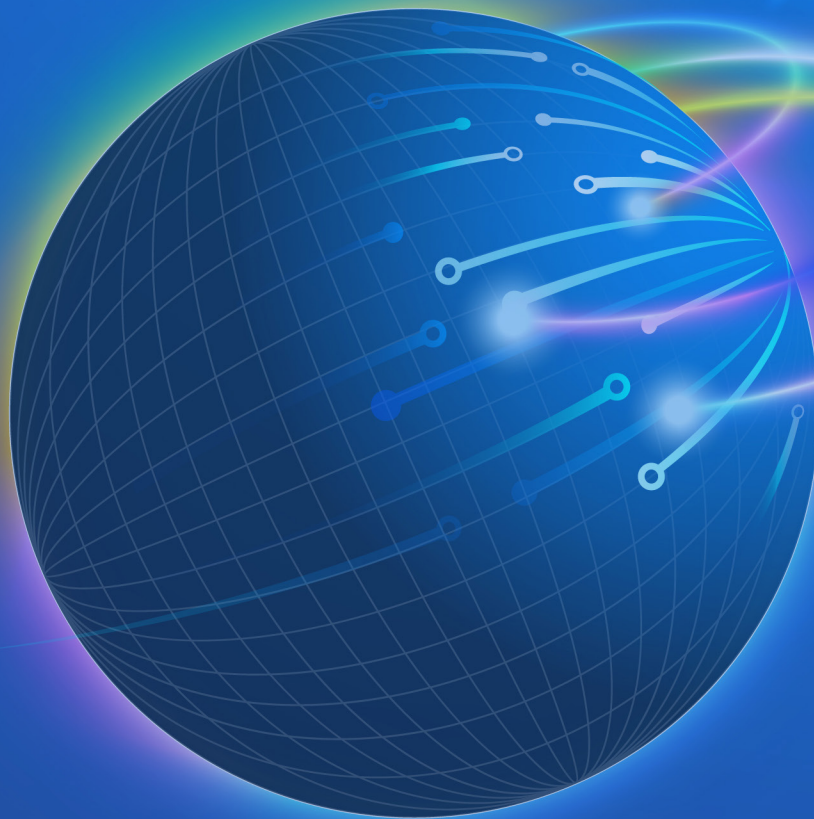




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Web-GIS and Artificial Intelligence A Panacean for Agriculture Advancement in Developing Countries - A Review

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ABSTRACT

Agricultural contributions to the economies of developing countries, including Nigeria, have been declining. This paper proposes leveraging Web-GIS and artificial intelligence (AI) to rejuvenate agriculture in these regions. It aims to dissect the components of Web GIS, examine spatial data capture methods, delve into AI for image processing, and develop revenue-generating strategies to boost Nigeria's agricultural sector. Despite substantial capital investment, agricultural outputs remain below expectations, primarily due to informational gaps regarding land use, planting techniques, and storage. The bureaucratic management of public agricultural sectors further delays disseminating research findings to farmers. Adopting Web-GIS and AI offers a modern solution to these challenges, facilitating real-time analysis and communication of vital information related to soil conditions, farmer challenges, and broader socio-economic and environmental concerns. This approach promises to elevate agricultural practices by integrating technologies like the Internet of Things, GIS, and extensive data-sharing capabilities across the web. The paper emphasizes the potential of ubiquitous smartphone use and widespread internet connectivity to transform agricultural information dissemination. It advocates for leveraging the digital infrastructure of smart cities to enhance access to agricultural data, ultimately improving farming practices across Nigeria. The fusion of Web-GIS and AI with existing telecommunications networks presents a viable path forward, enabling farmers to make informed decisions, improve productivity, and contribute more significantly to the national economy.

INTRODUCTION

Access to information relating to good high-yield agrarian land, improved hybrid seedling, and crops by farmers will contribute positively to the growth of the developing Country's economy. It is not out of place to emphasize that agriculture is practiced by the private sectors and not until recently when some State Governments collaborated with foreign partners to produce local home grown rice to alleviate the hardship faced by the citizenry. Specifically, Japanese Grant Assistance for Grassroots Human Security Projects gave a cheque of \$148,209 to the New Initiative for Social Development to increase rice production potential in Ekiti State through the acquisition of modern technology (NIPC, 2020). However, the role of Government before now hinges on the provision of farm tools, insecticides, fertilizers, and lands under rain-fed methods in the southern part of the country, while a poor irrigation system is the other day in Northern Nigeria. Never has any farmer practiced a 'dry irrigation' system in the mangrove area of the southern part of Nigeria to convert the waterlogged areas to dry land in line with Konukcu *et al.* (2005)? The resultant effects of shackles agriculture practice are low yields in farm products. The presence and impacts of research institutes in Nigeria like IITA.org. Ibadan, Universities and colleges of Agriculture, etc are not readily felt in the region where it domiciles and not to think of other regions within the Federation. More effort should be directed

towards result oriented research that centered on the determination of soil Physico-chemical properties across target area of the country instead of been generalized.

The production of geoinformatics maps that will essentially depicts area that have propensity for large scale farming become imperative. Soil information and associated thematic map should reach the farmers before planting season commences. Agric extension worker and geoinformatics expert that will train and interprets specific soil characteristics and thematic maps should visit consortium of farmers across Nigeria. These activities will be time consuming, cumbersome and involve huge capital outlay. The leeway from the conventional approaches is to imbibe the use of Web- GIS and AI as panacea for agriculture development in Nigeria. It will efficiently enable complex, socio-economic, and environmental issues confronting agricultural advancement in the country to the next level be shared and discuss on the fly.

The role that internet, World wide web (www) and GIS on the web will play when deploy as a platform where issues relating to soil characteristics, farmers challenges and Government endeavors would be unprecedented in the history of agricultural practices in Nigeria. The availability of affordable smart android cell phones and broad band internet access across the nook and cranny of Nigeria will act as the vehicle for the dissemination and transformation of Nigeria agriculture.

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Proposed Basic Components of Web GIS

The deployment of agricultural practice in Nigeria on the web will invigorate the present deplorable methods if metadata access, electronic mail service, real time data analysis and field note capabilities are provided. It will enhance farmers and non-farmers ability in the modern way of practicing agriculture. The components will make agriculture practice in the country thick, result oriented and provide potential for exports of goods and services to African Sub-regions and beyond leading to foreign exchange earning.

Metadata Access

It is envisaged that metadata about agriculture in Nigeria will be contributed from various regions. Hence, it will be huge and space-consuming. The rise and awareness of distributed processing, World wide web and internet should be annexed to distribute the data to the farmers in their remote locations. Many GIS packages on the web can efficiently use metadata in a multiuser approach regardless of data accessing technology. Farmers can download agricultural data and information on demand or simply viewed on a locally displayed client web browser. The metadata could be on offline mode once downloaded to minimize the inherent and insistent fluctuation in Global Satellite Mobile communication network.

Electronic Mail Service

The ubiquitous ways though which electronic mail can support and contribute to the development of agriculture in the Country cannot be over emphasis. For instance, farmers can be notified by e-mail service the instant metadata updater discovered that new maps, referents lands, soil characteristics, high yield crops types from latest research are available online. It is also possible for farmer to exchange idea, request assistant from farmers in any part of the World, and to also share pertinent latest agricultural data stored in standard structures that is accessible through on-line clearinghouse via electronic mails. This approach would tremendously enhance farmers in the Country to favorably compete and collaborate with their colleagues in other nations. It will also promote seamless agricultural resources visualization via the web.

Real Time Data Analysis

Recent advancement in computing has initiated the plan of computing cyber infrastructure which is also known as grid or cloud computing on the web (Al-Bayari, 2019). Cyber infrastructure will provide great capabilities by allowing farmers to linkup through a network with system where data, programs, information and knowledge on agriculture new initiatives domicile. Also, it will enhance easy access and communication with the researchers to garner the procedure of how to carryout real time analysis on available data. The availability of open-source software and online spread sheet will provide the necessary leverage the farmer required for real time

analytical operations on the fly. For example, soil sample derived from a generalized soil sample database can be link with a digitized local Government boundary to generate web-based soil suitability location map analysis in real time. The possibility of simple online based agricultural land analysis will revolutionize agriculture practice in city to limitless possibilities.

Field Note Capabilities

The United State department of Defense's GPS, the European Space Agency's Galileo, the Russian's GLONASS, and the China COMPASS Navigation(Clarke, 2011) system has the capability to provide reliable centimeter accuracy of any location in the World. Also, the availability of cheap java, Symbian and android phones that has been incorporated with GPS tools in Africa will allow farmers to record the position and image of infested crops on the field to be transmitted online to any agency for identification and treatment actions.

These devices can be pre-programmed to precisely navigate farmers to the point of diseases infestations from farmstead. Never again would any farm assistance ask for the location of diseased crops when these technologies with its inherent flexibility are incorporated into daily farm operations. Also, these devices become handy and useful tools to capture various data relating to advancement of agriculture for uploading into web GIS directly in line with Clarke (2011). The highest precise location determination of these portable devices constitutes a benefit to web GIS and agricultural advancement in real time

Spatial Data Capture for Agriculture

Spatial data relating to agriculture advancement in Nigeria need to be capture and downloaded into web GIS. The data include soil characteristics, spatial pattern of land use types, settlement, roads network types, water bodies etc. Landsat imageries, Quick bird, and Lidar imagery are natural repository of these data. Drone, an airborne device can also be used to capture real-time spatial data of the farmland. The data need to be downloaded from the link and device containing them and geo-rectified to WGS84 or International Terrestrial Reference System (ITRS). The WGS84 has received unprecedented acceptance and usage throughout the nook and cranes of the World but ITRS is the most precise, better maintained and acclaimed to be of international standard (Clarke, 2011). Also crowd sourced mapping approach can be deployed to enhance speedy real time data acquisition from the field (Capineri, *et al* 2016). This involves the construction of a crowd source platform and a ground truth data submission platform with cloud computing application (Al-Bayari, (2019) using any of the free online GIS software. The data submission system will be utilized for generating ground truth data by digitizing the Country agricultural boundaries based on ecological zones with the capability of visual interpretation of satellite images (Haklay & Weber 2008)

Data Processing

The image processing can be executed using two basic approaches namely image processing in GIS environment and image processing using artificial intelligence approach. The former involves a procedure to extract various classes in each ecological zone and matched with the digitized regional map of smart cities. Specifically, training sites would be created and digitized in the imageries based on verified land uses from the field. Here, hard classifier would be done using the Maximum Likelihood classifier algorithm and Land use/cover mapping of each ecological zone on regional basis would be analysed to reveals the most suitable land for a particular crop. Also, Idirisi Selva and, ILWIS software plus other sophisticated image processing software can be used to achieve this laudable objective. The resultant spatial map will be vectorize / polygonise to allow further analysis.

Similarly, the latter involves the deployment of artificial intelligence image processing procedure according to Holzinger *et al* (2023) and (Nivanya, 2024). and AI image-processing Python libraries or image recognition platform such as Nanonets can also be used. Specifically, artificial intelligence approach will significantly improve the potential and ability to understand, interpret, and manipulate visual data that may escape the human eye by utilizing sophisticated algorithms and machine learning strategies classification process. Given that a large number of supervised classification methods such as random forest, artificial neural networks, support vector machines, Bayesian decision rules etc are available for image classification process and geospatial mapping. The overall objectives of the AI image processing are to obtain a better and definable vector map products that will be serve online for users.

Web GIS Technology

The choice of mapping, database creation and standards are the necessary steps towards the development of web GIS and AI application for agriculture advancement in Nigeria. Web GIS is essentially an integrated web-accessible software, a 2-D database comprising one or more base maps and an associated collection of services (Longley *et al.*, 2011). An important part of every web mapping application is its mapping or visualization technology, which makes it possible to show data in the form of web map (Adnan *et al.*, 2010).

The defining characteristic of a web GIS and AI approach to map suitable soil and agricultural resources of any Nation are significantly the quality of the base map. The visualization of data as maps has become increasingly popular, with hundreds of websites presenting geographic data while the popularity of web GIS applications and the entrant (AI) arises in large part through the wide dissemination of software that makes it easy for users and developers to publish map data (Adnan *et al.*, 2010; Nivanya, 2024).

The visualization and publishing of soil suitability map for agriculture development should be based on genuine

cartographic concept and reliable principle. The accepted principle involves map compilation; map designing; map visualization and production of hard and soft copies of multivariate land use and land cover maps to communicate soil suitability characteristics information to farmers. The basic GIS data processing steps to successively transform a database of geographic information into a web map are: data collection, editing and maintenance, data management, analysis, visualization and web publishing shown in figure 1.

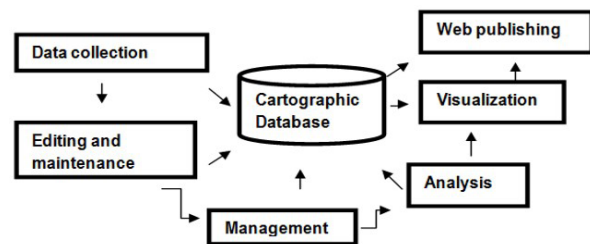


Figure 1: Basic GIS data processing steps

Source: Adapted and Modified from Longley *et al.*(2011)

The improvements in usability through non expensive, portable, improved and interactive user technology interfaces inform of LED-backlit glossy widescreen, multi touch display with IPS technology, high pixel resolution, fingerprint-resistant oleo phobic coating, support for display of multiple languages and characters simultaneously, couple with Wifi, Bluetooth and high storage, camera, photos and video recording capability. These qualities explain the reasons for the increased worldwide acceptance of visualization techniques (Aoidh *et al.*, 2008). Flash maps techniques (FMT) based on vector images, slippy maps techniques (SMT) implemented on tile-based maps, and Static Map Renderers techniques (SMRT) are some of the basic ways in which visualization functionality can be implemented (Adnan *et al.*, 2010)

SMRT has the capability to render maps to an image formats such as PNG , Jpeg, GIF etc. and then re-send the image back to the farmer or other user who then view it with the help of web browser or desktop applications. Alternatively, Web access is provided in the SMRT via user interactive accessible open interfaces and typically, a request can be issued from, and responses processed and visualized in a standard web browsers of farmer's viewing device (Adnan *et al.*, 2010; Longley *et al.*, 2011). This is the ideal web GIS technology that should be use for agriculture advancement in the Country base on IOT.

Web Application Development Standards

These are basically divided into two great categorical standards: design standards and development standards. The former involves the pre- development organization, configuration and capability of a web application, decided by the web designer prior to starting the development of the web application for agricultural advancement using web wire-framing- i.e., 'simple line drawing' to show the placement of elements on the web

page thereby showcasing how the web page will look like after development. Some of the tools that are available to design web wireframes include Adobe Illustrator, Visio and ProtoShare.

The development standard would essentially be used to determine the choice of an appropriate development technology for the web application. For instance, Dot NET (.NET) is a development technology that can be used to develop software or web applications while, SQL Server is a database server which can be used as the back end of web applications. Other notable development technology includes ASP (Active Server Pages), JSP (Java Server Pages), ASP.NET (Active Server Page dot Net), PHP (Pre-Hypertext processor) (Adnan *et al.*, 2010). Also Hypertext Markup Language (HTML), Cascading Style Sheet (CSS) (W3C, 2016) and python (Charles, 2009). The choice of developmental standard to use depends upon the developer's operating environment. However, the combinations of PHP, HTML, and CSS should be used as the development technology standard for agriculture advancement on the web.

Web GIS for Agriculture Development and Management

The internet of things serves as a tool for extending the capabilities of GIS to multi-users and for multi-tasking around the globe. These capabilities will be used to present the output from agriculture resources in Nigeria to the Global community.

GIS Modeling of Data and Integration into the Web

In order to model data and integrate into the web in GIS environment, the vectorised / polygonised soil suitability maps obtained after hard classifier in section 4.0 will be exported to ArcGIS environment where it will be converted into a Shapefile format and stored in a geo-database.

Geo-database Design

The geo-database creation involves a three phase procedure: design/conceptual phase, construction phase and the implementation phase. The design phase involves the selection of either Tessellation data model, vector data model and object-oriented data model (Worboys, 2005) to model the reality e.g. Modeling the reality essentially involves symbols and color determination (graphic symbolization), configuration of graphical and non-graphical files, active layer definition, layers scale, visualization of web GIS products (report generation format), access and file restrictions.

The construction phase conspicuously involves: the use of logical and physical design models to set up the geo-database; provision of ways of converting data source into geo-database and providing the methodology of maintaining the geo-database after creation. Any of the following specialized database management system (DBMS) software which guarantee data integrity and longevity can be used to implement the geo-database: relational

(RDBMS), object (ODBMS) and object-relational (ORDBMS). Others include – DB2 Spatial Extender and Informix Spatial Database (IBM); SQL Server (Microsoft); Oracle Spatial (Oracle) and PostGIS (Open source) (Longley *et al.*, 2011). The following add-on fields could also be a necessity: URL, addresses of farmer's home page, remarks, e-mail subscription window etc.

However, the most popular DBMS are Oracle and SQL Server. The SQL (Structured or Standard Query Language) is the standard database query language adopted by all mainstream databases, and so: it may be used directly via interactive command line interface; it may be compiled in a general-purpose programming language such as C/C++/C#, Java, or Visual Basic; or it may also be embedded in a graphical user interface (GUI) (Adnan *et al.*, 2010 and Longley *et al.*, 2011). SQL Server by Microsoft should be used to perform analytical query in the geo-database for agriculture advancement in Nigeria because of easy availability. Similarly, the procedure for the development and implementation of a web mapping application for agriculture advancement is presented in the following subsection

Implementation

In order to implement a web mapping / display service aspect for agriculture advancement, the following steps should be taken:

- i. A map server application e.g. ASPMAP.net, ARCIMS, Arc Server, Python, etc should be installed on the mapping server machine to drive the application on the web in order to enable the application to work. This aspect will be handled by a web hosting company;
- ii. A scripting language should be used to write basic scripts program that the map server software will work with to display the maps on the browser or to perform some basic custom applications as may be desired e.g. PHP.net language – this is an open source application package or a more robust application may be used;
- iii. Web wireframes should be used to: show the placement of elements in the web page, provide a visual guide to the website and demonstrate the links between different pages in the website (Miller, 2008). For instance, HTML and CSS application package should be used to produce the wireframe (skeleton) and provide color and graphical appearance while Java scripts for interactive display;
- iv. An amount of money in American Dollars will be paid to the web hosting company for web hosting service to allow the service provider install the chosen web mapping software on the server;
- v. A domain name should be paid for and registered. The domain name is the platform from which the web service will be accessed. The domain name and the hosting service can be obtained from one source.
- vi. Maps / data to be displayed on the web mapping service will be prepared by an experienced programmer in the formats that the mapping server software will implement – example is the ArcGIS Shapefile format.

Web GIS Revenue Driven Approach and Job Creation

Huge capital is required to fund agricultural research oriented viz: designing, hosting and maintaining of a robust dedicated website for agriculture advancement. Ordinarily, Government agency should finance the new concept but where this is not the case interested private organization initiative can saddle herself with the responsibility. The operation of the web GIS for agriculture advancement should be based on the principle of indirect beneficiary payment and an outright online user's payment syndrome.

The former payment system is based on the concept of pay per viewing. For instance, each time any user around the globe accesses the dedicated website for either information, viewing a smart cities Agric products through unsolicited pop-up advert on a Google webpage or downloading contents, such user is indirectly making payment without actually realizing it through his/her online activity.

The latter would be based on the purchase of online scratch card from Banks, Post Office, online media, and major business outlets in Nigeria. Both approaches will yield high revenue and a self-sustaining system.

The system when operational has the potential to create at least one million jobs at it take off. For instance, in 2012, Agric Employers in Nigeria was 7,858,161 males and 5,277,961 females while Agric employees were 5,226,561 males and 4,609,050 females (Kale, 2013). The youth in agriculture employment figures was when the employer had no access to real time information on soil suitability data, planting methods, fumigation time, harvest and storage of farm products.

CONCLUSION

Web GIS and AI for agriculture advancement applications will empower individual farmers as well as farmers organizations to have access to soil suitability spatial maps seamlessly, integrate information, visualize scenarios, present powerful and motivating ideas about cropping, and develop effective and efficient knowledge base solutions to inherent agricultural problems. The soil suitability maps of Nigeria digitally generated and cartographically rendered and serve on the web will enhance comparative analysis between soil suitability maps for agriculture advancements based on the ecological zones to be quantitatively determined. Also, solutions to agricultural problems militating against high yield from the six geopolitical zone of Nigeria can be published on the World Wide Web for multi-user access and updating.

RECOMMENDATION

The research recommends that, Governments in Nigeria both Federal and State should as a matter of urgency adopt and execute this research in order to put an end to hunger, unemployment and poverty. Also, there must be a policy issue to be approved by Nigeria Senate on sustainable agriculture practices driven by modern technology. In addition, Nigeria Government should collaborate with other Nations in the World to proffer

solution to any problem confronting agriculture practices.

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