

Computerized Geospatial Information System for Rice Farmers Association of Nigeria (RFAN) Adamawa State, Nigeria

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Abstract - Computerized Geospatial Information System for Rice Farmers Association of Nigeria (RFAN) Adamawa State was design to improve operation of the organization. The application of modern information and communication technologies (ICT), such as cloud computing, remote sensing, and Internet of things (IoT) in agriculture to increase agricultural productivity as “smart farming”. Precision farming can offer significant benefits to farmers. The aim of this project is to design a computer system for RFAN in Adamawa State so that the organization will improve their operations. The Existing System in RFAN was analyzed, the proposed computerized system for RFAN has the following advantages over the old system as follows, very quick service delivery, Visual presentation of data, The security of the data in the database is guaranteed and maintained, Distribution of farm inputs will be fast and accurate., Duplication of farm inputs to farmers will be averted, Recovery of rice after harvest from farmers will be easier, It will lead to greater far yield. Farmers data was collected from the organization, a field work using modern survey equipment’s was carried out, both the attribute data and geospatial data obtained were converted and use to design the computerized system.

Keywords: Geographic information system, computerized system, model, RFAN, E-agriculture, geospatial database.

I. INTRODUCTION

In the late nineties, the term precision agriculture or wired farms came into existence. These terms grouped several technologies, including Global Positioning Systems (GPS), Geographical Information Systems (GIS), and other state of the art technologies (Husemann & Novković, 2014). The advent of precision agriculture led to increasing amount of data being generated leading to the development of several Decision Support Systems (DSS), that were helping farmers make informed decisions. Some of the examples of specialized agricultural DSS, include Dairy Comp 305for herd

managements of milking cows, and DSSAT tool for land cultivation etc. (Husemann & Novković, 2014).

Precision agriculture as well as the use of AIS can help reduce the cost of agricultural production, minimize the pre-cultivation time, and increase the agricultural productivity (Santoso & Delima, 2017).

Another term that is often used in conjunction with AIS is Farm Management Information Systems (FMIS). Farmers often do not have access to tools to help them in financial management of their business. FMIS are information systems that facilitate the storing and processing of farm-related data providing farmers support in decision making in daily farm management (de Oliveira et al., 2014). FMIS could be a part of AIS or could also be considered as an extension to AIS as these systems provide information required not just for agricultural activities but also some of the supporting activities. Some of the available commercial FMIS, include Ag world, Farm Works, and 365FarmNet (de Oliveira et al., 2014).

Sørensen et al. (2010) defined Farm Management Information Systems (FMIS) as a planned system of collecting, processing, storing, and disseminating data in a form needed to carry out farm-related operational functions. FMIS are essential parts of farming enterprises because farming has evolved from simple production tasks to businesses with multifunctional sectors (Paraforos et al., 2017). FMIS assist in the storage and processing of farm data for everyday farm management. Some of the popular FMIS, include 365FarmNet, AgriWebb, AgWorld, and Farmwork’s (Paraforos et al., 2017).

FMIS support the various domains of the agricultural sector, including dairy farming, crop management, field management, and financial management (Tummers, Kassahun, & Tekinerdogan, 2019). FMIS have evolved in the last decade from simple farm record-keeping into advanced complex systems helping in strategic decision making and handling several essential aspects, including managing

production costs, compliance with agricultural standards, offering simulation, and decision-making tools, as well as weather forecasting capabilities (Rupnik et al., 2019).

Another important term is an extension of AIS, also referred to as Agricultural Knowledge and Information Systems (AKIS). This term, initially coined by Roling (1988) refers to information systems linking people and institutions and promoting the generation and sharing of agriculture-related technology, information, and knowledge (Gichamba & Lukandu, 2012). Several countries in Africa developed AKIS meeting their localized needs, as these systems are more accessible when the content is offered in local languages and at an appropriate technical level for the rural community to understand and use (Semeon, Garfield, Meshesha, & David, 2013). The success of AKIS depends on the ability of these systems to motivate farmers to trust and use these systems (Semeon et al., 2013).

Another term often used to refer to the use of ICT in agriculture is e-agriculture. E-Agriculture refers to the need to transfer knowledge and experience in the use of ICT in agriculture (Novković, Vasiljević, & Matković, 2013). Kumar et al. (2019) defined e-agriculture as the use of information and communication technology and processes to improve agricultural and rural development. This also includes the processes of conceptualization, design, development, evaluation as well as application of ICT in agriculture (Novković et al., 2013). E-agriculture is more of a philosophy or methodology rather than a set of technologies. E-Agriculture is encouragingly used to promote this way of thinking, especially among the farming communities in Asia and Africa that are yet to use ICT in the farming activities.

AIS can also be a contributing factor towards the use of information and communication technologies for development (ICT4D) (Okewu & Okewu, 2015). The ICT4D philosophy is essential to the development and growth of developing and emerging economies in Asia and Africa. Okewu and Okewu (2015) suggest four key areas integral to the ICT4D philosophy, namely, agriculture, education, health, and social security. E-Agriculture is an essential component of the larger ICT4D philosophy.

Successful implementation of AIS would require both access and usage of these information systems by the farming communities (Bitrus, Strang, & Vajjhala, 2019). Access to the systems is influenced partly by the requirement of adequate infrastructure, especially in the case of developing countries with infrastructural problems. Farmers would need adequate training and knowledge to operate most of these technologically sophisticated information systems.

FMIS can help provide farm holders access agricultural information using digital technologies with a potential for increasing farm yield by 4% and also increase the chances of adopting the recommended farm yield by over 22% (Fabregas, Kremer, & Schilbach, 2019). The use of FMIS is more prevalent in large-scale farms as compared to small to medium sized farms. This is because of several reasons, including the lack of knowledge and the complexity of the existing FMIS (Husemann & Novković, 2014). The management aspect of FMIS, includes planning, organization, monitoring, and controlling of activities in farms (Husemann & Novković, 2014)

This article aimed at designing and developing a new computerized system and GIS based model for the organizations monitoring and evaluating farming activities of its farmers for better decision making and planning.

II. LITERATURE REVIEW

E-Agriculture Framework, according to (FAO, 2009), is an evolving field that can be described as tools that digitally collect, store, analyze and share electronic data and information in agriculture. These data collected intersect from different fields such as technology, agricultural services, entrepreneurship, and agricultural informatics ensuring that agricultural services and information are disseminated efficiently through the Web and other related technologies.

More precisely, it entails innovatively using available ICT technologies and adapting new technologies in the conceptualization, designing, developing, and evaluation of new agricultural digital tools (Singh & Sohane, 2016) to be used primarily and extensively for agricultural purposes in remote or rural places (Birthal, 2013). According to (Amadu, McNamara, Davis, & Rodriguez, 2015; Wyche & Steinfield, 2015), the utilization of ICT in agricultural-related research and development can be grouped into categories base on farmer's needs.

Information requirements and needs of farmers vary considerably within a country and from country to country due to the fact that farmers have different perceptions of what information is useful for them and how they can access it. The fundamental message underscoring all these differences among farmers shows that the farmers' needs and priorities change throughout the production cycle (World Bank, 2011). Therefore, there is a need to engage all agricultural stakeholders during the process of integrating ICTs in agriculture. The quality of information available to farmers has negatively impacted their capability to make informed decisions, and this is due to inconsistent data formats and standards.

Well established frameworks such as the Knowledge Discovery in Databases have been successfully deployed in other fields and therefore relevant methodologies can too be applied in the agricultural sector, a framework that takes in farmer’s needs in all their formats and ends up providing crucial information in the right format for consumption by the farmers (Anyan & Frempong, 2018). Before information is delivered to the farmer it has to be captured from different sources, thoroughly processed, and analyzed using data mining technologies, then integrate to make it ready to be delivered to the farmer (Gandhi, & Armstrong, 2016).

Constant research needs to be directed at developing frameworks that enhance the understanding of farmers’ informational sources. And because data is generated rapidly, there is an urgent need of developing new systems that will do the following; disseminate information after understanding the needs of the target community (Msoffe, & Ngulube, 2016), document and predict the information searching behavior of farmers (Mahindaratne & Min, 2018), considering social-economic influences that affect technology adoption (Lubua, 2022), or farm inputs (Kante, Oboko, &Chepken, 2019). For instance, Ahmad et al. (2020) utilized a framework that correlated livestock farmers to their social-economic characteristics. They postulated that there is a significant relationship between social-economic characteristics with effective information sources. Adoption of relevant technologies required for livestock production among farmers is ultimately affected.

Application of ICT in agriculture is increasingly becoming steady in developing countries and this could facilitate self-reliance for national growth. Agriculture plays a vital role in the social and economic development of most African countries and is the main contributor to economic growth and stability (Munyua and Adera, 2009; Bhalekar et. al, 2015). Electronic agriculture describes an emerging field focused on the enhancement of agricultural and rural development through improved information and communication processes. The e-agriculture disseminates useful information through Decision Support System (DSS), Management Information System (MIS) and Expert System (ES) by infusing the User Interface and Knowledge Management System (Behera et al, 2015; Bhalekar et. al, 2015).

Singh et al (2015) reported that Agriculture Information System (AIS) is a computer-based information system which contains all the interrelated information which could really help farmers in managing information and policy decision making. The ICT devices that help facilitating farming activities encompassed applications like radio, television, cellular phones, computers, tablets and networking, hardware

and software, satellite systems (Munyua and Adera 2009; Pande and Deshmukh 2015).

In the same way, (Yimer, 2015; Munyua and Adera 2009) reports that radio is extensively used to inform users on agricultural topics, including new and upgraded farming techniques, production management, and market information. This shows that farmers may take advantage of using radio in the absence of technology especially rural farmers.

The Internet and web-based applications are extensively used in sharing and dissemination of agricultural knowledge, marketing of goods and services. Ramli et al, 2015, have shown evident that ICT is an effective solution to problems that militate against the development of agricultural industry, such as weak marketing linkages, poor information management, low productivity, low income, and lack of diversity. Singh et al, (2015a) noted that the importance of ICT in agriculture by sharing agricultural information system to farmers at all levels.

III. STUDY AREA

Adamawa state is located at the northeastern part of Nigeria. It lies between latitude 7 and 11 N of the equator and between longitude 11 and 14 E of the Greenwich meridian. It shares boundary with Taraba state in the south and west, Gombe state in its northwest and Borno to the north. Adamawa state has an international boundary with the Cameroon republic along its eastern border. The state covers a land area of about 38,741 km square with a population of 3,500,345 people. Adamawa state is divided into 21 local government areas. Nzigoline is a village in Demsa local government area where RFAN farm is located, the farm has a total area of 210 hectares.

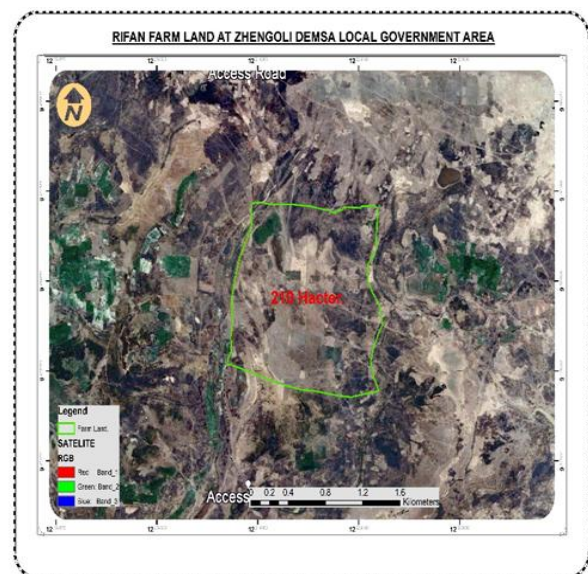


Figure 1: Study Site

IV. MATERIALS AND METHODS

This paper adopts a pragmatic methodology that uses both quantitative and qualitative data collection methodology. Two types of research methods were employed to collect data, the quantitative and qualitative methods of data collection.

The quantitative data collection method is basically the primary method employed in collecting firsthand data on the organization (RFAN) and field work using modern survey equipment's, android phone with a downloaded GPS camera software; coordinate of the RFAN farms were collected using the android phone, a folder was created develop using the ArcGIS software were the name of the farmers, farm size, crop type, crop yield yearly, farm inputs were stored etc.

Quantitative is the secondary method of data collection, satellite images of the farm were downloaded from the USGS using google earth pro. Maps of the farm collected from GN Tsundass Nigeria limited Yola a RFAN consulting firm, textbooks and journal were consulted for more information about the development of a computerized system for agriculture.

System Investigation and Analysis - System investigation in concerned with the in-depth and comprehensive study carried out on the old system to find out relevant (information) that will be of help in designing the new system. The following task of system investigation are: i. Facts findings on old system ii. Analysis of data collected on old system.

Fact Findings this involves gathering facts about the existing system of operation in the organization (RFAN). The purpose of facts findings is to identify the application and implication of the system to the management of the organization.

Analysis of Data Collected on the Old System - It is vital to analyze facts collected. The collection of facts is not the end of the study. However, the results of the investigation of the existing system were analyzed and presented in orderly manner to the organization for easy comprehension and understanding.

Analysis of the Proposed System - It is probably the most difficult stage in the system analysis and design cycle. It is also the process of developing a plan for improving the existing system based on the results of the system analysis.

Various design alternatives can be developed based on the analysis made. Once an alternative has been selected, the purpose of this proposed system is to design a system that will address the problems of the existing system. The design stage is to work from the system requirement to a system

specification with a document containing the detailed features of the proposed system.

Advantages of the Proposed System - The proposed computerized system for RFAN has the following advantages over the old system as follows:

1. Very quick service delivery,
2. Visual presentation of data,
3. The security of the data in the database will be guaranteed and maintained,
4. Distribution of farm inputs will be fast and accurate,
5. Duplication of farm inputs to farmers will be averted,
6. Recovery of rice after harvest from farmers will be easier,
7. It will lead to greater farm yield.

System Design - The biggest and most difficult stage is the system development life cycle. This involves developing a plan for the proposed system based on the system requirement of give the system specifications. Falowo (2006)

Life cycle is description of the distinct phases through which each product passes during its product life. This includes phases such as requirements definition, concept design, production, operation, maintenance, etc. This includes phases such as a requirements phase, a development phase, an installation phase, an operation phase, and a retirement phase. A life cycle is a plan, composed of several phases, aimed at maximizing the efficient development of a quality, usable product. A life cycle is a set of procedures, some required and others optional, which serve as a template for generating an individual design process.

The plan is not meant to be a strict step by step process, but rather a flexible process ensuring that users, designers, and management are directly involved in the development of the final product.

The typical life cycle is composed of five phases: Investigation, User Requirements, Analysis, Design, and Implementation & Release. Each phase is defined by activities, deliverables, and checkpoints.

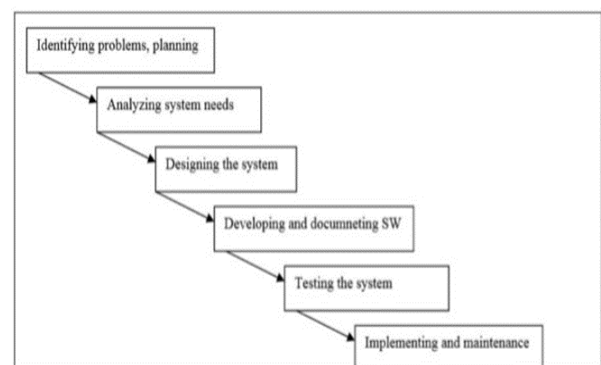


Figure 2: Phase of System Development Life Cycle

Identifying problems and planning - This is the first and very important phase of system development life cycle. This phase is critical to the success of the project. We identify the need for a new or enhanced system. Information needs of the organization are examined and projects to meet these needs are proactively identified. Two additional major activities are also performed during the planning phase, the formal, yet still preliminary, investigation of the system problem or opportunity at hand and the presentation of reasons why the system should or should be not developed by the organization.

Analyzing system needs - In this phase special tools help the analyst make requirement determinations. One such tool is the use of data flow diagrams. With DFD, input, processes and output of the business functions are converted into structured graphical form. During analysis, we studied the organization's current procedures and the information systems used to perform organizational tasks. We prepare materials that summarize what has been found, provides cost and benefits analyses of alternatives, and makes recommendations on what should be done. Once after recommendation was accepted, then we begin to make plans to acquire any hardware and system software necessary to build or operate the system as proposed.

Designing the system - In this phase of SDLC, we use the information collected earlier to accomplish the logical design of the information system. We design accurate data entry procedures so that data going into the information system are correct. In addition, we provide for effective input to the information system by using techniques of good form and screen design.

Developing and documenting software - In this phase the analyst works with programmers to develop any original software that is needed. But here we adopted ArcGIS software as the software for the design and development of the new programme.

Testing the system - The system is built but is not ready for implementation. Before a company can run the system, it must be tested. It is much less costly to catch problems before the system is signed over the users. Some of the testing is completed by programmers alone, some of it by system analyst in conjunction with programmers. A series of tests to pinpoint problems is run first with sample data and eventually with actual data from the current system. The system was tested with the organization management as can be seen in the analysis carried to select farmers' farm sizes.

Implementing and maintenance - This is the last phase of system development. The analyst helps to implement the information system. This phase involves training the users to handle the system. Some training is done by vendors, but

oversight of training is the responsibility of the system analyst. In addition, the analyst needs to plan for a smooth conversion from the old system to the new one. This process includes converting files from old formats to new ones or building a database, installing equipment, and bringing the new system into production.

V. RESULTS AND DISCUSSIONS

The use case diagram design is the graphical depiction of the user's possible interaction with the system, it shows the various use cases and different types of users the system has. The use case diagram models the behavior of the system and it also help in capturing the requirements of the system, it describes the functions and scope of the system and it also identifies the interactions between the system and the actors.

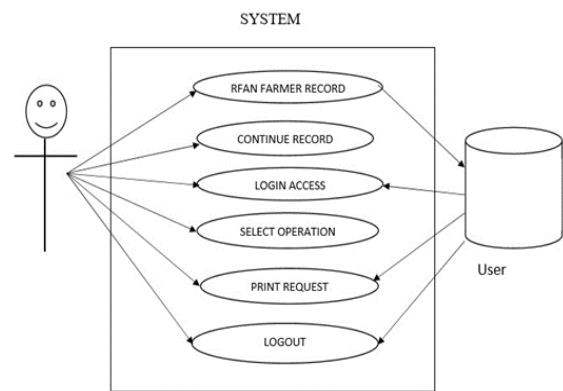


Figure 3: Use Case Diagram of the System

The sequence diagram design shows the process of interaction arranged in the system. It depicts the processes and objects involved and the sequence of messages exchange between the processes and objects needed to carry out the functionality of the system.

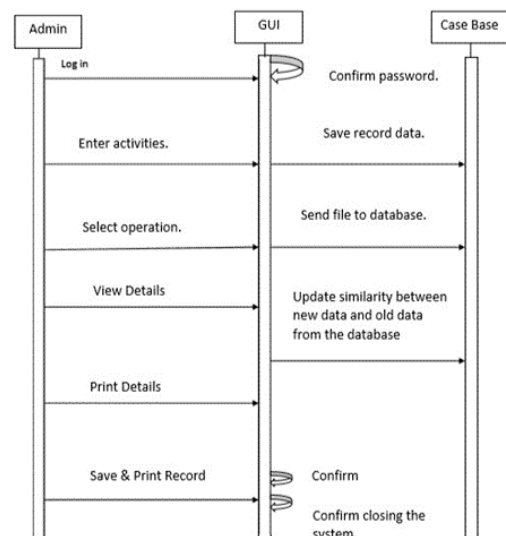


Figure 4: Sequence Diagram of the System

The flow chart diagram designed represents a workflow or process of the system. It's the diagrammatic representation of an algorithm, a step-by-step approach to solving a task, it shows in identification of the essential steps of the model process.

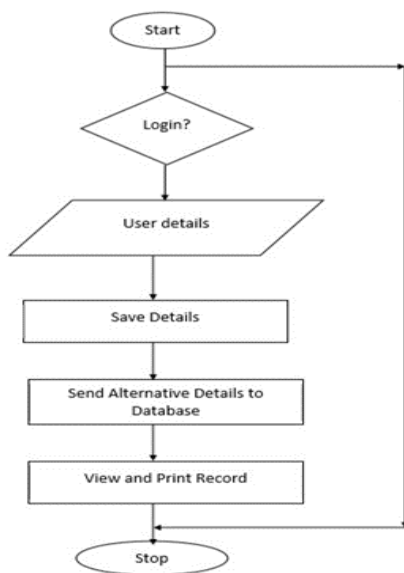


Figure 5: Flow Chat Diagram

This system was designed to handle RFAN database for easy operations in the organization. The management system is divided into four modules. This system was designed to handle RFAN database for easy operations in the organization. The management system is divided into four modules.

- i. Input module
- ii. Storage module
- iii. Analysis module
- iv. Display module

Input module- is the first stage of the system. It involves inputs of both spatial datasets such as; farm images, farm boundaries, farm photographs and maps. While the attribute datasets include, farmers names, age, bank, phone number, addressee, BVN, and far inputs given to each farmer.

Storage module- the storage module is the central geospatial datasets system, that stores both the spatial datasets and attribute datasets in form of and object base data model for easy analysis.

Analysis module- the analysis module is where all the necessary analysis of the system take place, e.g., analysis of farm inputs given to farmers, analysis of sizes of farms, analysis of expected recover from farmers etc.

Display module- the display module is used to view all the analysis carried out on the analysis module e.g., it displays the analysis in form of tables, figures, maps, and statements based on the query instituted by the analyst.

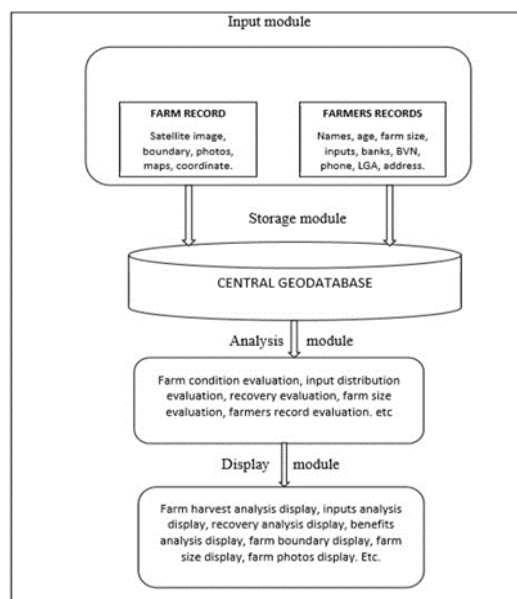


Figure 6: Conceptual GIS Based RFAN Farm data Management System

The RFAN new computerized GIS based system was developed using GIS SOTFWARE, the ArcGIS software that is embedded with C++ COMPUTER programming language and other database system as explain in the previous paragraphs. It also uses different database models such as relational databased model, network databased model, hierarchical databased model, and object-oriented databased model. It also uses query language like the MSQl e.tc. this makes the software more user friendly for this project.

The components of the design are explained below, the design is divided into two phases, phase I is the data phase, while phase II is the user interface.

The data phase components- the data phase component is where all the information of the new system were developed and stored, this information include the spatial data and attribute data of the farmers and the RFAN farms. The data phase is used for data for old and new data, the update of the data too. Data in this phase are developed in two models, the relational database model and object base data model for easy analysis and extraction of information in the system.

The user phase components- this phase has the web base server and the complete system functionality. Information from the phase I are analyzed in this phase, searching of information, analysis of information, display of information and printing of information are all carried out in this phase.

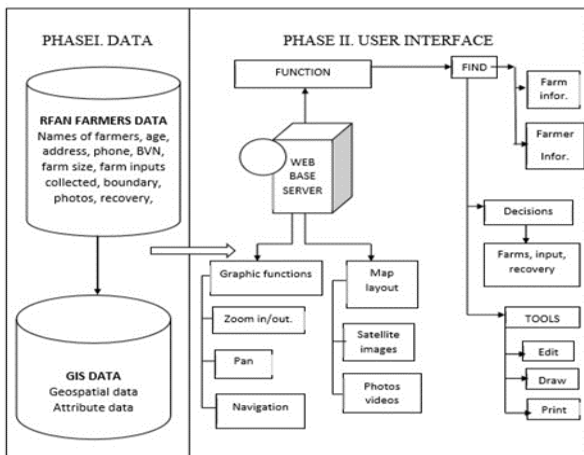


Figure 7: Computerized GIS Based RFAN System

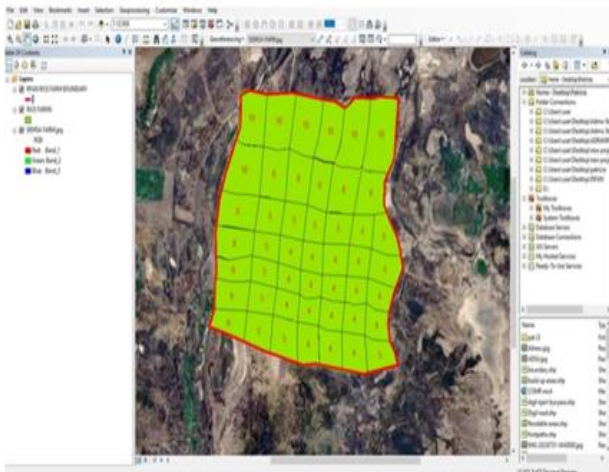


Figure 8: GIS user interface for the new system

Figure 8 is the geographic information system user interface of the new model design, it shows the satellite images of the farmland, the plots of farms divided in hectares, the geospatial database, and the attribute data of each farm/record of farmers, this interface is user friendly.

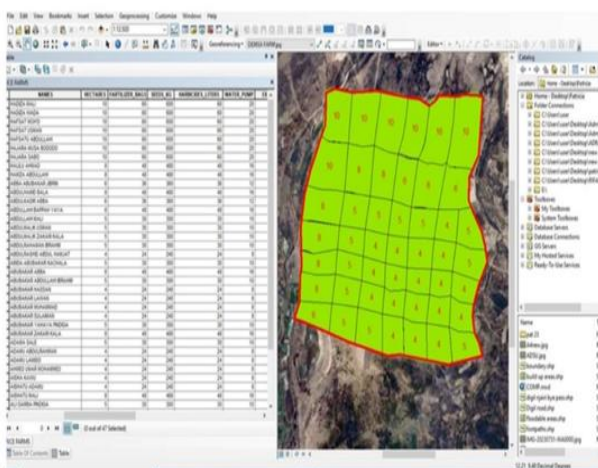


Figure 9: The new system data table and the GIS user interface

Figure 9 shows the new system data table and the GIS user interface displayed together to show the advantage of the new system and the capability of the system to showcase both data table and farm map together.

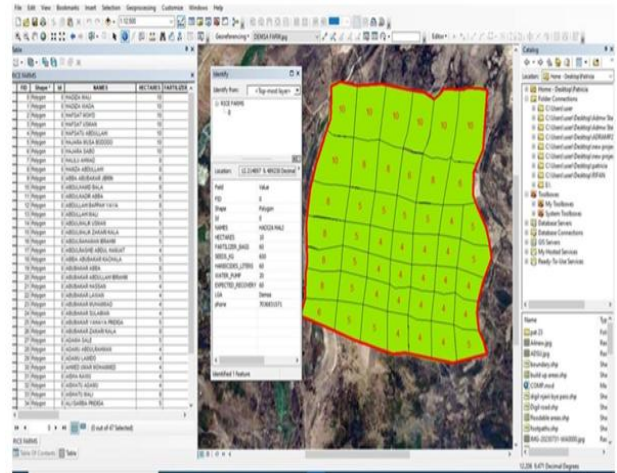


Figure 10: The use of the identifiers to search or select data

Figure 10 shows a query analysis using the identifier tool; this after selecting a farmland it automatically shows the information of the farm by the side of the map. This model simplifies searching of information of a farmer in thousand in a database of farmers. The advantage of the search operations in the model is that it gives quick information about a particular farm and the information is displayed on the dashboard of the user for decision making and planning.

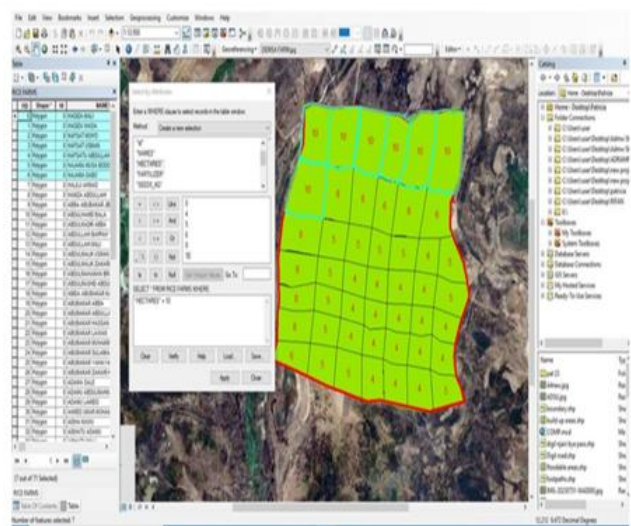


Figure 11: The MSQL to query for result

Figure 11 shows the use of the MSQL to search for information in the databased and it automatically shows on the map and data table together. This query was used to select farmers with 10 hectares of land and above, the result was automatically display both on the database table and on the farm map. This system gives the advantage of retrieving data

on the table and showing the data on the map. This will help the organization in the distribution of farm input and monitoring farmers performance.

Is time consuming and tedious, Unreliable and is prone to loss of data and records, Difficult in assessing records, Insufficient record control, Duplication of farm inputs on distribution, very difficult to retrieved farm produce after harvest,

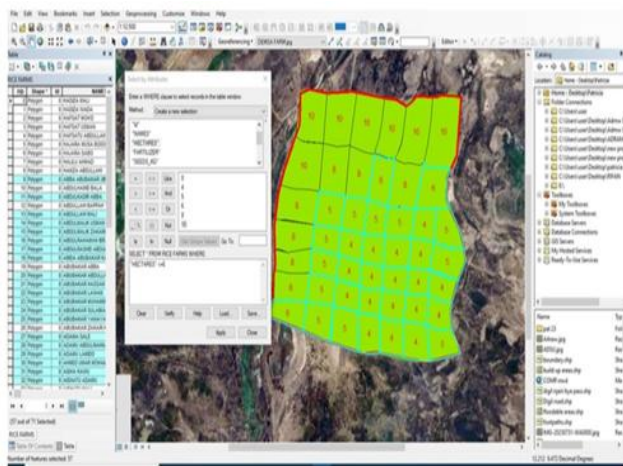


Figure 12: Using the query to select hectares less than or equal to 6 hectares

In the same vein figure 12 select farmers with 6 hectares of land and below, the results are also displayed on both the attribute database of the farmers and the map.

In other to get the best out of the project an Analysis of the Proposed System was also done. The proposed computerized system for RFAN has the following advantages over the old system as follows, very quick service delivery, Visual presentation of data, The security of the data in the database will be guaranteed and maintained, Distribution of farm inputs will be fast and accurate., Duplication of farm inputs to farmers will be averted, Recovery of rice after harvest from farmers will be easier, It will lead to greater far yield.

After analyzing the old system and the proposed system, a new system was design adopting already existing software called ArcGIS which is very user friendly, and it displays both information on the databased table and maps format.

VII. CONCLUSION

In conclusion this project designs a new computerized system for rice farmers association of Adamawa State (RFAN) using Geographic Information System software. The design was presented to the organization for implementation. This system will improve the organizations operations greatly. The project researcher after a complete analysis of the new system developed recommends as follows.

More research should be conducted in the field (agriculture) in other to develop more computerized system for farming. Further research is needed to the project so that the design can be a web-based design that will publish data and information on the web. Government and private organizations should encourage the use of computer system in their operations.

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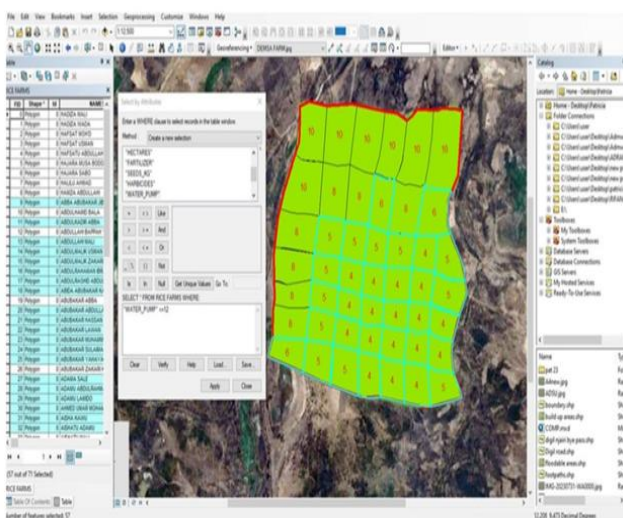


Figure 13: Searching for water pumps

Figure 13 shows another result of the queries for those farmers that were given water pumps, these results will be very useful for the organization for planning and management of the farmers that were given farm inputs.

VI. SUMMARY

The aim of this project is to design a computer system for RFAN in Adamawa State so that the organization will improve their operations. The project started by the Analysis of the Existing System in RFAN. In analyzing the existing system, it was found that the current system has the following.

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