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Geoinformatics in Agricultural Development: Challenges and Prospects in Nigeria

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KEYWORDS Remote Sensing. Geographic Information System. Global Positioning System. Precision Farming

ABSTRACT The paper reviews agricultural development in Nigeria, in the context of the emerging technologies of Geoinformatics, specifically Remote Sensing, Geographic Information System (GIS) and Global Positioning System (GPS). It expounded on the principles of Geoinformatics and their relevance in agricultural development. A critical analysis of the prevailing situation in Nigeria reveals the shortcomings of the current methods of data collection, analysis and management. This emphasizes the need to adopt Geoinformatic methods to improve agricultural productivity to meet the nutritional need of the teeming Nigeria masses as well as for export income. The challenges in this wise are low level of technological development, inconsistency and inept implementation of government policies, low level of investment, small land holdings, heterogeneity of cropping systems and market imperfection. To surmount these constraints a number of measures are suggested.

INTRODUCTION

The less developed countries hold sixty percent (60%) of the world's 6 billion people (Lexicon Universal Encyclopaedia 1983). In these countries high birth rate in the face of depleting resources and poor agricultural land management practices have resulted to a preponderance of food and environmental problems. Africa is made up of less developed countries, bedevilled with the ills of rapid population growth and declining agricultural productivity. The consequences are manifested in widespread cases of food shortage, poverty, poor resource utilization and land degradation.

Nigeria, with a population of 140 million people (provisional result of the 2006 population and housing census), is the most populous country in Africa. Successive governments since national independence in 1960 have introduced a myriad of agricultural development programmes and policies aimed at enhancing agricultural productivity to feed the rapidly expanding population, provide raw materials for the agro-industries and for export income (Ingawa 2004; Akinbode 2000). But, the agricultural problems in Nigeria and in particular, food self-sufficiency have assumed alarming proportions largely because the rate of growth in the sector has not been commensurate with that of population. Hence, the need to improve agricultural productively is real and urgent.

A fundamental constraint of agricultural development in Nigeria is the use of poor methods of data and information acquisition on agricultural land potential, crops condition and farming activities. The consequence is poor knowledge and unreliable data for agricultural planning and policy formulation. For instance, unguided use of land whose consequence is often the misuse of prime agricultural land is characteristic of agriculture in Nigeria. This has adverse implications for agricultural development since the bulk of agricultural production takes place under traditional systems, with a high dependence on natural forces and processes for the maintenance of yield and the quality of produce (Areola 1991).

To address the problem of misuse of agricultural land and improved productivity, it is necessary to adopt Geoinformatic techniques of Remote Sensing, Geographic Information System (GIS) and Global Positioning System (GPS), which enable the acquisition of relevant and timely data and information on agricultural land and activities. For instance, improvement in remote sensing technology have opened newer possibilities of improving agricultural statistics systems as it offers accelerated, repetitive and spatial-temporal synoptic view in different

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windows of the electromagnetic spectrum from its vantage point in space (Singh et al. 2003). It also has the advantage of wide coverage, provision of permanent record, mapping base, cost-saving and real-time capability (Balaselva kumar and Saravanan 2003). Geographic Information System (GIS) is a potential tool for handling voluminous remotely sensed data and has the capability to support spatial statistical analysis (Singh et al. 2003; Balaselvakumar and Saravanan 2003). Global Positioning System (GPS) is for the determination of accuracy in the location of equipment, soil sampling points, inputs application, adjustment of tillage to suit variability in field conditions, as well as recording yield data across the field (Precision Ag. Org. 2003; Mishra et al. 2003).

While the developed countries of the Western World have been reaping immense benefits from the application of geoinformatic techniques in agricultural practice, Nigeria and many other countries of the Developing World are yet to take advantage of the opportunities offered by these technologies. However, with the launch and subsequent operation of NigeriaSat 1, the need to exploit the merits of geoinformatics in agriculture in Ngeria is rife. Therefore the objective of this paper is to expound the relevance of geoinformatic techniques in agricultural development, examine the situation in Nigeria and consequently make a case for the adoption of geoinformatic techniques, and in particular Precision Farming techniques in Nigeria.

GEOINFORMATIC CONCEPT AND PRINCIPLES

Geoinformatics is a new discipline concerned with the modeling of spatial data and the processing techniques in spatial information systems (Molenaar 1998). It is a multidisciplinary science that integrates the technologies and principles of digital cartography, remote sensing, photogrammetry, surveying, Global Positioning Systems (GPS), Geographic Information Systems (GIS), and automated data capture systems using high-resolution geo-referenced spatial information from aerospace remote sensing platforms. Thus, *geoinformatcs* provide tools that allows for the processing, manipulation and analysis of spatial data into information tied explicitly to, and used to make decisions, about portions of the earth and environmental problems (DeMers 1997). The techniques can include all stages of data collection, data processing, data base management, data analysis and modelling and data presentation, to end use in the creation of maps and spatial information products. We can understand the concepts clearer when we consider the principles of the following component sub-fields (Ikhuoria and Rilwani 2002):

- *Cartographic principles* involve map compilation, map design, and map visualisation and production in analogue or digital computer environment.
- *Remote sensing* involves the acquisition of spatial data of the environment without physical contact with the objects or features being sensed by using electromagnetic energy radiation, interaction and detection principles in analogue or digital formats.
- *Photogrammetric principles* involve the art and scientific processes of obtaining reliable information about the physical environment by interpreting remotely sensed aerospace data (aerial photographs and satellite imageries) in analogue or digital formats.
- *Surveying principles* involve the adroit use of fundamental methods (processes) and technologies (instruments) to determine the precise position and dimensions of points (features) on the earth's surface and the presentation of the results in analogue or digital format.
- *Global Positioning Systems* (GPS) involve precise surveying (determination of position and dimensions of points) by applying resection and satellite constellation principles and the presentation of the results in analogue (maps, tables) or digital formats.
- *Geographic Information Systems* (GIS) principles involve data gathering, data processing, database management, data modelling and visualisation in a digital computer environment.
- *Automated data capture systems* include multi-spectral remote sensing processes, GPS data, map digitisation and scanning, and computer input and output technologies.

THE RELEVANCE OF GEOINFORMATICS IN AGRICULTURE

Geoinformatics, and in particular remote sensing, Geographic Information Systems and Global Positionong Systems technologies have become indispensable in modern agriculture. Advances in remote sensing have revolutionized the gathering of information on agricultural activities, including land use, soil condition, weather condition etc that are essential for site characterisation and consequent site selection for farming. For instance the biophysical components of the soil and environment can readily be deduced from information interpreted from satellite imagery, which will in turn serve as the basis for determining site suitability for specific agricultural purposes when duly analysed in a Goegraphic Infromation System environment (Iyalla 2004).

Since remote sensing techniques have the unique capability of recording data in visible as well as invisible (including ultra violet, reflected infrared, thermal infrared and microwave) parts of the electromagnetic spectrum, it enables us see beyond the capability of the human eye. For instance trees or plants, which are affected by diseases or insect attack, can be detected by remote sensing technique much before human eye sees them (Balaselvakumar and Saravanan 2003). Such early detection is vital for the application of remedial measures. Remote sensing techniques are also useful in the determination of the spatial distribution of plant status (health or efficiency) and corollary expected yield by measuring the greenness of the field (Iyalla 2004).

Detection, identification, measurement and monitoring of agricultural phenomena are predicated on the assumption that agricultural landscape features (such as crops, livestock, crop infestation and soil anomalies) have consistently identifiable signatures on the type of remote sensing data (Balaselvakumar and Saravanan 2003). These identifiable signatures are a reflection of crop type, state of maturity, crop density, crop geometry, crop vigour, crop moisture, crop temperature, and soil moisture as well as soil temperature. Detection of features to a large extent depends on the type of sensor used and the portion of the electromagnetic spectrum used in sensing. Table 1 shows the regions of the electromagnetic spectrum relevant in agricultural resources survey for sensors operating in the green, red and near infrared regions of the electromagnetic spectrum, while Table 2 shows some specific areas of application.

Geographic Information System is another geoinformatic technique that is quite relevant in agricultural development. There are numerous definitions of Geographic Information Systems in the literature (Maguire et al 1990; Ayeni 1998; Abumere 1997). For our purpose however, DoE (1987) definition will suffice. DoE, defined Geographic Information System as a system for capturing, storing, checking, manipulating, analysing and displaying data, which are spatially referenced to the earth. Thus, a true Geographic Information System is designed to accept, organise, statistically analyse and display diverse types of spatial information that are geographically referenced to a common coordinate system of a particular projection and scale.

Table 2: Areas of specific application of remote sensing in agricultural surveys

Applicable to Crop Survey

Crop identification; Crop acreage; Crop vigour; Crop density; Crop maturity; Growth rates; Yield forecasting; Actual yield; Soil fertility; Effects of fertilisers; Soil toxicity; Water quality; Irrigation requirement; Insect infestations; Water availability; Location of canals.

Applicable to Range Survey

Delineation of forest types; Condition of range; Carrying capacity; Forage; Time of seasonal change; Location of water; Water quality; Soil fertility; Soil moisture; Insect infestations; Wildlife inventory.

Applicable to Livestock Survey

Cattle population; Sheep population; Pig population; Poultry population; Age sex distribution; Distribution of animals; Animal behaviour; Disease identification; Types of farm buildings.

Source: Balaselvakumar and Saravanan (2003)

Table 1: Use of wavelength region for agricultural survey

Area of agricultural phenomena	*Wavelength employed*
1. Plant diseases and insect infestation	0.4-0.9 mm and 6-10 mm
2. Natural vegetation, types of crop and fresh inventories	0.4-0.9 mm and 6-10 mm
3. Soil moisture content (Radar)	0.4-0.8 mm and 3-100 mm
4. Study of arable and non-arable land	0.4-0.9 mm
5. Assessment of plant growth and vigour for forecasting crop yield	0.4-0.9 mm
6. Soil type and characteristics	0.4-1.0 mm
7. Flood control and water management	0.4-1.0 mm and 6-12 mm
8. Surface water inventories and water quality	0.4-1.0 mm and 6-12 mm
9. Soil and rock type and conditions favourable for hidden mineral deposits	0.4-1.0 mm and 7-12 mm

Geographic Information System comprises five major components and three main subsystems (Kufoniyi 1997; Abumere 1997). The main components of a Geographic Information Systems are:

- The hardware which include a host computer, data acquisition device(s) such as digitiser, scanner, digital image processing system, digital theodolite, analytical and digital photogrammetric plotter and output device(s) such as plotter, printer, high resolution screen amnog others;
- The spatial database, containing the objects of interest, including the objects' geometric (position and spatial relationships) and thematic data in structured form;
- Software for the acquisition, manipulation and management of data in the database;
- Procedures (conventions and algorithms to guide its operations);
- Expertise in terms of skilled human operators. The main subsystems of a Geographic Information System are:
- Data acquisition subsystem for collecting and /or processing spatial data from existing maps, remotely sensed data, aerial photography, land survey among others;
- Database management subsystem for the storage, retrieval, manipulation and analysis of data;
- Visualization and reporting subsystem for displaying database query results in graphic and/or alphanumeric form.

Geographic Information Systems are needed for the collection, analysis and management of agricultural data for the purpose of timely decision-making. The database will contain layers of spatial data from remote sensors, existing maps or field surveys. Geographic Information System has the capability to integrate diverse data sets from these diverse sources and ensure compatibility of the various data sources.

Geographic Information System analysis basically includes rectification for geometrical correction of digital image data, spatial and spectral enhancements, classification and visualization of digital images. In this way, information on vegetation and soil types, plant stress, crop infestation etc. can be harnessed. Geographic Information System modeling capability through analytical functions like overlay, cluster analysis, clumping functions, reclassification, indexing and spatial searching provides information on which agricultural landuse planning can be based. For instance spatial models will allow for the production of fertility and pest infestation maps as well as maps of spatial distribution of plant nutrients and productivity potential (expected yield). Yield monitoring can be achieved with Geographic Information System technology when yield and moisture sensors are combined with Global Positioning System to provide geo-referenced location specific yield data for the generation of yields maps (Iyalla 2004).

The Global Positioning System is yet another geoinformatic tool required for agricultural development. Global Positioning System enables positional accuracy in the location of terrain features. It receives signals and positioning information from a series of satellites in space. Global Positioning System is basically for the georeferencing of terrain attributes. Geo-referencing is done because location serves as a means to link terrain data collected by different mapping disciplines through overlay analysis (Molenaar 1998). Therefore, Global Positioning System capability is necessary in the integration of the diverse agricultural data sets from diverse sources, in Geographic Information System environment. Spatial data collected by Global Positioning System can be automatically recorded with the Geographic Information System programme. In addition the use of Global Positioning System allows for the accurate location of soil sample points within a field, and hence the determination of physical, chemical and biological characteristics of the soil at different locations. Consequently, fertility levels can be mapped across the field to serve as a basis for the application of farm inputs. The Global Positioning System is also required to establish the accurate location of yield data collected. It is thus needed for the production of yield maps, and for yield monitoring.

The integration of remote sensing, Geographic Information System and Global Positioning System technologies have taken agriculture to the space age. This has given rise to a new concept variously termed Precision Agriculture (PA), Precision Farming (PF) or Site Specific Crop Management (SCCM). Precision farming is an information and technology-based agricultural management system that identifies, analyses, and manage site-soil spatial and temporal variability within paddocks (farm fields) for optimum yield or productivity, profitability, sustainability, and protection of the environment (Mishra et al. 2003; Metternicht et al. 2001; Bouma 1997). The concept identifies the agricultural suitability of land parcels from the spatial variability of soil fertility status, and other land qualities (water and oxygen availability and retention capacity, plant root conditions, salt hazards and topographic conditions). The concept recognises that variations occur within agricultural fields, and thus seeks to identify the spatial location and extent of such variations. The objective is to assess the causes of such variations to ensure that the right decision is taken with regards to type of crops to be cultivated, time to cultivate, and management practices required. According to Berry (1998), precision farming implies doing the right thing, in the right way, at the right place, and at the right time.

The components of precision farming are remote sensing, Geographic Information Systems (GIS), Differential Global Positioning System (DGPS), and Variable Rate Applicator (VRA). Remote sensing techniques play a pivotal role in precision farming by providing continuous data on spatial and temporal variability in agricultural fields. Sensors provide data on soil properties, crops condition, and for yield monitory, fertiliser flow, as well as weed detection (Upadhyaya and Teixeira 2003). GIS is a potential tool for handling voluminous remotely sensed data, and has capability to support spatial statistical analysis (Singh et al. 2003), presentation of spatial data in the form of a map, as well as storage, management, modelling of input data, and presentation of model results.

Differential Global Positioning System (DGPS) is used for precise location of activities. Global Positioning System (GPS) device makes use of a series of military satellites that identify the location of farm equipment within a metre of an actual site in the field (Mishra et al. 2003). This is required to accurately link location and result of soil samples to a soil map, prescribe farm inputs to fit soil properties, adjust tillage to suit field conditions, and determine yield data across the field. Variable Rate Applicator is used to operationalise precision farming at the farm level. Variable Rate Technology (VRT) consists of the machines and systems used to apply a desired rate of crop production materials at a specific time, and by implication a specific location (Giles 2003). The components are a *control computer*, a *locator*, and an *actuator* (Mishra et al. 2003). The control computer co-ordinates field operations with the aid of database in its memory. Based on the desired activity, the computer from the locator (which holds a GPS) receives the current location of equipment, and issue command to the actuator, which does the input application.

The operational procedure of precision farming requires geo-referenced point data obtained with grid spacing with minimal number of observations. Patterns are obtained by geo-statistical interpolation of these point data (Bouma 1997). The techniques involves the integration of databases or sensors that provide information needed to develop input response to site-specific conditions; positioning capabilities to know where equipment is located; and real-time mechanism for controlling crop production inputs. The new paradigm is being adopted in the United States and Europe since the middle of the 1990s (Looijen et al. 1995; Berry 1998). Its exploration in Third World economies such as Nigeria is yet to receive significant attention.

The Situation in Nigeria

Nigeria is naturally endowed with factors necessary for the production of various staple foods, including legumes, roots and tuber crops, fruits and vegetables, fisheries and livestock etc. (Ingawa 2004). In the pre oil boom era, agriculture played a significant role in foreign exchange earning. Even now agriculture remain the major economic activity in Nigeria, especially in the rural areas. That there is problem of food security in Nigeria is essentially a consequence of a neglect of the agricultural sector by successive governments largely due the apparent gains in the oil sector

The folly of relying on an exhaustible and economically unstable resource like oil as a major foreign exchange earner is becoming increasingly glaring. Thus, the need to enhance agricultural productivity for local consumption and export income has been recognised by the present national government. However, a fundamental issue that needs to be adequately addressed is the role of data collection analysis and management in the quest for agricultural improvement. Relevant and timely information is needed for programmes conception, planning, implementation, management, and monitoring. Information is required to guide current decision-making and future planning. For instance information on land potential (in terms of capability and suitability) and input requirement for the cultivation of various crops are crucial for agricultural improvement. So also is information on crop performance in agricultural fields, crops yield and yield monitoring, crop infestation etc.

Several methods have been used to collect data and information on agricultural activities in Nigeria. For instance information on land potential have often be acquired through land evaluation studies. Land evaluation involves the matching of land quality and land characteristics with the requirements of the envisaged land use/land utilisation types (Braimoh 2000). The systems of land evaluation that have been used for studies in Nigeria include, land capability classification, land suitability classification, fertility capability classification, soil quality rating, and soil productivity index.

By and large, a critical assessment of the land evaluation methods in Nigeria so far show that they are numerous crop-yield prediction models that relate crop yields to a single set of factors. These models have been of limited utility, largely because they are location-specific, and do not take into consideration variability in soil and crops conditions at regional, local, and farm levels (Rilwani and Ikuoria 2006). Furthermore, most of the models are based on biophysical assessment of land potential alone, while holding other factors of crop production (such as economic factors) constant. Such models, which have been the basis for recommending organic fertiliser application for crop farming in Nigeria, have become inadequate with the new concept of precision farming. It would be better to evaluate what the natural soils are best suitable for, and those crops should be grown for optimum yield. The application of fertilisers, if necessary, would only be in marginally suitable farm fields.

Information on other agricultural activities such as crop yield estimate and monitoring, weather condition, incidences of pest and diseases, application of seeds and farm inputs etc have been acquired through a variety of methods. The methods include Objective Measurement Techniques, Rapid Rural Appraisal (RRA), Participatory Rural Appraisal (PRA), visits, guestimates, and memory recall (Ingawa, 2004). Cropped Area Yield Survey (CAYS) is an objective measurement technique often used by the projects co-ordinating unit of the Agricultural Development Programme (ADP) to estimate areas under cultivation as well as production and yield of various crops in project areas. The procedure involves annual sample surveys using equipment such as prismatic compass, measuring tapes, ranging poles, pegs, measured ropes and weighing scales. The objective is to physically assess in the field areas under cultivation as well as crop yield, and consequently monitor crop yield. However the quality of data generated is often weak in terms of integrity, precision, accuracy, completeness, reliability and timeliness (Ingawa 2004). For instance the samples considered may not be a true reflection of the actual situation on the ground. Moreover, the method may have varying degree of spatial and temporal efficiency in applicability, depending for instance on ecological/climatic factors, type of crops cultivated, cropping systems etc. Again, there is the problem of inexperienced, inept, lazy, or unfaithful enumerators.

The Rapid Rural Appraisal, Participatory Rural Appraisal, guesstimates and memory recall are essentially subjective assessment methods. The procedure involves the despatch of a team of diverse professionals in the various sectors of agriculture to states to interact with the farmers and government officials with a view to obtaining data and information on agricultural activities. With the aid of a checklist information is obtained on rainfall arrival and amount, incidence of flooding, erosion, drought, pests and diseases. Information is also sought on the status of procurement and application of seeds, agro-chemicals, fertilisers, drugs, and livestock feeds as well as farm inputs; and the likely levels of cultivated area and output in the current year/ season compared to the preceding one.

The subjective methods are even more fraught with problem of accuracy, reliability, precision, completeness and reliability of information. These problems emanate basically from the inadequacies of the source of information i. e. the farmers who are mostly illiterates. Thus they are not familiar with the conventional methods of quantification and cannot take nor document relevant information. Memory recall that essentially is the recourse cannot be relied on for agricultural development in the 20th century. The cumulative effect of all these factors is the generation of spurious and unreliable information and when used as basis for decision-making leads to programme failure.

Challenges and the Way Forward

Nigeria with an escalating population currently estimated to be Nigeria, with a population of 140 million people (provisional result of the 2006 population and housing census) Nigeria, with a population of 140 million people (provisional result of the 2006 population and housing census) people should take advantage of the benefits of modern technology provided by geoinformatics to develop the agricultural sector. This is fundamental in meeting the challenge of increased productivity, while also maintaining environmental quality. Remote sensing, GIS and GPS technologies are required to generate, analysis, model and manage data and information to provide a reliable basis on which decisions on agricultural development are taken. However, there are some basic challenges that must be addressed.

First is low level of technological development. Agricultural practices in the country are still wholly traditional, with a high dependence on nature and the use of raw human labour. Rainfed agriculture is predominant. Large-scale irrigation projects are few and generally restricted in scope. Input application especially fertizers as well as the use of pesticides and herbicides is low. There is also a dearth of technical expertise to guide the farmers on appropriate farming techniques.

The second is inconsistency and inept implementation of government policies, which has been the bane of agricultural development in Nigeria. All the agricultural improvement programmes initiated by the government since national independence in 1960 have met with catastrophic failure largely due to inconsistency in policies, and inept management of resources by corrupt government officials.

Low level of investment is yet another challenge. The individual farmers are too poor to make meaningful investments in agricultural productivity. Financial policies meant to assist the farmers are only effective on papers. Meeting production cost (particularly labour) is a perpetual source of worry for the local farmer. The government since the oil boom of the 1960s gradually neglected the agricultural sector, which hitherto was the major foreign exchange earner for Nigeria.

Other technical problems are small land holdings of farmers, heterogeneity of cropping systems, and market imperfections, which is perhaps more appalling as the farmers have no control over market forces.

These challenges are real and constitute hindrance to the adoption of geoinformatics in Nigerian agricultural development. Concerted efforts and careful planning is required to surmount the problems. The greatest challenge is perhaps the acquisition of relevant space technology. Remote sensing, Geographic Information Systems, and Global Positioning Systems are expensive tools, and are currently very scarce in Nigeria. However, with the successful launch of an earth observation satellite, NigeriaSat-1 in March 2003, the Nigerian government has definitely taken the first step towards the application of space technology to solving some of the socio-economic problems in the country, including the agricultural sector. The satellite will improve the efficiency and reliability of agricultural data collection. Akinyede (2003); Obba (2003); Ingawa (2004); Iyalla (2004) have expressed in various ways the capabilities and relevance of NigeriaSat 1 in Nigerian agricultural development. Raji (2004) has demonstrated the capability of NigeriaSat 1 in agricultural planning and management. He integrated data from NigeriaSat 1 with existing soil and topographical map in a Geographic Information System environment to assess the current and potential agricultural land use in the Kadawa sub sector of the Kano River Irrigation Project.

An alternative to satellite remote sensing that could be adopted in Nigeria is Airborne Videography. This technology provides greater levels of spatial details (between 0.25m and 4m pixel size) than current satellite technology (Mishra et al. 2003). This advantage in addition to the flexibility in the frequency and time of coverage make it ideal for site-specific management of soil and crop conditions

The success of any programme in a developing country like Nigeria depends largely on the provision of an enabling environment by the government. The government should constitute an interdisciplinary team (comprising of space technology experts, agricultural scientists, experts in the biological sciences, economists, and other relevant stakeholders) to articulate an agricultural policy with a focus on the following issues:

1. Conduction of a national land appraisal programme to establish land potential, in particular suitability assessment for the

cultivation specific crops. This will allow for the identification and zoning of areas for agricultural development. An interdisciplinary team of experts and stakeholders should be constituted to undertake this appraisal.

2. Provision of space technology services (including Remote Sensing, Geographic Information Systems, and Differential Global Positioning Systems) to farmers at subsidized rate. The government should provide the basic infrastructure which the farmers can take advantage of by pooling resources in the form of co-operative societies.
3. Education and awareness creation among farmers on the need to embrace modern techniques of farming with geoinformatics.
4. Well-trained extension workers to disseminate modern farming techniques to farmers.
5. Provision of assistance in terms of finance and farming inputs to farmers.
6. Conduction of experimental farms in various farming localities to demonstrate the feasibility of geoinformatic techniques in farming, for the farmers to appreciate the benefits therein.
7. Provision of an enabling environment for the marketing of agricultural produce both locally and abroad.
8. Provision of electricity, portable water, and good road network, particularly access roads to farm holdings, as well as storage facilities for perishable agricultural produce, in farming communities.
9. Encourage young Nigerian graduates to take to farming by providing them with basic requirements in terms of land and financial resources, farming equipment and inputs etc on loan. Affluent Nigerians should also be encouraged to take to farming.
10. Tertiary institutions and relevant research institutes in Nigeria should be challenged to undertake researches that will ensure sustainable development in the agricultural sector, particularly in the application of geoinformatic techniques.
11. Provision of a framework for the successful implementation, and monitoring of projects.

CONCLUSION

The urgent need to develop the agricultural sector for nutrition and economic well being of Nigerians have become more imperative, largely due to the escalating population and the need to develop alternative sources of foreign exchange. To achieve this, the focus should be on the productive capacity of our soil resources vis-à-vis the production technologies, research approaches, as well as the producers (farmers) situation on which the production and supply of food lies (Aighewi 2000). The approach should necessarily emphasis the provision of data for the management of in-field variability in soil fertility status and crop conditions. This is the goal of precision farming. Geoinformatic techniques (in particular, remote sensing, Geographic Information System and Global Positioning Systems are indispensable in this respect. The successful launch and subsequent operation of NigeriaSat 1 has offered a unique opportunity of local capacity to apply geoinformatic techniques in agricultural development in Nigeria. What is required now is the will, particularly on the part of the government, the National Space Research and Development Agency (NASRDA), the farmers, financial and research institutes as well as tertiary institutions of learning to actualize the application of these techniques in agricultural development.

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