

Leveraging Food Security Challenges in South Eastern Nigeria Using GIS and Geospatial Education

Njike CHIGBU, NIGERIA, Daniel ONUKAOGU, NIGERIA.

Keywords: Food security, Geographic Information System, Precision Agriculture, Remote sensing.

SUMMARY

Achieving food security can be a herculean task as it is dependent on agriculture, trade, health and the environment as a whole. A number of climatic changes occur in our environment which have adverse effects on agricultural production both directly and indirectly as a whole thus leading to some worth of “*food insecurity*”. It is very essential that citizens of every nation are catered for judiciously with respect to its growth and all developmental processes. The South Eastern Nigeria is generally densely populated and in order to measure the state of deprivation which may arise, proximity analysis will be undertaken with respect to the population, food availability, accessibility and utilization. This study tries to define the concept of food security, the reviews of food security situation in South Eastern Nigeria and also hopes to highlight the importance of Geographical Information System (GIS) approach to food security scenarios and its associated benefits with respect to South Eastern geo-political zone and Nigeria generally. Consequently conclusion is drawn by highlighting the adoption of precision Agriculture (precision farming) to improve food production in South Eastern Nigeria.

Leveraging Food Security Challenges in South Eastern Nigeria Using GIS and Geospatial Education

Njike CHIGBU, NIGERIA, Daniel ONUKAOGU, NIGERIA.

1.0 INTRODUCTION

A number of publications on food security issues in the South Eastern states of Nigeria have confirmed the fact that different scenarios exist in this geo-political zone in relation to the looming scarcity of food (Information Nigeria, 2012). In “*Does Agriculture have a future in South-East Nigeria?*” Nwajiuba in his inaugural lecture warned the government and the entire people of the South Eastern region on the impending dangers of food insecurity. He reiterated that some of the most profound and direct impacts of climate change over the next few decades will be on agricultural and food systems. Lobel et al., (2006) also adduced that increasing temperature and declining precipitation over semi- arid regions are likely to reduce crop yields for corn, wheat, rice and other primary crops in the next two decades. These changes if not properly managed, would have substantial impacts on global, regional, national and local food security.



Fig 1: Cross section of market women showcasing their food crops for sale (source, Authors Lab. work, 2012)

A number of factors such as climatic changes, soil fertility and variability, and lastly population explosions are examples of some factors that can lead to foods security constraints. These fluctuations in weather patterns pose serious threat to mankind and its environs and may have overall adverse effect on food security issues. The Sahel was hit by disastrous droughts in the

1960s and 1970s, sparking the concept of the Sahara desert advancing into the Sahel region, and bringing the region to the forefront of scientific interest (Hutchinson et al., 2005).

According to a recent United Nations (UN) publication, there are strong indicators that regions that cut across the Sahel including northern Nigeria (even Southern part), Niger, Mali, Chad, Burkina Faso, Mauritania, northern Senegal and northern Cameroon are faced with outrageous prices of food commodities (West Africa Insight, 2010). This scenario could as well lead to serious crisis within our community and may result to disloyalty from the citizenry and eventual breakdown of law and order. Though, Nigeria is not the only nation found wanting with respect to food security issues. Both developed and developing countries that cannot cater for her respective inhabitants with respect to food availability, accessibility and utilization (food security) have failed as a nation and cannot be referred to as a proud entity.

The Food and Agricultural Organization (FAO), reacting to the state of Food insecurity in the World, indicated that Nigeria had about 12 million people reported as undernourished as at 2003; the report strongly recommended that all nations must take agriculture seriously by mobilizing and investing a good proportion of their resources into agriculture to achieve food security (FAO, 2006).

The persistent reliance on importation of food has exposed Nigeria global food crisis issues which was one of the reasons Nigeria was affected by the global food crisis in 2007 and 2008 (West Africa Insight, 2010). Despite the heavy funds pumped into food importation, the grass-root production of food items within Nigeria seems to have collapsed and neglected and as such has steadily contributed to the alarming and wide spread rate of food insecurity in Nigeria today.

Since the emergence of crude oil explorations in Nigeria, the agricultural sector has been badly neglected. Nigeria was once reckoned to be self sufficient and sustaining in food production and was a heavy exporter of food to several geographical locations in the world back then in the 1950s and 1960s (West Africa Insight, 2010). Estimates from the Federal Ministry of Agriculture in 2009 showed that Nigeria was spending over \$3 billion yearly in food importation yearly.

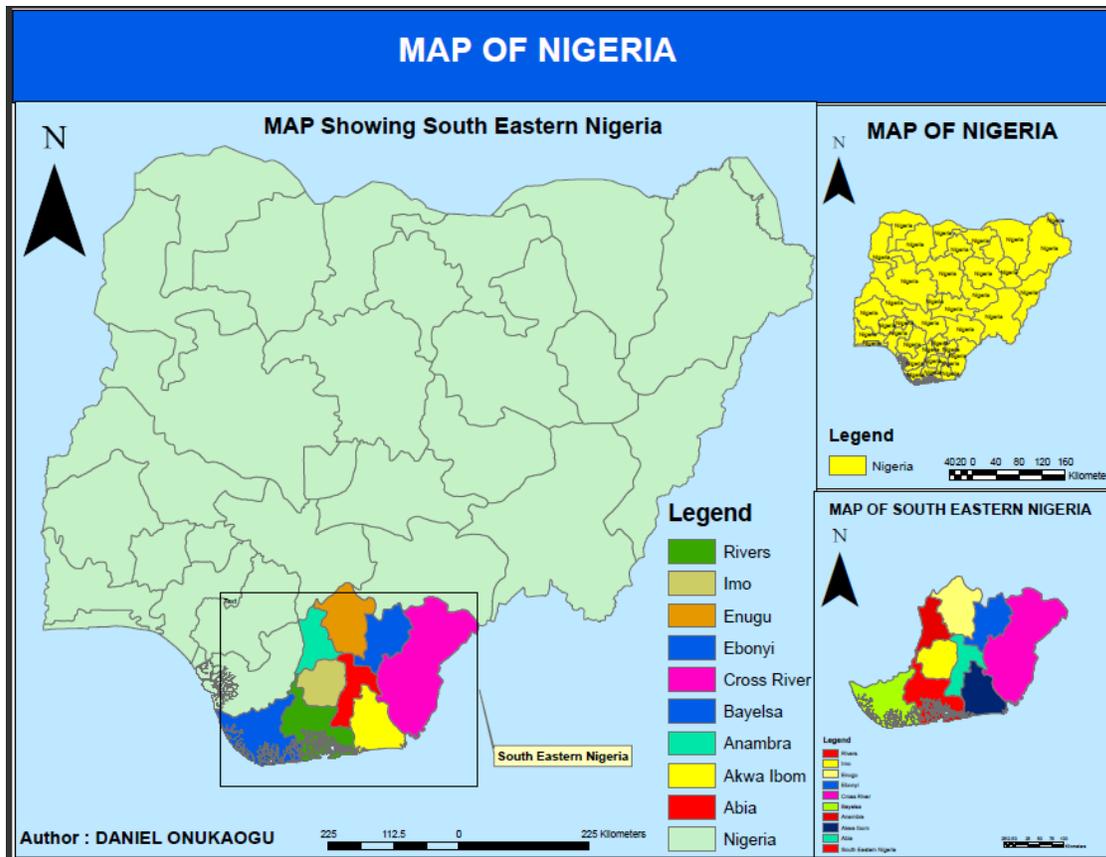


Fig 2.0 Map Coverage of Nigeria Showing Eastern States (Source, Daniel 2012)

2.0 FOOD SECURITY SCENARIOS

Food security is a term commonly linked to hunger and food access related issues (West Africa Insight, 2010). Advocates of food related issues are of the opinion that access to healthy food is a fundamental human right and insist that policies guiding our Agricultural system should be properly harnessed to ensure that no form of deprivation manifests with regards to accessing healthy food. The term food security comes into play when populations existing in a particular geographical location are faced with no form of hindrance but rather with adequate and sustainable access to healthy food to cater for their well-being (FAO, 1996).

Due to the so much reliance on importation of food crops in Nigeria, the country has neglected its own natural endowment. For instance, the capital city of Nigeria (Abuja) prefers to promote the importation of fruits such as apples, kiwis and grape from the United Arab Emirates which are stocked in their numbers in many shop outlets. Yet, about 125 miles north, in Kaduna, Nigerian mangos rot on the farms because of the lack of preservatives and storage facilities which have a rippling effect on its sales (Global post, n.d). Yakubu Umaru Barde, a member of

the Nigerian Parliament, posited that “*The government policy on agriculture is the reason we face food insecurity today,*” (Global post, n.d.).

Past records have shown that in 2002-2004, approximately 864million people (14% of the world population) were undernourished (FAO, 2006). Food starvation results in humans suffering, aids the rates of disease and mortality, limits neurological development, reduces labor productivity, and even holds back a nation’s economic growth (UN Millennium Project, 2005).

In southeastern Nigeria, the changing population densities, urbanization and poverty has resulted to variations in land use and land cover which has given rise to environmental problems such as gully erosion, landslide, flooding, air and water pollution and depletion of land with high agricultural potentials.

The Southeastern zone of Nigeria comprises of nine states namely, **Abia, Anambra, Akwa Ibom, Bayelsa, Cross River, Ebonyi, Enugu, Imo and Rivers** which can be found between latitude $4^{\circ} 15'$ and $7^{\circ} 00'$ N and longitudes $5^{\circ} 50'$ and $9^{\circ} 30'$ E. The zone largely lies within the rain forest belt of Nigeria which is known for its high temperatures and humidity, with substantial amount of rainfall during rainy seasons. Talking about the growth rate recorded in 2003, Akwa Ibom state was said to have steady rising population in the urban areas which gave rise to negative impact and decline Agricultural production in the rural areas. Camp & Myers (1990), observed that the poor residents in any community in their bid to fight for survival are left with no choice than to disrupt the activities of the immediate environment through felling of trees, over grazing range lands and excessive fishing.

Food security has three factors in its operational cycle. It is now widely observed that the availability of food is no longer the sole determinant of food security but rather one of the three pillars. Other factors are accessibility and utilization (Jojob Faal, 2010).

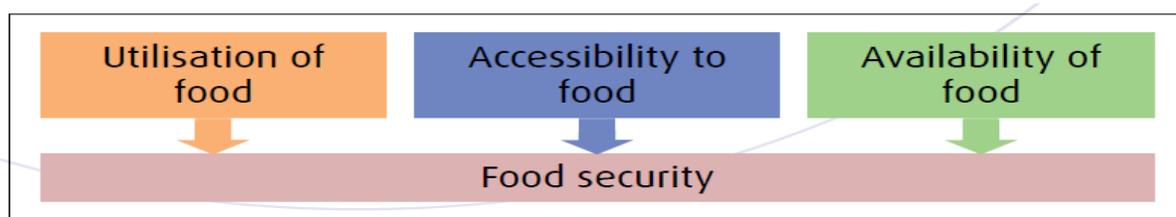


Fig 3.0 Adapted from: ICT4D Project 2010

3.0 CAUSES OF FOOD INSECURITY IN SOUTH EASTERN NIGERIA.

3.1 FLOODING

Food insecurity could occur due to decreased farm land holding sizes due to population explosions, constant droughts & floods, etc. Floods could arise from climatic change. Climate change affects agriculture in so many ways and this can further lead to food shortage. For

instance, environmental floods have been on the increase in recent times in Nigeria and this would in no doubt affect farmlands and also lead to crop failure resulting to food security issues.



Figure 4.a: A south Eastern part affected by the recent flooding in Nigeria (Authors Lab. Work, 2012)

Flood hazards have constantly posed serious threat to food security since it is more or less anchored on rainfall and rainfall amount and also the ability of the farmers to know exactly when to begin and end cultivation practices. Almost half of the farmland in the affected communities has been submerged by water. The Federal Government's warning about an impending food shortage is not enough. The farmers whose livelihood may have been washed away by the flood need to be supported, by granting them soft loans and provision of seedlings and fertilizer.

3.2 CRUDE OIL SPILLAGE IN RURAL COMMUNITIES

Oil is the main stay of Nigeria's economy, but most residents in the oil producing communities still depend entirely on the environment for their sustenance; and so likely to have a problem of food security in the event of a deleterious impact on the environment. Crude oil spillage can increase household food insecurity and childhood malnutrition in the affected communities.



Figure 4(b) oil spillage scenario. (source: <http://www.ncbi.nlm.nih.gov/pubmed>)

The growing cases of oil spill in the Niger-Delta region have become recurring phenomena. For decades, oil producing communities in the South-East and South-South have been battling with multinational oil companies and the Federal Government on the need to pre-empt and contain oil spills that had culminated in gross environmental pollution, destruction of sea lives and diminishing quality of soil texture

3.3 BUSH BURNING

Research has shown that soil erosion, desertification, bush burning, ocean upsurge, deforestation, land degradation are on increase in the country with few people showing serious concern. Our activities are inimical to the environment, our daily work and behaviour domestically, industrially and even agriculturally are threatening the stability of environment as well as balance of the ecosystem. We often burn bushes to farm, we practice agriculture without due regard to the environment (oil), we cut/fell trees down without knowing that we are altering the eco- system and nature.

3.4 POOR CULTURAL PRACTICES

Domestic production of most food commodities had not kept pace with demand. Population growth, change of food preference, urbanization, inflation and demand from neighboring countries are among some of the factors that continued to affect food availability, its accessibility and affordability to most Nigerians. Most of the farmers in this region are peasants and engage mainly on subsistence agricultural activities. Their produce can hardly support their families less the economy. The methods employed for agricultural farming are crude and out of date. Modern techniques of farming are not employed. The farmers do not even access to fertilizers, loans, mechanized tools and good/hybrid crops. Erosion is a serious problem in the region and soils are highly weathered and infertile. The major tree crops of the region are cocoa, oil palm, rubber, kola-nut, citrus, and plantain.

3.5 DEFORESTATION

Forests and trees make an essential contribution to food security by helping to maintain the environmental conditions needed for agricultural production. They stabilize the soil, prevent erosion, enhance the land's capacity to store water, and moderate air and soil temperatures.

The importance of these effects has often been ignored in the past, with the clearance of tree vegetation and the subsequent loss of millions of hectares of productive land. Furthermore, as forests continue to be cleared-exposing the land to direct attack from wind and rain-soil erosion and land degradation are still undermining agriculture's resource base.

4.0 REMEDIAL ACTIONS

4.1 GIS AS A DISCIPLINE

GIS technology is an important tool for the advancement and sustainability of food production to support the survival of the human race (ESRI, 2008). Major benefit of studying GIS is its improved management technique and it gives people the geographic advantage to become more productive and more spatially informed.

Employing a good and functional GIS permits the integration and analysis of data on population, climate, price, soil, and the various types of crops in order to produce an assessment of the vulnerability of the food situation at the regional, national and local levels. It could operate in such a way that crop area can be determined and also the total field area and locations predicted as well as estimating crop yield.



Fig 5.0: Corn and peanut profit maps from sequential years indicating that significant portions of the field result in losses (adapted from TAPAC, 2004)

GIS creates a platform where some variables such as proximity measures, connectivity and density determination with regards to attributes of house hold and individual behavior are integrated and studied (Saelens et al., 2003). This major feature of GIS enables it to be used as a tool to detect changes in neighborhood conditions over time and also to investigate spatial patterns among socio-economic conditions. GIS have been extensively used in accessibility

issues. Past researches have shown that there are three major constraints to easy access to food (i) informational factor (ii) geographic factor (iii) the economic factor

i. Informational factor

This aspect cuts across large numbers of factors that are linked to educational, cultural and social drawbacks which have impact on variations in human consumption.

ii. Geographic factor

Basically, geographic factor entails the features of locations or individuals which Kwan et al (2003) has described as “the term place and personal accessibility” in the “zone based aggregate spatial framework”.

iii. Economic factor

Poverty studies highlight that food security is closely associated with poverty (Baker et al 2006) However, economic access cuts across not only poverty but also some financial factors that affect one’s ability to obtain food (Mc Entee and Agyeman, 2010).

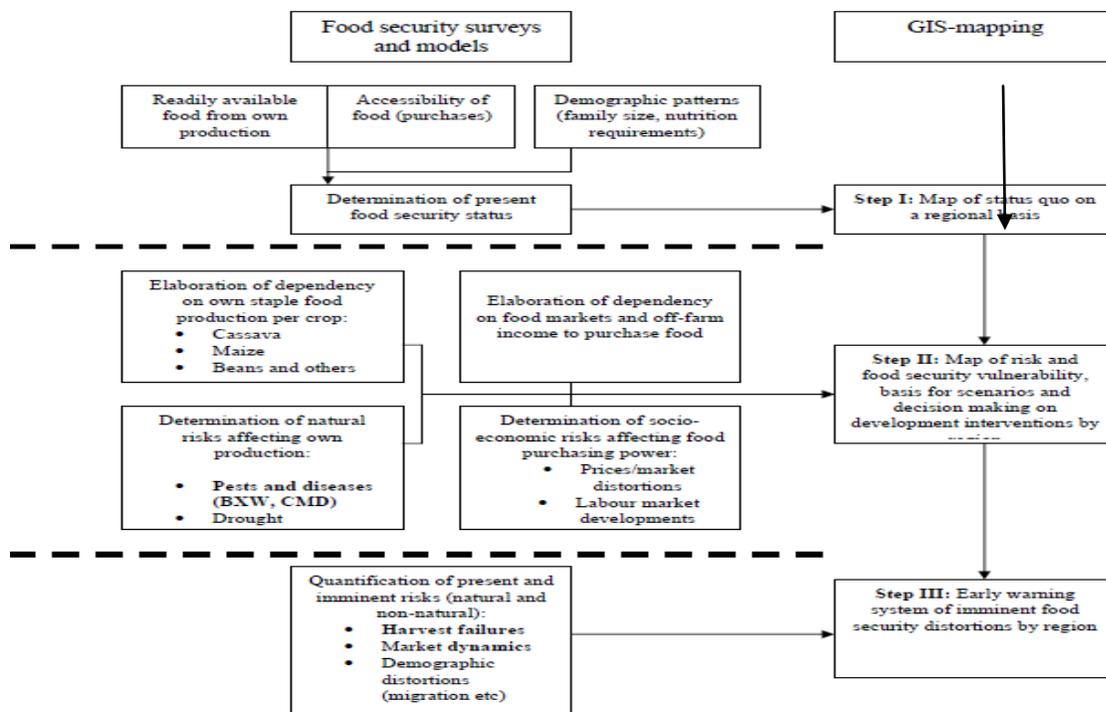


Fig 6.0: A typical food security GIS Model (Adapted from Crop Crisis Control project, 2007)

4.2 LIMITATIONS ON PROXIMITY ANALYSIS/MEASUREMENTS

In Nigeria today, most cities except for places like Lagos and the Federal capital territory (Abuja) have few roads that are classified. Talking about developed countries like the United Kingdom which have better road classification such as motor ways, etc. Motor ways are directly equivalent to US interstate highways. These primary routes are the major traffic routes which are usually over 99% while A- roads can be B- roads or even C- roads which are the preferable routes for *goods transportation* (REF). Several cities in the South-Eastern states of Nigeria lack in these classifications.

6.0 GEO-SPATIAL LITERACY

6.1 REMOTE SENSING TECHNIQUES

Remote sensing technology has in recent times become an essential toolbox for site specific crop management in agriculture (Cassady and Palm, 2002). Remote sensing is a medium of science that acquires and gives better insight on observed objects of interests and requires sensors that are in no way in contact with the objects in view (Jensen, 1996). In precision farming, the most appropriate method to determine field variability can be achieved by the use of Remote Sensing (Schueller et al., 1993)

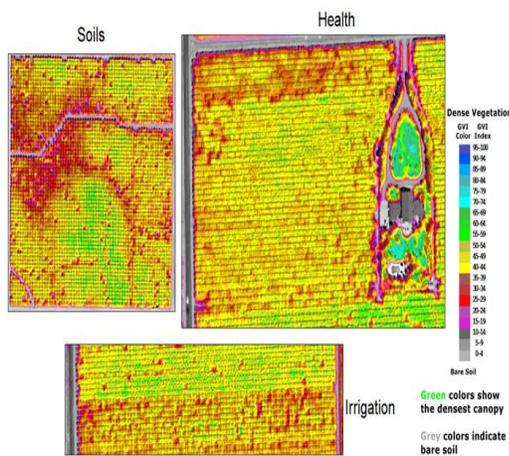


Fig 7.0(a) Managed Canopy Assessment
60cm satellite image (acquired 03/2/2004)



Fig 7.0 (b) Oil Facility, Nigeria: Quick bird
(Source: Digital Globe, 2008)

Remote sensing is of much significance in geospatial literacy and also with respect to food security issues and environmental issues respectively. This can only be achieved through the acquisition, utilization and integration of remotely sensed data which help in good decision making processes which proffer a better observation, explanation, projection (forecasting) and finally its application.

6.2 LAND USE AND LAND COVER STUDIES OF SOUTH EASTERN NIGERIA

A lot of countries around the world have lost so much vegetation cover to urbanization. Land use and Land cover study is therefore very essential in the conservation and preservation of agricultural farmland and the environment as a whole. This helps to prevent not only food security problems but also help curtail deforestation problems as this could lead to natural and man-made made disasters. Patterns of future environmental losses such as agricultural farmland, vegetation, built-up areas and exposed soil surfaces and also disasters can be predicted from output maps generated by these analyses and this can be used to leverage a number of environmental and climatic related challenges in local communities and also helps the government in planning for remedial and emergency situations (Linkie et al., 2003).

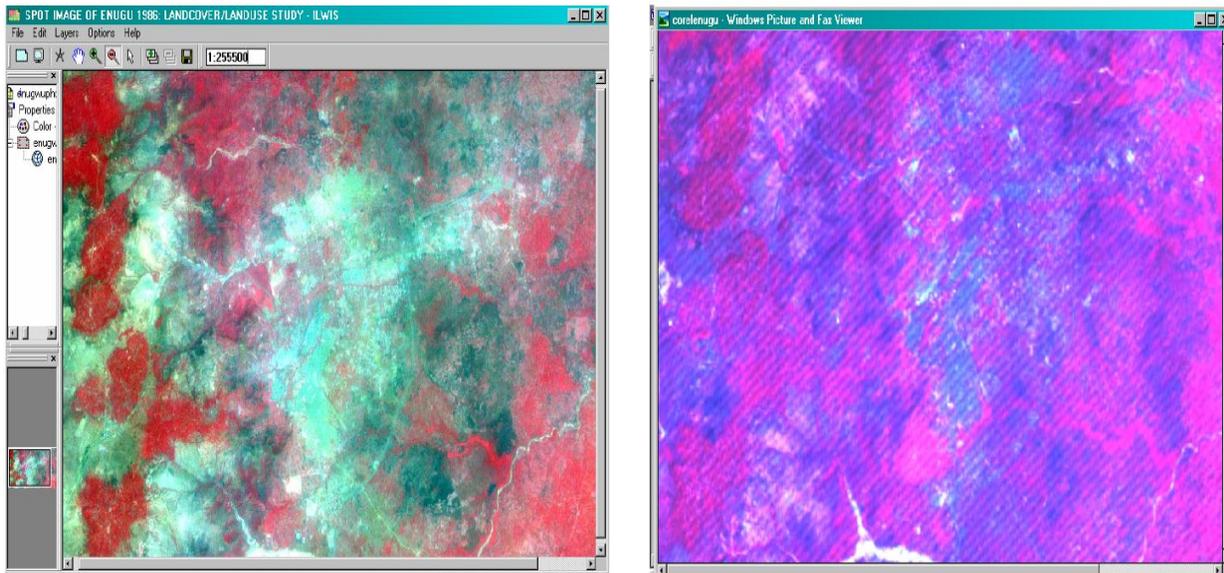


Fig 8.0: (a) False color composite of 'SPOT' image & (b) Nigeria Sat-1 of Enugu (1986)
Source: (RECTAS) Adapted from Onu and Igbokwe (2003).

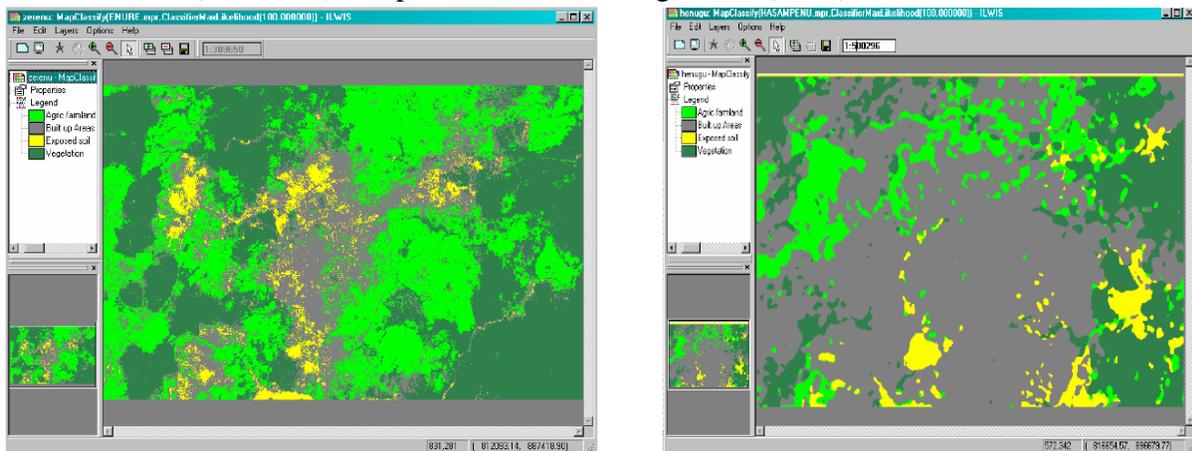


Fig. 9.0 (a): Classified 1986 SPOT image of Enugu. **(b)** Classified 2003 NigeriaSat-1 image of Enugu. **(Source:** Lab. Analysis Onu and Igbokwe (08)

Land use and land cover analysis of Enugu and environs was carried by Igbokwe et al., (2008) as depicted in the figure 8.0 and 9.0 above. In the work, the land cover and land use changes in Enugu and environs were studied using SPOT 4 Satellite imagery of 1986 and NigeriaSat-1 imagery of 2003. The total area studied was 345176.69 hectares. From the above study, there was empirical evidence that massive changes have taken place between 1986 and 2003 on the land cover of Enugu and environs (see table 1.0 below).

Table 1 Classified Image statistics for 1986 and 2003.

Landcover/ landuse	1986 coverage (hectares)	2003 coverage (hectares)
Vegetation	131792.6	42835.1
Agric farmland	124640.7	80296.6
Exposed soil surfaces	14735.2	2730.1
Built up areas.	74008.2	219314.9
Total	345176.7	345176.7

Source: Adapted from Onu and Igbokwe (2008)

Further to the above, Igbokwe, et al., (2008), in their study "Estimating soil loss in Gully Erosion in Southeastern Nigeria from Remotely Sensed Imageries", deduced that Southeastern Nigeria is a typical gully erosion region in Nigeria. The presence of gully sites is one of the hazard features that characterize this zone. Satellite Remote Sensing and GIS were used to map and monitor the spread as well as the impact of gully erosion in South-Eastern Nigeria. The estimation of annual soil loss in gully erosion in Southeastern Nigeria was an aspect of the project titled "Comprehensive Mapping and Monitoring of the Impact of Gully Erosion in South eastern Nigeria Satellite Remote Sensing and GIS Techniques. The project which was a collaborative research by Nnamdi Azikiwe University, Awka and the National Space Research and Development Agency, Abuja (Igbokwe, 2006) made the following recommendations:

- Development of Geo-information –Based Early Warning System (GEOBEWS) for estimating Soil loss in Gully Erosion in Southeastern Nigeria from Remotely Sensed Imageries.
- There need for building of capacity for environmental studies especially on early warning Systems.

- Development of follow up Advocacy group for sensitization, mobilization and aware creation on the prevailing environmental challenges.
- Immediate environmental inventory to unravel areas prone to erosion and other challenges.
- This study is very important in the overall agricultural (food) production of southeastern Nigeria. The generated Digital Terrain Model (DTMs) was used to generate slope maps of the states. This slope maps are important not only on its influence in soil formation and development but also on degradation of land, caused by soil erosion (Igbokwe et al., 2005).

Furthermore, Land use and land cover study of Aba (ABIA STATE) using RS and GIS tools, was undertaken with the under listed objectives aimed at finding out the percentage /rate of vegetal consumption and its overall effect on food security and sustainability of the area of study:

- (i) Selection and extraction of a sub-scene covering of Aba Main Township from the Landsat ETM+ (2000) and Nigeria Sat-1 (2005) images of the area.
- (ii) Overlaying the classified datasets and obtain changes in Land uses and Land covers of the study area.

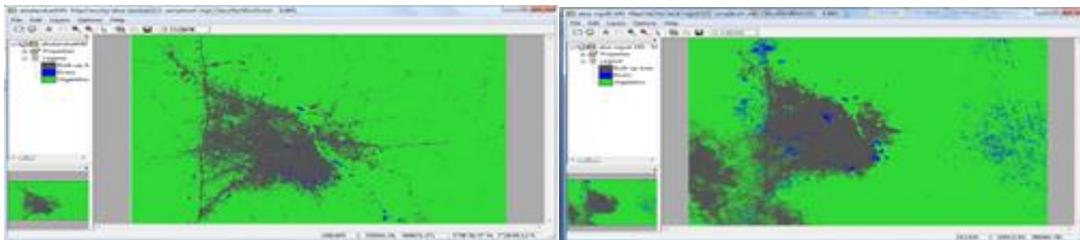


Fig. 4(a) Classified 2000 Landsat ETM+ (b) Classified 2005 NigeriaSat-1(chigbu,2010)

Table2: Aba Land use/cover Change Analysis

Landuse	River			Built-up Area			Vegetation		
	1991	2000	2005	1991	2000	2005	1991	2000	2005
Area (Ha)	62	91	92	89	110	150	260	210	169
Covered (%)	15.1	22.1	22.4	21.7	26.8	36.5	63.2	51.1	41.1
% diff.	0	+7.0	+0.3	0	+5.1	+9.7	0	-12.1	-10.0

(Source: chigbu, 2010).

Based on the results and the analysis done in the study shown on table 2 above, it is concluded that Remote Sensing and Geographic Information System can be used as effective tool to analyze land use changes over the years. Land use pattern and dynamics in the Aba (Abia State) showed phenomenal increase in the Built-up areas and the River body while the vegetation decreased tremendously. If this scenario is left unabated, this will impact negatively to food production in the Southeastern Nigeria.

6.2 IMPORTANCE OF ADOPTING GIS IN FOOD SECURITY STUDIES

- ✓ Serves as an early warning system which helps with the prediction of flood, drought and other natural disasters that could arise and lead to loss in crop yield and destruction causing food insecurity.
- ✓ Accessibility measures which happens to be one of the three pillars of food security can also be estimated using network analysis embedded in Arc GIS desktop
- ✓ It serves as a good decision support system
- ✓ Information based on household compositions and surveys could be determined, mapped out and overlaid with other socio economic gradients.
- ✓ Better and more precise information can also be derived based on the availability of food in that region.

6.3 OTHER MITIGATIONAL MEASURES

- Adopting good forest policy and legislation
- Designing projects to meet local needs
- Capacity development and building
- Investing in Research and Geo-spatial training(Early Warning studies on food security challenges)
- Avoidance of bad cultural practices
- Encouraging the local populace on best methods of agricultural practices through the use of mechanized farming, provision of loans, modern farming equipment and fertilizers.

- Avoidance of indiscriminate bush burning, oil spillage, and illegal mining operations.
- Precision agriculture and machine guidance agriculture should be practiced.
- Government of the day should be proactive and responsive in handling all environmental issues that might impact negatively or otherwise on food security issues in the region and the country at large.

6.3 CONCLUSION AND RECOMMENDATIONS

GIS gives people the geographic advantage to become more productive, more aware and more responsive citizens of our environment. It therefore cannot be over emphasized knowing that the sustenance of a nation's economy partly depends on agriculture. However, GIS and geospatial technology has helped in so many ways not only to analyze views about our immediate environment but also to make and implement relevant agro-climatological and food security decisions which are attached to it.

In a bid to eliminate the increasing reliance on food importation in Nigeria, it is essential that productivity enhancing measures be implemented in the agricultural sector not only in the south eastern part of the country but Nigeria as a whole. The south eastern part should not just be solely dependent on the livestock ventures been introduced into the region but to also embrace the advancement of horticulture in order to preserve the environment and also combat the heavy/bad weather forecast that may arise soon. Taking into considerations all the many benefits derived from GIS and geo-spatial utilization, it is therefore advisable and paramount to emphasize the adoption of precision farming methods knowing the fact that for any large farm management to record success stories, investment in equipment and labour is necessary. Conclusively, it is evident that spatial enablement of our environment through GIS-based studies stand to place in the hands of individuals and professionals a ready and timely access to spatial information base which is an essential and critical tool for making informed decisions on their day-to-day activities and also on key economic, environmental and social issues for sustainability.

RECOMMENDATIONS

- ✓ Land holdings that support the usage of these vast technologies should be thoroughly revisited such that farmers can optimally utilize the variability that exist within their fields and thereby not be restricted to a particular mode of farming techniques.
- ✓ Considering the spatial relationship and constraints faced with respect to distance travelled from major suppliers of food to markets and also from residential areas to these retail points vice versa, there is need to reconstruct and improve on our road network/transport system not only in the south eastern part but throughout the nation Nigeria.
- ✓ Agricultural data and climate data should be made readily available to end users as this will help in making well informed decisions that can help increase production and reduce

- cost that could be expended in the event of any future disaster outbreak
- ✓ The government should set up policies that will help in the reformation of the agricultural sector and also pump in more funds such that the expansion and embracement of geospatial technology and infrastructure.
- ✓ Producers (farmers) and suppliers (middle men) should be able to read climate risk maps, yield maps and profit maps as this will help in the production and dissemination of food items in the south eastern region as well as the entire nation in order to avert and form of shortage and loss with respect to distribution to end users.
- ✓ To develop a GIS-Based topographic database of the Study Area using GIS and Remote sensing technology that allows for easy updating, retrieval, manipulation, query and analysis in a problem solving environment.

REFERENCES

ARECA (2010), Precision Farming and Variable Rate Technology Guide First Edition Agricultural and Research Extension Council of Alberta (Available from http://areca.ab.ca/userfiles/files/VRT_Resource_Manual_Mar_2010.pdf)

Chigbu, Njike (2010). Analysis of land use and land cover changes of Aba Main Township Using Medium Resolution Satellite Imagery. Unpublished M.sc Thesis, Dept. of Surveying and Geoinformatics, Nnamdi Azikiwe University, Awka, Anambra state, Nigeria.

Donkin, A. J., Dowler, E. A., Stevenson, S. J., & Turner, S. A. (1999). Mapping access to food at a local level. *British Food Journal*, 101(7), 554.

FAO (2005) FAOSTAT - Food and Agricultural Indicators, Country, Nigeria.

Prepared by ESSA October 2005.

FAO (2006a) FAOSTAT: FAO statistical databases. Food and Agriculture Organization of the United Nations, Rome.

Jesse McEntee and Julian Agyeman (2010). Towards the development of a GIS method for identifying rural food deserts: Geographic access in Vermont, USA. *Applied Geography*: www.elsevier.com/locate/apgeog

Jensen, J. R., (1996). *Remote sensing of the environment: An Earth Resource Perspective*. 3th Edn., Prentice Hall, USA, pp: 1-28.

Kwan, M. P., Murray, A. T., O'Kelly, M. E., & Tiefelsdorf, M. (2003). Recent advances in accessibility research: representation, methodology and applications.

Journal of Geographical Systems, 5(1), 129–138.

Onu I.C and Igbokwe (2008) Analysis of Landuse Dynamics in Enugu and Environs between 1986 and 2003 Using Satellite Remote Sensing

West Africa insight (2010) Concerning Food security in Nigeria. December 2010 farming

World Bank. (1986). Poverty and hunger: Issues and options for food security in developing countries. Washington, DC: World Bank Policy Study.

Wrigley, N. (2002). ‘Food Deserts’ in British cities: policy context and research priorities. Urban Studies, 39(11), 2029–2040.

CONTACTS

Njike Chigbu

Dept of Surveying and Geo-informatics

Abia state Polytechnic

+2348033423624

njikec@gmail.com

Daniel Onukaogu

Dept of Surveying and Geo-informatics

Abia state Polytechnic

+2348105113856

danielonukaogu@yahoo.com