obtained using Newton's formular as given by Husch *et al* (2003). The maps of the reserves were generated using Arcview GIS 2.3a, which involves; Image processing, Vectorization and Map production. Different forest types within the forest reserves were digitized as polygons with different distinct colours. Lines of different thickness and colours were used for roads, rivers and drainage while towns, settlements and enclaves were represented with points of different sizes and colours.

Development of geospatial database

MS SQL server (2008 Edition) was used to develop the database for forest reserves in this study. The analysed primary and secondary data obtained were loaded into MS SQL server to create tables at the data access layer. The tables are as follows: *natural forest common information*, which contained general information on natural forest; *natural forest other information* contained other information on natural forest that are not plot specific; *natural forest plot specific information*; *natural forest products* contained information on the products from the natural forest; *plantation common information*, which contained general information on the plantations; and *plantation specific information*. The tables were then populated using the analysed data and the database generated from the information provided in the tables. DataSets were generated 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.

Development of Geospatial Database Software

Geospatial database software for this study was developed using Visual Studio (2010 Edition) with C# Programming Language. During the development of database above, especially when query was added to the TableAdapter, codes were written by the computer to perform the operation as the DataTables were configured. The codes for configuration of the DataTable when the TableAdapter is queried are genrated by the computer. All other transactions carried out at the presentation layer to make the database user-friendly also required codes to make them function. These codes were written by the developer, and not the computer. All these were done at the business logic layer of software development in this study. Apart from the business logic layer, another layer called presentation (where the user will be able to access information in the database) was created so that the user does not necessarily need to know how to use Microsoft SQL server before using the database. At the presentation layer, the design of the software was done for the user to be able to perform basic transaction such as input, delete, select, update, *etc*.

The Interactive Development Environment (IDE) which made the packaging and development possible is the Visual Studio 2010 Edition. 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 1.4GB after deployment. The system requirement for deployment is as follows: computer should have either a 32-bit or a 64-bit Windows Operating System with a minimum of 2GB RAM, otherwise, the system will be extremely slow with time. The hard disc should have a minimum free space of 2GB; computer should have Microsoft Office already installed on it to facilitate the installation of Microsoft SQL server 2008 Express on the computer system; the software is deployed with an automatic installation of Microsoft SQL server 2008 Express, which was used to develop the database, SQL server Compact 3.5 SP2 and Visual Studio 2010 Edition.

III. RESULTS

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 1), there are four menus at the menu bar namely; *'File', 'Admin' and 'Forest Reserve'* From the same homepage, a quick search can be obtained for forest reserves in the State at the bottom right corner of the page. 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.

Administrative Page

The next menu on the menu bar is '*Admin*' (Figure 1). When '*Admin*' is selected, it navigates to *'Forest Reserves*'. When '*Admin Forest Reserve'* is selected, it loads the password page and the user is required to supply an administration pin for authentication. The pin or password page will be discussed latter. Each time there are changes (updates) in the database through the *Administrative page*. All changes must be saved before exiting the *Administrative page*. *Administrative pages* of natural forest and plantation for update are presented in Figures 2 and 3 respectively.

From *Administrative page* of natural forest in Figure 2, before editing or update can be made possible, the user should first select name of forest reserve from the group box situated at the top right corner of the page to make changes on the existing forest reserve. Both old and

current map can be changed as well as the picture showing the current situation in the forest. Plot specific information like volume of trees per plot, volume per hectare with respect to plot number can be updated. Forest products both timber and NTFPs can be updated under *Name Specific Product Information.* Mean dbh, number of observations of the timber species with respect to plot can as well be updated.

The database was designed to accommodate plot specific information, which can be pooled together to obtain stand information because of the fact that there is possibility of creating permanent sample plot from which a continuous forest inventory can be carried out from time to time. At the *Administrative* plantation page in Figure 3, there are four arrows at the tools bar at the top left corner of the page, which are; first arrow takes the user to the beginning of the list of forest reserve, second is *previous arrow* takes the user to the previous forest reserve on the list, third is *next arrow,* which takes the user to the next forest reserve on the list and forth is *last arrows,* which take the user to the last forest reserve on the list. Between previous and the next arrows is status bar telling the user the serial number of forest reserve is working with *e.g.* 1of 10 or 5 of 10. This implies that the user is working with forest reserve number 1 or 5 out of 10 available respectively. These four tools are used to navigate to the existing forest reserves.

In case of additional forest reserve in the future, the plus sign tool, next to the first four arrows discussed earlier, is used to add a new record to the list of existing forest reserve while *'delete'* next to the plus sign tool is used to delete from the list. All other information can be updated appropriately for each forest reserve. From the bottom right corner of the page, there is a rectangular button called "*Activate Update/Edit"*. This must be selected before the user can change or update any information on the *Admin* plantation page. "*Activate Update/Edit"* has been selected at the bottom of the group box at the right corner of the page, the button changes to "*Deactivate Update/Edit".*

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 two items; *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 *Forest Reserve page* by selecting any of them 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.

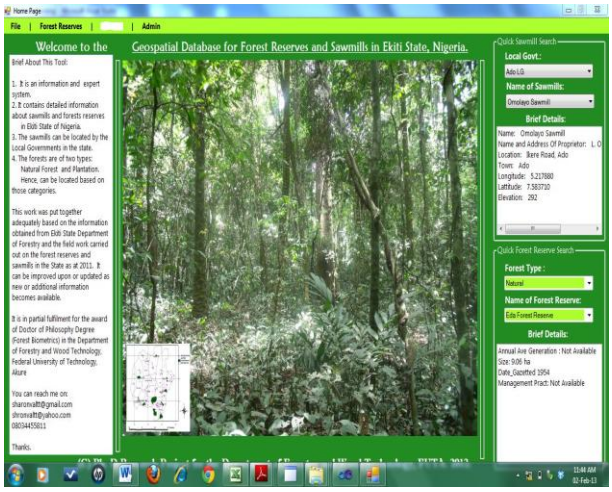

Fig.1. Home page of the Database

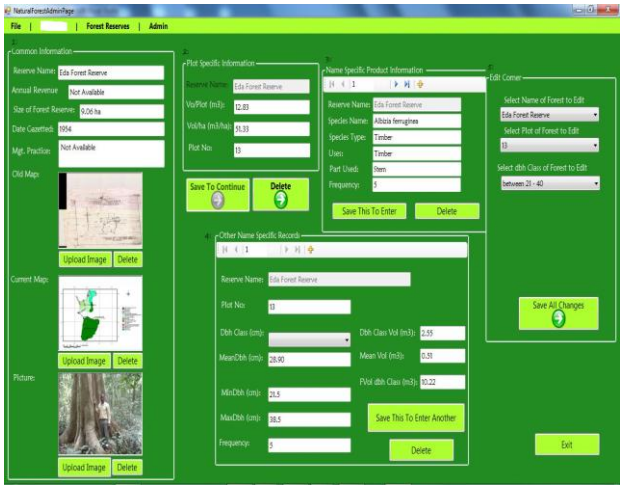

Figure 2: Adminstrative page for updating natural forest information

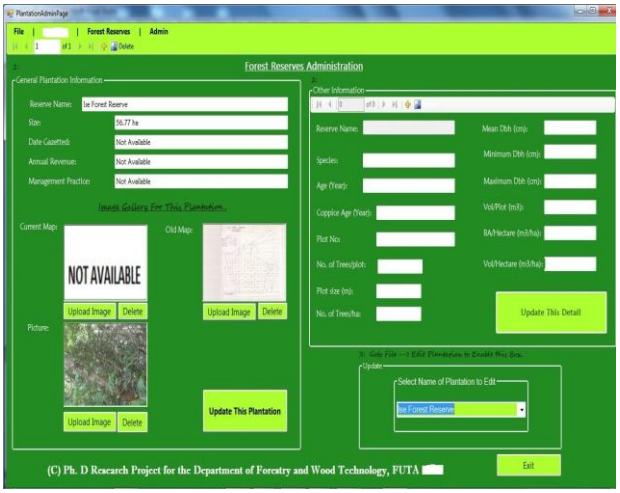

Figure 3: Adminstrative page for updating plantation forest

Forest Reserve Page

Next to *Admin* on the menu bar is forest reserve. From the Forest reserve menu, user can navigate to forest '*Type'* and further to '*Natural'* (Figure 4) and *'Plantation'* (Figure 6) to call for information in the database on all the forest reserves in the state both in the natural and plantation forestry. When the *'Natural'* forest is selected, it navigates to a natural forest page where information on natural forest can be accessed from Figure 4. At the top left corner of the page is a box containing list of all the forest reserves in the state. The page also contains a Table of information on the forest products obtainable from each forest reserve (natural forest) and three group boxes on general, extended and specific plot information as well as old and current map with the photograph of selected forest reserve. In other words, all these information are forest reserve specific.

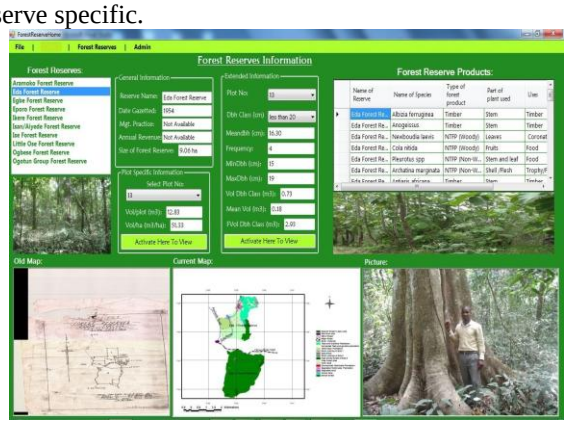

Fig.4. Natural forest page of the database

As one scrolls down the list of forest reserves at the top left corner of the page, the information on them also changes with change in the forest reserve. Extended and plot specific information needs activation to function. The activation buttons are situated under them. They old maps are the sketched map obtained from the Ekiti State Department of Forestry while the current maps are the digital map produced in this study using GIS. Since only two forest reserves were selected to do detail study, other forest reserves' current map were represented in the digital map of the State showing the locations of all the forest reserve in the State. Forest products were divided in this database into timber and non-timber forest products (NTFPs). This offers an opportunity for the forest product to be sorted according to their uses, type and name.

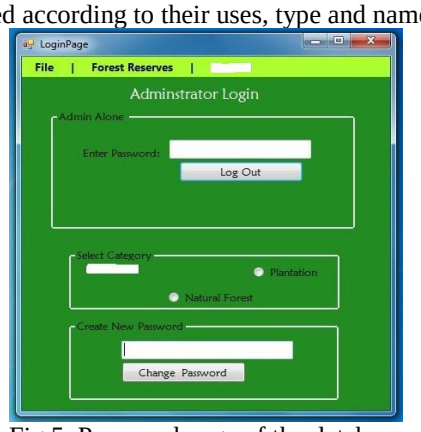

Fig.5. Password page of the database

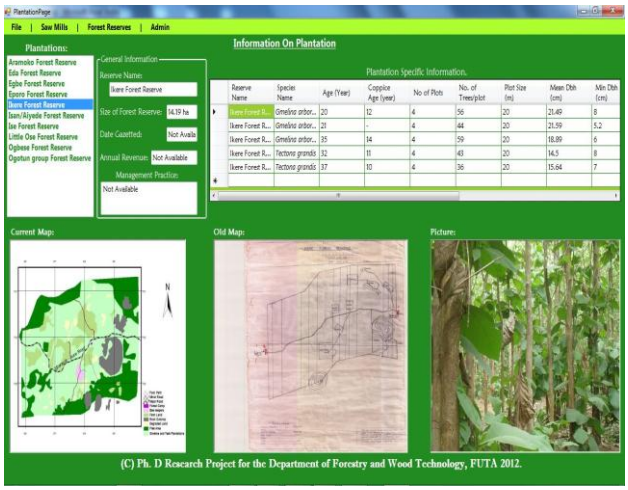

Fig.6. Plantation page of the database

Plantation Page

When the *'Plantation'* is selected from *'Type',* from the forest reserve menu, it navigates to plantation page where information on plantation can be accessed (Figure 6). At the top left corner of the page is a box containing list of all the forest reserves in the state. The page also contains a Table of *plantation specific information* on the growth characteristics of various species of trees in the selected forest reserve with respect to their ages (plantation age and coppices age) The *current map* of the forest reserve, which is the digital map produced in this study as well as the old sketched map of the selected reserves are placed beside each other together with the photograph of the reserve are displayed at the bottom of the page as was displayed in *Natural forest page* above.

IV. Discussion

The menu bars (file, Admin, forest reserves) used in the development of geospatial database were not standard items (file, edit, tools and help) used in conventional software like Microsoft Office made for all kind of users. Geospatial database is not meant for all users but specifically for people in the forestry sector. In essence, it is designed for the purpose of making relevant information available on forestry [12], [13], 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 database is similar to one explaind by [9] and the data used to populate the database was guided by the information required to manage the forest ecosystem [15]. 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. *'Extended and plot*

specific information' are so designed to accommodate data update on future permanent sample plots where a continuous forest inventory can be carried out. A gridtable was used for the forest product to offer possibility of sorting the items from each column in a chronological order depending on the purpose for sorting by the user.

There were no digital maps available for all the forest reserves. Where there were maps at all, they were old sketch maps for some of the forest reserves. These maps were not georeferenced and lacked necessary details. The Geospatial database developed in this study have been able to provide digital maps that shows the forest reserves in Ekiti State, Nigeria.The displayed maps of the forest reserve help users to view the old and the new maps while the photographs in the hotlinks gives the true picture of the current status of the forest reserve. It also offers the user opportunity to be able to contrast and appreciate some of the changes that have occurred over time within the forest estate. This is is similar to work done by [14] when they use GIS as a tool to develop forest information system for Turkey when the use of GIS was not widely known.

Having developed the a comprehensive geospatial database for forest reserves in Ekiti State, Nigeria, from relevant information on forest reserves that was naturally scattered in various sections of the forestry sector while some were at the custody of some individuals who have worked in the sector over time and have retired. The information system has been able to provide a solution to scarcity of information by having it at the click of the mouse by collating relevant data/information (growth data, management information and spatially referenced data) and packaged it in form of software.

It will help the State Government and other policy makers in forestry sector to decide which silvicultural intervention to employ based on actual facts [7], [8], [9], [14], [15]. Before now, the Government decisions were based on what they have on paper, very many at times would have been outdated, but not on what is actually left in the forest. This is because adequate information of the actual facts on the reserves was not readily available. Where little information was available, it was obvious that it was obsolete [4].

V. Conclusion

Going by the details made available by the database generated for this study, capturing data from the forest reserve and from the State Department of Forestry, the information in this database is adequate to help forest manager make relevant decisions on how to manage the forest ecosystem in a sustainable manner. The database was developed in such a way as to make it user friendly and there is a provision for regular update of all the data in the database. Although all users can have access to the database, only personnels that are authorised can update the information in the database. This has immensely increased the integrity of the data in the database. It must be noted that the Information system developed in this study is to facilite efficient data storage and prompt information retriever. From the information provided by the system, management decisions can be made on which forest reserve requires urgent re-afforestation programm, conservation or sustainable management. It is not meant to map out fully stocked reserves for exploitation. It has been proven beyond reasonable doubt that GIS is veretable tool in forestry and in the development of geospatial database for forest reserves in Ekiti State.

Recommendations

The Geospatial database developed in this study for forest reserves 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 Ekiti State. It should therefore be utilized by all stakeholders in the forestry sector.

The database in this study was designed in such a way to accommodate regular updates as soon as additional information is made available and the nature of data collected for the database is also dynamic. This implies that the values obtained for the growth charaterictic for all the tree species would have increased in another five years and spatial distribution of sawmiils across the state too would have changed as well as a result of availability of raw material and market for the products of wood based industry. Sequel to this, there is the need to update the database from time to time to accommodate all the changes that may ocuur over time. The database can be enriched by collecting relevant data to fill existing gap.

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

This study has revealed that there are some agricultural farms inside forest reserves. In order to ensure sustainability of our forests in the state, there is the need to adopt community-based forest management system.

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