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Framework Model for a Soil Suitability Decision Support System for Crop Production in Nigeria

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Abstract: - A typical problem is faced in Nigeria, where agricultural lands are largely underutilized and mostly suffering from degradation leading to an unmitigated food security problem. Currently, food production growth rate in Nigeria remains unable to feed its fast growing population. This is largely attributed to the farm management practices on agricultural lands employed in crop production. A step in the right direction is to provide a central repository of data and knowledge where decision support on the best crop production practices to provide optimum yield in quality and quantity is made available in a view easily interpreted by the chief implementers, which in this case are the local farmers. This can be accomplished in part by building a system to provide soil suitability decision support. In this paper, a framework for building a soil suitability decision support system (SSDSS) to tackle the problem of poor farming methods and low crop growth is presented. It documents a solution of coordinating the diverse nature of variables faced by the decision-maker in the crop production process into a software system that would support decision making activities and hide the user of the system from the technicalities and complexities of the underlying data.

Keywords: - *agricultural lands, crop production, soil suitability decision support system, decision support framework*

I. INTRODUCTION

Nigeria faces huge food security challenges. Nigeria has about 79 million hectares of arable land, of which 32 million hectares are cultivated. Smallholders, mostly subsistence producers account for 80% of all farm holdings. Both crop and livestock production remains below potentials. Inadequate access to and low uptake of high quality seeds, low fertilizer use and inefficient production systems has led to this shortfall. Despite a seven percent growth rate in agricultural production (2006 – 2008), Nigeria's food import bill has risen. The growing population is dependent on imported food staples, including rice, wheat and fish (Nwajiuba C., 2012).Nigerian agriculture contributes to global warming albeit to s small extent through bush burning and other poor land management practices. This matches the findings on the state of agriculture in sub-Saharan Africa, summarized in the international assessment of agricultural knowledge, science and technology (IAASTD, 2008 cf. Nwajiuba C., 2012).

The problems of agriculture in Nigeria begin with the soil. Most of the farmable land in Nigeria contains soil that is low to medium in productivity. According to the Food and Agriculture Organization of the United Nations (FAO, 2001), "with proper management, the soil can achieve medium to good productivity".

To obtain optimum results in crop production, certain strategies must be taken into consideration, which includes the extensive use of arable land and where necessary with the application of irrigation. According to the Global Land Assessment of degradation (Glasod) estimation, in Africa, of the 3.2 billion hectares available which are under pasture, 21 percent are degraded, while of the nearly 1.5 billion hectares in the crop lands, 38 percent are degraded in various degrees. The degradation of cropland appears to be most extensive in Africa affecting 55 percent of the crop area, compared with 51 percent in the Latin America and 38 percent in Asia. This all limits the extent of which we can make use of available arable land. Declining yields or increasing input requirements will be the consequence. Another strategy of making intensive use of the available arable land is to irrigate it where necessary. The potential for increasing the overall irrigated area in the developing countries is at 110 million hectares. This could provide an additional 300-400 million tons of grain, enough to provide a basic diet for more than 1.5 billion people (FAO Food Security Assessment Document WFS/tech/7, Rome 1996, p.16. cf. Sakariyawo O. S., Bugaje S. M., Kuta D. D., Magashi A. I., Ubale A. S., 2000).

The constraints earlier highlighted leave us with the option of intensive method of Agriculture, which is knowledge based. The role of the crop research cannot be overemphasized namely: agronomy; plant breeding: plant physiology and biochemistry; plant protection; biotechnology etc. According to Ben Miflin (Journal of Experimental Botany, Vol.51, No.342 MP special issue, pp1-8, January 2000), the vast majority of the increase in the crop yields that took place in the last century has been powered by changes in the genetical potential of the crop and the way in which it has been managed (Sakariyawo O. S., Bugaje S. M., Kuta D. D., Magashi A. I., Ubale A. S., 2000).

The application of Soil Suitability Decision Support System (SSDSS) in the Nigerian Agricultural sector/ domain combines data, knowledge and mathematical models from crop production research to enhance the decision-making capabilities of farmers in their bid to optimize the quality and quantity of cultivated crops.

II. THE STUDY AREA, RESEARCH SIGNIFICANCE AND OBJECTIVES

Soil types in Nigeria are influenced by and follow very broadly, the climatic and vegetational zones of the country. This is expected because the degree of available moisture in the soil is an important factor in soil reactions and fertility and productivity. The soils of the humid tropical forests are quite different from those of the drier forests and the savanna zone, which in turn are different from the savanna zone (Oyenuga, 1967). The major soil types in Nigeria, according to FAO soil taxonomy legends are fluvisols, regosols, gleysols, acrisols, ferrasols, alisols, lixisols, cambisols, luvisols, nitosols, arenosols and vertisols. These soil types vary in their potential for agricultural use (Aregheore, E. M., 2005).

The irrational use of agricultural lands as well as the adoption of archaic methods has resulted in the sector producing less than its expected capacity and in the process contributes to the current food security challenges. Zhi-Qiang, W., &Zhi-Chao, C., 2010 states that more advanced methods and technologies are needed to manage all the information from different sources, and interruptedly analyze all the information to get better strategies for crop production. A SSDSS can, obviously, meet the needs. But up to now, there is no such decision support system available in the field.

The paper aimed at developing a SSDSS framework to cater for the best practices needs of farmers to produce optimal results during the crop production process. The facets to be operated upon by the decision maker are, cropping systems, fertilizer and their right uses, tillage practices, seed & seedlings, soil and water conservation, irrigation and drainage, weed and weed control, pest and diseases, crop improvement, harvesting and processing of field crops and storage of field crops, to determine the suitability of a particular soil type to produce optimum yield in quality and quantity for a particular crop specie in a particular location within the country.

The decision support to be catered for includes:

- The analysis and characterization of the samples for physical and chemical properties; in the case of soils and quality characteristics in respect of water.
- The recommendation of types of fertilizers, application rates, application methods and optimum time of application for each crop in the state.
- The recommendation of land management practices to be adopted by each state, to maintain soil fertility.
- The recommendation of water management practices based on baseline values on surface and groundwater generated during the study.
- The recommendation of disease and pest control practices to be adopted by each crop in a particular soil location.
- The recommendation of seed varieties to be cultivated in a particular soil location.
- The recommendation of weed and weed control practices to be adopted by each crop in a particular soil location.
- The recommendation of crop improvement techniques to be adopted in a particular soil location.
- The recommendation of harvesting and processing techniques to be adopted in a particular soil location.The recommendation of the climatic condition in a particular soil location as it affects a particular crop.

III. SSDSS FRAMEWORK

With the development of the Internet, Web-based Decision Support Systems (DSS) have become a new trend in DSS research. Compared to traditional DSS, there are two changes brought by the Web-based DSS. First, the underlying architecture for Web-based DSS has moved from main frames, to client–server systems, to Web- and network technology-based distributed systems. Consequently, large amounts of data and related decision support tools from multidisciplinary sources, which may be located in a distributed computing environment, have the possibility to be integrated together to support decision-making. Second, differing from traditional DSS, such as data-driven DSS focusing on access to and manipulation of a timeseries of data, model-driven DSS focusing on access to and manipulation of a domain-related model, and knowledge-driven DSS focusing on high-level knowledge extraction and data mining, Web-based DSS provide the ability to build a hybrid DSS (Zhang, S. & Goddard, S., 2005).

The framework for the SSDSS is shown in Figure 1 below.

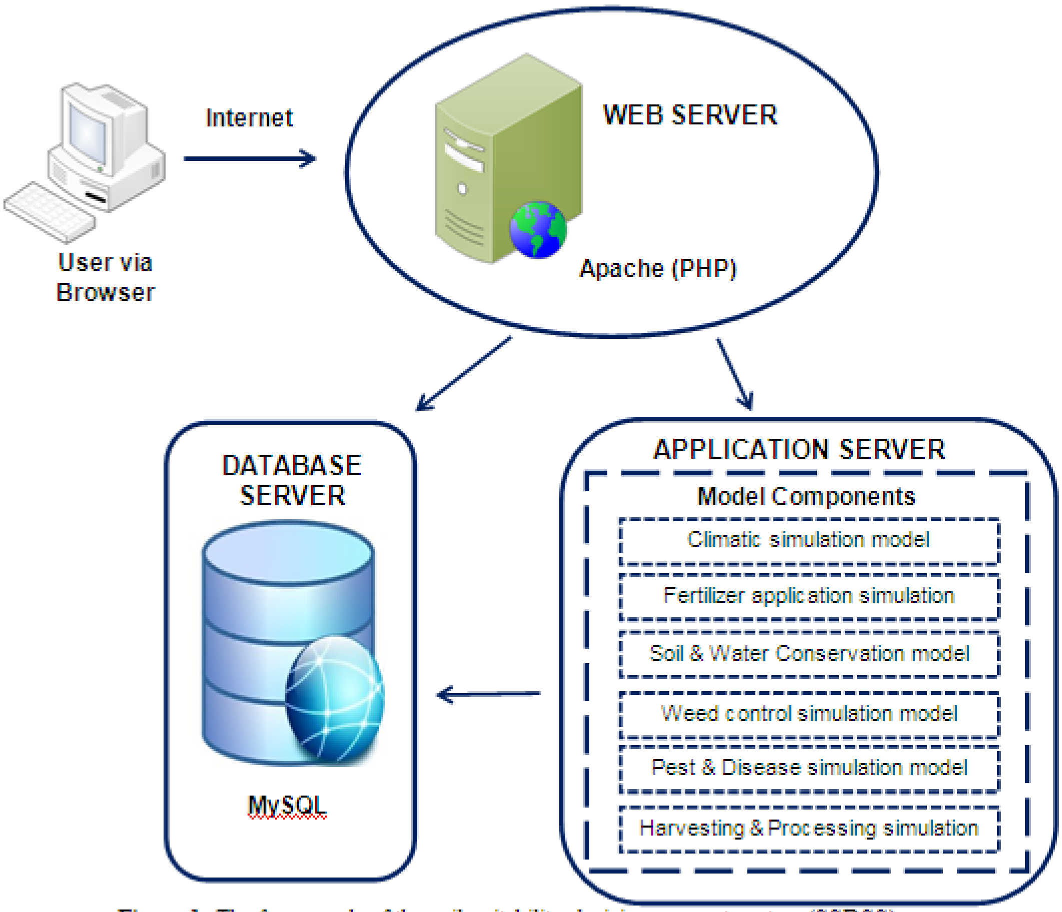

Figure 1: The framework of the soil suitability decision support system (SSDSS)

There are three fundamental components of the SSDSS as it corresponds to the components of a DSS as shown in Druzdzel and Flynn, 2002.

- Database management system (DBMS). It serves as a data bank for the DSS. It stores large quantities of data and provides logical data structures (as opposed to the physical data structures) with which the users interact. It separates the users from the physical aspects of the database structure and processing.
- Model-base management system (MBMS). It provides independence between specific models that are used in the DSS from the applications that use them. The purpose of the MBMS is to transform data from the DBMS into information that is useful in decision making. Since many problems that the user of a DSS will cope with may be unstructured, the MBMS can assist the user in model building.
- Dialog generation and management system (DGMS). As their users will mainly be farmers who are not computer-trained, the DSS is equipped with intuitive and easy-to-use interfaces. These interfaces aid in model building, but also in interaction with the model, such as gaining insight and recommendations from it. It is the user interface accessed from the browser.

IV. DEVELOPMENT OF THE SSDSS

IV.1 Development of data warehouse for soil suitability decision variables

The SSDSS data warehouse includes data to provide decision support for each crop in a particular soil type (i.e. fluvisols, regosols, gleysols, acrisols, ferrasols, alisols, lixisols, cambisols, luvisols, nitosols, arenosols and vertisols), the databases contained are:

- database for cropping systems,

- database for fertilizer and their right uses,
- database for tillage practices,
- database for seed & seedlings,
- database for soil and water conservation,
- database for irrigation and drainage,
- database for weed and weed control,
- database for pest and diseases,
- database for crop improvement,
- database for harvesting and processing of field crops,
- database for storage of field crops, and
- database for physical and chemical properties of soil types,

The database was developed using MySQL to input, store, manage, query and index data to provide soil suitability decision support. MySQL is picked as the DBMS of choice because it supports a rich set of data types capable of representing nearly every conceivable data format with powerful security models. Web frameworks help the programmer to embrace best practices, simultaneously decreasing errors and eliminating redundant code. A number of them are PHPMyAdmin, MySQL Administrator, MySQL Workbench 5.3 CE, etc.

IV.2 Development of soil suitability decision models

By examining the variety of decisions to be made and the variables that surround them, many problems faced by the user of the DSS will be unstructured. Data from the DSS can be used in model building to generate information useful for decision making. Some of the models that can be generated include:

- ✓ Climatic simulation model,
- ✓ Fertilizer application simulation model,
- ✓ Soil & water conservation simulation model,
- ✓ Weed control simulation model,
- ✓ Pest & disease simulation model,
- ✓ Harvesting & processing simulation model, and
- ✓ Storage simulation model

IV.3 Development of the View and Controller

PHP Hypertext Pre-Processor is employed as the preferred language for server-side development to coordinate the request – response cycle from the web browser to the server for processing. It is well suited for the creation of dynamic user interfaces (views) in conjunction with client side technologies such as HTML, CSS, JavaScript and AJAX thatinteract with the database as well as generated simulation models. It is ideal for a web based software development.

The architectural design pattern employed here is the MVC (Model-View-Controller) design pattern, which dividesthesystem into three interoperable albeit loosely coupled components. The model represents the data warehouse/ simulation models for crop production recommendation and prediction. It notifies the view when it changes and lets the controller access the system functionality encapsulated by the model. The View on the other hand gets data/ information from the model and specifies how it should be presented to the user of the system. It updates data representation each time the model changes. The controller is responsible for the application behavior as it dispatches user requests and selects views for presentation.

AJAX calls are employed to facilitate a seamless transfer of user request from the browser to the server; this is done by asynchronously passing information to the serverthereby enhancing the overall user experience while using the system.

V. CONCLUSION

In Nigeria, we have a rich pool of agricultural data available yet little or no knowledge gleaned from it. A famous aphorism goes that "we are drowning in data, but starving for knowledge!!" as is the case in the Nigerian agricultural sector. Various researches and scientific explorations have been conducted over the years by government agencies, non-governmental organizations (NGOs) and university scholars that have produced ground-breaking results, with huge potentials to take the agricultural sector in Nigeria to the next level. Unfortunately we find this knowledge being swept under the carpet in the archival shelves as the proverbial candle lighted and put under a bushel and not readily available to the common populace especially for the chief implementers, which in this case are the farmers. Those that are available are either too technical for common consumption or have a narrow spread, hence not accessible to all stakeholders across the country. As this information is not readily made available, it has become quite common for crop farmers to use substandard approaches which have resulted in low productivity in terms of quality and quantity. We also find many farmers holding on to archaic ideas/ methods, therefore not being able to achieve maximum productivity in crop production. A SSDSS solves this problem.The future of this work is to add intelligence to decision making by computing inferential rules and metrics to provide decisions based on data read from our design model. Consequently it becomes possible to tell the soil type that would provide maximum yield in quantity and quality for a particular crop based on computations on the chemical and physical properties of the soil types matched with computations on the chemical properties of the crop, to find the optimal result. This example and other matrices can and should involve computational analysis to increase decision support.

REFERENCES

[1] Aregheore, E. M., Country Pasture/Forage Resource Profiles. Nigeria. http://www.fao.org/ag/AGP/AGPC/doc/Counprof/nigeria/nigeria.htm#2b, 2005.

[2] Druzdzel M. J., Flynn R. R., Decision Support Systems. Decision Systems Laboratory School of Information Sciences and Intelligent Systems Program University of Pittsburgh. To appear in Encyclopedia of Library and Information Science, Second Edition, Allen Kent (ed.), New York: Marcel Dekker, Inc., 2002.

[3] Nwajiuba C., Nigeria's Agriculture and Food Security Challenges. http://www.ng.boell.org/downloads/Agriculture_-_Green_Deal_Nigeria_study.pdf, 2012.

[4] Sakariyawo O. S., Bugaje S. M., Kuta D. D., Magashi A. I., Ubale A. S., Food Security in Nigeria: The importance of Crop Research. Paper presented at the conference of young agricultural specialists: "Food security in Nigeria", which took place between 22nd July - 5th August at the People's Friendship University of Russia, Moscow. The conference was organized by SELHOZ (A Nigerian NGO, based in Russia). http://www.nigeriaworld.com/feature/article/food_security.html, 2000.

[5] Zhang S., Goddard S., A software architecture and framework for Web-based distributed Decision Support Systems. Elsevier. Decision Support Systems 43 (2007) 1133– 1150, 2005.

[6] Zhi-Qiang W., Zhi-Chao C., A Web-based Agricultural Decision Support System on Crop Growth Monitoring and Food Security Strategies. ISBN 978-952-5726-10-7. Proceedings of the Third International Symposium on Computer Science and Computational Technology (ISCSCT '10). Jiaozuo, P. R. China, 14-15, August 2010, pp. 487-491, 2010.