Geographic Information System (GIS) And Its Nexus To Agriculture: Making Improved Technology Accessible To Farmers In Nigeria.

Asiru Monday ABBAS, Unekwu Hadiza AMANABO

Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria, Kaduna State. Tel: +2348035921964
E-mail: asiruabbas@gmail.com

National Space Research and Development Agency, Abuja, Federal Capital Territory.
E-mail: uneks55@gmail.com

ABSTRACT: The study examined agriculture, its challenges in Nigeria and how GIS can be applied effectively to help farmers to increase their yields. The study opined that agricultural production in Nigeria has taken a serious nosedive since the discovery of crude oil and for the country to regain her lost glory, improved technology must be applied to raise production in order to meet domestic needs, reduce dependence on imports which is costing the country billions of Naira on annual basis and one of such technologies is GIS. The study enumerated useful applications of GIS in agriculture in areas such as water quality control, soil suitability, agro-climatology, management of natural resources, disease and pest control. Also, the use of GIS helps to avoid excessive use of fertilizers and other chemicals which can have negative environmental effects based on analysis of data. It is recommended that government should make agricultural information, weather forecasts available to farmers in order to guide them in their decision making processes especially on annual rainfall pattern, soil suitability for a particular type of crop, disease and pest control, water quality control etc. The study suggested that farmers should embrace improved technologies such as GIS to plan their crop's cultivation in cost effective manner so as to maximize yield.

Keywords: nexus, geographic information system, applications, agriculture.

1. INTRODUCTION

Agriculture has always played a significant role in Nigerian economy, it contributed about 42% of the Gross Domestic Product as against 13% for oil and gas in 2009 and 40% in 2010 [1]. Agriculture is pivotal to the Nigerian economy as it employs more than 60% of the populace, majority of whom live in rural areas. Agriculture used to be the mainstay of the Nigerian economy before the discovery of oil and it brought prosperity to farmers all over the different regions of the country. Farmers in the north concentrated on arable crops such as groundnut, rice while those in the west focused on crops such as cocoa, coffee and farmers in the old mid-western region specialized in palm oil production. With the discovery of oil, agriculture began to take the back seat. In Nigeria today, we import different food items such as rice, sugar, fish that can be produced locally and our import bill on annual basis keeps skyrocketing. Continuous import means that we export job to other countries of the world at the expense of the local population especially in a country like Nigeria where unemployment is a major problem. Also, lack of basic amenities in the rural areas results in rural-urban migration which makes active young population to leave the rural areas for urban areas leaving the aged population behind to practice agriculture in subsistent manner with crude implements resulting in low agricultural yield. Agricultural practice in Nigeria is plagued by a lot of factors such as rudimentary technology, inadequate farm inputs, volatility in market prices of agricultural produce, inadequate storage and processing facilities etc. As at 1961, Nigeria was the leading exporter of groundnut with a global share of 42% and the country also had 27% of the world's palm oil export, 18% of cocoa and 1.4% of cotton as the major West African cotton exporter [2]. This glory however took a serious nosedive, declined over the years, hence, Nigeria dominance in the export of groundnut was eclipsed by China, United States of America (USA) and Argentina as at 2008. Indonesia and Malaysia took over in palm oil, Cote d'voire and Ghana also become the leading exporter of cocoa while Mali and Bukina Faso led cotton exports [2]. Greenhouse effect has made sustainable agriculture to become increasingly difficult. Vagaries weather all over the world as a result of global warming which is being precipitated by green house effect has assumed an important dimension globally and this has resulted in changes in pattern of rainfall and temperature; and events like floods, storms, prolonged dry spell, erosion, sea level rises, forest fire have become common occurrence. Global warming results in changes in climatic conditions which has serious implications for agricultural productivity. For instance, prolonged dry spell affects crops' growth, flowering, fruiting, yield etc. Also, some farms have been washed away by floods leading to serious economic losses on the part of the farmers. Poor agricultural yield will lead to increase in prices of available agricultural produce in the market and this can make food difficult for the poor to afford, thereby leading to hunger in the land and where there is hunger, malnutrition and diseases are not far-fetched. Also, deadly clashes have been reported between farmers and herdsmen as a result of decline in pasture and water supply which are effects of changes in climatic conditions. Conflict over land and river between farmers and nomadic herdsmen has become a frequent issue in Nigeria. For instance, so many lives were lost in early part of 2017 in Agatu controlled areas of Benue State, North Central Nigeria as a result of clashes between farmers and nomadic herdsmen. Agricultural practice in Nigeria is almost entirely rain-fed which makes it vulnerable to changes in weather conditions. This indicates that rain-fed agricultural practice that is subject to vagaries of weather may likely lead to a decrease in yield which can lead to food insecurity, hunger and poverty. Under such conditions, Geographic Information Systems are incredibly helpful in being able to map and project current and future

fluctuations in precipitation, temperature, crop output, and more [3]. By mapping geographic and geologic features of current (and potential) farmland scientists and farmers can work together to create more effective and efficient farming techniques; this could increase food production in areas that are struggling to produce enough for the people around them. GIS can analyze soil data combined with historical farming practices to determine the best crops to plant, where they should grow, and how to maintain soil nutrients' levels to best benefit the plants [3]. In order to reduce hunger and ensure regular food supply throughout the year in a country like Nigeria that depends largely on rain-fed agriculture, it is important that improved technology is applied and GIS is a powerful analytical tool that can be used especially in precision agriculture because it is efficient and also helps to cut cost.

2. GEOGRAPHIC INFORMATION SYSTEM AND ITS APPLICATIONS IN AGRICULTURE

Geographic Information System (GIS) is a computer oriented system that is used to capture, store, analyze, manage, model and display spatially referenced data and is used to provide solutions to a wide range of problems in numerous fields of endeavor such as agriculture, geography, aviation, engineering, geology, environment, astronomy, archaeology, architecture etc. The application of GIS in this study will be focused primarily on agriculture. GIS is an advanced technology that makes us of hardware, software and data. According to [4], the data can represent anything as long as it has a geographic component in it while the hardware can be anything from a desktop computer or laptop to satellites, drones, and handheld GPS (Global Positioning System) units. There are a few different software packages, but ESRI's ArcGIS suite is the industry standard [4]. Some of the applications of GIS in agriculture include water quality monitoring, determination of soil suitability for a particular use, agro-climatological importance, management of natural resources, disease and pest control.

2.1 Water Quality Monitoring

GIS can be used to investigate the quality of streams, rivers and oceans in order to determine the suitability of such water body for agricultural purposes. Through GIS, pollutants in water body can be detected and through such means, decision can be taken on whether such water can be used for aquaculture, irrigation or other agricultural purposes such as drinking water for livestock. Knowing the suitability of water source for a particular agricultural purpose will go a long way in reducing losses because it will serve as a useful guide to farmers thereby helping them to avoid needless economic losses especially for some of them who normally take loan to carry out agribusiness. This is particularly important for those who practice large scale fish farming because a mistake like using polluted water to raise fish can lead to high mortality rate and this can even lead to the farmer losing whatever he used as collateral security to secure loan from bank which could be his house, land or sometimes leads to suicide on the part of the farmer.

2.2 Soil Suitability Determination

GIS is used to determine the suitability of a particular piece of land for agricultural purposes. GIS software can be used to analyze data like soil nutrient composition. If farmers have information about nutrients that are available and those that are deficient at a spot in a particular soil, this will guide them on the type of fertilizer to purchase and where this fertilizer can be applied in appropriate quantity and this will help to cut cost of production and boost farmer's output. This will go a long way in guiding farmers in making the right decision on the type of crop to grow or raise on a particular type of soil. In general, farmers can use geographical data to select the best location or site for a particular crop by looking at data on rainfall, soils etc. GIS is also used to determine the vulnerability of land to erosion based on the slope of such land and this will serve as a useful guide on where to locate farm site, road, drainage channels etc. Also, GIS serves as a useful guide in disposal of dead bodies of animal. For instance, if there is high mortality rate in a large scale poultry farm or any other animal farm, with the use of GIS, soil can be mapped and their properties analyzed and the best site for such disposal activity can be determined so that there is little or no damage to the environment, biodiversity and water sources such as rivers, streams etc. The response to such an emergency situation or disaster will be much more rapid if government agency in charge of such information such as soil suitability for a particular purpose already have them in their archive.

2.3 Agro-climatology

The need to make agro-climatological information available to farmers cannot be over-emphasized as agricultural activities have to do with time i.e. planting time, harvest time are very important. In applying GIS in agro-climatology, data collected from the field are very important and direct field observation is also very key. Data collected from the field can be used directly and sometimes they can be subjected to additional treatment before they are made use of. GIS can be used to produce images, not only maps, but cartographic products, drawings, animations or interactive instruments as well and these products allow researchers to analyze their data in new ways, predicting natural events, explaining events and planning strategies [5]. [6] indicated that GIS has huge potential for agroclimatic modelling. [7] reported that by incorporating temperature and aridity thresholds, agroclimatic models can be logically adapted to be species specific. For example, [8] identified four potential agroecological zones for the growing of Maize in West and Central Africa, whereas [9] used temporal remote sensing data along with spatial soil, rainfall and temperature data to derive a potato growing index for West Benghal. [10] made use of thin plate splines to model climatic gradients in Canada to determine plant hardiness zones. Utilizing a trivariate position of latitude, longitude and elevation, rainfall and temperature maps were used which enabled the mapping of each variable required for plant hardiness formulae at 1km resolution.

2.4 Management of Natural Resources

Natural resources such as water, forest can be effectively managed through the application of GIS technology. For instance, GIS is used to analyze geographical distribution of water in an area as water is a vital resource in agricultural production. This is very important and serves as a guide to farmers whether there will be any need for irrigation or not

in such an area. As a result of rapid increase in population, there is enormous pressure on land and this can make farmers to encroach on protected areas such as games reserve, parks, forests etc. With the aid of GIS and GPS, it is possible to fix boundaries between lands designated for conservation purposes and agricultural uses. Also, forests are important renewable natural resources and provide such resources as grazing land for animals, wildlife habitat, water resources and recreation areas [11]. GIS can be used to monitor the rate or extent of deforestation thereby helping to raise awareness about the enormity of the problem which can prompt government or community to take proactive steps in tackling the problem. Geospatial data are of immense importance and they can be deployed in the management of plants and animals whether they are endangered species or newly introduced species.

2.5 Disease and Pest Control

Diseases caused by different microbes and pest infestation affect crop growth, delay flowering and maturation; and eventually reduce yield and economic value of such crops. GIS is an effective tool that can help in mapping out areas of farms that have been affected by disease and pest infestation especially on a large scale farm. This mapping helps farmers to focus on the affected areas instead of applying drugs and pesticides indiscriminately on the entire farm thereby helping to prevent excessive use or application of chemicals which can have negative impact on the environment and even raise cost of production thereby reducing farmer's profit.

3. CONCLUSION

Agriculture is a big employer of labour particularly in a developing country like Nigeria but there is no doubt denying the fact that a larger proportion of Nigerian farmers still use rudimentary technology in their agricultural production and that is why it is important for government to make improved technology like GIS accessible to farmers and farmers too should embrace the use of GIS to carry out precision agriculture which ensures that both crops and soil get exactly what they need for optimal performance. GIS application in agriculture is of immense proportion and government at all levels should assist farmers by making agricultural information available to farmers in the language that they understand particularly at the appropriate time. Information on soil type that is suitable for a particular crop type, annual rainfall pattern prediction, areas vulnerable to flooding etc should be made regularly available to farmers by agencies of government and agriculture-related research institutes in order to guide them in their decision making processes. GIS can be used to develop highly efficient farming techniques which can lead to increase in safe and nutritious food production thereby helping to avoid the problem of food insecurity with its attendant consequences such as malnutrition, food swamps, food deserts etc.

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